1940.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(FOURTEENTH ANNUAL REPORT OF THE).

Presented to both Houses of the General Assembly by Leave.

CONTENTS.

MINISTER'S STATEMENT.

THE outbreak of war in September last necessitated the full co-ordination of all the Dominion's resources for the prosecution of our war effort. Research is essentially a continuous operation, which must be carried on both in times of war and of peace. The immediate effect of the outbreak of hostilities is to re-orient a country's research facilities and personnel to attack problems of prime importance arising out of war conditions. Immediately on the outbreak of war the resources of the Department of Scientific and Industrial Research were placed at the disposal of the Defence authorities, the Ministry of Supply, and the various controllers operating thereunder. Investigations relating to problems of supply, increase of production, and conservation of natural resources were initiated by the Department itself.

Maximum production of foodstuffs requires that losses from disease be minimized and that the soil and crop resources be utilized to the best possible advantage. Furthermore, care must be taken that in securing increased production the fertility of the soil is not exhausted. In order to provide against such eventualities steps have been taken by the Department to intensify its agricultural research work in many directions. The campaign against plant diseases and insect pests has been intensified. Soil surveys, which are basic to sound and economic land development, and which point the way to the most economic use of fertilizers, are being accelerated as rapidly as possible, and hence a rapid survey of the soils of New Zealand is being undertaken and is already well advanced in the North Island.

Every phase of every primary and secondary industry is being brought under close investigation, so that, if at all possible, maximum exploitation of the Dominion's resources as a war effort will go hand in hand with conservation of these resources, thus ensuring that they will remain unimpaired by the stress of the times and be available for future expansion and development.

A new industry which is now well on the way to successful establishment is the production of linen fibre. Prior to the outbreak of war, investigations, both local and overseas, into the possibilities of the establishment of such an industry had been made with very encouraging results. Trial plantings of selected varieties of linen flax in Canterbury showed that fibre of the desired quality could be successfully grown, and would at the same time provide for a profitable diversification of farming practice. Further developments in the war situation had the effect of cutting off supplies of linen fibre formerly obtained by Britain from European sources, and an appeal has been made to the Dominions to accelerate production of linen flax as rapidly as possible to help to supply the deficiency. Steps will be taken in the coming season to plant the maximum acreage possible in New Zealand with the seed available, and at the same time plans are being formulated for the development of the industry so as to provide the necessary organization for the processing and marketing of the crop. This provides an example of the value of patient and thorough research in the establishment of an industry and in making provision for supplies necessary in times of national emergency.

Problems relating to the storage of foodstuffs assume great importance in war-time, and the Department is giving special attention to methods of storing fruit and dairy-produce designed to meet emergency conditions.

Problems of supply are not concerned wholly with primary products. Supplies of materials for many of our secondary industries have become more difficult to obtain or are unavailable as a result of the war, and it has become necessary to look more closely at our local resources of minerals, and, indeed, all other raw materials, with a view to supplying substitutes. In this connection close liaison with the Department of Industries and Commerce has been effected through a special Inter-departmental Technical Committee upon which both Departments are represented.

The Geological Survey has carried out quantitative surveys of deposits of such minerals as bentonite, manganese, chromite, clays, refractories, oil shale, sulphur, and coal, which are of special industrial importance at the present time. The Geological Survey has actively assisted the Mines Department and the various companies engaged in the exploration of the potential petroliferous areas of the Dominion by providing basic data on structural geology and by undertaking palæontological work which has a direct reference in the interpretation of oil-bearing strata.

The detailed survey of New Zealand's coal resources, which has made substantial progress during the past two years, and is now being further extended, is a work of first importance in relation to the further development of our industries—*e.g.*, the iron and steel industry. The Dominion Laboratory has participated in this work by carrying out the necessary chemical investigations.

The Dominion Laboratory is also undertaking special work in relation to the gas storage of fruit, which is of importance in relation to local marketing. Investigations of substitute fuels for use in emergency—*e.g.*, producer gas—are an important part of the Laboratory's present activities.

The Research Associations for the leather and shoe manufacturing and the wool manufacturing industries have given special attention to maintaining the standard of quality of the products of these industries. Through these Associations it has been possible to render very real help in technical problems arising from the greatly increased demands to meet extensive additional Government contracts, in addition to supplying the ordinary requirements of the trade.

The Dominion's scientific man-power has been surveyed through the compilation of a national register of scientists, from which men with qualifications for special work are being selected immediately as required. The Universities and scientific bodies and individuals generally have been prompt and generous in their offers of help in the national crisis, and I would like to take this opportunity of thanking them on behalf of the Government.

Although work directly related to the Dominion's war effort has necessarily occupied a prominent place in the Department's activities since the outbreak of war, scientific services required in connection with safeguarding the health and general well-being of the people must be fully maintained, and are even more necessary in times of war than in peace.

The year's activities of the Department have been fruitful in many directions. In matters of research it is not always possible to point directly to quantitative results, but it is clear that our social and economic progress is largely conditioned by the effectiveness of continuous research. The long-range view must be taken in regard to this work, for it is to be remembered that the great achievements of science have come only after long periods of assiduous and co-operative effort by scientists. In this work New Zealand is playing, and must continue to play, her part.

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 Department.

I have the honour to submit herewith the annual report of the Department for the year 1939–40.

The Council of Scientific and Industrial Research held six 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.
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).

Dr. R. R. Milligan, M.B., Ch.B., who succeeded Professor J. Malcolm on the Council resigned during the year.

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

Dr. E. Marsden during the year visited Great Britain and Australia, and during his absence Mr. F. R. Callaghan was Acting-Secretary of the Council and Department.

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 Imperial Institute, and the Carter Observatory	15,286
Dominion Laboratory (with branches)	21,885
Dominion Observatory	2,887
Geological Survey	10,300
Meteorological Office	22,654
Apia Observatory	3,099
Magnetic Observatory	2,836
Grants to Imperial Agricultural Bureaux	5,438
Research Investigations	120,357
	204,742
Recoveries	47,693
Net expenditure	£157,049

Grants were made to the following research organizations in Great Britain:—

	£
Imperial Agricultural Bureaux Headquarters	1,438
Imperial Forestry Bureau	187
Imperial Bureau of Dairy Science	113
Imperial Institute of Entomology	450
Imperial Mycological Institute	350
Farnham House Laboratory	600
Cambridge Low Temperature Research Station	2,000
British Wool Industries Research Association, London	300
	£5,438

EMERGENCY ACTIVITIES.

During the state of emergency which prevailed during the year the Department's activities have been directed to the fullest possible extent towards assisting the Dominion's war effort.

On the outbreak of war in September, 1939, the Meteorological Office and Apia Observatory were immediately transferred to the control of the Air Department so that the service supplied by this office would be primarily available to the Defence Forces. This transfer is a temporary arrangement to last for the period of the war.

Certain members of the Department's staff possessed of special qualifications have been transferred wholly for work with the defence services.

All branches of the Department have intensified their efforts to assist both primary and secondary industries in dealing with problems arising out of the circumstances of the war. In September, when the Supply Control organization was set up, contact was established with all Controllers, and the full services of the Department were made available to enable supply problems to be dealt with. Realizing that still greater effort was required, the Department initiated investigations which experiences of the last war indicated would be necessary, and in the course of this work there has been compiled a valuable fund of new information which may prove to be of very real assistance to industry during the war period. Realizing the need for having readily available particulars of the qualifications of scientists residing in the Dominion, the Department has compiled a register of the scientific personnel of New Zealand, and the detailed information provided therein has already been found to be of real practical use.

Physical Testing Laboratory.

For many years the chemical services required by the Government have been provided by the Dominion Laboratory and its branches. The growing importance of physical testing both to the Government and to industry has become increasingly apparent in recent years, and consequently a Physical Testing Laboratory was established in Wellington during the year. As yet the Laboratory is not fully equipped, but its services have been in very full demand for defence, departmental, and industrial requirements. Attached to the Laboratory is a workshop which is proving most useful for the construction of delicate instruments and machinery which often have to be devised for special purposes.

Secondary Industries.

To assist actively in the Government's policy of developing secondary industries in New Zealand and to provide for the needs of existing industries faced with the necessity of seeking substitutes in consequence of supplies having been reduced or stopped by war conditions, a special Technical Committee representative of the Departments of Industries and Commerce and Scientific and Industrial Research was constituted during the year. The Committee meets regularly, reviews the Dominion's natural resources and the problems confronting secondary industries, and initiates both scientific and commercial investigations designed to promote sound development either of existing or of possible new industries. The efforts of this Committee have been responsible for the speeding-up of chemical and geological investigations relating in particular to the Dominion's mineral resources.

Research Associations.

During the year considerable progress was made in negotiations preparatory to the formation of research associations for the building and laundry industries.

Implementation of Research Results.

Publications dealing with the findings of investigations have been issued in considerable number during the year, and special steps have been taken to ensure that their results have been brought to the notice of all those directly interested. A number of meetings were arranged so that research workers could discuss their investigations directly with representatives of industry or of other Government Departments. Regular articles on popular lines have been prepared for the press so that the results of research work in progress could become widely known.

Library.

The Department's library has been established on a proper basis during the year and is now reasonably well housed.

Research Progress.

In co-operative and organized scientific research spectacular results seldom appear. Progress comes rather by steady accretion of new information, all of which is received by the investigators themselves with critical caution. Ultimately this is built into the edifice of knowledge and practice where it is thoroughly tried out. To-day the advent of new knowledge is, as a rule, absorbed into industrial practice gradually. There is ample local evidence of this—for example, in the extent to which cobalt salts are used in fertilizers as a matter of course to check stock anæmia, boron applied to apple-trees to prevent internal-cork disease, and certified strains of rye-grass and clover used by farmers. All of these are instances of the widespread use of research findings of very recent years.

During the past year marked progress has been made in many spheres of research—measures have been devised for the effective control of a number of plant diseases of recent introduction to the Dominion; hopes for readier and economic control of club-root disease of turnips are more promising; the increasing importance of magnesium as a minor element affecting plant and animal thrift has been ascertained; the pasture resources of the whole of the North Island have been surveyed and mapped, and a similar survey regarding soils is rapidly approaching completion.

New machines have been designed and constructed for the drying of grass-seed to enable its quality to be maintained during transport overseas, and again to deal with the winnowing of kauri-gum chips in the field.

In the fibre industries the new decorticator for treating phormium has been thoroughly proved in actual practice, the possibility of fibre-production from young seedling plants has been tested and found promising, and new knowledge gained of the swamp conditions under which phormium thrives best and which, applied in practice, will permit considerable savings in the management of planted areas. In the case of linen flax, all the problems connected with the growing of the crop have been solved, and knowledge and experience of harvesting and processing the crop are available, and so sound foundations for the establishment of the industry have been laid.

In the sphere of minerals the completion of quantitative surveys of many deposits represents a distinct advance, while in some cases—*e.g.*, bentonite much new knowledge has been assembled whereby local exploitation of this mineral (for which overseas industry is finding many new uses) may be promoted. In the search for mineral oil in New Zealand the expert services of the Department have been regularly drawn upon by the various prospecting companies. Soil research has indicated to the tobacco industry directions for expansion in areas where planting can be safely undertaken without deterioration in leaf-quality, while plant pathological studies have rendered real assistance in reducing losses due to the leaf-mosaic disease.

These examples of advances made during the year are quoted to indicate that research is rendering to the Dominion steady, consistent results over a very wide range of problems, and that these results are being regularly absorbed into industrial practice and usage.

E. Marsden,
Secretary.

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

DAIRY RESEARCH INSTITUTE.

Dairy Research Management Committee.—Mr. A. Morton (Chairman), Professor H. G. Denham, Messrs. T. C. Brash, A. H. Cockayne, C. H. Courtney, G. A. Duncan, H. E. Johnson, A. Linton, C. A. Marchant, A. J. Murdoch, J. Murray, W. M. Singleton. Secretary: Dr. E. Marsden. Director, Professor W. Riddet.

During the year Mr. T. C. Brash was co-opted to the Committee as an active member on his retirement from the post of Secretary to the Dairy Board.

The Committee held six meetings during the year at approximately two-monthly intervals. At each meeting it carefully reviewed research work in progress and projected at the Institute, checked expenditure on all work carried out, and surveyed the requirements of dairy research work in the Dominion. It made arrangements for a grant to be made to Mr. P. O. Veale, B.Sc., dairy scientist, Hawera, for the carrying-out of a project concerned with dairy-factory drainage. At the outbreak of war it placed the services of the Institute at the disposal of the Government to utilize to the best advantage, and made such adjustments as were necessary for the prosecution of research work during the period of hostilities.

Research Work.

Considerable progress has again been made in the overcoming of difficulties in the manufacture of butter and cheese, and substantial contributions have been made to the science of dairying.

The cheesemaking investigations undertaken during the year embrace—

(*a*) Continuation of past research work to determine methods of preventing the failure of cheese-starters in factories.
(*b*) The cheesemaking technique best suited to the use of starters in factories.
(*c*) Determination of the commonest sources of those organisms which give rise to slit openness in cheese.
(*d*) The causes of cracked rinds.
(*e*) Methods of controlling mould growth in cheese, with special reference to the control of temperature and humidity.
(*f*) Standardizing of cheese annatto.
(*g*) Methods of controlling the growth of cheese-mites.

Buttermaking investigations have included—

(*a*) The control and elimination of cress taint in cream and butter.
(*b*) Methods of prolonging the keeping quality of butter.
(*c*) The influence of churning factors on the body of butter.
(*d*) The influence of locality on the composition of butterfat.

Part of the first-named taint project was carried out at the factory belonging to the Tauranga Co-operative Dairy Co. after preliminary work undertaken at the Institute.

Dairy-husbandry investigations carried out in the past in collaboration with the Grasslands Division of the Plant Research Bureau were continued and, in collaboration with the Wallaceville Laboratory of the Animal Research Division of the Department of Agriculture, the animals used in the dairy-husbandry investigations were employed for research work concerned with the control of mastitis and the incidence of grass staggers.

A considerable amount of work was carried out on the composition, uses, and efficiency of dairy cleansers; this has shown that considerable economy and increased efficiency can be effected in the purchase and use of these. A survey has been made of dairy factory operating costs which has yielded very interesting results.

Arising out of difficulties in recent years of disposing of casein, a survey was made of the New Zealand casein industry and of the world's trade in casein. Subsequently contact has been established with local manufacturers of casein, and material assistance has been given to them in explaining the use of this locally made product. Various other projects of lesser importance were undertaken during the year.

The following statements prepared by officers in charge of the projects give a fuller account of the progress made. More detailed results are communicated in technical papers as the work becomes far enough advanced for report.

Cheesemaking Projects.

(*a*) *Cheese Starters* (H. R. Whitehead and G. J. E. Hunter).—It had been discovered during the previous year that failures of cheese starters in dairy factories were in a large measure due to contamination with air-borne bacteriophage. During the past season efforts were concentrated on trials of various methods for the elimination of such contamination. The most crucial experiment was that conducted at the Bell Block Dairy Factory, where, with the financial assistance of the Dairy Board, a special starter-room quite separate from the factory building was erected. This room was put into use at the beginning of September, 1939. It was a complete success throughout the season; no failures of starter due to bacteriophage contamination were experienced. On three occasions cans of bulk starter were abnormal and were discarded, but this proved to be due to the use of "non-acid" milk in the starter cans. There was no trouble with either mother cultures or with the cheese-vats. Thus the process of cheesemaking at Bell Block Factory was reduced this season almost to complete regularity from day to day, the only variations necessary being those due to changes in composition of the milk as the season advanced. This result is, of course, the object of all the work on starter propagation, and if the starter-room at Bell Block gives equally satisfactory results next season it can justifiably be assumed that the main problem has been solved.

At another commercial factory experiments were made throughout the season to determine whether it is possible to protect the starter from air-borne phage under somewhat crude conditions and without much expenditure. During the course of this work the mechanism of the development of air-borne phage was made clear. It has previously been shown that bacteriophage commonly develops in the whey in cheese-vats, even when the process is proceeding normally. The reason for this is not known, but it may be accepted as a normal occurrence in cheesemaking practice. The separator which is used to remove the last traces of fat from the cheese whey revolves at approximately six thousand revolutions per minute, and it was found this season that the separation process resulted in the emission of a finely atomized whey (usually containing phage). This proved to be the major source of the air-borne phage in the factory building. The concentration of phage in the air was so strong on occasions that the mere removal of a cotton-wool plug from a flask of sterilized milk for ten seconds was enough to cause immediate failure of a starter in that milk. This finding emphasized the necessity for removing the starter mother culture from the factory environment. By complete closure of the starter cans and inoculation through a small orifice plugged with cotton-wool it did prove possible to maintain the bulk starters with only very occasional failures in the factory buildings. The whole trend of the results, however, showed that, while various makeshift devices gave considerable relief from starter failures, nothing short of a special room completely cut off from the main factory building gave security.

Several dairy companies are now contemplating the building of special starter-rooms. Experience over the next season or two will show how near complete success with starter cultures the average factory can come.

Single-strain starter cultures were used throughout the work mentioned above, but there is ample evidence to support the view that cultures containing several different strains of streptococci such as have commonly been prepared from commercial powder will be more steady in activity under commercial conditions if they are similarly protected from air-borne contamination.

(*b*) *Technique of Cheese-manufacture with Active Starters* (W. Riddet and H. R. Whitehead).—The single-strain starters R_1 and HP were used throughout the season for the manufacture of cheese in the experimental factory. The paramount influence of the acidity at the time of removal of the whey from the curd on the character of the cheese was confirmed. Other factors such as the rate of acid development throughout the process, the acidity when the curd is milled, and the acidity at salting have a very subsidiary influence. The optimum acidity at the drying stage naturally varies with the composition of the cheese milk. It ranges between 0·20 per cent. and 0·28 per cent. lactic acid (for whey draining from the curd immediately after drying). Drying the curd at too low an acidity (say, 0·20 per cent. instead of 0·23 per cent.) tends to give a cheese with a weak "rubbery" body, while drying at too high an acidity (say, 0·26 per cent. instead of 0·23 per cent.) tends to give a cheese with a firm but sticky body and a sharp acid taste. The minor influence of the rate of acid development on cheese quality makes it possible within limits to reduce the time the curd is cooked in the whey where an active starter is used. Similarly, the times between drying and milling and milling and salting can often be reduced without any significant influence on cheese characteristics becoming apparent. There are slight differences in the effect of the various single-strain starters which have to be recognized and allowed for in the cheesemaking process. When a cheesemaker becomes accustomed to the use of a particular single-strain starter, its regularity of behaviour gives him an excellent chance to adjust his making procedure so as to get the best possible result.

(*c*) *The Sources of Lactobacilli important in Cheese-ripening* (I. R. Sherwood).—In earlier reports the important influence of lactobacilli upon the ripening of Cheddar cheese has been discussed. During the past year an investigation of the sources of these organisms has been carried out.

The Milk employed in Cheese-manufacture: In New Zealand cheesemaking practice the milk is usually flash-pasteurized. This heat treatment destroys most of the organisms in the milk, but it has been shown in the present investigation that an appreciable proportion of the lactobacillal population survives and passes into the cheese-curd.

Milking-machines and Utensils used in the Production of the Milk: Owing to the extensive use of milking-machines in New Zealand, a special study was made of the bacterial flora of selected machines. By the use of a selective cultivation procedure it was shown that all types of lactobacilli of common occurrence in cheese also occurred in milking-machines. In *individual machines* one or two types usually predominated. Experiments carried out on the Institute machines showed that while metal parts and rubber parts in good condition were fairly easily sterilized, yet worn rubbers displaying cracks and scratches could not be sterilized satisfactorily by ordinary methods. From other utensils used in milk production cans, buckets, &c. lactobacilli were frequently, but not invariably, isolated.

Sources from which Lactobacilli may gain Access to Milking-machines and Utensils: Earlier workers have shown that lactobacilli occur in *ensilage* and *dung*. Other sources are—

(1) Dust from the Cowyards and Environs: Examination of samples of dust from cowyards and adjoining roadways revealed the presence of lactobacilli (*Sbm. casei*, *Sbm. plantarum*, and betabacteria). These organisms were found to gain access readily to milking-machine parts in the sheds, especially the teat-cups. Although in practice the extent of contamination which occurs in this way is usually relatively small, yet once the organisms gain a foothold in the machines, rapid multiplication may occur under suitable conditions.

(2) Grasses: Lactobacilli were isolated from grasses by the use of a laboratory modification of the ensilage-making process. Perennial rye was found to harbour three varieties of *Sbm. plantarum* (varieties 2, 3, and 4, described in the last report). The same varieties of *Sbm. plantarum* were isolated from brown-top and a few other grasses. From red and white clovers and from cocksfoot the only lactobacilli isolated were all strains of *Sbm. plantarum*, variety 1. There would thus appear to be some specificity in the occurrence of lactobacilli on grasses, but seasonal and climatic factors have not yet been adequately investigated.

(*d*) *Cheese-rind Investigations* (R. M. Dolby).—The occurrence of cracks in cheese-rind by permitting the entry of mould may cause the spoilage of a considerable portion of the cheese. Under present conditions, when delays in transport may increase storage periods, such defects may be accentuated. Investigations both in the Institute factory and in a commercial factory have shown that cracks are most likely to develop during the first week after manufacture, when the knitting together of the curd particles is still incomplete, and that cracks do not usually extend appreciably after the cheese is two weeks old. The experiments demonstrate the necessity of using an outer bandage which is in good condition and of avoiding wrinkles in the inner bandage. Other factors tending to produce rind cracks are the placing of cold curd in the hoops, inadequate pressing, oversalting of curd, displacement of curd where morning dressing is practised, and damage to cheese by rough handling after removal from the hoop. Normal variations in moisture content of curd or in temperature of curd at hooping did not appear to influence the development of cracks in the rind. The omission of scalding of the hoops, while reducing the adhesion of the bandage, did not cause increased cracking. Storage at high temperatures and low humidities, and storage in a current of air, also did not produce cracks in the rind.

(*e*) *Standardization of Annatto* (C. R. Barnicoat).—Further evidence has been accumulated to support the view previously put forward that annatto extract (cheese colour) is best standardized in alkaline solution by examination in transmitted light.

(*f*) *Controlled Temperature and Humidity of Cheese-curing Rooms.*—See section "Mycological Projects."

Buttermaking Projects.

(*a*) *Land Cress and other Feed Taints in Cream* (F. H. McDowall). It has been previously reported that land cress on steam distillation yields an oil of high boiling-point and consisting for the most part of benzyl cyanide. Addition of the oil in small proportions to cream used in butter-manufacture gave a flavour in the butter which had some resemblance to land cress taint but which was not true land cress taint. Treatment of cream tainted with land cress in the small Vacreator at the Institute was effective in removal of taints of medium intensity and in reducing to small proportions the taint of heavily tainted cream. An attempt was made in a commercial factory to obtain similar results by use of the large-scale Vacreator. It was found that the large machine was less efficient in this respect, and some modifications introduced by the makers were tried out. The preliminary trials showed that the modifications gave an improvement in the degree of taint removal. Arrangements are now in hand for a large-scale trial during the period of cress taint incidence in the coming season. The Vacreator modifications also increased the efficiency of removal of feed (clover) taint.

It has been shown that taint from land cress passes into the milk in the udder within thirty minutes after consumption of the plant by the animal, and that it persists in the milk for several hours, and sometimes for more than twelve hours. The period of persistence of the taint in the milk and cream varies to some extent, however, with the individuality of the animals.

(*b*) *Keeping Properties of Butter* (C. R. Barnicoat).—(i) Temperature of Storage and Addition of Anti-oxidants: A study has been made of the keeping qualities of New Zealand finest-quality butter held at temperatures above freezing-point, in order that information on this subject should be available if required. It was found that butter containing 1·5 per cent. salt had a better keeping quality on storage at 35° F. than butter treated with various anti-oxidants and preservatives. Finest salted butter held for four months at 35° F. usually graded 90–91 points after storage. After removal to room temperatures, however, there was a rapid deterioration; hence butter held for any considerable length of time at temperatures above freezing-point should be passed on to the consumer as soon as possible after removal from storage.

(ii) Metallic Contamination: It was shown that the presence in cream of 0·6 parts of copper per million had a pronounced effect on the quality of the resultant butter stored at 14° F. After one week the grade had been lowered by half a point, after five months by one point, and after twelve months by two points and a half. Iron (both ferrous and ferric) present in the cream to the extent of three parts per million had only a slight effect. The importance of keeping cream and butter away from bare copper surfaces is thus emphasized.

(iii) Effect of Light: It has been observed that in some butter-factories there are skylights through which direct sunlight can impinge on the butter in the making-room. It is known from work here and elsewhere that light accelerates the deterioration of fat. Some experiments have been carried out to study the effect of light of varying intensities on butter under conditions of handling similar to those existent in commercial factories. Blocks of butter exposed to light were found to undergo oxidation at the surface. When this butter was passed through the packing-machine and the surface layer was thus mixed into the remainder of the butter by the action of the packer screws, the evidence of deterioration disappeared. The butters are being held in cold storage for some months. The gradings of the stored butter, when they become available, will be of interest, as they should indicate whether the incipient deterioration noted on the surface of the block has spread through the whole mass of the butter.

(*c*) *Hardness of Butter* (R. M. Dolby).—(i) Apparatus for Measurement: A new apparatus for measuring hardness has been developed. This instrument, which determines the resistance of butter

to cutting by a wire, while giving results in general agreement with those obtained from the Scott-Blair apparatus used previously, has proved more satisfactory in that it gives much more reproducable values and is not affected by a tendency of the butter to crumble.

(ii) Relation of Manufacturing-conditions to Hardness of Butter: A continuation of the factory experiments has confirmed the observations previously reported on the effect of rate of cooling of cream after pasteurization and of temperature of wash water on hardness of butter. It has also been shown that the temperature at which the cream is held during the ripening period has a definite effect on butter hardness, a lower holding temperature giving a firmer butter. A comparison of Vacreator with flash-pasteurizer treatment has shown that the method of pasteurization has no effect on the hardness of the butter.

(iii) Composition of Butterfat and Hardness of Butter: It has been shown that the iodine value of butterfat has a definite influence on the hardness of butter. It is evident, however, that other factors in the composition also exercise an effect.

(*d*) *Variations in the Composition of Butterfat* (G. A. Cox).—Samples of butter obtained at monthly intervals from nine factories scattered throughout New Zealand have been analysed in a study of variations in the composition of the fat. The results show clearly a seasonal variation in the properties of the fat common to the butters from all the factories. Determinations of iodine value on samples of butterfat from the different groups of cows in the Institute experimental herd fed under controlled conditions show that the same seasonal variations occurred viz., a depression in the November-January period—in spite of alteration in the feeds.

Mycological Projects. (T. R. Vernon).

During the year mycological work has been directed mainly to the control of "mould" in cheese-factories.

The survey work has shown the difficulties of controlling contamination. The amount of contamination varies greatly from factory to factory, and while more or less proportional to the general sanitary condition of the factory itself, many factors lie outside the control of the manager. In spite of this, certain common factors contributing to mould contamination have been noted. These are avoidable—*e.g.* (*a*) the storage of local and export cheese in the same room, (*b*) the prolonged storage of cheese from slow vats, (*c*) careless storage of salt and cheese bandage.

To prevent mould growth in spite of contamination three methods have been investigated: (*a*) Controlled temperature and humidity, (*b*) ozone, (*c*) ultra-violet radiations.

(*a*) *Controlled Temperature and Humidity of Cheese-curing Rooms.*—The advantages of controlled temperature in cheese-curing rooms is well known, and the connection between humidity and mould growth has long been appreciated. Although managers have kept daily records of temperature and humidity, no attempt at humidity control has been made. Investigations showed that controlled humidity could control mould in spite of contamination. Once expensive, machinery is now available at a reasonable cost, and three local factories are now equipped with temperature and humidity control apparatus. One of these factories which has been in operation for a whole season has been completely free from mould troubles. Humidity has been controlled between 80 per cent. to 85 per cent.

A study has been made of the effect of controlled temperature and humidity on shrinkage losses and quality. While it has been difficult to assess values to changes in quality, a saving of $\frac{1}{4}$ per cent. has been observed in the shrinkage of cheese held under controlled conditions compared with that of similar cheese held in an uncontrolled room.

Work is now in progress to determine the effect of controlled humidity on cheese stored for long periods.

(*b*) *Ozone.*—There is ample evidence to show the inhibitory effect of low concentrations of ozone on mould growth, and from Australian reports it would appear that it has been tested in cheese-curing rooms with favourable results.

In a series of experiments carried out during the season it has not been possible to duplicate these favourable results. It has been found that if the humidity is high enough to encourage "mould" the rate of ozone production is drastically reduced, and although mould growth and spore formation are retarded somewhat they are not entirely controlled in spite of the fact that the apparatus was handling a volume of air less than one-tenth of its capacity. After removal from the ozone chamber, "mould" developed rapidly.

The apparatus tested does not appear to be of any practical value in cheese-curing rooms.

(*c*) *Ultra-violet Radiations.*—By means of a commercial apparatus for the production of ultra-violet rays the common dairy moulds have been tested. The results show that fungal spores are much more resistant to ultra-violet rays than are bacteria, and that wide variations occur amongst the moulds themselves. Resistance depends largely on the colour of the spore coat. At a distance of 3 in. an exposure of five minutes brings about a reduction in numbers of more than 90 per cent. for most moulds, but species with dark-coloured spores proved more resistant. In one case a complete kill was not obtained after eighty minutes' exposure. In general, the results indicated that the apparatus would not be readily applicable to cheese-curing rooms. Tests have also been carried out on milk-bottles contaminated with bacteria. When direct irradiation was possible the reduction in numbers was high, but the curvature of the bottle produced a blind spot and complete sterilization was not obtained.

(*d*) *Casein Paint.*—With the object of increasing the mould resistance of casein paint, tests are being carried out with a variety of fungicides.

GENERAL.

(*a*) *Cleansing-powders for use in Dairy Factories* (F. H. McDowall).—A study has been made of the alkaline powders in use for the cleaning of dairy equipment. In the main these have been found to consist of one or more of the following substances: sodium bicarbonate, sodium carbonate (soda ash), caustic soda, sodium metasilicate, trisodium phosphate, and soap. The prepared mixtures are thus made up of the raw alkaline materials well known to commerce. It has been shown that a considerable reduction in costs could be effected at the factory by purchase of the raw alkalis instead of the prepared mixtures. It is considered that the factory workers have been greatly handicapped in the efficient use of the cleansers by the lack of information on the composition of the mixtures *e.g.*, there has been a widespread wastage through the admixture of a cleanser containing caustic soda with a cleanser containing sodium bicarbonate. The sodium carbonate formed as a result of the chemical action between these two compounds could have been purchased as soda ash at one-third of the price paid for the mixture. In addition, the sale of a cleanser containing a high proportion of caustic soda without any warning to the user must be regarded as dangerous. Several formulæ for mixed cleansers are being proposed, and factories are recommended to buy the raw alkalis and prepare the mixtures in stock solution as required, or, alternatively, to buy the prepared mixtures to a specified composition. Some attention has been given also to the methods of applying cleansers to the various types of equipment, and to the improvement in the efficiency of can-washing machines.

(*b*) *Dairy Factory Costs* (J. F. Tasker).—During the year an analysis was made of the 1937–38 manufacturing and marketing costs of a group of forty-nine buttermaking companies scattered throughout the Auckland and Wellington Provinces. The companies covered ranged in production from 110 tons up to 4,830 tons for this season, and altogether produced approximately 70,000 tons of butter—*i.e.*, about one-fifth the total Dominion production and over half that of the Auckland and Wellington Provinces. The companies were grouped according to their production for the season into classes of 500 tons. The unit used was the pound of butterfat.

The study showed that, on the average, total costs steadily decreased as production increased, but that the rate of fall decreased with increased production. Manufacturing charges, repairs and maintenance costs, and depreciation showed a close relationship to volume of production, while cream-collection costs and factory to f.o.b. charges showed practically no connection with this factor. Overhead charges were shown to be affected indirectly by volume of production.

The greater part of the differences in the costs of the small and the large creameries arose from differences in manufacturing charges, and these in turn were affected mainly by variation in manufacturing wages. The study also indicated that the optimum size of the average creamery from the point of view of costs was from 2,000 tons to 2,500 tons.

(*c*) *Dairy Factory Drainage* (P. O. Veale).—In an attempt to get definite information on the volume and composition of drainage from different types of dairy factories there was recorded during the year the daily volume of drainage discharged at different times during the day at three cheese-factories, two butter-factories, and one casein-precipitating station in Taranaki. There was also estimated at regular intervals the volume of water flowing in the streams into which the drainage was discharged. From composite samples of the drainage there were determined pH value, acidity, total solids, organic nitrogen, oxygen absorbed from permanganate in four hours, and five-day BOD (biochemical oxygen demand). Bacteriological and chemical examinations were made of samples drawn from the streams into which the drainage was discharged at points above and below the drainage outlet. The work is not yet completed, but data of great interest to the industry have been collected. This is the first time data of this kind have been collected in New Zealand. They indicate that the volume and type of drainage from New Zealand cheese-factories differs from that reported on by workers overseas. The data also indicate that the drainage from butter-factories differs markedly from the drainage from cheese-factories. A detailed report on this will be prepared and published at the conclusion of the investigation.

(*d*) *Casein* (W. R. Mummery).—A survey has been made of the international trade in casein during recent years. A study has also been made of the extent to which rennet and lactic casein are used in different industries, and of the different methods for precipitating and treating casein in different countries and particularly in New Zealand. A successful effort was made to contact all local users of casein, with a view to extending the local demand for this product. Advice has been given to several manufacturers on the preparation of adhesives containing casein, and work is in progress to help local manufacturers out of difficulties. Attention is also being devoted to increasing the use of casein in the manufacture of paints for particular purposes, the possibility of making casein plastics in New Zealand, using casein in sheep dips, and in various other ways.

(*e*) *Dairy Husbandry* (S. L. Green).—During the year several lots of milking animals have been grazed separately on pastures consisting of (*a*) perennial rye-grass, (*b*) perennial rye-grass and white clover, (*c*) cocksfoot, and (*d*) cocksfoot and white clover. Daily records have been made of the milk produced by all experimental animals, and from three-day composite samples the milk of each cow has been analysed for its fat content, solids-not-fat, total protein, and lactose. In addition, the milk of each cow has been examined at the Wallaceville Veterinary Laboratory, Department of Agriculture, for the presence of mastitis, by leucocyte assessment at weekly intervals and by cultural examination at monthly intervals. Also Dr. Cunningham, of the Wallaceville Animal Research Station, has determined the calcium and magnesium in the blood of each experimental animal. Since the animals have not yet completed their lactation for the year, results cannot be studied in detail, but it is noteworthy that although they have been milked by machinery now for two years none of these animals have been affected with mastitis. The production of all the animals has been normal.

In a trial conducted with six milking animals kept indoors the feeding value of perennial rye-grass was contrasted with that of Italian rye-grass. At the outset of the experiment the milking animals did not take kindly to the pure perennial rye-grass, but as the plants started to grow vigorously this feed became quite palatable. A detailed report on this experiment will be published when the results have been worked up.

Collaboration with New Zealand Standards Institute.

As in past years, several members of the staff have assisted the Standards Institute in work concerned with standards for dairy products. Drs. F. H. McDowall and H. R. Whitehead have continued to act as Joint Secretaries of the Dairy Products and Requisites Committee.

Pasteurization and Bottling of Milk for Schools.

The Institute has continued to pasteurize and bottle milk for supply to schools in the Palmerston North district, in accordance with arrangements made with the Department of Health. The entire cost of this work has again been borne by the Department of Health.

Dissemination of Results of Work.

As in past years the research work carried out during the season was reviewed at the Dairy Factory Managers' Week. This took place from 7th May to 10th May, and was attended by eighty-seven factory-managers and first assistants and seven others connected with the dairy industry. During the year addresses were given by members of the staff at the National Dairy Conference, and at meetings convened by the New Zealand Dairy-factory Managers' Association, by the South Island Dairy Association, and by dairy companies.

Institute Publication No.	Title.	Author.	Journal
115	Annual Report, 1938-39	..	..
118	Oxidation of the Fat of Butter during Cold Storage	W. J. Wiley ..	*J. Dairy Research.*
119	Payment for Milk for Cheese-making: A Trial of the "Costed Cheese" System in Seventeen Commercial Factories	F. H. McDowall ..	*N.Z. Jour. Sci. & Tech.*
120	The Relation of certain Lactic Acid Bacteria to Open Texture in Cheddar Cheese	I. R. Sherwood ..	*J. Dairy Research.*
121	Bacteriophage-organism Relationships in the Group of Lactic Streptococci	H. R. Whitehead and G. J. E. Hunter	*J. Dairy Research.*
122	The Bacterial Flora of New Zealand Cheddar Cheese	I. R. Sherwood ..	*J. Dairy Research.*
123	Lactic Acid Bacteria in Relation to Cheese Flavour—II: Observations on the Inoculation of the Milk employed in Cheese-manufacture with Lactobacilli	I. R. Sherwood ..	*J. Dairy Research.*
124	Examples of Variations within Pure Cultures of *Streptococcus cremoris*	G. J. E. Hunter ..	*J. Dairy Research.*
125	Butterfat Losses in Churning	W. J. Wiley ..	*N.Z. Dairyman.*
126	The Removal of Undesirable Flavours from Cream used for Butter-manufacture	W. Riddet *et al.* ..	*N.Z. Jour. Sci. & Tech.*
128	The Colorimetric Estimation of Diacetyl and Acetoin in Dairy Products	G. A. Cox and W. J. Wiley	*J.C.S.I.R.* (Australia).
129	Formation of Diacetyl by Starter Cultures—I: A Comparison of Single Strain and Mixed Culture Starters for Butter-manufacture	W. J. Wiley, G. A. Cox, and H. R. Whitehead	*J.C.S.I.R.* (Australia).
130	Formation of Diacetyl by Starter Cultures—II: Rate of Diacetyl Production by Lactic Streptococci	W. J. Wiley, G. A. Cox, and H. R. Whitehead	*J.C.S.I.R.* (Australia).

The following are in the press:—

Institute Publication No.	Title.	Author.
127	The Action of Chemical Disinfectants on Bacteriophages for the Lactic Streptococci	G. J. E. Hunter and H. R. Whitehead.
131	A Note of the Influence of High-temperature Short-time Pasteurization on the Phosphatase Reaction and Creaming of Milk	W. J. Wiley.
132	An Accurate Constant Temperature Bath and Storage Cabinet for Operation below Room Temperature	R. M. Dolby.
133	Studies in the Chemistry of Cheddar Cheesemaking—VII: The Measurement of the Acidity of Cheese and the Relation of Acidity to Grading Score	R. M. Dolby, F. H. McDowall, and W. Riddet.
134	Causes and Prevention of Foaming of Lactic Casein	W. R. Mummery.

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; Messrs. C. A. Marchant and Alan Grant, representing North Island and South Island farmers respectively; Mr. F. Callaghan, Secretary and Chief Executive Officer.

The Plant Research Bureau now comprises five Divisions, viz.:—

	Location.	Director.
Plant Diseases Division	Owairaka, 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 Division	58 Bowen 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.

Quarterly meetings of the Plant Research Bureau Committee have been held during the year, when programmes and progress of the research work have been reviewed.

AGRONOMY DIVISION, LINCOLN.

Director: Mr. J. W. Hadfield,

This Division is concerned with all phases of crop improvement, and this objective is approached mainly by plant introduction, plant breeding, and pure-seed production.

Wheat.—The production of pure and smut-free seed wheat continues each season to be a useful service performed by this Division. Nucleus seed is raised annually from single plant selections and is sold to the Canterbury Agricultural College and selected growers, who increase and distribute the product under Government certification. The following varieties were grown during the past season: Cross 7, Dreadnought, Tainui, College Hunters, Montana King, Marquis.

Oats.—Five new varieties were imported during the past year, making the total number of varieties tested 117. Of those imported during recent years, three are worthy of mention—namely, (1) Binder, an importation from Holland, which not only stands better, but has considerably outyielded Abundance in two consecutive seasons; (2) "Line 834," an introduction from Belgium, which has, for a second time, outyielded all other varieties: (3) Victorian hybrid, which has proved to yield as well as Abundance, and, in addition, has shown a high degree of resistance to both stem and crown rust.

The most advanced breeding material—namely, Ruakura × Lampton has now reached the seventh generation. Ten lines either equal to or better than Algerian in yield are being further tested, and seed will be available for field trial in 1941–42. Due to the very limited material available for crossing when this work started, these F_7 segregates are not as promising as some more recent crosses in which full use has been made of the most recent improved material obtained from overseas breeders. Of the cross Ruakura × Abundance now in F_6, five lines remain equal to or better than Abundance. The F_4 material consists of crosses between Resistance and several other varieties of particular merit, and the segregates appear very promising in regard to yield, grain quality, and strength of straw. Material now in F_1 and F_2 consists mainly of crosses between standard varieties and material recently introduced and proved to be highly resistant to leaf and stem rust.

Barley.—Of some forty varieties of malting barley originally introduced, five varieties deserve further trial. Severe bird damage so reduced yields in the increase blocks that there has been insufficient seed for malting tests, and all seed that has been saved will have to be resown.

Of sixty-nine six-rowed barleys that have been under trial for some years, two, one being a smooth awned variety, Newal, and the other Oderbrucker, are very promising as green-feed barleys and appear to give a satisfactory yield of seed. Their early growth is considerably more rapid than either Cape or Black Skinless.

Field Peas.—Great Britain cans one hundred million cans of dried peas per annum, using for this purpose about 500,000 bushels of dry peas, of which 70 per cent. to 80 per cent. are imported from the Continent and Japan. This is exclusive of the large quantity sold as dry peas in packets. New-Zealand-grown peas are not acceptable in Great Britain for canning on account of their hardness and the toughness of their skins. A project was commenced some years ago to breed varieties suitable for New Zealand and more acceptable to the British trade. While these efforts have resulted in improvement in yield and appearance, it has not been possible to overcome hardness and toughness. These features appear to be associated with climatic conditions.

More progress has been attained in the production of a high-yielding white pea for the split-pea trade to replace White Ivory, the yields of which are too uncertain.

It was hoped that trials conducted this past season would finalize many points regarding the segregates now fixed and ready for distribution. Unfortunately, weather conditions rendered the trials inconclusive and they will have to be repeated next season. It is also intended to extend these trials more widely over New Zealand than has been possible in the past.

Garden Peas.—Attempts to improve on Greenfeast in the matter of yield and double podding have met with partial success. These segregates have for some years given satisfactory results in the

North Island, but in the South Island have not proved superior to Greenfeast. Next season trials are to be conducted in Nelson and Hawke's Bay under commercial production. The crosses are fixed and ready for distribution as soon as trial results indicate clearly which one is the most promising.

A second series of crosses now in F_4 has been raised by the bulk-population method and will go out as single plant selections next season. Crosses between Greenfeast and a mosaic-resistant rogue which was discovered by the Plant Diseases Division are now in F_2.

Lupins. For some years past trials have been conducted with the Sweet Yellow Lupin, the alkaloid content of which is of the order of 0·01 per cent., as against about 0·9 per cent. in the ordinary bitter New Zealand Blue. About 3 bushels of seed are now awaiting distribution for trial. The Sweet Yellow does not produce as much forage as the New Zealand Blue in the South Island. The high palatability of the Sweet Yellow is, however, proved beyond doubt.

The introduction from Europe last year of the Sweet Blue Lupin is a matter of outstanding interest. The variety is similar to the New Zealand Blue except that the alkaloid content is as low as 0·002 per cent. Its high palatability has the unexpected drawback of making it highly susceptible to insect damage, and during the past season thrips have interfered seriously with its healthy development and with seed setting.

An extensive use of sweet lupins as a forage crop and soil renovator may have far-reaching beneficial effects on production, more particularly in the cropping areas.

Lucerne.—Two main lines of approach have been followed in the improvement of this crop. The first has been by the combination of parent plants selected on the behaviour of their inbred progenies. The strain so raised has, in trials of spaced plants, given an increase in yield of 15 per cent. above Marlborough, and the plants are very much denser and carry more leaf. Of this strain about 80 lb. of seed is being saved this season for use in field trials and for increase.

A second line of approach has been by the combination of inbred material, and this also has resulted in marked improvement over Marlborough in yield and quality as judged by plots of spaced plants. About 20 lb. of seed is available for trial and increase.

It is yet too early to predict what measure of success has been obtained, because the behaviour of spaced plants may prove to be unreliable as a guide to the behaviour of the same plants under field conditions.

Rape.—Progress in the commercial production of rape-seed under certification by the Department of Agriculture from types raised by this Division has, in view of the embargo on the export of rape-seed from Great Britain, avoided what might have proved a very serious position. Apart from raising mother seed of strains under certification, work is developing in four directions and combined yield and grazing trials have been carried out.

A new cross (Giant × Broad-leaf Essex) × Broad-leaf Essex has outyielded Broad-leaf Essex and proved to be more palatable. Of this cross, 1,000 lb. of seed has been harvested to permit extensive field trials to be undertaken next season.

Giant Rape crossed with Swede-like Rape, although not as productive as Giant, tends to be earlier in maturity by a week to ten days.

(Swede × Rape) × Rape, although not as productive as Giant Rape, is proving even more palatable; and from Rape Kale × Rape a late cross has been developed which is more productive than Giant.

Marrow-stem Kale.—During the past season three strains selected in 1937–38 have been compared in a yield and grazing trial. From the two best strains sufficient seed is available for field trials next season, and approximately 1 acre of each has been sown for seed production next season. This is a first stage toward certification.

Many crosses have been made between different types of kale in the hope of discovering improved forms.

Turnips and Swedes.—An attempt is being made to effect improvement in type and disease resistance, but the work has not progressed very far owing mainly to the difficulty experienced in overwintering selected bulbs. Last year, however, a number of selections were carried through successfully in pots and a certain amount of material is now available for trial during the coming season.

Potatoes.—Crosses between South American species and commercial varieties are being studied and others are being made, in all cases having in view certain definite objectives such as (*a*) resistance to late blight, (*b*) resistance to frost, (*c*) yield and quality, (*d*) yield irrespective of (*a*), (*b*), and (*c*).

Some success has been attained in obtaining resistance to late blight, and the ultimate objective is to combine high quality and yield with resistance by back crossing to commercial varieties and reselection within the resistant segregates. No accurate tests have been possible to determine frost resistance in crosses made so far because of lack of glasshouses and other equipment.

Linen Flax.—The part being played by this Division in the establishment of the linen flax industry is mainly along the following lines:—

(*a*) The introduction of a number of varieties from Europe for trial in New Zealand. Seed stocks of Liral Prince, Giza Purple, Stormont Cirrus, and Stormont Gossamer are being built up, and it is hoped that special treatment will ensure freedom from seed-borne disease.

(*b*) Trials are being carried out with varieties and fertilizers, and others are designed to determine the best method and rate of seeding. In all cases the yield per acre of both seed and fibre is determined.

(*c*) Determination of fibre yields are made from all experimental work, both that undertaken by this Division and that by the Fields Division.

(*d*) Investigations into retting, for which purpose two small experimental tanks are in course of erection.

(*e*) Advice on commercial production, the Director of this Division having spent some months abroad investigating the industry.

Linseed.—Some forty-five varieties and selections are under trial. The outstanding introduction is Rio. It has proved, so far, highly resistant to wilt, immune from rust, and practically immune from browning. Seed yield is high and iodine number fair. It has the fault, however, of being rather short in the straw. The production of linseed-oil in New Zealand has lapsed in recent years, but the possibility of re-establishing the industry is under consideration, and for this reason steps are being taken to determine varieties more suitable than those grown in the past.

Vegetable Crops.—Investigations have been along the following lines:—

(*a*) Investigations into the varietal characteristics of dwarf beans.

(*b*) Seed production, with particular reference to Holmes's carrot, a variety used extensively in Taranaki for stock feed.

(*c*) Building up of "Hawkesbury Wonder," a variety of dwarf bean showing some resistance to bacterial wilt.

(*d*) Study of lettuce varieties, and an attempt to discover varieties resistant to botrytis. Imperial 847 and 44 have shown promise.

(*e*) Preliminary studies of varieties of asparagus and their culture are designed to lead to selection for New Zealand conditions.

Co-operation with other Institutions.—Grasslands Division: An officer of the Grasslands Division is stationed at Lincoln, and facilities are made available for him to carry on his work. The Agronomy Division is also increasing seed stocks of herbage crops selected and raised by the Grasslands Division. The Grasslands Division is reciprocating by carrying out at Palmerston North certain cereal and other trials and the production of some brassica seeds for this Division.

Plant Diseases Division: An officer of the Plant Diseases Division is stationed here, and facilities are made available for him to carry out his work. The Agronomy Division obtains considerable assistance and advice from this officer and from his Division in Auckland especially in connection with diseases of linen flax, potatoes, and oats.

Fields Division, Department of Agriculture: Close contact is maintained between the two Divisions. The Agronomy Division is dependent upon the Fields Division for all field work carried out in connection with the trial of new varieties and selections. The Fields Division, on the other hand, looks to this Division to supply nucleus seed to be built up in connection with the scheme of seed certification.

Lincoln College: Lincoln College has priority in drawing supplies of pure seed wheat raised by this Division.

Wheat Research Institute: Our programme of work in connection with wheat is discussed fully with the Wheat Research Institute and is thus mutually helpful and avoids overlapping.

Entomology Division: An officer of the Entomological Division is already carrying out certain investigations utilizing the facilities offered by this Division, and he may be stationed here permanently in due course.

BOTANY DIVISION, WELLINGTON.

Director: Dr. H. H. Allan.

A. Routine.

(1) *Identification of Specimens and Advice thereon.*

This work proceeded on the lines indicated in previous reports, over 1,600 specimens being dealt with. Several weeds not hitherto recorded were met with, but none are of very serious import. The "Handbook of Naturalized Plants of New Zealand" is now in the press, and should be of use to those interested in our weed flora.

(2) *Herbarium.*

Regular additions have been made, and the usual exchange material sent out. A valuable set of European weeds has been received from Dr. P. Aellen, and useful contributions made by the Auckland Museum, the Bailey Herbarium (Ithaca), and Messrs. R. M. Laing and H. Scarfe. Considerable advance has been made with the building-up of a seed herbarium.

(3) *Introduction of Plants*

Through the courtesy of Mr. R. O. Dalrymple, further supplies of Valonia Oak have been received. Seed of Giant Star Grass and related species were kindly forwarded by the Department of Agriculture, Kenya, and will be tested for erosion-control purposes in the warmer parts of the North Island. Seed of the high tannin species *Eucalyptus astringens*, *E. calophylla*, and *E. gomphocephala* were kindly sent by the Conservator of Forests, Perth, Western Australia. These have germinated well, and will be distributed to appropriate localities.

B. Research.

(1) *Sphagnum Resources.*

Reports were furnished on the nature of sphagnum, its utility as a surgical dressing, and methods of preparation. A survey, greatly assisted by the Director and officers of the State Forest Service, was made of the sphagnum areas of New Zealand. Some 347 samples have been examined, and graded as: Good, 71; fair, 97; inferior, 106; and useless, 73. Five areas of reasonable access and of considerable area, whence supplies could be obtained, were located. From these approximately 1,250 sacks of good and 1,420 sacks of fair material could be obtained. The gatherings are being subjected to botanical classification.

(2) *Seaweed Utilization.*

The possibilities of seaweed utilization in New Zealand are being explored, and a full report is in the press. This gives details of the uses to which seaweeds have been put, including the preparation of fertilizers, potassium chloride, iodine, stock food, human food, agar-agar, alginic acid, &c. Methods of harvesting, processing, and cultivation are discussed. The useful New Zealand species are reviewed, and the extent to which they are or can be made use of. Work is in progress on a survey of their distribution and availability.

(3) *Tussock-grassland Investigations.*

A detailed study of the taxonomy of the indigenous grasses has been nearly completed and will be made use of in the field work planned for the coming year. Studies were made on the effect of spelling, with especial consideration to the regeneration of the better grasses. Erosional studies were continued, and a paper has been published on certain effects resulting from interference with the plant cover. Evidence was given before the Sheep-farming Industry Commission, and reports submitted concerning the botanical aspects of changes in the tussock-grassland and on the relative palatability of the component species. The Director attended the conference of runholders held at Lake Tekapo in April, and discussed various problems with members. Assistance was given to the regrassing work at Pisa Flats conducted by the Department of Agriculture, and further experimental work is planned for the coming year.

(4) *Weed Investigations.*

Intensive laboratory and field work on hard-fern control has been continued, and a report is in preparation. Some work has also been done on St. John's wort and tutsan, with especial reference to seed germination and spread. Work on Californian thistle is being planned. Experiments with the scythe method of sodium chlorate treatment are proposed. The botanical work on ragwort has been completed, and a bulletin is in the press. Bulletins on noxious weeds and poisonous plants are in preparation. Preliminary ecological work on gorse and broom has been commenced.

(5) *Medicinal Plants.*

Work has proceeded on various medicinal plants, both from local and from overseas sources. Supplies of foxglove leaf have been collected locally, dried, and stored. Preliminary tests indicate that the leaf contains glucosides beyond the minimum required by the British Pharmacopœia. A small supply of *Digitalis lanata* seed has been procured from Kew for trial.

Supplies of locally grown leaf of *Datura stramonium* have been tested, and the leaf satisfied the standard requirements.

Roots of a native gentian are under test for glucoside content.

Seeds or bulbs of the major medicinal plants have been procured from abroad. Germination has proved very poor, but it is expected to raise enough plants to secure seed supplies for further work.

(6) *Vernalization.*

Preliminary trials with rye-grass and white and red clover justified field experiments. Further work, with investigations on the effect of temperature and light on growth factors, was held over to a more opportune time. A pot trial with Algerian oats indicated significant responses. The results are being statistically analysed.

A small trial with cocksfoot is under way, and suggests that a more rapid establishment, with better tillering, is likely.

(7) *Phormium.*

During the year work on the Batchelar Area, Massey College, was put on a maintenance basis, as there is every possibility that in the near future this area will be combined with the Easton Area on the Moutoa Estate.

The plantation on the Easton Area has been maintained and some 10 acres broken in for nursery work. On this area about 1 acre of seed-beds were sown and approximately 100,000 seedlings of selected varieties lined out. This work was done in anticipation of the acquisition of the Moutoa Estate by the Government and the laying-out of it as a phormium area.

Attention has been directed to the need of fine fibres for string and fabrics. A considerable amount of crossing was therefore done with a fine-fibred type of *Phormium tenax* and *Phormium colensoi*, which has fine and silky fibre. A quantity of *P. colensoi* leaf was cut from the cliffs of Wellington and the fibre from it is awaiting a large-scale string test. Also, for the purpose of obtaining fibre for string, a quantity of leaf was cut from two-year seedlings at the Batchelar area.

A vegetation survey of the Moutoa Estate, recently acquired by the Government, has been completed. Important ecological results derived from this should assist in the laying-out and maintenance of the estate.

(8) *Miscellaneous.*

An examination has been made of the seed content of moa-crops, and further work will be done as opportunity offers. An examination of the histology of rye-grass leaves at various stages of growth, and under various conditions, is in progress, to ascertain its bearing on problems of facial eczema in sheep.

A map of the primitive vegetation of New Zealand is in preparation for the Centennial Atlas, and papers on the taxonomy of indigenous plants and general ecology are in preparation.

A report was prepared on the possibility of growing various plants for the production of essential oils in New Zealand, including oil of lemon, oil of coriander, peppermint oil. Seeds of a high-oil strain of castor oil from America have been planted for trial. Seeds of species used for flavourings, including coriander and caraway, and a special strain of fennel have been received from Romania, and small trials have been laid down.

The glasshouse came into use during the year, and has materially assisted the routine and research work of all officers. The Director and staff have given lectures and other public services during the year where it seemed appropriate to do so. In co-operation with the Botanist, Auckland Museum, Miss Moore staged a display at the Exhibition on behalf of the Fisheries Branch, Marine Department, illustrating the utilization of seaweeds.

PLANT DISEASES DIVISION, OWAIRAKA, AUCKLAND.

Director: Dr. G. H. Cunningham.

Work undertaken during the year under review is discussed under four main sections:—

(*a*) Investigations into the diseases of plants produced by insects, fungi, bacteria, viruses, and by physiological agency.
(*b*) Investigations into methods of combating diseases by chemical agency.
(*c*) Timber protection.
(*d*) Pomology.

I. Plant Diseases Investigations.

General.

During the year several diseases and pests new to New Zealand were found. Among the major diseases were Sclerotinia disease, *Sclerotinia sclerotiorum* on imported kumara tubers, barley-scald, *Rhyncosporium secalis* on commercial malting barley in Canterbury, flax-wilt, *Polyspora lini* on linen flax in Canterbury, and a virus on daphne plants. Insect pests included soft wax-scale, *Ceroplastes destructor* on citrus trees, Australian grape-vine moth, *Phalaenoides glycinae* on grape vines in Auckland, Australian grass-grub, *Pentodon australis*, Australian gum emperor-moth, *Antheraea eucalypti*, on eucalypts.

Each year extends the list of new diseases imported into the Dominion, and, as each importation increases production difficulties and costs, it is apparent that more stringent quarantine measures are necessary.

(*a*) *Brassica Diseases.*

(1) *Dry-rot (Phoma lingam).*—The fungus was obtained from cabbage stems in Auckland, which is the first record of its attacking this host in New Zealand, though commonly collected from this source in other countries.

(2) *Club-root (Plasmodiophora brassicae).*—Strains of rape, selected for their resistance to the disease, were tested out in several areas in Otago and Southland. They showed such a high degree of resistance that selections were seeded and handed to the Agronomist for tests of their agronomic properties.

(3) *Diamond-back Moth (Plutella maculipennis).*—Tests conducted at Owairaka showed that best control of this pest on cabbages was secured with derris dusts, which proved more efficient than nicotine sulphate-spray or lead and calcium arsenate sprays. Arsenates when applied as dusts give unsatisfactory results.

Considerable variations were experienced in results obtained by the use of commercial derris dusts, some giving satisfactory control, but the majority proving almost or completely worthless. Consequently, in later trials tests were made with dusts prepared by the staff from imported raw materials of known composition checked by analyses made by the Spray Chemist of the Dominion Laboratory, Wellington.

(*b*) *Cereal Diseases.*

(1) *Cereal Rusts.*—Work has been continued on identification of biotypes of stem-rust (*Puccinia graminis*) and leaf-rust (*Puccinia clymi*) of wheat. Only one biotype of stem-rust was found in New Zealand during the past season, though in previous years two (Nos. 34, 45) were isolated by overseas workers.

It would appear from the results of this season's work that seven biotypes of leaf-rust are present in the Dominion, though it has not yet been possible to identify them all exactly.

Some two hundred wheat hybrids bred by Dr. Waterhouse, Sydney University, were introduced and subjected to testing in the field for susceptibility to leaf-rust and stem-rust.

(2) *Cereal Smuts.*—Work was undertaken with a view to developing a technique for inoculating wheat with loose-smut (*Ustilago tritici*). Eight processes were tested, of which two gave satisfactory results. By using these it has been possible to ascertain that at least two biotypes of this smut are present in New Zealand.

Some three hundred and twenty strains of wheat selected by the Wheat Research Institute were artificially infected, with a view to ascertaining their susceptibility or resistance to loose-smut.

(3) *Wheat Foot-rot.*—Two cases occurring in autumn-sown wheat in Canterbury were investigated, and from field evidence it was considered the condition had been induced by drought.

(*c*) *Grass Diseases.*

(1) *Blind-seed of Rye-grass (Helotium* sp.*).*—Evidence has now been obtained to show that the fungus responsible does not perennate within the vegetative tissues of rye-grass, infection being confined to the seed. Drying or conditioning the seed greatly reduces the amount of infection in heavily infected seed intended for sowing in the autumn following harvest.

Field experiments at Owairaka on the relation between percentage germination of seed sown in the autumn and the number of apothecia and amount of infection in spring were inconclusive, since no apothecia developed nor was there any natural infection in the plots.

(2) *Ergot.*—A study made of strains of ergot isolated from various grasses showed that two species of fungi only are present. One, *Claviceps paspali*, is confined to paspalum; the other, *C. purpurea*, infects a wide range of grasses, including rye-grass, cocksfoot, Yorkshire fog, tall fescue, &c., as well as barley, wheat, and oats.

Proof has been secured that the fungus does not perennate in the host plant, therefore cannot be toxic to stock other than when grasses are allowed to seed.

(3) *Lolium Endophyte (Helotium* sp.*).*—Much has been learned about the occurrence and distribution of the fungus, and a simple means of control has been evolved should it be found that the organism is harmful to rye-grass or to stock fed upon rye-grass pastures.

A field grazing trial is being laid down by the Department of Agriculture at Ruakura with seed of the same strain of rye-grass with and without the fungus.

(4) *Cocksfoot and Meadow-foxtail Midge.* Seed heads of these grasses infested with midge, collected from various parts of the Dominion by officers of the Department of Agriculture, were forwarded to Rothamsted by the Entomologist. The midge infesting meadow-foxtail was identified by Dr Barnes, of Rothamsted, as *Stenodiplosis geniculati*, that attacking cocksfoot as *S. geniculati* var. nov.

(*d*) *Potato Diseases.*

Late-blight (Phytophthora infestans).—A technique has been developed for testing resistance of potatoes to attacks from this fungus. Some ninety-three potato selections produced by the Agronomy Division were tested, several being found to possess a high degree of resistance to late-blight.

(*e*) *Legume Diseases.*

(1) *Bacterial-wilt (Bacillus medicaginis).*—All varieties of French beans were infected in the trial plots, resistance to wilt being displayed by two only—namely, Burnley selection of Canadian Wonder and Pale Dunn.

(2) *Pea-mosaic.*—Various crosses of garden peas produced by the Agronomy Division are being grown at Owairaka and tested for resistance to this virus.

(3) *Bean-mosaic.*—A variety of French bean, said to be immune to this virus, has been introduced from the United States and is being grown for test at Owairaka.

(4) *Lucerne Nodule Organism.*—During the season cultures of the organism, sufficient to inoculate 148,530 lb. of lucerne-seed, were distributed to 1,603 farmers throughout the Dominion. This shows an increase in inoculated seed of 31,710 lb. over that of last year, and exceeds that of any previous year.

(5) *Clover Nodule Organism.*—While at the East of Scotland College of Agriculture, Edinburgh, in 1939, the bacteriologist continued his researches on the organism producing nodules on white clover. With the outbreak of war he was forced to return to New Zealand before the work had been completed, and subsequently has correlated results secured in Scotland with those secured in the Dominion. Results suggest that the different bacterial strains isolated vary in their efficiency in different districts and that, under practical conditions, it will be necessary to select and test specific strains for each of the provinces of Auckland, Wellington, Canterbury, and Otago.

(*f*) *Fruit-tree Diseases.* (See Fruit Research report, p. 45.)

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

Tomato Diseases.—Blotchy-ripening: A further series of soil treatments was undertaken in two glasshouses in which the disease was prevalent. None of the materials used gave any measures of control. Potassium sulphate, which has been claimed to give adequate control in England, failed to do so in these trials.

Hard-core: At Owairaka in the experimental plots this physiological disease was widespread. Injections and soil treatments were carried out with borax, cobalt, copper, iodine, iron, magnesium, manganese, nickel, nitrogen, phosphorus, potassium, and zinc. As all failed to remedy blotchy-ripening or hard core, it is evident both are not caused by deficiencies of these elements.

Verticillium-wilt (*Verticillium albo-atrum*): To enable work to be undertaken on soil treatment for control of this disease, soil of a small experimental glasshouse was inoculated with cultures of the fungus. One hundred plants were set out and many subsequently developed the disease. Soil treatments are now being applied.

Tomato-streak: This serious disease has been found to be caused by a combination of tobacco-mosaic and a second unidentified virus which is under further study.

Leaf-mould (*Cladosporium fulvum*): Seed of two tomato varieties resistant to the disease have been imported from the United States. Preliminary work has shown that they remain resistant under New Zealand conditions. Further tests under commercial conditions will be made during the coming season.

Tomato mite: This pest, which made its appearance in glasshouses four years ago and was held in check by promptly applied remedial measures, again made its appearance during the early autumn in several houses. Investigations showed that the growers concerned had failed to carry out the simple remedial measures found adequate for control of tomato-mite.

(*h*) *Linen Flax Diseases.*

All varieties of flax held by the Agronomy Division have been tested for resistance to flax-wilt (*Fusarium lini*) and flax-browning (*Polyspora lini*). The oil variety Rio proved resistant to wilt and immune to browning. Immersion of seed for ten minutes in water at 126° F. eliminated browning, and by this means small nuclei lines of disease-free seed have been procured. A disease survey was made of linseed and linen flax crops in the South Island during the season.

II. Plant Protection.

(*a*) *Therapeutant Testing.*

(1) *Cereal Dusts.* Numerous replicated field trials have been carried out at Auckland and Christchurch on tests of various dusts offered for certification.

Apparatus has been developed for testing seed disinfectants under controlled soil environment, and with the information secured during the past year from field tests will enable the Division to certify suitable types of such products.

A technique has been developed for inoculating oats with smut fungi. Under test it was found to give, over a wide range of soil temperatures, infections of from 30 per cent. to 95 per cent. Similar work has been undertaken with covered-smut of barley (*Ustilago hordei*) and stinking-smut of wheat (*Tilletia foetens* and *T. levis*), but results were less satisfactory owing to the greater influence of soil temperatures on infection.

An experiment was set up in Canterbury to ascertain the effects of several organic mercury dusts on germination of wheat, with varied moisture content, and, if so, whether or not artificial conditioning would obviate injurious effects.

As far as the experiments have proceeded, dusted wheat has not declined in field germination, though in some cases germination was somewhat retarded in the laboratory with samples containing a high moisture content.

(2) *Copper Sprays.*—Field and glasshouse tests have been continued in the development of a technique for testing copper sprays. While work has not been completed, results so far secured indicate (*a*) none of the Bordeaux substitutes equals Bordeaux mixture in disease control when compared on the basis of equal concentration of copper; (*b*) the superiority claimed by manufacturers for copper compounds over Bordeaux in leaving inconspicuous spray residues arises from the relatively weak copper content of such, together with presence of high proportions of wetting and/or spreading agents. By use of weaker Bordeaux mixtures together with wetting agents the apparent advantage is offset; (*c*) at equal concentrations all the Bordeaux substitutes tested have proved more liable to cause plant injury than Bordeaux.

Work has been continued on developing methods for assessing the damage factor of copper sprays, which has so far not been possible under glasshouse conditions. In the field some measure of success has been secured by the use of young apple and peach trees.

(3) *Sulphur Sprays.*—A technique for testing sulphur products has been standardized, but its operation in routine practice will not be possible until equipment is installed in the glasshouse whereby temperature and humidity factors can be regulated.

(4) *Salicylanilide Sprays.*—In glasshouse tests under commercial conditions the proprietary product "Shirlan A.G." (containing 25 per cent. salicylanilide) has given excellent control of tomato leaf-mould, provided sprays are thoroughly applied. A technique has been developed for testing the product and others of this type for control of this disease of tomatoes. By its aid it was found that "Folosan," a proprietary organic dust, was inferior to "Shirlan A.G."

(5) *Derris Dusts.*—Numerous analyses have been made of ground derris roots by the Spray Chemist of the Dominion Laboratory with a view to ascertaining physical and chemical standards whereby derris products may be certified. They have shown that statements made by manufacturers as to the rotenone content are merely relative, and that it is necessary to correlate them with some standard method of analysis. Further, it is necessary to consider such a physical property as fineness of division of the dust particles (hitherto ignored in experimental work), since this materially influences coverage and, consequently, disease control.

Field trials have been undertaken to ascertain the possible uses of derris products under field conditions, and standards of concentrations required. They include work on control of white butterfly and diamond-back moth on crucifers; red-mite, leaf-hopper, and codling-moth on apples; and mealy bug on pears. The present high price of the commercial product precludes use of derris on a field scale, save possibly for small nursery gardens and the like. With a view to cheapening derris dusts, investigations are being conducted to ascertain the possibility of using fillers of New Zealand origin in their preparation.

(6) *Control of Citrus-moulds.*—Six treatments were undertaken to ascertain the most efficient methods of combating moulds attacking lemon fruits. Although fruits were slightly injured and inoculated before treatment, results were inconclusive since, owing to dry conditions of storage, little mould developed even in the check cases. Chambers in which temperature and relative humidity can be controlled are necessary before the work can be continued. These are now being erected in the basement of the laboratory.

(*b*) *Improvement in Spray Programmes.*
(See Fruit Research report, page 45.)

(*c*) *Improvements in Orchard-disease Control.*
(See Fruit Research report, page 45.)

(*d*) *Certification of Therapeutants.*
(See Fruit Research report, page 45.)

III. Timber Preservation.
(See Timber Protection Research, page 58.)

IV. Pomology Investigations.
(See Fruit Research report, page 45.)

V. Miscellaneous.

(1) *Kumara Varieties.* Although the past season has been a poor one, a fair crop of tubers was harvested from the numerous varieties which were imported from overseas for test under New Zealand conditions. The heaviest cropping variety proved to be Belesilika, a selection from the Cook Islands. Makusi, from the same source, also bore a heavy crop of large roots, although the varieties grown commercially in New Zealand—Blackberry and Tauranga Red—came close to them in productivity.

Samples of all varieties were stored and examined periodically, the local variety, Blackberry, proving to be a good keeper, as were also Norton, Red Bermuda, Early Butter, Southern Queen, and Porto Rica.

Promising varieties will be tried out in the main kumara-growing districts next season. Some of the early ones may prove of value in extending the cultivation range of this crop to districts where the season is not sufficiently long to permit other more slow growing ones to reach maturity.

(2) *Daphne-mosaic.*—Inarching experiments have shown that a mosaic condition of the leaf of daphne may be transmitted to healthy plants, suggesting that the condition is of virus origin.

(3) *Pyrethrum Production.*—Work has been extended to ascertain the effect of locality on the pyrethrin content of pyrethrum flowers. Analyses made from flowers grown at Auckland, Ruakura, and Palmerston North showed that the pyrethrin content of any one strain is not consistent in the three localities, but nevertheless a strain which showed a high content in one locality also showed a relatively high content in the others. On the average there was no marked difference in the pyrethrin content of flowers grown in the three localities.

Flowers from three strains grown in an additional eight localities in North and South Islands have been harvested and forwarded to the Dominion Laboratory for analysis.

(4) *Huapai Experimental Orchard.*—At the conclusion of this season's work (May) the three-year period for which this orchard was taken expires. As the orchard has been offered for sale, it will be necessary for the Division to procure an area elsewhere.

The trees in the orchard are growing vigorously and most varieties carry a heavy crop, indicating the successful manner in which neglected areas of the type can be brought into successful commercial production. The variety Gravenstein has not responded to treatment, however, since trees, in common with most others of the variety grown in Auckland, are affected by a condition known as "strangulation".

(5) *Owairaka Area.*—The whole area is now under cultivation, most being planted to permanent crops and trees, save those portions reserved for annual cropping. A stationary spray plant, electrically driven, was installed during the winter, and the entire area reticulated with piping. Two additional glasshouses and an insectary were erected, bringing the total to five.

A soil-sterilizing shed was erected and a 4-horse-power boiler installed, so that facilities are now available for steam disinfecting all soil used in the glasshouses, an essential in investigational work.

Despite the unfavourable season, most crops have grown well, fruit-trees especially so.

GRASSLANDS DIVISION, PALMERSTON NORTH.

Director: E. Bruce Levy.

All phases of activity of the Grasslands Division have tended to increase and a very full year's work has been successfully accomplished. The work may be enumerated in the following sections.

(1) Plant Breeding and Strain Studies.

(*a*) *Improvement of Types.*

Improvement of type of the following: (1) Perennial rye-grass; (2) short-rotation rye-grass; (3) Italian rye-grass; (4) white clover; (5) Montgomery red clover; (6) broad red clover; (7) timothy.

The pedigree seed production stage has been reached in regard to perennial rye-grass, Italian rye-grass, white clover, and Montgomery red clover. Seed increases have been made of the short-rotation rye-grass selection and No. 2 white clover selection for extensive field trials. Breeding work in regard to broad red clover is well advanced. The work on timothy has just commenced. The above study has involved the raising, planting, and study of approximately seventy-five thousand single plants.

(*b*) *Genetical Studies on Cyanogenesis in White Clover.*

Detailed study of the inheritance of cyanogenesis to safeguard against the possibility of breeding towards an unduly high hydrocyanic acid (HCN) content in pedigree lines.

Differentiation of plant types into the following groups has already been established: (1) Those plants that contain enzyme and glucoside; (2) those that contain enzyme only; (3) those with glucoside only; (4) those with neither enzyme nor glucoside.

(*c*) *Blind-seed Disease of Perennial Rye-grass.*

Blind-seed disease of perennial rye-grass has again this season greatly reduced the yield of high germinating seed and it is the prime cause for the low stocks and high price that now obtains for certified perennial rye-grass seed.

Two modes of attack are being made to reduce the ravages of this fungus: (i) Selection for resistant types, and (ii) modification of field growth conditions to reduce the spread and infection to a minimum.

(i) *Work on Resistance.*—Field trials to date at Winton and Palmerston North have indicated a degree of resistance within some lines, and in the systematic search for material naturally resistant some three hundred seed lines have been sown out and these will be artificially inoculated with culture supplied by the Plant Diseases Division. Some seven hundred single plants have been inoculated to test the degree of resistance between different plants. The evidence to date is encouraging for the possibility of establishing resistant material that will form the basis of a pedigree line.

(ii) *Modifications in Seed-crop Technique in the Field as a Basis of Control.* Such modification is based on the ecological behaviour of the fungus under field conditions. From the above study the following modifications of field-crop technique are suggested:

(1) The crop should be shut up early rather than late. Experiments on closing-up date for seed have been conducted at the Station over both the two past seasons and in each year the early shut up crops have given better germinations than the late shut up ones. The early shut up crops were also much freer of ergot. In both cases temperature may be the vital factor.

(2) Those crops that had a dense sward bottom and which completely lodged gave a better germination than light crops with open sward bottom and which stood erect until ripening time. In the former case it is surmised that initial infection is low and the dense bottom inhibited the upward spore thrust from the apothecia situated on the soil surface, and that later when the crop is lodged the chance of secondary infection from wind-borne spores was minimized compared with the higher chance of infection in the standing crops. Seed-production trials are being extended, and a block of 1½ acres of rye-grass has been differentially manured and will be differentially managed to give early to late closing up time, together with differential sward density.

(*d*) *The Endophyte of Perennial Rye-grass.*

The Plant Diseases Division has recently reported an endophyte fungus of perennial rye-grass. Nothing is known of its agronomic significance in regard to the plant itself or to the grazing animal. In co-operation with the Plant Diseases Division, investigations are now being extended to the study of these two problems.

Some six hundred single plants with and without endophyte infection have been planted out for observation and measurement. A field trial in co-operation with the Dairy Research Institute has been sown, and calves will be grazed on two areas composed of endophytic and non-endophytic rye-grass respectively.

(*e*) *Nucleus Pedigree-seed Production.*

The following crops for nucleus seed production are established at Palmerston North:

1½ acres perennial rye-grass.	¼ acre short-rotation rye-grass.
¾ acre Italian rye-grass.	¼ acre crested dogstail.
1 acre white clover.	¼ acre No. 2 white clover.
1 acre Montgomery red clover.	

Five acres of Italian rye-grass and 2½ acres of short-rotation rye-grass are sown out for seed production at Lincoln.

(*f*) *Cocksfoot-seed Production Trials.*

Cocksfoot-seed production is on the wane in New Zealand, and this is largely as a result of decreasing yields of viable seed from the older-established areas. Trials have been laid down to investigate the cause of this decline and to test methods of seed production under differential treatments of the growing crop, of the aftermath stubble, and on manurial requirements. Seed production of a truly permanent stand as against more temporary stands in a definite crop rotation is being compared.

(*g*) *Strain Testing for Certification Purposes and for Critical Examination of Bred Material.*

To define and maintain standards for the certification of the following species: (1) Perennial rye-grass; (2) Italian rye-grass; (3) cocksfoot; (4) brown-top; (5) *Phalaris tuberosa;* (6) white clover; (7) Montgomery red clover; (8) broad red clover; (9) subterranean clover.

The above programme has involved the sowing of approximately two thousand five hundred plots and in reporting on these individually during the year. Measurement trials have been instituted to test pedigree lots against the standard certified material. Some new work has been inaugurated on the improvement of timothy, prairie grass, crested dogstail, *Lotus* sp., and strawberry clover.

(*h*) *Field Strain Trials.*

A total of 416 trials have been sown and 249 are still in operation. These are laid down and reported on by the Instructor in Agriculture, Department of Agriculture, and cover a wide range of soil and climatic types. They serve as excellent demonstration material, and give guidance to the progress of our breeding for the particular district in which they are laid down.

(*i*) *Sets of Species and Strains for Study by Schools.*

These sets are very popular, and two hundred and fifty sets have been supplied.

(*j*) *Plant Introduction and Seed Exchange.*

A total of three hundred and ninety samples of new introductions have been critically studied, and limited supplies of seed have been harvested for trial here under broadcast conditions. One hundred and fifty of such plots have been autumn sown, and these will be grazed by sheep to determine swarding capacity, palatability, and persistency under grazed conditions.

Requests for New Zealand seed from overseas have increased, and all lots sent are followed up to learn how these have performed under the conditions of the test.

(*k*) *Substation at Lincoln.*

The substation at Lincoln is proving very valuable as a testing and demonstration centre. The trials cover approximately 2 acres, and the area is worked under the general management of the Agronomy Division. Seven acres for nucleus pedigree-seed production has also been sown at Lincoln.

Some reciprocal service at Palmerston North has been instituted on behalf of the Agronomy Division in the growing of certain of its crops.

(2) Pasture Surveys.

The general pasture map of the North Island has been printed, and *Bulletin No. 79* has been published incorporating the pasture map. Detailed pasture surveys of Hawke's Bay Land District (over 4,000 square miles) are now completed, and a map of a portion of this district has been published. Pasture surveys of Banks Peninsula and the Matakaoa County have also been done. Reports and maps are in course of preparation.

(3) Sheep Pasture Research.

This work is being undertaken in collaboration with Massey Agricultural College, on whose property the trial is laid down. The prime aim is to study animal thrift in relation to luscious, high producing pasture. These consist of two groups: (1) Pedigree strains versus ordinary certified strains, both under a programme of high soil fertility maintenance; and (2) certified mother seed strains of perennial rye-grass and white clover under a differential manurial programme where simple and light manuring is contrasted with complex and heavy manuring.

The Grasslands Division undertakes the measurement and recording of—

(*a*) Botanical composition over the year.
(*b*) Rate of growth of species.
(*c*) Total herbage available at any time to act as a guide to stocking density.
(*d*) Total production of herbage.
(*e*) Collection of botanical samples for chemical study by the Plant Chemistry Laboratory.

The 47 acres sown in 1939 are now fenced into 1 acre blocks, and pampas is being planted for shelter-belts, each paddock to have shelter on two sides. The pastures and stock to date are in excellent condition.

(4) Dairy Pasture Research.

Over the past few years work has been concluded on feed taints, and preliminary work has been done on the nutritive value of perennial rye-grass and Italian rye-grass (stall fed). Pure perennial rye-grass pastures have also been compared with permanent rye-grass - white clover, pure cocksfoot, and cocksfoot - white clover. This autumn 30 acres have been ploughed and resown to provide feed for the commencement of spring lactation. The programme is being modified to study single versus complex pasture mixtures, and dairy cow reaction to these as far as quality and quantity of dairy products are concerned. The above swards consist of (1) perennial rye-grass - white clover, (2) cocksfoot - white clover, (3) complex association of species. The above (1), (2), and (3) pastures will be under grazing, and there will be an indoor feeding trial of (1) and (3) to study appetite as derived from feeding simple versus complex pasture feeds.

The Grasslands Division undertakes (1) laying down of pastures, (2) joint management of pasture, (3) botanical analyses of all paddocks and feeds fed, (4) measurements of yield of pastures, and (5) collection of samples for chemical determination.

(5) Conservation of Supplementary Fodder Research.

The objects are to study the methods of conserving pasture and the nutritive value and palatability of the products. Eight pits of silage (approximately 2 tons each) were made using the following methods:—

(*a*) Natural fermentation.
(*b*) Molasses.
(*c*) Whey.
(*d*) Molasses unconsolidated.
(*e*) Natural fermentation at high temperatures.

Preliminary chemical analyses on progressive samples have been carried out. Feeding trials to study relative palatability to dairy cows and sheep are being arranged.

(6) Facial-eczema Research.

The following work has been assigned to this Division by the Facial Eczema Management Committee:—

(1) Study of growing grass in glasshouses or otherwise to obtain control of growth conditions, particularly in regard to control of temperature, soil moisture, and humidity, and having particular reference to alternate wilting and flush periods of growth. Swards of pure perennial rye-grass are being grown under the following conditions:—
(*a*) Normal outside conditions—non-irrigated.
(*b*) Outside conditions—irrigated.
(*c*) Outside conditions—soil temperature controlled by soil-heating element.
(*d*) In two small glasshouses control heated with soil cables and fitted with exaust fan.
(*e*) Small lot in cold frames, unheated but covered with moveable glass frames.
The herbage produced is used by the Chemical Laboratory for their intensive studies into chemical changes that take place in plant growth according to changes in environmental conditions.
(2) Assistance in field observation and in certain grazing and feeding trials. Mapping pastures and statistically sampling these. Twelve farms were under observation in the Waikato, and small grazing and feeding trials were conducted at Wairoa.
(3) Observations on pasture growth conditions in the Manawatu, and collating growth conditions elsewhere.
(4) Dissection of herbage for determination of botanical composition in connection with the Waikato stations and East Coast work. Approximately one thousand five hundred samples have been botanically analysed to date.

(7) Fundamental Technique Research on Nutritive Value of Herbage.

The work envisages a very detailed programme of botanical and yield determinations on areas subjected to various environmental conditions with the object of determining the reliability of research technique in relation to pastures. The objectives in the work now designed are—

(*a*) To measure the influence of the grazing animal on sward development—*i.e.*, effect of dung, urine, treading, and grazing.
(*b*) To compare and devise plot technique trials with and without the influence of the animal.
(*c*) To study the effect of mode and severity of defoliation on production and botanical composition of pasture swards.
(*d*) To provide material for nutritive value of herbage studies being inaugurated in conjunction with the chemical laboratory and Massey Agricultural College. An area of 1½ acres has been sown to a complex pasture mixture, and steps are now being taken to fence this area into small enclosures and for the erection of a feeding shed for nutritional studies using sheep.
(*e*) The elaboration and use of statistically sound methods in botanical analyses. Satisfactory progress has been made in standardizing the methods of sampling and analysing, and an efficient technical staff is being gradually trained.

(8) Greenkeeping Research.

The present scheme has now been in operation for eight years, and this year it has been considerably modified and enlarged to incorporate information gained by prior experience. Approximately four hundred plots are receiving individual treatment. A series of certified brown-top lines has been laid down to study whether any type variations exists in the certified seed when grown and managed under actual lawn conditions. The annual Greenkeepers' Conference was again held, and a diploma course in greenkeeping was instituted during the year.

(9) Lectures and Demonstrations.

Interest is still well maintained in the work of this Division, and frequent demonstrations to visitors have been given. The demand for lectures has continued, and requests have been acceded to whenever possible.

(10) Buildings.

A very useful and commodious shed has been erected to incorporate storage, seed cleaning, and to house implements, soil-sterilizing plant, &c. A set of cold frames has been erected, and arrangements are made for the erection of two additional glasshouses. Much needed tractor power arrived, but the machine sent is unsuitable in many ways and negotiations have been opened up to have it replaced by a more suitable machine. A top-dresser was secured, and this has proved eminently satisfactory. The old implement shed has been converted to a workshop.

ENTOMOLOGY DIVISION, NELSON.

Director: Dr. D. Miller.

The following are the main features of activity upon which the Division of Entomology has been engaged during 1939–40:—

(1) Diamond-back moth.
(2) White butterfly.
(3) Subterranean grass-caterpillar.
(4) Lucerne-flea.
(5) Cheese-mites.
(6) Timber insects.
(7) Tussock-moth.
(8) Routine.
(9) Publications.

(1) Diamond-back Moth.

(*a*) *Investigations at Farnham Royal.*

Work at Farnham Royal on the diamond-back-moth investigation has proceeded along the lines of determining which parasites from a list of those recorded would be most suitable for introduction into this country. Some very interesting and useful work has been carried out in connection with the inter-relationship of the different species of parasites, and when completed will prove to be of fundamental importance to biological control work as a whole.

(*b*) *Breeding-work at Laboratory.*

During the past year both species of parasites—that is, *Diadromus collaris*, the pupal parasite, and *Angitia cerophaga*, the larval parasite—were bred in the glasshouse, and as soon as the weather was suitable in the early summer this work was carried into the field and again large numbers of the parasites were bred up for distribution in definite localities.

(*c*) *Field Survey of Plutella.*

Field collections of the diamond-back moth were commenced in Hawke's Bay at the end of December, 1939, and were carried out until the middle of April, 1940. The survey was undertaken to determine—

(i) Whether *Diadromus collaris*, which had been liberated there the previous year, had successfully overwintered; and
(ii) How far it had spread from the initial point of infestation.

The survey showed that it had successfully overwintered and was well established. The survey extended as far north as Rissington, a point twenty miles from the place of liberation, and in the south as far as Woodville, which is approximately seventy miles from the point of liberation; the survey also extended to Porangahau on the coast. Large numbers of collections were made within this radius.

During January and February the severity of the diamond-back-moth injury to crops appeared to vary a great deal from place to place, and it is suggested that the influence the weather had upon the diamond-back moth was largely responsible for these variations. The majority of the crops where collections were made seemed to be quite vigorous, although in some instances they were suffering from lack of moisture. During this period the adult Diadromids were quite prevalent through the crops within a radius of twenty miles from the point of liberation, and the parasitized cocoons were readily recovered. During March and April it was observed that the crops were not as severely damaged by the moth as during the period of January and February, and it would seem that the reason for this was the prevalence of fungus attacks upon the moth larvæ and pupæ; during this period also adult Diadromids were not so noticeable throughout the crops and the percentage of parasitism of the pupæ had dropped considerably, except in three cabbage patches in Hastings, where it was quite easy to recover parasitized cocoons in fair numbers. From the last results of the survey it was found that the parasite had spread as far south as Woodville.

(*d*) *Field-cage Breeding.*

At the latter part of December, 1939, a small portion of a rape crop on the property of Mr. L. C. Ferguson, Halcombe, was fenced off for the purpose of erecting field cages, in which the work of breeding *Diadromus collaris* was carried out. The first cages were erected and infested with *Plutella* on 22nd December, 1939, and the remainder were erected and infested with *Plutella* at different intervals, the last one being erected on 14th January, 1940, the number of cages used totalling one hundred. As the material in the cages became ready for the parasites, adult Diadromids which had been bred up at headquarters were sent out for this purpose. The parasites were successfully bred through in this fashion, and it is estimated that at least five thousand were concentrated in this manner.

In addition to the above method of obtaining parasites for liberation, use was also made of material which emerged from the field collections. During March and April approximately two thousand were obtained in this manner and liberated on a cabbage patch in Palmerston North.

(*e*) *Field Survey in Manawatu.*

The majority of the crops in the Manawatu were only moderately damaged by *Plutella*, and in most cases were in a vigorous and healthy condition. However, a collection of *Plutella* was made in this locality to determine whether *Diadromus* had established or not, and also to ascertain if *Angitia cerophaga*, a small number of which had been liberated there in 1936, could be found. The above collections have not yet been analysed.

(*f*) *Field Survey, South Island.*

Liberation of *Angitia cerophaga* was carried out on Mr. McKenzie's farm, twenty miles south of Ashburton, the Division being greatly assisted by the local Instructor in Agriculture by his active participation in this work.

Field surveys were made simultaneously in the locality, and it was revealed that *A. cerophaga* was already well established in the district. Subsequent surveys indicated that it has been established over an area extending from Nelson to the Waitaki River.

The dry season in Canterbury was very suitable for *Plutella*, and consequently abundant host material was provided to render possible a thorough establishment of *Angitia*, which was found to be active in its parasitizing work—in one instance reaching a figure of 75 per cent. There was also a remarkable absence of attack from native hyper-parasites.

It is interesting to mention at this stage that the pupal parasite, *Diadromus*, is also spreading in the South Island. The only liberations of this parasite made in the south were at Nelson, but our field surveys showed that it has already spread as far as Blenheim.

(2) White Butterfly.

During the past season supplies of *Apanteles glomeratus* and *Apanteles rubecula* (both larval parasites of Pierids) were received from Farnham Royal. Of these, the most important for consideration was *Apanteles rubecula*, a solitary larval parasite of *Pieris rapæ*. Unfortunately, only a small number were received and we were not successful in getting them established.

(*a*) *Field Survey, Hawke's Bay.*

A survey was made in Hawke's Bay during April of this year to ascertain the position regarding white butterfly in that district. The survey extended from Dannevirke to Hastings, and all investigations showed that the butterfly was causing only very slight damage, the larvæ being scarce. Collections of pupæ were made from fencing-posts and from grass surrounding the crops. In the majority of cases no pupæ were found on either fence-posts or in the grass, but from the small numbers collected it was found that they were heavily parasitized.

(*b*) *Field Survey, Manawatu.*

A survey of the white butterfly in the Manawatu was also carried out during April. An investigation of brassica crops in the Marton district indicated that damage attributed to white butterfly was in reality caused by diamond-back moth, though it is possible that in one or two isolated cases the loss from butterfly attack was fairly severe. Collections of pupæ were made from fencing-posts and grass, and in both cases the percentage of parasitism was high. On one or two crops only were butterfly larvæ found to be causing damage, and in these cases the crop was poor, with a large number of weeds growing through it. Other than these cases mentioned, the crops were not suffering from butterfly injury.

(*c*) *South Island Survey.*

Surveys were also carried out in the South Island, though they were less intensive and far wider spread. It can be said that from Nelson to as far south as Timaru the white butterfly has been held under very good control. There were, of course, odd places where the butterfly appeared to be quite prevalent, but of all the crops examined it can be said that none was at any time likely to be devastated by the butterfly, though, of course, some slight injury would result.

(3) Subterranean Grass-caterpillar.

In the spring of 1937 and in following years the subterranean grass-caterpillar (*Porina* sp.) was responsible for considerable damage to improved pastures in Canterbury, Otago, and Southland. In view of the fact that no effective method of controlling this insect was known, an assistant was

appointed in January, 1939, and stationed at Lincoln College to work on this problem. In October, 1939, a senior officer was transferred to this problem also. The work to date may be summarized as follows:—

(a) Field Surveys.

The field surveys have been so far confined to the east coast of the South Island, since it is in the area that *Porina* damage appears to be of greatest importance. Areas which are known to have suffered serious damage exist in the Wairau Valley, in Marlborough; around Culverden and Hawarden, in North Canterbury; throughout the area between the Waimakariri and Rangitata Rivers, in Mid-Canterbury; around Oamaru, in North Otago; in the Hillend area, in South Otago; and in the Balfour and Kaiwera districts, in Southland.

The information available at present indicates that the Hillend area is the one most subject to consistent damage. In most of the areas mentioned above there is a possibility of *Porina* damage in the second or third year after establishment of a new pasture, but in the Hillend area the probability of damage is so great that farmers are said to be reluctant to put down new pastures.

The majority of these areas have a rainfall between 25 in. and 30 in. per annum. The surveys have not so far demonstrated that *Porina* infestation is confined to any particular type of soil, nor that the condition of the pasture at the time of moth flight has any bearing on susceptibility to infestation. No instance has been seen of damage to pasture in its first year, and it appears that where the ground is being worked at the time of egg laying or egg hatching the conditions are unfavourable for the survival of the larvæ. No instance has been seen of damage to crops (other than occasional damage to lucerne stands). It is likely that eggs are laid on cereal crops, but that these are mature and harvested before the *Porina* larvæ are large enough to do any damage.

The principal damage is to improved pastures of rye-grass and clovers, which have in Canterbury a normal life of four years and perhaps double that in areas farther south. In years of equal infestation the damage to the pasture is likely to be accentuated by conditions which are unfavourable for plant growth or by injudicious grazing.

Old pastures which have been reverted largely to brown-top may carry a large *Porina* population without showing any evident damage.

The clovers seem to suffer more severely than other pasture plants from *Porina* defoliation, and the fact that the most severe damage occurs in improved pastures may be related to their high clover content. Grasses such as twitch, cocksfoot, and *Phalaris* appear to be more resistant or to have better powers of recovery than perennial rye-grass.

(b) Light Traps.

A number of light traps were set up in different localities in both North and South Islands with the object of gaining information on the species of *Porina* occurring in different districts and the time over which the flight period of the different moths extended.

The results show that the principal species of economic importance in Canterbury, and probably in Otago and Southland also, is one which has been provisionally identified as *Porina jocosa*. This is a species which has not been recorded from the North Island, where it is possible that *P. cervinata*, which has approximately the same flight period, is the principal economic species.

Porina jocosa commences to fly early in October, but the peak of the moth activity was in the second half of October. The two sexes of the moth were attracted to the lights in approximately equal numbers. In both Canterbury and Southland a second species, *Porina umbraculata*, began to appear in the traps in the beginning of November, and its numbers increased as the numbers of *P. jocosa* decreased. Even at its peak of activity, *P. umbraculata* was present in much smaller numbers than *P. jocosa*, and is considered to be of minor importance.

The systematics of the *Porina* species is somewhat confused, and the material secured from the light traps will be useful in clarifying the position.

(c) Chemical Control.

Any immediate relief from the *Porina* damage can come only by the employment of chemical control measures. For this reason the first requirement is an effective and practicable method of controlling *Porina* larvæ in a field which is known to be infested. As the *Porina* larvæ are surface feeders there is some prospect of success by using poisonous dusts, sprays, or baits, and work is proceeding along these lines. The time of application of such measures may have a great bearing on their efficacy, since it appears possible that there may be very little feeding by *Porina* larvæ in winter and spring. If this were so, the control measures would have to be applied in late summer at a period when it is not easy to distinguish infested from uninfested pastures. Since it is likely that arsenical poisons may prove to be the cheapest and most efficient, attention is being given to the problem of arsenical residues on the pasture in relation to stock poisoning.

(d) Ecology of Porina.

There is at present no information as to the conditions of soil, climate, and farm management which increase the likelihood of *Porina* infestation. An experimental area has been sown down at the Agronomy Division at Lincoln for the purpose of obtaining information on these points. It is possible that an investigation of the oviposition habits and preferences of the moth may provide useful information bearing on control.

(4) Lucerne-flea.

The lucerne-flea position has been kept under observation during the year. Several visits were made to the area of subterranean clover which is infested at Maraekakaho. The flea population was considerably reduced in comparison with the previous year and little damage was evident.

The reduction in population in 1939 had been expected owing to the prolonged dry period in summer and autumn, which delays the hatching of the eggs, and the low winter temperatures, which retard the rate of growth of the insect. In this area the predaceous mite, *Biscurus lapidarius*, is not present, and an attempt which was made to obtain supplies from Australia was unsuccessful.

There has been only one report of lucerne-flea damage during the year. In this instance the damage was done to lucerne at Takapau. Not all of the crop was infested, but in the part which was infested the damage was moderately severe. Damage of such severity to lucerne has not been encountered previously in New Zealand. The severity of the damage indicates that there must have been a high population of lucerne-flea in winter and spring, and it is difficult to reconcile this with the position at Maraekakaho, where the population was low. A point of some importance is that the predaceous mite, *Biscurus lapidarius*, was present in this lucerne area and, in fact, was more abundant there than in any of the other localities in which it had previously been recorded. It may be possible to use this area as a collecting ground for the mite if it is necessary to disseminate it artifically.

The opinion is still held that the lucerne-flea in localities such as Hawke's Bay, which are favourable to it, is likely to do quite serious damage to both subterranean clover and lucerne in particular seasons when weather conditions are especially favourable to it.

(5) Cheese-mites.

Preliminary work in connection with the control of cheese-mites has been undertaken in anticipation of the control of mites under abnormal conditions likely to be occasioned by the stoppage of transport of our primary products. The investigations to date have revealed that some measure of control may be secured by the use of ammonia and paraffin oil.

Ammonia, on account of its lethal effect on the mites, must be seriously considered for the control of the mites in cheese storage, but further experiments would be necessary with this material to determine methods of application.

Paraffin oil merits consideration because of its mechanical effect on the mites, and if under storage conditions it would act in the same way as it does under experimental conditions it would probably be an effective controllant.

(6) Timber Insects.

Research activities in regard to insects attacking constructional timbers have been developed during the year, under the direction of the Timber Protection Research Committee.

For the most part attention has been given to the termites, or "white-ants," which have recently come to the fore as of major importance in certain parts of the Dominion. Among these termites are both the Australian earth-dwelling forms and the New Zealand "dry-wood" forms; the former require to be in contact with the ground, but the latter do not. It has been found that the Australian species, *Coptotermes acinaciformis*, is well established, and outstandingly destructive. This species is known in Australia as "termite enemy No. 1" in so far as constructional timbers are concerned. In New Zealand all the commonly used timbers, including rimu, totara, matai, and kauri, are attacked. This species also attacks trees, and there are indications that our native forests may be subject to attack, as the insect has been found already well established in such species as puriri and pohutukawa. In regard to exotic trees, the insect has become established in oak and poplar, and eucalypts are doubtless within the range of infestation. It is unlikely, however, that species of *Pinus* will be attacked to any great extent. Control measures have been inaugurated, and a publication on the subject of termites has been issued and may be secured from the Cawthron Institute.

In regard to other timber-infesting insects, attention is being given mainly to the native two-toothed longhorn beetle (*Ambeodontus tristis*), which is also of major importance.

In checking the spread of timber insects, a universal practice to be condemned is the marketing of timber from infested buildings that have been demolished. This spreads both termites and wood-borers to uninfested areas, and the suppression of the practice is a very urgent need in New Zealand. All infested timber should be burned.

(7) Tussock-moth.

A study of these insects showed that their caterpillars were not the primary cause of deterioration of tussock country.

(8) Routine.

Apart from the major research activities, considerable attention has been given to giving advice to farmers and horticulturists, to public lectures, to the preparation of publications, to quarantine problems, and to the indentification of insects and the keeping of records regarding their activity. Assistance has been received from and given to the Department of Agriculture.

PLANT CHEMISTRY LABORATORY.

Director: Dr. J. Melville.

The Plant Chemistry Laboratory has continued its investigations along the lines which were indicated in its initial annual report last year. The staff has been engaged largely on what can be termed the initiatory stages of a long-term investigation, This has involved the application of the most approved methods of analysis for single substances or groups of closely related substances, and the working-out of new methods for materials whose presence has been known or suspected but for which analytical methods have not been available.

The object of the investigation is, in general terms, a much fuller knowledge of the chemical substances which are present in aqueous plant extracts—*i.e.*, of those metabolites which can be translocated and which are assumed therefore to be of prime importance in the synthesis or breakdown of protein. The need for such an investigation is becoming increasingly obvious. Before it is possible to correlate stock health with the pasture on which the animals are grazing, a knowledge of the materials present in the ingested food, together, with an appreciation of their pharmacological as well as their nutritional properties, is essential; while, almost equally desirable, are analytical methods whereby the concentrations of such materials can be quantitatively determined.

The Cyanogenetic Glucoside of White Clover.

The ability of certain strains of white clover to produce hydrocyanic acid (HCN) has been of great interest to pasture and animal investigators. The relative amount present in various lines is being used in New Zealand as a means of seed certification, while it is obvious that the presence of so toxic a substance as HCN in this universal pasture plant is a matter of concern to the veterinarian. Although no case of HCN poisoning on clover has ever been recorded, it is obviously desirable to have further information on the glucoside which produces HCN, and on its breakdown to give free HCN under the action of the corresponding enzyme.

The isolation of the glucoside, lotaustralin, has been accomplished by Australian workers, but the yield obtained from white clover by their method was so small that it gave little promise of being suitable for building up a reasonable quantity of the material. By working with fresh material, and extraction of a clarified and concentrated extract with ethyl acetate, the yield has been much increased, and it is hoped that sufficient can be prepared for toxicological studies.

In a study of the possibly toxic effects of clover containing high amounts of the glucoside it is important that due weight be given to the way in which the glucoside is broken down by the corresponding enzyme It must be stressed that in the absence of a hydrolytic enzyme, lotaustralin would be quite harmless even if fed in comparatively large quantities. Only in the presence of the enzyme is the glucoside dangerous, and then only if conditions in the digestive tract are such that HCN is rapidly liberated.

That an enzyme capable of causing the liberation of HCN from the glucoside is present in clover is evident from the breakdown which occurs when the leaves are cytolysed or allowed to autolyse; but, due to the large range of concentrations of the enzyme in various lines of clover, and to the difficulty of obtaining highly active preparations, the preliminary work has been carried out on linseed. This easily available raw material is an excellent source of the enzyme, and by the use of methods elaborated for the purification of other similar materials a product of high activity has been obtained. The most active preparation hydrolyses one hundred and twenty times its weight of glucoside in two hours, representing an increase in activity over the original linseed of two hundred times. It is believed that even this material is far from pure, but it was sufficiently free from extraneous materials to make possible a precise study of its reaction with the purified glucoside.

The purification of the enzyme from white clover is a much more difficult operation, but it has been possible to show that its properties are practically identical with that from linseed. The conditions of pH and temperature under which the enzyme hydrolyses the glucoside have been accurately defined. It should be possible, therefore, to supply both glucoside and an active preparation of enzyme for toxicological work, while the information as to optimum conditions for hydrolysis will be of value. The preparation of the enzyme from linseed has been very useful in determining the quantity of glucoside in fresh clover, since individual variations in the quantity of enzyme present have no effect, and it is necessary only to allow the reaction to proceed overnight to get maximum amounts of HCN. The value of this in breeding and selection work has already been demonstrated in a study which is being carried out on white clover by the Grasslands Division.

One further observation has been made as a result of these investigations—viz., the extraordinary rapidity with which a certain amount of the glucoside is broken down after the clover is cut. It has been established beyond doubt that there exists no free HCN in the leaves on the plant; yet in certain cases it has been found that ten minutes after cutting no less than 25 per cent. of the total glucoside has been broken down. Further breakdown does not occur until the leaves begin to autolyse, which generally requires more than forty-eight hours. What initiates this almost explosive reaction is unknown, but it illustrates how carefully interpretations of analyses of cut herbage must be made.

Analytical Methods.

It has become increasingly apparent during the year's work that more refined methods of analysis for the materials which comprise the soluble fraction of leaf tissue are essential, and considerable work has been done to that end.

(1) *Carbohydrates.* The soluble carbohydrates are of importance in that they are believed to be the end products of photosynthesis and supply the carbon chain not only for the structural carbohydrates of the cell wall, but also for the nitrogenous derivatives. A method for the estimation of sugars having advantages in both simplicity and specificity over the accepted methods has been worked out. Further work on this fraction is proceeding, with the purpose of determining the individual sugars which comprise the soluble carbohydrate fraction.

(2) *Amino-acids.* The amino-acids are the units of which proteins are composed, and probably comprise the most important group in the soluble nitrogen fraction. Methods for the quantitative estimation of the amino-acids have been in process of continual improvement and depend almost entirely on the properties of the amino group. Since, however, substances other than true amino-acids cause considerable interference, there still exists doubt as to the interpretation of the values obtained for amino-nitrogen. Progress has been made in an examination of current methods and in the application of new ones, and it is believed that it will be possible to define the degree of interference fairly accurately.

Peptides are composed of amino-acids and may be looked on as proteins of a low order of complexity. They contribute largely to the soluble nitrogen fraction, and methods for their determination are available. The criticisms which apply to the amino-acid fraction apply also to the estimation of the peptides.

(3) *Purines.* The purines are constituents of all nuclear material and form an important part of certain enzyme systems concerned with cellular oxidation, while recent work has shown that those virus proteins which have been available for intensive investigation contain adenine and guanine as part of the molecule. Methods of estimation have hitherto been tedious and of doubtful specificity, and an accurate micro method has been eminently desirable. By a modification of a method developed for the analysis of animal tissues a considerable improvement has been achieved. Analyses of clover and rye-grass indicate that purine nitrogen may account for as much as 5 per cent. of the total nitrogen, and that most of the purine occurs in combination, probably as nucleic acid.

(4) *Rest-nitrogen Fraction.* Of the soluble organic nitrogen fraction in pasture plants, amino-acids and peptides are undoubtedly the most important constituents, and a fair estimate of their contribution is possible. The amides, glutamine, and asparagine, together with free ammonia, can also be estimated with a fair degree of certainty. But when the nitrogen derived from all these sources is added together it is found that a considerable discrepancy still exists between the sum and the total soluble nitrogen figure. This nitrogen unaccounted for by present methods of analysis is conveniently referred to as the "rest-nitrogen" fraction, which may vary from as little as 20 per cent. to as much as 60 per cent. of the total soluble nitrogen. Comparatively little work has been done on this fraction by plant physiologists, either qualitatively or quantitatively, yet the chemical individuals of which it is comprised and their relative amounts is a matter of the greatest practical importance.

The analyses which have been briefly described are of interest to the animal physiologist who wishes to have as complete a knowledge as is possible of the food ingested by the animal. But they are of little use to the pathologist who is investigating some stock ailment directly attributable to the pasture on which the stock is grazing. Amino-acids, peptides and the amides, asparagine and glutamine, are normal constituents of any animal diet and no pharmacological action can be ascribed to them. If, however, amines, alkaloids, or other nitrogenous materials with possible pharmacological activity are present in grass, and the many stock ailments which have been reported would point to that conclusion, they will appear in the rest-nitrogen fraction.

The fraction is of almost equal interest to the plant physiologist who is interested in the role played by the constituent parts in the metabolism of the leaf, and who desires to know whether they are intermediary metabolites in the synthesis of protein or by-products of synthesis and breakdown. No answer can be given at the moment to this question, and it will be obvious that an investigation which sets out to answer it must necessarily be a long-term one. Certain preliminary experiments have been made in order to establish the identity of the materials present in the rest-nitrogen fraction of rye-grass, and a fraction containing about 6 per cent. of the total soluble nitrogen has been isolated. Its examination is proceeding.

Facial-eczema Investigations.

The work which has been outlined above, and its extension, is the chief contribution which this Laboratory can make to the study of diseases such as facial eczema, where composition of the herbage eaten by the animal is suspected as being the primary cause of the complaint. But simultaneously with such studies it is necessary to carry out experiments which are designed as a result of observations made in the field. One of these observations relates to the high soil temperatures in seasons when the disease is prevalent, and an investigation of the effect of high soil temperatures on the growth of perennial rye-grass has been initiated in collaboration with the Grasslands Division and the Department of Agriculture. This has involved the growing of rye-grass in glasshouses and outside under conditions where soil temperatures can be controlled. As is stated in the report by the Director of the Grasslands Division, difficulties were experienced with grass grown under glass, and modifications in treatment will be tried in order to give a better sward.

The analyses of the samples of rye-grass are proceeding, and results to date indicate no marked differences in the carbohydrate or nitrogenous fractions studied. But as has been pointed out above, the fractions for which analytical methods are available are not those which would be suspected of causing a pathological condition. When adequate methods for determining the components of the rest-nitrogen fraction are worked out, the material from these experiments will prove of value in determining the effect of at least one environmental factor on this interesting fraction.

Phytohormones.

Extension of the work on the rooting of cuttings through the use of phytohormones has been in the direction of determining the effect of various nitrogenous materials used in conjunction with naphthaleneacetic acid. Cuttings of *Rhododendron maddenii* var. *jenkinsii* were chosen for the investigation, since difficulties have been experienced in promoting rooting in this species. Some thirty nitrogenous compounds of varying degrees of complexity and markedly different chemical constitution were used, and considerable variations occurred in the rooting response. Thus, betaine, alloxan, and tyrosine, when applied to the cuttings after a preliminary treatment with naphthaleneacetic acid, gave 100 per cent. rooting in two months, naphthaleneacetic acid alone giving virtually no rooting over the same period. Other materials did not give so marked a response, although all the materials tried, including ammonium and nitrate salts, produced some effect. It is noteworthy that concentrations of these chemicals as low as one part in twenty millions exerted as great an effect as concentrations four hundred times as great and that at the lowest concentration of 0·05 mg. per litre each cutting would take up no more than 0·025 γ of the substance. No satisfactory explanation can be put forward as to the action of these nitrogenous materials, since such infinitesimal quantities can hardly be acting as plant nutrients.

Other Investigations.

The analyses of the rations fed to milking cows in stalls have been carried out for the Dairy Research Institute in connection with their nutritional investigations.

The soil and pasture studies on the Marton area, which have been in progress for a number of years, will come to an end in 1941, when a full report of the whole investigation will be submitted. Meanwhile current analyses are going forward satisfactorily.

Publications.

The following papers have been published in the *New Zealand Journal of Science and Technology* during the year:—

"A New Method for Clarification of Plant Extracts for the Determination of Reducing Sugars," by B. W. Doak.

"The Effect of various Nitrogenous Compounds on the Rooting of Cuttings treated with Naphthaleneacetic Acid," by B. W. Doak.

"Nitrate Nitrogen in Plant Material: I—A Micro-method for the Determination of Nitrate; II—A Micro-method for the Determination of Total Nitrogen in the Presence of Nitrate," by I. Reifer.

"The Estimation of Nitrogen by the Hypobromite Method, using Copper as Catalyst," by I. Reifer.

"The Micro-estimation of Adenine, Guanine, Xanthine, and Hypoxanthine in the Presence of Uric Acid," by I. Reifer.

ANIMAL RESEARCH.

The Animal Research Management Committee held no meetings during the year, owing to the fact that it was deemed necessary by the Government to review the policy and departmental organization concerned with the administration of animal research.

Reports on researches relating to animal problems are included in the sections of this report referring to the work in progress at the Agricultural Colleges and Cawthron Institute.

SOIL SURVEY.

Land Utilization Committee.—Sir Theodore Rigg, Director, Cawthron Institute (Chairman); Mr. A. H. Cockayne, Director-General, Department of Agriculture; Mr. E. J. Fawcett, Assistant Director-General, Department of Agriculture; Mr. R. B. Tennent, Director, Fields Division, Department of Agriculture; Mr. R. P. Connell, Land Utilization Officer, Department of Agriculture; Professor W. Riddet, Massey Agricultural College; Mr. G. A. Pascoe, Factory Controller, Department of Industries and Commerce; Dr. L. I. Grange, Director, Soil Survey Division, Department of Scientific and Industrial Research; Mr. R. G. McMorran, Under-Secretary, Lands and Survey Department; Mr. F. R. Callaghan, Chief Executive Officer, Plant Research Bureau, Department of Scientific and Industrial Research; Dr. I. W. Weston, Agricultural Economist, Canterbury Agricultural College; Mr. F. J. A. Brogan, Assistant Secretary, Department of Scientific and Industrial Research (Secretary).

REPORT BY DIRECTOR (DR. L. I. GRANGE).

The Soil Survey Division was occupied during the greater part of the year in detailed surveys in North Auckland and Hawke's Bay. In North Auckland soil types were delineated in Hobson and Otamatea counties.

The mapping of soils in Hawke's Bay Province was completed with the exception of about 150 square miles at the southern end and that portion which lies to the east of Wairoa in northern Hawke's Bay.

The mapping of soils was continued in the Waikato lowlands between Hamilton and Morrinsville. Aerial photographs have been used as topographic maps, and these have expedited the work. Samples of soil types for determination of nitrogen and ammonia were forwarded regularly to Wellington.

A report was made on the soils of Matakaoa County. The survey indicates that several of the soil types on the hilly country have a natural fertility greater than that of the average of New Zealand hill soils.

Information on the market-garden soils of Lower Hutt and all the districts between Waikanae and Feilding and Ohakune, as well as the general soil types in the Manawatu, was obtained. This survey has value in that the analyses indicate the effects on fertility of continuous cropping. It is evident that the pedologist can co-operate usefully with the horticulture officer in the field of fertilizer requirements. This aspect of the survey needs expanding when opportunity permits.

Reports were made on the Mission Block, Manakau Harbour, and Ruakaka area south of Whangarei, and on Wairakei, Taupo blocks, for the Lands and Survey Department.

Late in the year the programme of the Division was radically changed in that detailed surveys were discontinued for the time being and a start made on a general survey of the soils of the North Island and South Island. Data rapidly obtained of the whole of our soils were considered to be much more useful during the present emergency than intense knowledge of isolated districts. Fortunately, it happens that the detailed surveys already in existence include practically all the main soil types in New Zealand, with the consequence that general mapping can proceed with some confidence and reasonable speed. In this task the pedologists are keeping in close contact with the Agricultural Instructors in order to tie in with their observational fertilizer trials and to ensure that useful soil types are marked out. Soil maps of both Islands on a scale of four miles to the inch will be compiled and can be then used by officers of the Fields Division as a basis for extending their information for farmers on top-dressing and for the general problem of the utilization of various classes of land. As mentioned in the reports which follow, a considerable area has been mapped in North Auckland, the east coast of the North Island, and the Manawatu.

The chemists at the laboratories at Cawthron Institute and at Wellington have continued to supply analyses of the plant foods, &c., of the soils and to interpret results for field officers. Besides maintaining this service they have improved their methods of analysis (*e.g.*, for magnesia and for total nitrogen) and have made substantial progress on soil problems (*e.g.*, wilting-point of soils, magnesia in relation to fertility, and phosphate fixation).

The magnesia content of soils is well worthy of attention in intensively developed districts, since fertilizers now contain only small amounts, and the usual programme of top-dressing tends to hasten the leaching of this compound. Values on the low side have been obtained in Waihi and the Waikato.

The standard tests show high phosphate fixation for Waikato and Taranaki soils, and this is usually ascribed to the iron and aluminium compounds in the soil; but this cannot be the case for these types, for they are in general only slightly acid. Whether or not the clay itself is an agent in fixation is being investigated.

NORTH AUCKLAND SOIL SURVEY: PROGRESS REPORT.

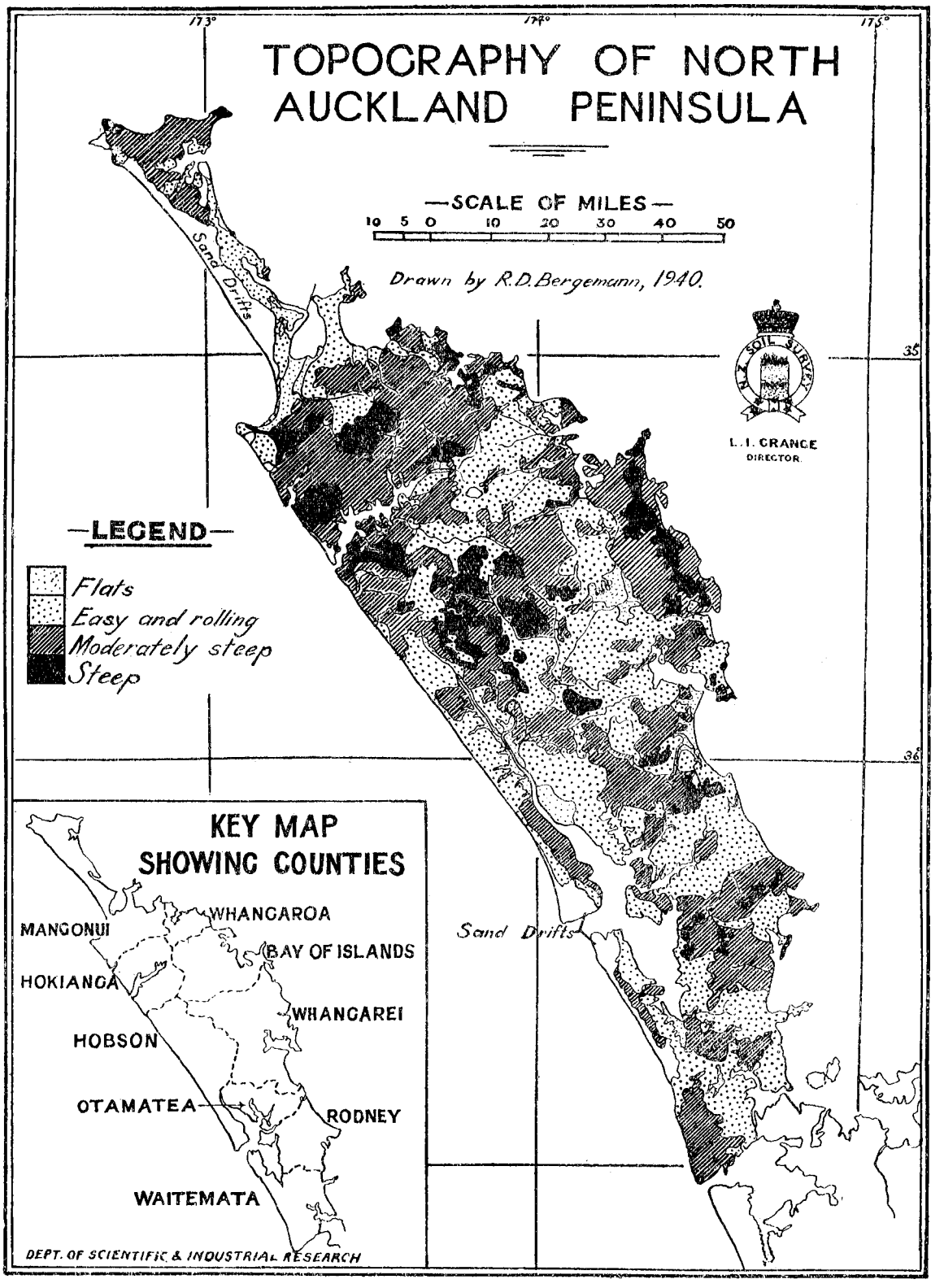
NORTH AUCKLAND: DETAILED SURVEYS.

During the 1939–40 season 290 square miles were mapped in detail in Hobson and Otamatea counties.

Co-operative work with other Departments was continued. For the Public Works Department, an aerodrome-site was mapped in detail and the drainage qualities of the various soils reported on. A report and soil maps were also prepared on a landing-ground. For the Lands and Survey Department an investigation was made of the soils of the Mission Block at Matakawau and of the Ruakaka area south of Whangarei.

NORTH AUCKLAND PENINSULA: GENERAL SURVEY.

In previous annual reports the properties of the chief soil types and their relation to the climate, vegetation, lithology, and topography have been noted. In this summary the 5,200 square miles of the peninsula surveyed is divided into four topographic land types, the flats which cover approximately 500 square miles, the easy and rolling land which covers 2,100 square miles, the moderately steep hill country of 2,000 square miles, and the steep hill country amounting to 600 square miles. The distribution of these types is shown in simplified form in the accompanying sketch map.


TOPOGRAPHY OF NORTH AUCKLAND PENINSULA
173°
174°
175°
—SCALE OF MILES—
10 5 0 10 20 30 40 50
Drawn by R.D.Bergemann, 1940.
N.Z. SOIL SURVEY
L. I. GRANGE
DIRECTOR
35
36
—LEGEND—
Flats
Easy and rolling
Moderately steep
Steep
Sand Drifts
Sand Drifts
KEY MAP
SHOWING COUNTIES
MANGONUI
WHANGAROA
BAY OF ISLANDS
HOKIANGA
WHANGAREI
HOBSON
OTAMATEA
RODNEY
WAITEMATA
DEPT. OF SCIENTIFIC & INDUSTRIAL RESEARCH

The Flats.

The chief soils of the flats are the recent alluvial soils (130 square miles), the meadow clays (250 square miles), and the peaty soils (120 square miles).

The *recent alluvial soils* are mainly brown clay loams. They occupy the narrow valley bottoms and are well distributed throughout the area. They are probably the most fertile soils of the peninsula, but owing to their situation are subject to flooding.

The *meadow clays* are divided into four types, all of which are poorly drained types, and consequently a good system of drainage is essential for their successful development. The more fertile grey clay types occur extensively in Mangonui County (near Kaitaia), around the shores of the Kaipara Harbour (near Dargaville, Ruawai, and Helensville), and in Whangarei County, where a large area near Hikurangi is subject to heavy flooding. These soils are used mainly for dairying, but owing to the poor drainage and heavy texture they are not suited to heavy stocking in winter. A brown granular clay derived from basic alluvium covers about 17 square miles of the river terraces in Mangonui and Hobson counties. This type also supports good pastures, but responds less readily to fertilizers. The two remaining meadow types have low natural fertility coupled with poor drainage. These are the low flats formed from gumland wash and the grey granular clays covering the higher terraces of rivers draining from the basic volcanic hills. Each of these types covers about 20 square miles and is but little developed.

The *peaty soils* are of three main types—the peaty sandy loams, the peaty loams, and the peats. The peaty sandy loams cover about 70 square miles and lie mainly in Mangonui, Hobson, and Whangarei counties, where they occupy hollows and swampy valleys in the lightly consolidated coastal sandstone. Near Whangarei they have been recently developed for dairying, but elsewhere they are but little used. Many of the swampy valleys in Hobson and Mangonui counties are difficult to drain and contain much timber.

The Easy and Rolling Land.

The soils of the easy and rolling land can be divided into two main groups, the soils derived from sedimentary rocks and the brown granular clays and brown loams derived from basic volcanic rocks. The first group embraces the soils derived from blown sand, the limestone soils, the brown clays, and clay loams from mudstone, sandstone, and greywacke (immature podsol), the more leached grey brown and grey clays (semimature podsols) and the gumlands (submature and mature podsols).

Sandhills fixed by weathering occupy some 130 square miles along the west coast of the peninsula and are covered with dark sandy loam and sand topsoils capable of supporting good pastures if top-dressed with phosphate. The subsoils are moderately heavy and do not dry out in summer as do the loose soils of the younger sandhills. This type should be further developed.

Fertile limestone soils cover some 48 square miles of the easy country. They are well developed in Otamatea County, and are used for dairying and sheep farming.

The brown clays and clay loams have developed under a mixed forest containing a high proportion of broad-leaved trees. These are moderately fertile soils and are used for dairying and grazing. They cover about 300 square miles, and are well distributed throughout the peninsula.

The grey-brown and grey clays have developed under kauri and podocarp forests, and in many places now support scrub. They are acid soils requiring heavy repeated dressings of lime for their successful development. The grey clays, which are locally referred to as the clay gumlands, are less fertile than the grey-brown types. These soils cover some 500 square miles, half of which is of the grey-brown type. The grey-brown clays lie mainly within Whangarei, Hokianga, and Rodney counties, where considerable areas are now being farmed. The grey clays lie mainly within Whangarei, Rodney, and Waitemata counties. Other than in Waitemata County, these soils are not farmed to any extent.

The gumland soils cover 600 square miles and are of three main types—sand gumland (200 square miles), sandy loam gumland (190 square miles), and silt loam gumland (210 square miles). The sand gumland, which is practically confined to Mangonui and Hobson counties, is generally not suited to present-day development and is mostly still in scrub. Areas developed are in poor pasture.

The sandy loam and silt loam gumlands occur extensively in Bay of Islands and Whangarei counties and are scattered elsewhere throughout the peninsula. They are being rapidly developed, but much still remains in stunted scrub.

On the easy country the brown granular clays derived from basic volcanic rocks are for the most part soils of low fertility requiring heavy dressings of lime, together with phosphate and potash. They cover about 70 square miles in northern Hokianga County and in adjoining parts of neighbouring counties. A related type in this area is the upland meadow soil of Tutamoe Plateau (40 square miles).

The brown loams derived from basic volcanic rocks are of three main types, locally known as the fertile volcanic loams (young and immature), the poor volcanic loams (semimature), and the ironstone soils (mature).

The fertile volcanic loams cover about 70 square miles and lie mainly in Whangarei and Bay of Islands counties, where they are used for dairying and sheep-farming. On 10 square miles of this type, however, the soils are thin and bouldery. The poorer volcanic loams (48 square miles) lie in Whangarei, Bay of Islands, and Hokianga counties, and with heavy dressings of lime and phosphates can be made to support good pastures. The ironstone soils cover some 100 square miles in the Bay of Islands and Whangaroa counties. Most of the area is not farmed and development awaits further experimental work.

Moderately Steep Hill Country.

The soils of the moderately steep hill country can be divided into types similar to those described for the easy and rolling lands.

Soils on recent sand-dunes fixed by vegetation cover some 40 square miles, mainly in Mangonui and Hobson counties. These soils are light and free and dry out during summer months. In part they are used for sheep-farming, but are subject to severe wind erosion where the cover is incomplete. Until the drifting sand near the coast is fixed only a small part of this type is suitable for development. The limestone hill country (30 square miles) lies largely within the Bay of Islands County, but a further 50 square miles of closely related fertile soils cover the calcareous sandstone hills of Mangonui and Hokianga counties. These are used for sheep and cattle grazing.

Immature brown clays and clay loams cover 700 square miles of hill country, 400 square miles of which lie within the Whangarei County. They have moderately fertile topsoils, but the initial fertility is steadily lost on poorly-farmed hillsides, and there is much reversion to scrub and fern. Sheet erosion is common, and in places the country slips badly.

The grey-brown hill soils cover some 260 square miles and are widely distributed. They are less fertile than the previous types, and the reversion problem is more acute. In places sheet and slip erosion is severe, and the exposed subsoil is difficult to regrass.

The gumland hills cover 100 square miles, 30 square miles of which lie within Whangarei County. This land has little or no agricultural value and is still mainly in scrub.

Fertile brown granular clays cover about 300 square miles of the basic volcanic hills in the six northern counties. They are used largely for grazing, but a fairly large area is still in forest. In Hobson and Waitemata counties there is similar country with a somewhat lower natural fertility.

Poor granular clays cover 100 square miles of hill country, 80 square miles of which lie within Mangonui County. This type is difficult to farm owing to the low fertility of the topsoil and to the readiness with which it erodes; it should, however, be suitable for reafforestation.

Steep Land.

The steep land is largely confined to the six northern counties, where much of it has been reserved for State forests. The soils are generally thin and, owing to the danger of erosion, are not generally adapted to farming. Some fertile areas are being successfully farmed, but much that was previously felled and grassed has now been abandoned and has reverted to scrubland.

HAWKE'S BAY SOIL SURVEY: PROGRESS REPORT.

During the 1939–40 season field-work on this project was virtually completed when, in February, 1940, the staff were transferred to general soil-survey work. Final details were added to soil maps covering about 500 square miles in Southern Hawke's Bay, and small areas in Northern Hawke's Bay were also finalized. A small area near Tautane in the south-west of the province remains to be mapped, and it has also been decided to map the Wairoa-Mahia peninsula for the final reports. The four base maps for the first bulletin which deals with Mid-Hawke's Bay have been printed, and one has already been produced in colour. The text of this bulletin is largely completed, and draughtsmen are engaged on the final maps of the southern district. Some time will elapse before the publication of the first bulletin, but the results of the work are available if required.

It is now possible to review the completed soil survey and to indicate generally its usefulness. Pasture and farm management surveys have been made in association with the soil survey, and the land-utilization survey as a whole has been aptly described as an "inventory of our soil resources." The results of the soil survey alone are reviewed here; they have been described in greater detail in earlier reports.

Description of Area Surveyed.

The survey covered the Hawke's Bay Land District (4,500 square miles), which extends from Wairoa to Woodville and lies between the backbone mountain range of the North Island and the sea. The following major physiographic divisions are recognized: (1) Western and north-western ranges; (2) western foothills south of the Ngaruroro River; (3) coastal hill country; (4) north-western pumice country; (5) plains—(*a*) western plains, (*b*) eastern plains.

(1) *Western and North-western Ranges.*

The Ruahine, Wakarara, Kaweka, and Kaimanawa ranges are the main mountain chains. All are formed from hardened sandstones and mudstones, known as greywacke and argillities, but north of the Ngaruroro River they are covered by layers of volcanic ash, of which the Taupo pumice is most important. Forest still covers many of the higher ridges. Where it has been removed, or where the orginal cover was scrub and fern, heavy stocking and continued burning have initiated soil erosion. In the neighbourhood of the Wakarara Range and in the lighter volcanic ash regions many hills have reached that crucial stage where bare rock occupies most of the surface. The soils are light and well drained, and in the north are of low fertility. Soils on the Ruahine Range, however, are not quite so poor, and on a few slopes pastures seem to have been maintained under skilful management.

(2) *Western Foothills South of Ngaruroro River.*

Flanking the ranges on the east is a narrow belt of moderately steep and rolling country crossed by gorges and extending in narrow arms towards the middle of the district, where it intermingles with the western plains. Sandstones, conglomerates, and mudstones are the main rock formations. The rainfall is high, and heavy forest once flourished on much of this belt. The rolling hills are ploughable and the soils are light and friable. The regions formerly in forest have an initial high fertility, but this is susceptible to severe and rapid depletion, and phosphatic top-dressings are required to maintain productivity. The soils of the formerly scrub-covered areas are low in natural fertility, deteriorate very slowly, and are deficient in phosphate and apparently in lime.

(3) *Coastal Hill Country.*

This is the typical Hawke's Bay hill country and occupies the eastern half of the province. The belt comprises steep, moderately steep, and rolling hills, and is fairly narrow in the north, but widens greatly west of Napier and again in the extreme south. The underlying rocks are muddy sandstones, mudstones, sandstones, limestones, argillites, and stony conglomerates.

Light forest once flourished in a few areas, particularly in the south, but much of the area was in tall fern when Europeans first arrived. The rainfall is normally fairly low (30 in. to 40 in.), but is somewhat higher in the west and north, and again in a few south-eastern areas. As a rule natural fertility is high, although a few soils are distinctly poor. Phosphate is almost universally deficient, but the content of lime is rarely seriously low, even on gentler slopes. Most of the soils are loamy and easily worked. On the steeper country slipping is a serious problem, but otherwise erosion is not severe.

(4) *North-western Pumice Country.*

Volcanic ash showers blanket the north-western quarter of the province. On the east of the ranges there is an extensive belt of gently rolling and moderately steep hill country, crossed by many deep gorges which is covered with volcanic ash. The underlying rocks have little influence on the soil, except where the ash shower is thin. The most important showers are known as the Taupo pumice and Gisborne pumice. The former covers about half the area and gives rise to poor soils usually deficient in cobalt as well as in phosphate. Lime is very low or absent, according to chemical analyses. The Gisborne pumice covers the south-western half of the belt. The soils are slightly more fertile and generally have a sufficient supply of cobalt. The Napier–Wairoa Railway has given access to a good deal of gently sloping country of the Gisborne pumice type, which is largely covered with fern.

(5) *Plains.*

(*a*) *Western Plains.* A few miles east of the ranges broad terraces extend intermittently from Woodville and Dannevirke towards Norsewood, Takapau, and the Ngaruroro River. They are generally many feet above stream-level, and their soils are derived from gravels, sands, and silts worn from the nearby mountains. These soils are light and friable and resemble those of the western foothills as regards plant-food content. They developed under high rainfall and heavy forest on the west, but under scrub and fern farther east.

(*b*) *Eastern Plains.*—Strongly contrasted with soils of the western plains are those of the plains in the coastal districts. Silts and sands from neighbouring mudstones, limestones, and sandstones form the parent materials of these latter soils, and their high fertility is noteworthy. The Heretaunga Plains surrounding Hastings, which are typical, have been described in a separate bulletin,* and other extensive plains of the same character occur north-west of Waipukurau. Similar soils occur on river-flats throughout the coastal hill country. The original vegetation was bracken fern or light forest, and the rainfall is not high (30 in. to 35 in.). Phosphate is on the low side on some of the older soils, but lime is deficient only on the wetter areas.

EAST COAST AND CENTRAL NORTH ISLAND: GENERAL SOIL SURVEY.

In February, 1940, the Hawke's Bay Soil Survey party was transferred to the North Island General Soil Survey. The region to be surveyed by this party includes the east coast districts of Wairarapa, Hawke's Bay, and Gisborne, together with the greater part of the Ruapehu-Taupo-Rotorua-Whakatane area. It is expected that the project will be completed late in 1940, concurrently with surveys of the remainder of the North Island.

Soil Groups.

The *Rendzina or Limestone Soil Group* is not very extensive, but occurs in widely scattered small areas. It is very fertile. The *new group soils* (which are possibly equivalent to the grey-brown podsolic soils of America) are found in the coastal half of the east coast districts. They are loamy and fertile as a rule, and respond well to superphosphate. Lime and sometimes potash may be beneficial on gentler slopes, but are rarely limiting factors in the development of the soils. The *brown-yellow loam soils* (which are probably equivalent to the brown podsolic soils of America) have developed under a higher rainfall than the new group soils and often under heavy forest. They are found on the ranges and adjacent foothills and plains. The soils are friable and may be very fertile when first broken in, but such initial natural fertility is susceptible to rapid depletion. On these soils phosphate is deficient and, according to chemical analyses, so also is lime, but lime deficiency does not limit their use as a rule. The *pumice soils* occupy most of the Central North Island and extend eastwards into the east

* "Land Utilization of Heretaunga Plains." *Department of Scientific and Industrial Research, Bulletin No. 70*, 1939.

coast area. They are generally poor in the natural state and are very deficient in phosphate. Deficiency in cobalt is a factor limiting farming operations in many areas, which will be delimited. Lime is shown by analysis to be absent or very low. The *recent alluvial soils* are found on river-flats and are usually very fertile. Plant foods are normally abundant, but phosphate may give responses on some of the older soils and lime on the wetter areas. The *organic soils* include peaty soils, and *saline soils* embrace those that are adversely influenced by high salt content.

Progress of Work.

Of the 20,500 square miles in this region approximately 1,000 square miles of Southern Hawke's Bay and Northern Wairarapa had been mapped at 31st March, 1940. Of the 4,500 square miles of completed detailed soil work in Hawke's Bay an area of about 2,500 square miles in Mid- and Southern Hawke's Bay was reduced and put in general form. A further 300 square miles was made available by the soil survey of Matakaoa County described elsewhere in this report. About 14,700 square miles remain to be completed in the field.

MANAWATU SOIL SURVEY: PROGRESS REPORT.

Introduction.

A general survey of Manawatu soils was commenced at the end of May, 1939, and progressed along with the survey of the market garden soils in that district. Up to the end of March, 1940, 1,110 square miles had been mapped, comprising all of the land between Waikanae and Palmerston North, from the sea to the foot of the hills, and most of the land north of Palmerston North to Kimbolton, from Coal Creek to the Rangitikei River. In addition to this some work was done on the mapping of the western slopes of the Tararua Range. During the survey of market-garden soils at Ohakune about 270 square miles of the broken mudstone and sandstone country lying to the west was mapped.

Soils.

The soils of the Manawatu are grouped under the headings of Recent soils, meadow soils, and podsols.

(*a*) *Recent Group.*

Recent alluvial soils are described in the account of market-garden soils. A strip about half to one mile wide of loose sand-dunes along the sea coast is classified under this heading. The top inch or two in places is coloured black by humus accumulation, and the underlying sands are grey. The chief cover is marram-grass and lupin; but many of the sandhills are shifting and carry little or no vegetation.

(*b*) *Meadow Group.*

Alluvial meadow soils occur in the Moutoa and Makarua swamps, the Kairanga district, and to a lesser extent elsewhere. The central parts of the swamps are peats or peaty loams, and the outer margins are recent alluvial sands and silts. Between the centre and margin lies a belt of meadow, heavy, silt loams, containing a varying amount of peaty material. Drainage is good on the recent alluvial soils, but on the meadow soils water lies for long periods at or near the surface. Big drainage channels run through these areas, and in the Makarua much of the land is now being farmed. As the land gradually subsides with drainage, buried stumps project above the surface and have to be removed; in some paddocks a second and third layer of stumps have appeared above the surface. When the land has been cleared and drained, good pastures can be established.

The very fertile young alluvial Kairanga soils are closely farmed, though in most parts considerable drainage is yet required.

(*c*) *Podsol Group.*

The podsol group is divided into young, immature, and semi-mature, according to the degree of podsolization.

The young podsols are found on moderately steep to steep greywacke slopes, and on the inland fixed sandhills where the topsoil is black to a depth of 12 in. and the subsoil loose and grey. The sandhills farthest inland have a black topsoil 12 in. or more in depth resting on rusty-brown sands which in places are loosely cemented with iron and represent a further stage in podsolization. Where top-dressing is carried on the greywacke and sandhill soils support a good mixed pasture.

Immature podsols occur on the terrace north of Levin, at Kimbolton, Te Horo, and along the Zig-zag Road, towards Apiti. The topsoils are dark brown to brownish black, and the subsoils are mainly yellowish-brown clay loams or heavy sandy loams, slightly compacted. The fertility varies from high on the Levin soils to low on the Zig-zag soils.

Semi-mature podsols occur on the terraces at the foot of the mountains, at Milson Aerodrome, and on most of the flat to gently rolling country north of Bunnythorpe and Sanson. The soils have a dark-brown or black topsoil, depending upon whether the original cover was heavy forest or light forest and manuka. The subsoils are brownish-yellow heavy clay loams to clays; and in most places at 24 in. to 36 in. from the surface is a very compact hard layer of hard clay content. This compact layer prevents free drainage. Where drainage and top-dressing has been applied, a good mixed pasture can be maintained.

MARKET-GARDEN SOILS OF LOWER HUTT.

A soil survey was made of the soils in the market-garden district of the Lower Hutt, extending from Waterloo Road to the northern end of Taita. The soil types recognized were Taita sandy loam, Cottle sandy loam, Hutt silt loam, Nae Nae heavy silt loam, and Waiwhetu complex with sandy loam to clay textures. All are derived from alluvial beds deposited by the Hutt River. The last three types are meadow soils, but are now well drained.

The soil types are similar in their plant-food content—namely, high available phosphate, satisfactory to low potash, and moderate acidity. This general level of high fertility extends down into the subsoil. The effects of continuous cropping on the fertility is mentioned in the Soil Survey Laboratory (Wellington) section of this report.

MARKET-GARDEN SOILS, MANAWATU.

In association with the Horticulture Division of the Department of Agriculture, a report is being compiled on the market-garden soils in the Manawatu from Waikanae north to Palmerston North. All types of soils were mapped, but below are described only those on which market gardening is already established to some extent. Comments as to the suitability of any of these soils for an extension of market gardening or whether other types can also be utilized can obviously be made only after all classes of survey have been completed.

Recent Alluvial Soils.

Recent alluvial, well drained, deep silt loams and sandy loams border the larger streams and rivers throughout the district between Waikanae and Palmerston North. In most of these soils there is little or no development of profile apart from a small amount of humus accumulation in the topsoil. Greywacke gravels lie at 2 ft. 6 in. to 5 ft. from the surface, and the water-table is generally to be found at 5 ft. to 6 ft. Fertility is high and crumb-structure is fairly good, though addition of humus would assist in improving texture. The lighter soils are the more rapidly exhausted and are usually cropped for two seasons and then put down in grass for a few years. Exhaustion of the land for gardening appears to be chiefly due to depletion of humus, with consequent loss of crumb-structure.

Older Alluvial.

The Levin silt loam—a composite type—is the main type of old alluvial soil. There is a considerable variation in soil texture over short distances, but roughly half of the area has a profile of 6 in. to 8 in. of dark brown to light chocolate-brown silt loam topsoil, resting on lighter brown to brownish yellow heavy silt loam subsoil. Drainage is good in those parts which have the above profile and the water table is about 5 ft. from the surface. Heavier soils in this composite have a clay loam subsoil and drainage is not good.

The recent alluvial and old alluvial soils, which are of high fertility, occupy an area of several thousand acres. The recent alluvial soils are found at Otaki, Ohau, Shannon, Moutoa, Opiki, and on the north bank of the Manawatu River from Hamilton's Line to Te Matai district. The areas of these blocks range from 300 acres to 2,000 acres, the largest one being located at Te Matai. Old alluvial soils are extensively developed to the north and south of Levin, but, as stated above, they have been mapped as a composite type in which there is a fairly wide range of soil quality.

MARKET-GARDEN SOILS AT OHAKUNE.

A survey was made of the market-garden soils in the Ohakune, Raetihi, Karioi, and Horopito West districts. In these districts a total of 1,500 acres is utilized for the growing of cabbages and potatoes, and the object of the survey was to obtain information on the distribution of soil types used for gardening and on the nature of the soils. As in the Manawatu, the Division is co-operating with the Horticulture Division of the Department of Agriculture.

Soils.

Ohakune Silt Loam.

The Ohakune silt loam, derived from andesitic volcanic ash, occurs on the flat to gently rolling country, north of Karioi. The usual profile is:—

8 in. silt loam; brownish black or chocolate black, free.
12 in. heavy sandy loam; chocolate brown, excellent crumb-structure.
On heavy sandy loam; light chocolate brown, slightly compact.

The most striking features of the profile are the extreme fluffiness of the topsoil and the very good crumb and nut structure of the subsoil. Over most of the type, drainage is good and the water-table is more than 3 ft. from the surface, but there are some wet areas.

Ohakune Silt Loam (rolling to moderately steep phase).

The rolling parts of the rolling to moderately steep phase give a profile similar to that obtained on the Ohakune silt loam. The moderately steep parts also give a similar profile except that below 30 in. from the surface is a yellowish-brown clay loam derived from the underlying mudstone.

All these types of soils on which market gardening is carried on at various places total about 30,000 acres. They differ from the alluvial soils used for gardening in other districts, in that the

fertility level of the subsoil is low. The topsoils contain a big percentage of humus—more than that in most market-garden soils. The base saturation of the topsoil is low, indicating that the reserve of lime is small, and consequently that the soils will not endure for long, fertilizers that produce acid conditions.

SOILS OF MATAKAOA COUNTY.

Following a request by the Department of Internal Affairs for a report on the agriculture of Matakaoa County, a soil survey was made, this marking the first stage in the attack on the project.

Matakaoa County, covering 295 square miles, lies at the northern end of the Gisborne Land District. The relief, in general, is steep, interspersed with dissected high-level terrace remnants and alluvial terraces and flats along the numerous streams and rivers, and portions of the coast-line. Steep and very steep country makes up 65 per cent. of the land, other topographic divisions accounting for—moderately steep, 21 per cent.; rolling and terraces, 6 per cent.; and alluvial flats, 8 per cent.

The soils are derived from mudstone, sandstone, shale, greywacke, basalt, and rhyolite pumice deposits. Altogether twenty-three soil types have been recognized and mapped on a scale of one mile to the inch. The soils have a fairly wide range of fertility—from rich alluvial soils of the valley bottoms to poor pumice soils of the high-level terraces. Of the soils on steep and very steep slopes about a third can be classed as moderate in fertility, lacking, according to chemical analyses, only phosphate for good pasture cover, and on moderately steep slopes as much as five-sixths of the soils are of moderate fertility. Soils on rolling country and high-level terraces are in general very infertile, being derived from rhyolite ash deposits. Besides being deficient in phosphate, potash, and lime, they are also low in magnesia. The alluvial soils are highly fertile except where light in texture.

CHEMICAL WORK AT THE CAWTHRON INSTITUTE.

Sir Theodore Rigg, Officer in General Charge.

As in previous years, the Cawthron Institute has co-operated with the Soil Survey Division of the Department of Scientific and Industrial Research in the chemical examination of soil samples taken by the pedologists during the conduct of soil surveys in North Auckland, Hawke's Bay, and the Waikato. In addition, soil samples have been received from Marlborough, the Grey-Reefton Valley, and from the Nelson district. These samples have been examined in the chemical laboratory and reports prepared thereon for the benefit of different Government Departments and for the Tobacco Research Committee.

North Auckland Soils.

Most of the samples have come from Whangarei County, where soil-survey work is in active progress. Great variation in soil types occurs in the county, such widely different soil groups as Rendzinas, brown loams, and mature podsols being found. For the most part the general trend of the chemical data indicates rather low natural fertility, as measured by content of available phosphoric acid and by the percentage of base saturation. Base-exchange analyses on these soils show that the topsoil has a much better supply of bases than the subsoil and lower horizons of the soil profile.

The parent material from which many of these soils are derived is low in bases. Through the growth of vegetation there has been a transference of fertility to the topsoil at the expense of the subsoil and lower depths in the profile. Under these conditions the prevention of soil erosion is a matter of great importance.

Owing to poor supply of phosphoric acid and inadequate base content, the use of phosphatic fertilizers and of lime will be important in the rapid improvement of fertility on many of these soils.

Hawke's Bay Soils.

Routine examination of soil samples forwarded by the pedologists from the Hawke's Bay soil surveys has been continued. In general the fertility level of Hawke's Bay soils is comparatively high. Percentage base saturation ranges from 40 to 100, while the amounts of available plant food, particularly on the Heretaunga Plains, are notably high.

Base-exchange data suggest that for many soils lime treatment will not be required. Phosphatic fertilizers, however, will be necessary to secure optimum returns from many pasture lands.

In striking contrast to the soils of the Heretaunga Plains, samples from the surrounding hill country —particularly soils under high rainfall—show a much lower fertility level. Available phosphoric acid is frequently low, while the soils of several well-defined groups are more acid in character.

Waikato Soils.

Studies have been made of nitrate and ammonia production in four typical Waikato soils when held at different moisture levels. The samples were representative of the Horotiu silt loam, Ohaupo silt loam, Te Kowhai loam, and the Kereone silt loam types. They were examined for nitrate and ammonia contents after incubation for definite periods at wilting-point and half-moisture-holding-capacity levels. At wilting-point, Te Kowhai and Horotiu soils showed no increase in nitrate nitrogen, the figures all being low. Figures for ammonia on these soils, although rather high, did not show any marked increase when the soils were incubated at wilting-point moisture-level. In the case of the Ohaupo and Kereone soils, nitrates remained high at wilting-point moisture-level. Ammonia increased in the Ohaupo soil, but remained low in the Kereone soil.

At half-moisture-holding-capacity level all four soils showed a pronounced increase in nitrate nitrogen, particularly marked in the case of the Ohaupo and Kereone soils.

Marlborough Soils.

In connection with the establishment of lime and fertilizer tests by the Department of Agriculture in Marlborough, a series of soil samples from the Wairau, Kaituna, and Rai valleys was examined. The soil samples were representative of the hill country at Hillersden in the upper Wairau, of the Vernon hills near Blenheim, and of the alluvial flats in the Kaituna and Rai valleys.

In striking contrast to many soils of the lower Wairau plain, the analyses show low pH values for all samples. Base exchange data as well as the pH values suggest that lime treatment will be required for these soils. The content of phosphoric acid tends to be low in all samples, particularly in those from the Rai Valley and the Vernon hills. The supply of available potash is satisfactory with the exception of some of the soils from the Rai and Kaituna valleys.

Soils of Mossy Creek, Ikamatua.

At the request of the Lands Department, a report was prepared on the possibility of developing portions of the Crown lands at Ikamatua in the Grey-Reefton valley. The land in question comprises Sections Nos. 54 and 13, Block 12, situated on the south side, and section No. 22, Block 12, on the north side of Mossy Creek. With the exception of approximately 30 acres located on a lower terrace overlooking the Grey River, the sections are situated on terraces 120 ft. to 150 ft. above Mossy Creek. The land has been in forest, but in recent years this has been felled and burnt.

Field examination of the soils showed much evidence of leaching under the high rainfall prevailing at Ikamatua. Although no "pan" formation was observed the soils are poorly drained. Over extensive areas surface drainage is far from satisfactory, resulting in wet peaty areas of considerable extent. The presence of umbrella fern and rushes indicates that soil conditions resemble those of the mature pakihi soils at Westport. Samples of soil analysed in the laboratory confirm the general conclusions drawn as a result of the field examinations, and show high soil acidity, a poor base content, and rather poor reserves of both potash and phosphoric acid. In addition, the cobalt content of all samples of soil analysed is low, indicating that cobalt supplements would be required for stock if the land is developed for pasture purposes.

The soil on the lower terrace facing the Grey River, although leached and showing a low base content, is well drained. The experience of farmers located on similar land on this lower terrace shows good prospects of developing it for stock purposes at a reasonable cost.

The use of adequate amounts of lime and phosphates would be essential to satisfactory pasture developments on the Mossy Creek sections.

Soil Survey of Tobacco Lands.

At the request of the Tobacco Research Committee a detailed soil survey of the alluvial soils in the Riwaka and Motueka district is being made with a view to the expansion of tobacco-culture on soils texturally suited to the crop. Owing to great local variation in soil texture, the mapping of the soils has proved a most laborious work involving repeated soil inspections on almost every acre of the Riwaka and Motueka flats. Good progress, however, has been made, and some 10,000 acres have been mapped. The soils have been classified and their extent marked on 20-chain-to-the-inch maps. An aerial survey of the district which was completed during the past summer should facilitate greatly soil mapping of the Motueka, Dovedale, and Moutere valleys which remain to be done.

Soil Colour.

In North Auckland different shades of brown and red are characteristic colours of some of the well-defined soil types. The colour of these soils appears to be dependent on the presence of different oxides of iron—*e.g.*, limonite and hæmatite. If the colour of these soils could be accurately defined, their classification would be facilitated. The Lovibond tintometer has been used for recording colour in such soils with marked success.

It has been found that a high yellow/red ratios for the brown loams differentiates them from the red loams. On ignition the yellow/red ratio for both brown and red loams are similar, suggesting that the brown colour is influenced greatly by the amount of hydrated iron oxide present in the soil. This conclusion is in keeping with the fact that the ratio of combined water to clay is greater for brown than for red loams.

Estimation of Magnesium in Soils.

The usual gravemetric method for estimating magnesium in soils after the removal of iron and alumina and the precipitation of calcium, tends to throw all errors into the magnesium determination. Where only small amounts of magnesium are present as in the estimation of exchangeable magnesium the error in the magnesium determination tends to be large. On this account, the 8-hydroxyquinoline method for magnesium (Berg (1927): *Z. Anal. Chem.*, *71*) has been tested for the determination of magnesium in soils. As a result of a large number of tests on prepared solutions of magnesium salts and on soil extracts, a technique has been elaborated whereby amounts of magnesium as small as 0·2 mg. to 0·5 mg. can be estimated with confidence.

The method would prove particularly useful for the determination of magnesium in soils associated with "sand-drown" of tobacco and "premature defoliation" of apples, disorders which are known to be caused by magnesium deficiency.

SOIL SURVEY LABORATORY, WELLINGTON.

HAWKE'S BAY SOIL SURVEY.

Analyses of a number of the soil samples collected by the pedologists in Hawke's Bay have been made in this laboratory. The samples from the southern portion of the province show a generally lower fertility, as indicated by pH, available phosphate, and percentage saturation than those from the middle portion. For the southern soils total nitrogen values vary a great deal. A few soils have nitrogen values which can scarcely be considered adequate, while others, particularly those of the brown-yellow loam class, have given values which were surprisingly high (of the order of 0·8 per cent. to 0·9 per cent.). In these cases also the carbon figures are very high, sufficiently high in fact to give C/N ratios approaching 15. Exchangeable magnesium figures tend to be lower in the southern soils than in those from the mid-district, but are well above some values which have recently been obtained on some other North Island soils.

WAIKATO DISTRICT.

The studies of the fluctuation of soil nitrate and ammonia have been continued. On the Ohaupo and Kereone types high nitrate figures (reaching as much as 80 parts per million) were found during April and May, 1939. A series of low values of soil nitrate then set in with all types, and continued through the winter. Early in October some farms on the Ohaupo and Kereone types showed a slight rise in nitrate. At this stage it was decided to concentrate on the Ohaupo and Kereone soil types, and some additional sampling sites were chosen. Some Te Kowhai samples, however, were still taken, to afford a basis for comparison as this soil type had given consistently low soil nitrate figures all through. After the rise in nitrate figures in October, 1939, on the two types mentioned above, a period of low nitrate values set in and continued till the end of March, 1940. The main point about the nitrate analyses is that during the summer and late autumn there were no high figures like those found during these seasons of the previous year.

Soil ammonia values, while not showing any definite correlation with soil moisture, were fairly high all round for the period ending May, 1939, when some high nitrate figures were recorded. They continued fairly high during the winter and spring, but fell to a lower level in the early summer and have continued relatively low since then.

Some additional fertility samples from this district have been examined for plant foods and exchangeable bases, some new soil types being included.

GENERAL SURVEYS.

Samples collected during general surveys in the Taranaki, Rangitikei, and North Auckland districts have been examined. The salient features of the Taranaki soils are satisfactory available phosphate, high organic carbon and nitrogen, available potash low in some cases, pH values indicating only moderate acidity, but percentage base saturation definitely low. Exchangeable magnesium figures tend to be of a low order, the Stratford sandy loam type giving the lowest value. Phosphate-fixation is high on all types. These Taranaki soils closely resemble the andesite ash soils of the Ohakune district described under the heading of "Market-garden Soils," except that the latter give figures indicating a rather lower level of fertility.

The Rangitikei soils are low in phosphate and of low base saturation. The acidity seems more marked than in the Taranaki soils.

The North Auckland soils so far examined have shown with a few exceptions very definite acidity, very low phosphate, and average to low carbon and nitrogen. Some exchangeable magnesium figures must be regarded as relatively low.

DRAINAGE TESTS ON AERODROME SUBSOILS.

A complete examination was made of the subsoils of two proposed aerodrome-sites, with special reference to their expected drainage properties. In addition to the usual mechanical analyses of samples, water-stable aggregates were determined and tests made in the laboratory of the rate of passage of water through them under controlled conditions. On both sites tests have been made in the field with the Janert permeability meter (*Imperial Bureau of Soil Science Technical Communication No. 27*). This apparatus measures the rate of passage of water into the soil formation under uniform conditions. The figures which this apparatus has given are regarded as more reliable than laboratory tests, where the sample is unavoidably disturbed to some extent. The data can only be regarded as comparative, but by including soil types where drainage is already in operation and where its efficiency can be judged it is hoped that a useful basis of comparison can be made.

MARKET-GARDEN SOILS.

Soils from the following areas in which market gardens are located were examined: Hutt Valley, Ohau–Levin, Palmerston North, Ohakune. The quantities to which special attention was paid were available plant foods, acidity, carbon and nitrogen reserves, textures, and natural crumb-structure.

In the Hutt soils it was very evident that on the market-garden land phosphate had been built up to a very high figure and acidity had been generally reduced, but it appears that in some, potash has been depleted. It was not possible to confirm any very definite decrease in organic carbon or total nitrogen as a result of intensive cultivation, but a deterioration of natural crumb-structure was noticeable in some gardens. This was shown up by field aggregate and water-stable aggregate analyses of the samples from virgin and cultivated land.

The soils of the Ohau-Manawatu district bordering market gardens give figures similar to the Hutt soils. There is evidence of some build-up of available phosphate on the intensively cultivated areas, but not to an extent approaching that found with the Hutt soils.

The Ohakune soils are rather similar to the Taranaki soils, but show lower phosphate and rather lower percentage base saturation. Their carbon and nitrogen figures are of the same order as the Taranaki soils and higher than those of the Hutt or Manawatu. They are slightly inferior to the soils of the two last-mentioned districts in respect of phosphate and base saturation.

Soils from Land-development Projects.

The projects from which soil samples were received were Matakaoa County, Wairakei–Taupo blocks, and the Mission Block (Manakau Harbour).

The Matakaoa County soils exhibit a fairly wide range in natural fertility. Phosphate figures are in general low, but potash is generally satisfactory. Some low base-saturation percentages were found and exchangeable magnesium in some cases reached a low level.

Wairakei Taupo soils are moderate in phosphate, low in potash, of low base-saturation, and of moderately acid reaction; C/N ratios tend to be high, and the texture corresponds to coarse and medium sands.

The noticeable features of the Mission Block soils are very poor phosphate content, low base-saturation, and magnesium bordering on low values.

pF Moisture Curves for Waikato Soils.

The pF moisture curves, from which the permanent wilting-point of soils can be determined, have been obtained for some Waikato soils.

Method for determining Total Nitrogen in Soils.

A modified micro-technique has been adopted since it has been found to give entirely satisfactory results with a great saving of time.

Determination of Magnesium.

In collaboration with the Soil Survey Laboratory, Cawthron Institute comparisons have been made of methods for determining exchangeable magnesium, using for this purpose solutions containing only calcium and magnesium salts and ammonium extracts of soils. The methods tested were (1) the standard pyrophosphate method, (2) the volumetric estimation of magnesium as magnesium ammonium phosphate, (3) an adaptation of a method for the estimation of magnesium in Portland cement using 8-hydroxyquinoline,* and (4) the 8-hydroxyquinoline method worked out at the Cawthron Institute. All have been found to give equally satisfactory results, but either of the 8-hydroxyquinoline methods is to be preferred for speed and convenience.

Soil Colloids and Phosphate Fixation.

It has been shown (Murphy, H. F. (1939): *Hilgardia*, *12*, 343) that soil colloids consisting largely of the mineral kaolinite have a high capacity to fix phosphate in a form which is not readily available to plants. Since many New Zealand soil types are considered to be of high phosphate fixing-power, it becomes of interest to find whether they contain the kaolinite type of clay. In the absence of X-ray apparatus the method employed is to extract from the colloid free iron oxides, alumina, and silica, and analyse the residue.

SOIL EROSION.

The report of the Special Erosion Committee was published during the year and attracted a great deal of attention. The Hon. the Minister directed that the findings of this report should be referred to a Special Departmental Committee for recommendations in regard to its implementation. The Departmental Committee has since met and has undertaken the preparation of recommendations concerning the necessary statutory authority required preliminary to taking active measures to combat soil erosion as it occurs in different parts of the Dominion. Reports have been prepared dealing with the extent of erosion occurring in different parts of the Dominion, and indicating action which should be taken to deal with it in each area.

MINERAL CONTENT OF PASTURES.

Cobalt Investigations at the Cawthron Institute, 1939–40.

Sir Theodore Rigg, Officer in General Charge.

The work during the past year has covered a wide field of activities, including cobalt surveys of soils and pastures in a number of districts in the South Island; the use of cobaltized fertilizers and other cobalt-containing materials for the control of bush-sickness; the cobalt status of limestones in the South Island; the cobalt status of fertilizers; animal experiments at Glenhope, Westport, and Southland; and a detailed examination of chemical methods for the estimation of cobalt.

* *U.S. Bureau of Standard Jour. of Research*, (1931), *6*, 113–120.

(1) Cobalt Survey of Soils and Pastures.

Cobalt surveys have been continued, and a considerable amount of data is now available for both soils and pastures in the South Island. In the Westhaven-Collingwood district of Nelson Province, analyses of soils and pastures have given cobalt figures which correlate well with stock history, and suggest that cobalt supplements will prove beneficial to stock over extensive areas of country. A very detailed survey of cobalt in both soils and pastures of the Sherry-Wangapeka district of Nelson has shown a rather widespread correlation of low cobalt figures with the granite soils of this district. Low cobalt status of the soil was almost invariably associated with a low cobalt content of the pasture. One interesting feature of the pasture analyses was the fact that in a number of cases low cobalt figures in the pasture were associated with relatively high figures for cobalt in the soil.

A more extensive survey of the cobalt status of pastures and soils in the Grey-Reefton Valley has been made. The analyses have not yet been completed, but the determinations which are available confirm those made in the previous year showing that the recent alluvial soils are moderately well supplied with cobalt, but a great area of terrace land, particularly where underlaid by gravels, has a low cobalt content. Analyses of pasture samples in the Ashburton County have been completed. With one or two exceptions the cobalt figures for the pastures are quite satisfactory. As far as can be ascertained, cobalt deficiency is not connected with sheep ailment in this county.

Further samples of pastures and soils have been obtained from the Wairau and Awatere Valleys of Marlborough, while further analyses have been made of pastures from North Canterbury. Full data for Marlborough and North Canterbury are not yet available, but the cobalt contents appear quite satisfactory. One or two somewhat low figures from North Canterbury are not associated, as far as can be learnt, with cobalt deficiency in stock.

Further sampling of pastures has been continued in Southland on farms representative of both healthy and unhealthy country. The analyses definitely show a low cobalt content of the reputedly unhealthy country, but several cases of abnormal figures have been noted both in the unhealthy and in the healthy groups. Soil contamination of Southland pastures is undoubtedly one factor which has contributed to abnormality of results. The differences in cobalt content between the reputedly healthy and unhealthy pastures, however, are not as great as those shown for corresponding pastures in the Nelson District.

(2) Value of Cobalt in Southland Limestones.

One of the outstanding features of the experiments in the Southland District has been the discovery that certain types of ground limestone have an appreciable cobalt content, and that the cobalt content of the pasture is definitely increased by the use of these ground limestones at ordinary farm rates of application. The results of the investigation have shown that certain Southland ground limestones have a cobalt content of approximately five parts per million. When applied at the rate of 3 tons of limestone per acre, the increase in the cobalt content of the pasture compared favourable with that obtained by the application of 4 oz. of cobalt sulphate per acre.

Table 1 shows the effect on the cobalt content of the pasture when 3 tons of a selected ground limestone, $\frac{1}{4}$ lb. cobalt sulphate, and $\frac{1}{2}$ lb. cobalt sulphate, respectively, were used for top-dressing.

Table 1.—Cobalt Content of Pasture.

(Parts per million on dry basis.)

Date of Sampling.	Control.	Quarter Pound Cobalt Sulphate per Acre.	Half Pound Cobalt Sulphate per Acre.	Three Tons ground Limestone per Acre.
Before top-dressing, 10th November, 1938	0·04	0·06	0·06	0·05
20th December, 1938	0·11	0·21	0·35	0·21
2nd February, 1939	0·04	0·17	0·19	0·13
4th March, 1939	0·06	0·09	0·11	0·06
20th May, 1939	0·06	0·06	0·07	0·06

The results presented above show that 3 tons of the selected ground limestone gave results somewhat similar to those obtained with $\frac{1}{4}$ lb. cobalt sulphate.

The cobalt content of livers of lambs grazing on pasture treated with these limestones showed an increase comparable to that obtained from the use of soluble cobalt salts. The results confirm the general belief of farmers that Southland lime has a special value to the stock industry on many Southland soils. Not only is Southland lime of value in reducing soil acidity and conserving phosphates, but its cobalt content has an appreciable effect—although probably of short duration—in improving the cobalt status of the pastures. An examination of the residual soils overlying the limestone showed that there was a concentration of cobalt in the residual soil, suggesting that a proportion of the cobalt minerals occurring in the limestone was less soluble to weathering than was calcium carbonate.

(3) Survey of Limestones in the South Island.

The results obtained in the Southland investigations suggested the desirability of obtaining figures for the cobalt contents of all commercial limestones in the South Island. A considerable number of samples has been received from the different lime-works, and they are now being analysed. The full data are not yet available, but variations in cobalt content from 6·1 p.p.m. to 0·2 p.p.m. have been found. The majority of the samples examined showed a cobalt content ranging between 1 p.p.m. and 2·5 p.p.m. One interesting feature of the examinations which have been carried out is the association of high cobalt soils in a number of cases with limestones carrying very small amounts of cobalt. In several cases the residual soils contain 26 p.p.m. of cobalt, while the limestones contain only 0·2 p.p.m.

(4) Cobalt in Fertilizers.

As recommended by the Cobalt Committee, samples of cobaltized fertilizer have been obtained from time to time from the different fertilizer companies and examined for cobalt. In general, the commercial samples of cobaltized fertilizer have shown a satisfactory cobalt content. After a period of eighteen months' storage, there has been no change in the amount of water-soluble cobalt contained in a prepared cobaltized superphosphate.

(5) Use of Cobaltized Fertilizers and other Cobalt-containing Materials.

In this section of the cobalt investigations trials have been made of the effect of cobalt phosphate and cobaltized superphosphate on the cobalt content of pastures. Cobalt phosphate used at the rate of 5 lb. per acre still shows, after two complete years from the date of application, a greatly enhanced cobalt content of the pasture.

Several series of tests with cobaltized superphosphate used at rates varying from 2 oz. to 1 lb. of cobalt chloride equivalent per acre have been made on two soil types in the Nelson District. Certain of these experiments are now finalized, and a considerable amount of data is available concerning the duration of effect of small applications of cobalt salts on the cobalt content of the pasture.

The applications of cobaltized superphosphate have been made both in the autumn and spring. For a March application, a dressing supplying 1 lb. of cobalt chloride equivalent did not prove more effective in duration of effect than a ½ lb. dressing. In each case there was no increase in the cobalt content of the pasture over the control by the end of the following December. In the case of August applications, a dressing supplying ¼ lb. of cobalt chloride equivalent per acre was ineffective after the end of December; in the case of the ½ lb. and 1 lb. dressings, some increase in cobalt content of pasture was shown up to the end of the following June. On this occasion, pasture from the 1 lb. treatment was showing 0·16 p.p.m. cobalt, and the ½ lb. 0·07 p.p.m., while the control figure was 0·06 p.p.m. It must be remarked, however, that the effect of the larger dressings of cobalt salts on the cobalt content of the pastures is pronounced for a relatively short period of three to four months, when the cobalt contents with the different dressings tend to converge.

Experiments dealing with the value of high cobalt soils derived from serpentine rocks have been established in the Sherry Valley, and preliminary results indicate substantial improvement in the cobalt content of the pastures by top-dressing with these soils.

(6) Animal Experiments.

Animal tests in connection with the use of cobalt compounds have been continued at Glenhope, Sherry Valley, the Rainy River district, Westport, and Southland. At Glenhope sheep have been maintained in perfect health on pastures top-dressed with cobalt phosphate. During the present season an attempt has been made to correlate health of sheep with the cobalt content of the animal organs. For this purpose a line of twenty-five hoggets has been run on an unhealthy pasture, a few animals being drafted out periodically for slaughter, so that a fairly complete picture should be available of the downward trend of cobalt in the animal as well as an upward trend after the administration of cobalt salts.

The experiment dealing with the use of cobalt licks for dairy cows in the Sherry Valley has been finalized. No difference in milk yield resulted from the use of cobalt licks. At Atapo, Rainy River district, an experiment with sheep on the value of cobaltized fertilizers has been carried out, but so far no differences have resulted from the use of the cobaltized fertilizer. It must be noted that this experiment is being conducted on the Moutere Hills type of soil, which has a rather low cobalt content, but not as low as that of the granite soils.

At Westport, further drench experiments have been made with calves, in order to ascertain whether copper deficiency in addition to cobalt is present on certain of the pakihi soils. The results of the drench experiment showed that the best result was obtained from the use of a combined copper-cobalt drench. The results with cobalt alone and copper alone were inferior to those obtained from the combined cobalt-copper drench. This result is in keeping with pasture analyses, which have shown low figures for both cobalt and copper on certain of the pakihi soils.

In Southland, difficulty has been experienced in obtaining sickness on the control plots. In the 1938–39 season no sickness developed in the case of any of the experimental sheep, but the cobalt figures for livers in the case of the control sheep were very low. This point is of interest, indicating that sickness does not always occur if the cobalt content of the liver is low.

During the present season an attempt is being made to induce sickness in the control hoggets which have been carried over from the previous season, and to obtain information from a new set of

lambs, concerning the value of cobalt-bearing limestones as against cobaltized superphosphate. Results just received from Southland show a very definite increase in weight of lambs from both the lime and the cobaltized superphosphate plots in comparison with the lambs grazing plots receiving superphosphate only.

(7) Chemical Methods.

A very detailed examination has been made of the technique elaborated at the Cawthron Institute for the conduct of the nitroso-R-salt method in the estimation of cobalt in pastures. The importance of adding the nitroso-R-salt before and not after the neutralization of the cobalt solutions is clearly revealed by the investigations.

WHEAT RESEARCH INSTITUTE.

Advisory Committee: Professor H. G. Denham, Council of Scientific and Industrial Research (Chairman); Mr. C. S. Sapsford, Department of Industries and Commerce; Mr. R. B. Tennent, Department of Agriculture; Mr. R. K. Ireland, Mr. R. J. Lyon, and Mr. J. P. O'Connor, representing flourmillers; Mr. C. E. Boon, Mr. W. H. S. Newsome, and Mr. R. T. H. Norton, representing bakers; Mr. W. W. Mulholland, Mr. J. Carr, and Mr. P. R. Talbot, representing wheatgrowers; Mr. W. O. Rennie, representing Canterbury Agricultural College; Mr J. W. Hadfield, Department of Scientific and Industrial Research; Mr. G. Fleetwood, representing grain-merchants. Director: Dr. F. W. Hilgendorf.

Staff.

The position of Junior Chemist was filled by the appointment of Dr. Rosa Stern, of Vienna, who has had a wide experience of cereal chemistry. Mr. H. R. Hansen, who had been Travelling Baker Expert for some years, accepted another appointment in May. His expenses and salary were shared between the Wheat Research Institute and the Wheat Committee of the Department of Industries and Commerce. The vacancy has not yet been filled, but it is hoped that during the coming year the Institute will have sufficient funds available to enable it to appoint a travelling baker to its staff. Dr. Frankel visited England to attend the International Congress of Genetics. He brought back much useful information.

Accommodation.

The new laboratory in Christchurch was ready for occupation before Christmas. The improved facilities for work are much appreciated.

A greenhouse is being erected at Lincoln, and it is anticipated that this will shorten by 10 per cent., or possibly 20 per cent., the process of producing new wheats.

The necessary authorities have been granted for the erection of the new plant-breeding laboratory at Lincoln.

The action of Lincoln College in providing ground for these structures is much appreciated.

Wheatgrowing Practice.

The figures collected by the Government Statistician on the threshing and sowing of wheat have again been made available to the Institute for analysis, and advice has been offered again to farmers on the varieties most profitable for them to grow.

Models have been made and widely exhibited showing the best methods of drying wheat on the farm.

Wheat-breeding.

During 1939 Cross 7 was sown on over 100,000 acres, an indication of the acceptability of the variety. Its quality continues to be highly satisfactory.

The variety to be known as Fife-Tuscan has now been under test for five years in sixteen localities. Its yield is on the average 3 bushels per acre higher than that of Tuscan and Cross 7, although its quality is no better than that of Tuscan. There are now about 500 bushels of seed available, and this will be sown on contract so as to provide about 10,000 bushels of seed for farmers' use next year.

Other more recent crosses continue to show promise for special conditions. The total number of plots grown at Lincoln in 1939-40 was in excess of 25,000.

Laboratory Work.

The harvest of 1940 stands on record as one of the best and quickest ever known. The wheat came into store with less than 14 per cent. of moisture on the average, and many lines were under 12 per cent. Despite this fact, nearly two thousand lines of wheat had been sent to the Institute for moisture testing by the end of February, this figure showing the increased interest taken by farmers in ensuring that their wheat was in good condition for harvesting, and also the spread in the use of header harvesters. It is estimated that 70 per cent. of the wheat on the flat land of Canterbury was headed this year.

The unusual dryness of the wheat introduced a complication for flourmillers whose mills are set to deal with wheat whose average moisture content is 15 per cent. to 16 per cent. Tempering therefore became necessary, and some assistance was rendered to millers by indicating the best methods to be adopted in this process, and the improvement in flour quality that resulted therefrom.

In contradistinction to the work on dry wheat, investigations were prosecuted on the drying of wet wheat, both by natural and artificial processses. The Institute is now in a position to recommend commercial procedures when a season of out-of-condition wheat occurs.

The quality of the wheat now being milled is very good, and highly satisfactory flour is being produced. This is due in part to the excellent harvest, and in part to the large proportion of Cross 7 now available for blending with other wheats.

The germ of wheat is not usually included in the flour because it causes a deterioration in the appearance and palatability of the loaf. During the year the Institute discovered a method by which the germ might be cheaply and expeditiously treated in such a way as to allow its inclusion in the loaf without impairing its quality. This process has been provisionally patented in New Zealand so as to prevent its exploitation, and it will shortly be published so that all bakers may freely take advantage of it. The inclusion of germ in the loaf will increase the vitamin content, which is sometimes regarded as deficient, and will secure for human consumption 1 per cent. more of the content of the wheat-grain.

Some work has been done in the preparation of dried gluten, which is used in starch-reduced breads. A good deal of the gluten now used in New Zealand is imported from Australia.

The routine testing of flours and wheats for millers and merchants continues to expand, although several mills have with our assistance installed their own testing laboratories. During 1939, 1,658 different lines of wheat were milled, and loaves were baked from 6,033 different flours.

Other Activities.

One course of the School of Baking was conducted during the year, efforts in this direction having been restricted by the absence of a Travelling Baker Expert.

The Department of Agriculture kindly arranged for an exhibit of the Institute's work to be included with its own at all agricultural shows in the wheatgrowing districts.

Five bulletins for millers have been published during the year, detailing the qualities of the wheats of different varieties in different districts. One bulletin was published for bakers, advising them of the peculiarities of the new season's wheat.

The assistance given by Lincoln College, by the Departments of Agriculture, and Census and Statistics, and by the Agronomy, Entomology, and Plant Diseases Divisions of the Plant Research Bureau, are again gratefully acknowledged.

FRUIT RESEARCH.

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

INTRODUCTION.

This report covers activities of the Plant Diseases Division of the Plant Research Bureau, the Appleby Research Orchard, the Horticulture Division of the Department of Agriculture, and the Cawthron Institute. The report is divided into main sections dealing with the various types of fruit, and storage aspects are dealt with separately in the section "Fruit Cold Storage Research."

The following abbreviations are adopted in discussing the manurial experiments: P = treated with phosphatic manure, normally as superphosphate, at 4 lb. per tree per annum; N = treated with nitrogenous manure, normally as ammonium sulphate, at 2 lb.; K = treated with potassic manure, normally as potassium sulphate, at 1 lb.

APPLES.

Fertilizer Experiments.

Research Orchard.—The present is an opportune time for reviewing the manurial experiments from an economic aspect, and the Appleby results are treated mainly from this angle in the present report.

Cox's Orange: Ammonium sulphate applied at the rate of 2 lb. per tree has now produced a significant and economic increase in crop over the untreated trees or the PK trees. PNK trees are much healthier than N trees, although crop increases are not yet statistically significant owing to variability of the material.

Dunn's Favourite: N and PNK trees are both showing to advantage in growth and foliage development over the untreated control trees. Variability of the trees has prevented the yields from reaching a significant level of difference, but the trend is strongly toward a crop increase paralleling the vegetative increases.

Delicious: Over the period of the experiment up to and including the 1939 crop the N trees had produced a total of 226 lb. more fruit per tree than the untreated control trees, and the expenditure on manure for the period was approximately 1s. 8d. The PNK trees yielded a further 107 lb. each at an extra cost of approximately 3s. 5d. for fertilizer. The PNK trees are in healthier condition than the N trees.

Jonathan: With a base dressing of phosphate and potash, 2 lb. ammonium sulphate per annum has given a total yield increase of 155 lb. fruit per tree, for a cost of approximately 1s. 9d. while 4 lb. ammonium sulphate has given only a further 70 lb. increase. The development of red colour has been strongly depressed by the nitrogenous treatments, and an approximate assessment of the market values of the crops, on the basis of current prices, suggests that the increased yields are fully offset by the reduced prices obtained. The trees themselves, however, show that some nitrogen, additional to a base treatment of phosphate and potash, is essential if they are to remain healthy.

Two heavy dressings of potash, followed by light dressings in subsequent seasons, have proved economic over the six-year period of the experiment to date, the yield increasing by 229 lb. per tree for an outlay of 5s. on potash: the colour grading of the fruit was improved at the same time.

Sturmer: Outlay on fertilizers has proved highly economic with this variety, particularly as regards the PN combination, in which, for an expenditure of approximately 3s. 1d., the yield has been increased by 560 lb. per tree over the seven years since treatments began. The extra 1s. 8d. per tree spent on potash in the PNK plots has scarcely been recouped in yield up to the present, but the trees are in distinctly healthier condition. It has again been found that the combination of phosphate and nitrogen has produced a yield increase considerably higher than the sum of the two separate increases.

Cawthron Institute. The long-term manurial experiments on the Jonathan variety at Upper Moutere were continued during the 1939 season. In addition, treatments were maintained on individual trees which formerly received no treatment. The results are similar to those noted in the last annual report, in which the PNK trees were superior to either the PN trees of the NK trees. Average yields (pounds per trees) for the 1938 and 1939 seasons show the value of the complete fertilizer in maintaining crop production:

Untreated.	N	PN	PNK	PNK with extra K.
44	69	109	128	147

Trees treated with nitrogen only are going back rapidly, and the fruit is poor in quality and small in size. The importance of potassic manures is clearly shown in the yield data.

Rootstock Experiments.

Research Orchard.—The trees are still in the juvenile stage and at the present time there are no developments to report.

Cawthron Institute.—Records continue to support the observations noted in last annual report that Northern Spy was superior to two seedling types for Cox's Orange, and that seedling types were better than Spy for Jonathan and Sturmer. With Jonathan, the Epp's Seedling stock continues to prove rather better than Double Vigour.

Plant Diseases Division.—In trial blocks of East Malling stocks established in 1934 in the main fruitgrowing centres of the Dominion, differences in tree growth and crop are now more in evidence, though it is apparent that the behaviour of any one stock may vary appreciably with different scion varieties. Analysis of the records kept from time of planting indicates the following stock-scion influences:—

Scion Variety.	Rootstock.		
	Very Vigorous.	Vigorous.	Inferior.
Sturmer	XVI, XV, XII	Northern Spy, XIII	I
Delicious	XVI, XV, XII	Northern Spy, I	XIII
Granny Smith	XVI, Northern Spy	XV, XIII, XII	I
Statesman	Northern Spy, XVI, XV, I	XIII	..
Jonathan	XII, XVI, XV	XIII	I
Cox's Orange	XII, XVI, XV	..	I

Stocks of Northern Spy were not included in trials with Jonathan and Cox's Orange, as no trees were available at the time the plots were laid down. Trials of these varieties on Northern Spy and East Malling stocks have been established at the Plant Diseases Division at Owairaka, but, owing to the check received by the trees after transplanting from Palmerston North, differences are much less marked than in the trials reported above.

Trees of Gravenstein and Delicious worked to their own roots continue to make growth superior to that of comparable trees on Northern Spy stocks.

Gravenstein on their own roots have also been planted out in the experimental area at Havelock North to ascertain if they would remain free from the gnarling to which the variety is commonly subject when worked on Northern Spy roots in this country.

Inarching Experiments.

At Haupai Orchard, operated by the Plant Diseases Division, vigorous clonal stocks were inarched into stunted Jonathan trees, but there has not yet been any indication of increase in vigour over untreated trees.

At Appleby a replacement set of one-year-old, M.XVI stocks has been planted in readiness for a repetition of the inarching test there.

Varietal Investigations.

Work on the strains of apple varieties has been continued by the Plant Diseases Division, and trees grown from budwood secured from twenty-six localities and worked to M.IX dwarfing stock are now cropping freely at Owairaka. With the Delicious variety one object is to find a strain that is not subject to mouldy-core. Five out of twenty-one types that had fruited were free from the disorder,

and in four of these most of the fruits had the passage from calyx to core through which spores of fungi penetrate to produce mouldy core closed by the bases of the styles and, in some instances, by formation of new tissues.

Delicious types include a number of solid red, partial red, and striped strains and work is being continued with a view to selecting those combining good colour with other desirable characters such as keeping quality and flavour.

Similar work is being undertaken with the varieties Cox's Orange (of which several colour-types are fruiting), Sturmer, Jonathan, and Northern Spy.

Pruning Experiments.

At Appleby a test of heavy spur-pruning before both the "on" and the "off" years of bearing has been laid down in an endeavour to overcome the biennial-bearing habit of the Dunn's Favourite.

A series of weekly thinnings, from blossoming till six weeks after petal-fall, is also being tried on the same variety during the "on" season, as this treatment has been reported elsewhere as inducing regularity of cropping.

An attempt is being made to convert some Cox's Orange trees from a lateral-bearing habit to a spur-bearing habit, with spurs arising directly from the leaders. Under this system in England the variety does not exhibit a biennial character.

Several modifications of the standard method of pruning the Jonathan are being tried out to see if it is possible to build up a different type of framework that can be more easily sprayed, thinned, picked, &c., without interfering with cropping capacity or fruit quality.

Plant-protection Experiments.

I. *Entomological Studies.*

(*a*) *Biological Control.*—Studies of the life-cycles of woolly-aphis and its parasite, *Aphelinus mali*, have been continued by the Cawthron Institute. Experimental colonies of woolly-aphis were established in December, 1938, for the purpose of following the seasonal cycle throughout the year. An exceptionally dry summer and early autumn was followed by heavy rains in late autumn and by exceptionally cold spells in the winter, so it is doubtful whether the results of the seasonal-cycle studies of woolly-aphis can be accepted as normal.

Seven generations of the aphis were obtained during the period December, 1938, to June, 1939. The last generation hibernated as nymphs, which were not observed to feed; on warm days they wandered about, but during cold periods they remained motionless. Owing to severe weather in July all the nymphs under observation died. Field studies likewise showed low survival of hibernating nymphs, though eggs were noticed. In the following spring, hibernating nymphs matured in October and then commenced to build strong colonies.

The first adults of the parasite *Aphelinus* made their appearance during the first week in September, 1938, and steadily increased during the summer of 1938-39. The parasite suffered a set-back during the following winter and, like the aphis, made a poor start in the spring.

(*b*) *Chemical Control.*—The Plant Diseases Division has continued experiments on the following insect pests:—

(i) Red-mite: Derris sprays, consisting of ground derris root, in various concentrations gave only partial control, and it is considered that derris product of this type cannot be regarded as suitable substitutes for summer oil.

(ii) Leaf-hopper: Tests indicated that derris sprays were effectual against this pest, and further work on a field scale will therefore be undertaken next season.

(iii) Bronze beetle: Records of injury caused by this insect have shown a progressive decrease in infestation over the past three years, resulting partly from reduction in carry-over numbers effected by use of arsenate sprays, and partly from killing of larvæ by summer cultivation.

II. *Mycological Studies.*

(*a*) *Mouldy-core.*—The data obtained in previous work on mouldy-core by the Cawthron Institute have been reassembled, and further culture work has been undertaken to elucidate several points connected with the species-limits in the Fusarium group of fungi.

Investigations carried out on this disorder by the Plant Diseases Division are linked with the varietal work, and results have been noted above.

A co-operative study was carried out by the Physical Testing Laboratory and the Fruit Research Officer to determine whether the presence of mouldy-core in the Delicious apple could be detected by the use of X-rays. Although a fair measure of success attended the actual detection of the trouble, the time involved and the cost of plant were found prohibitive.

(*b*) *Eye-rot.*—A disease known in Nelson as "eye-rot" or "dry eye-rot," common in Jonathan and Cox's Orange varieties, has been responsible for the rejection of fruit from export because of the danger that the fungus responsible, *Botrytis cinerea*, might continue growth.

To ascertain if the fungus in the lesions was viable, two cases of infected fruit were held in cold storage for five months and fruits were then forwarded to the Plant Diseases Division laboratory for culturing. All cultures remained sterile, indicating that the fungus was no longer present. Subsequently a further lot of samples, of the Gravenstein variety, was forwarded, and this was held for fourteen days in moist chambers at room temperature. No growth was secured from any of the

esions, and cultures prepared from them remained sterile. The evidence obtained so far would seem to indicate that it would be safe to export fruits exhibiting discoloration at the calyx.

(*c*) *Black-spot.* The usual notification service in connection with the maturity of ascospores has been maintained in Nelson by the Cawthron Institute.

Spray experiments of the Plant Diseases Division for control of this disease are reported later under the section "Spraying Experiments."

(*d*) *European-canker.*—To test the efficacy of wound dressings recommended overseas for treatment of fruit-tree cankers, fifty-two apple-trees were inoculated with the European-canker fungus, *Nectria galligena*, in 1939 by the Plant Diseases Division. When cankers had become well established they were pre-treated by two methods: (i) superficial discoloured tissues were removed, and (ii) all discoloured tissues were excised. Wounds were then painted with Bordeaux paste, two concentrations of zinc chloride, mercuric chloride, mercuric cyanide, and a proprietary emulsified bitumen paint.

Cankers continued to develop in most instances when dressings were applied to those from which only superficial, discoloured tissues had been removed, but were checked in all instances, irrespective of the dressing applied, when all diseased tissues were excised.

Results indicate that successful canker treatment lies in thorough excision of diseased tissues, rather than in the use of chemical agents.

(*e*) *Bitter-rot.*—Several Bordeaux substitutes were tried at Huapai for control of bitter-rot, *Glomerella cingulata*. Results were inconclusive, since the disease did not appear in the orchard. As compared with Bordeaux, however, all the substitutes caused severe fruit injury to an extent which condemns them as summer sprays.

III. *Physiological Studies.*

(*a*) *Internal Cork.*—Cawthron Institute: Chemical examination of apples from trees treated in 1935 with hydrated borax at the rate of 50 lb. and 100 lb. per acre shows these fruits still to have an augmented boron content, four years after applications were made. At one centre, however, where internal cork had originally been severe, the boron content of the fruit had again dropped to a critical level at which the disorder might be expected if climatic conditions favoured its development.

The influence of boron on cold-storage quality is noted in the Fruit Cold Storage section of this report.

(*b*) *Magnesium Deficiency.*—"Premature defoliation" was noted in last annual report as apparently being due to a deficiency of magnesium. The Cawthron Institute has continued its investigations in this connection. The magnesium content of leaves from affected trees is less than one-third that of leaves from healthy trees. Defoliation is invariably more severe where liberal potassic manuring has been carried out for several years.

Remedial treatments are being tested in three typical orchards, and the varieties include Cox's Orange, Jonathan, Delicious, and Sturmer. The compounds used are (1) magnesium sulphate (Epsom salt) at the rate of 7 lb. per tree, (2) ground dolomite (magnesium-calcium carbonate) at the rate of 12 lb. per tree, and (3) magnesium carbonate at the rate of 2 lb. per tree.

At Lower Moutere, magnesium sulphate greatly improved the trees. With the Sturmer variety, all treatments were beneficial, but magnesium carbonate was outstanding in its effect. At Tasman the results obtained from soil applications of magnesium were not decisive, but injection of magnesium sulphate into the branches of the trees controlled the defoliation symptoms. Liberal potassic manuring had been practised, and this appeared to operate adversely against a quick response to soil applications of magnesium compounds. Chemical analyses of leaf material are incomplete, but reflect the trends shown in the field experiments.

A series of mineral injections was carried out at the Appleby Orchard on the trees that were showing abnormal defoliation there, but none of the treatments have proved effective up to the present.

IV. *Spraying Experiments.*

(*a*) *Modified Spray Programmes.*—Field experiments of the Plant Diseases Division have been continued in the experimental orchards at Huapai, Havelock North (Hawke's Bay), and Appleby. The main interest in these lies in the evidence which is accumulating to show that greater dilutions than were formerly employed can be used in commercial orchards with safety. Work is necessarily correlated with greater efficiency in the application of sprays.

In Hawke's Bay a programme with lime-sulphur 1 300 plus colloidal sulphur (50 per cent. sulphur content) at 1 lb. per 100 gallons gave control of black-spot when adjacent check trees showed up to 20 per cent. infection of fruits. At Huapai, lime-sulphur 1 200 plus colloidal sulphur (25 per cent. sulphur content) at 2 lb. per 100 gallons gave control of both black-spot and powdery-mildew, although check trees were heavily infected.

In one programme at Huapai in which Bordeaux replaced sulphur from December onwards, apparent control of powdery-mildew was secured, since the fungus was prevalent in check trees but absent from those sprayed with Bordeaux. A similar result was secured in the previous season.

Further tests were made in the Huapai Orchard to ascertain the conditions under which the wetting agent, Agral 2, is liable to induce injury. During the season under review no fruit injury was produced except when the wetter was used in excess with Bordeaux.

(*b*) *Russet and Spray Injury.*—Experiments of the Plant Diseases Division to ascertain the russet-susceptible period have been extended to the varieties Delicious and Dougherty, and have been continued on Sturmer. Apples have again shown a fairly well-defined period during which they are specially susceptible to spray-induced russet, although the limits vary somewhat from season to season. Modified spray programmes are being tested with a view to reducing or eliminating russetting induced by sprays.

Tests have shown that on the variety Cox's Orange, and probably also on Delicious (though records are not yet complete), both lime-sulphur and Bordeaux can cause an appreciable amount of russet if applications are delayed a week beyond early green-tip.

Foliage injury which sometimes arises following use of two or more applications of 1 per cent. summer oil appears to be a cumulative effect. A single application of 3 per cent. concentration produced almost identical injury to that caused by three sprays of 1 per cent. concentration applied at fortnightly intervals.

V. *Therapeutant Testing.*

Certification.—Plant Diseases Division lists of certified therapeutants have remained substantially the same during the past twelve months. A few new products have been added, and an equal number of older ones withdrawn. In a few instances manufacturers have been requested to improve the quality of their products, as these were somewhat below the standards adopted by manufacturers of others sold at comparable prices.

It is gratifying to note that numerous samples taken in the field have proved on analysis to be equal to those on which the certification was originally based.

None of the hydrated lime manufactured in New Zealand attains the standard required for certification. Since importation of hydrated lime is prohibited, growers are forced to use non-certified, inferior products.

PEARS.

Plant-protection Experiments.

I. *Entomological Studies.*

Mealy-bug.—Glasshouse experiments of the Plant Diseases Division showed that mealy-bugs taken from pears could be killed with a single application of 1 per cent. summer oil plus 0·012 per cent. rotenone. Chemically pure rotenone and an equivalent of ground derris were equally effective. Oil or rotenone used separately gave poor results, as did a nicotine-oil spray. Field trials of rotenone-oil combinations are being undertaken.

II. *Spraying Experiments.*

Modified Spray Programmes.—At the Havelock North Orchard the Plant Diseases Division reports control of pear black-spot, *Venturia pirina*, with Bordeaux 1½–2–50, instead of 3–4–50, after blossoming, with marked reduction in russetting. Lime-sulphur sprays sufficiently strong to check the disease caused very little russet but seriously injured the foliage. As in previous seasons, this disease was much more difficult to control on trees which had been heavily infected in the past, indicating that the source of carry-over was by means of infected twigs on the trees.

Russet and Spray Injury.—It has been found that the Winter Nelis pear has a fairly well-defined period during which it is susceptible to spray-induced russet.

STONE FRUITS.

Plant-protection Experiments.

I. *Mycological Studies.*

Silver-leaf.—In last annual report it was noted that at the Plant Diseases Division two hundred young peach-trees had been artificially inoculated with the organism *Stereum purpureum*, and that they had been subsequently injected with numerous chemical compounds. No treatment succeeded in checking the spread of the disease, despite promising results secured in earlier experiments. The work is being continued with injections made at different periods and in more mature trees.

Brown-rot.—The Cawthron Institute has maintained the usual notification service regarding the date of ascospore maturity.

II. *Physiological Studies.*

Brown-spotting of Apricots.—In co-operation with the Horticulture Division of the Department of Agriculture, the Cawthron Institute has continued observations on the trees under test at Alexandra. Confirmation has been obtained of the control of the disorder by either a soil dressing of ½ lb. hydrated borax per tree or a 0·1 per cent. spray of the same compound. Trees so treated were practically free from the ailment and suffered very much less from bud-drop and leaf malformation.

Pitting of Cherries.—It was hoped to obtain evidence in the field in support of the analyses made by the Cawthron Institute, suggesting that pitting might be a boron-deficiency ailment. Again, conditions were such that pit failed to develop even on the untreated trees.

Gumming of Plums.—A field test by the Cawthron Institute on the possible control of this trouble in Angelina plums gave inconclusive results, for treated trees still showed a fair percentage of gumming. It is possible that the amount of borax (½ lb. per tree) was insufficient to give full control in the large trees used in the experiment.

Die-back.—A considerable number of stone-fruit trees in Central Otago showing symptoms of die-back have been examined by the Plant Diseases Division, and many have been dug out so that the roots could be studied. All attempts to isolate a pathogen failed, so the work is being continued on the assumption that the condition is physiological in origin.

SMALL FRUITS.

Strawberry.

Yellow-edge.—A survey made of commercial strawberry areas during the year by the Plant Diseases Division indicated that this virus was present in all crops. As the symptoms varied with several varieties, attempts are being made to ascertain if more than one virus is present in the Dominion.

Isolated plots of stock plants of a number of varieties have been established in the State Forest Service plantations at Riverhead. It is hoped that by rigorous selection virus-free lines will be secured and maintained.

Work is also being carried out on the popular variety, Marguerite, with a view to producing strains that will be free from disease.

Variety Trials.—Yield trials of the varieties Captain Cook and Marguerite, the two commercially grown in the Auckland District, did not give any significant difference in favour of either variety. Yield of Marguerite was, however, impaired by the presence of yellow-edge virus, upwards of 70 per cent. of plants being infected with the disease. Several other varieties imported from overseas or raised within the Dominion were included in the trial, but proved much inferior in cropping power to the two mentioned.

Root-rot.—Plants of Captain Cook and Marguerite infected with root-rot typical of the disease as it appears in commercial areas throughout the Dominion were secured from the Owairaka area. From many of these a species of *Ramularia* was isolated, and this will be used in the glasshouse or inoculation experiments, for which purpose seedling plants are now being grown.

Raspberry.

Cane-wilt.—Observations made during the survey of berry crops indicated that this disease, caused by the fungus *Leptosphaeria coniothyrium*, is the most serious raspberry disease in New Zealand. Although it can be effectually combated by three applications of Bordeaux mixture, few growers had applied sprays to their crops.

Crown-gall.—During the survey this disease, *Phytomonas tumefaciens*, was collected in most localities where raspberries are grown commercially. The casual bacterium has been isolated, and inoculation tests have shown that it will also produce typical cankers on blackberry and tomato. Work is being carried out to ascertain the effects and the economic significance of crown-gall on these three plants.

Silver-leaf.—The fungus causing silver-leaf disease of fruit-trees was found attacking raspberry plants at Kumeroa.

CITRUS.

At the end of the year under report, the lease of the Mount Albert rootstock and variety test area was terminated, and the whole work on citrus is now concentrated at the Plant Diseases Division at Owairaka. The Mount Albert area was laid down and controlled by a special committee of the Auckland District Council of the Royal New Zealand Institute of Horticulture, and a contribution towards maintenance was made by the Department. The trials at the area had served a very useful function for demonstrational purposes, but for critical comparison of stocks and varieties they were proving inadequate in scale in view of the amount of work that had been attempted.

Rootstock Experiments.

Some hundreds of stocks have been budded with a variety of sweet orange, and will be ready for selection and planting out in the winter of 1942. Material being grown includes double-worked trees in addition to simple combinations of stock and scion.

Varietal Investigations.

Sweet-orange stocks have been budded with thirty-eight varieties of sweet-orange, fourteen of mandarin, five of grapefruit, and three of tangelo. The scion varieties include many secured from Mr. Hayward Wright, of Avondale, who has an extensive collection imported from the United States of America, Palestine, India, China, Japan, Australia, and the Pacific islands. Several were imported direct from the Bureau of Plant Industry, United States Department of Agriculture.

Entomological Studies.

Dicky-rice Weevil.—Grease-banding has given adequate control of this pest in Auckland, the crop from treated blocks being quite free from blemish. Trials have shown that the sticky banding material may be placed directly upon the bark, without the use of an intermediate protecting band of grease-proof paper, provided the trunk is shaded from the direct rays of the sun. Banding material prepared from a petroleum source seriously injured the bark of test trees.

As the commercial banding materials are somewhat costly, attempts have been made to prepare a cheaper substitute, but so far without success.

A soil dressing of naphthalene failed to control the pest. The quantity applied was 3 lb. per tree, and this was spread over an area of 16 square yards round the tree and worked into the soil.

Hard Wax-scale (*Ceroplastes sinensis*).—A May application of 3 per cent. summer oil gave complete control of this scale. Results of other work suggest that the concentration of the oil could be reduced to 1½ per cent. and still give control.

Mycological Studies.

Wastage in Citrus Fruits.—A report on various aspects of citrus wastage during transport and storage is given in the Fruit Cold Storage section of this report.

Physiological Studies.

Mottle-leaf.—The Plant Diseases Division continued work on this disorder, and again found that spray applications of manganese gave an immediate response in the control of this disease; soil treatments, however, have not yet had any beneficial effect.

At the request of the Plant Diseases Division, manganese determinations were made by the Cawthron Institute on several samples of healthy and mottled citrus leaves from the Auckland district and the following results were obtained:—

Leaf material.	Healthy.	Slightly mottled.	Badly mottled.
Manganese, p.p.m. on dry matter	20·2 and 24·0	10·2 and 15·4	4·7 and 6·2

Mottling was associated with a low manganese content of the leaves. It must be noted, however, that magnesium likewise tended to be low in badly mottled leaves.

MISCELLANEOUS INVESTIGATIONS.

Unfermented Apple-juice.

Further observations and experiment confirm the points noted in last annual report on the suitability of New Zealand apple varieties for juice manufacture, on the juice yield obtainable, and on the characteristics of the juices of the principal varieties.

A repeat test on the Cox's Orange variety confirms that with fruit in good condition a very good product results, retaining much of the distinctive flavour and character of the variety.

With a view to reducing production costs, a test was made in which the final sterilization of the juice at time of filling was carried out by a flash-pasteurization instead of a cold, germ-proof filtration. The bottles were pre-heated in clean, warm water, and no difficulty was experienced from thermal breakages. The test was entirely successful with the Sturmer variety, but with the Cox's Orange the juice became hazy within a short time of pasteurization. It would appear that, although the initial pasteurization temperature had been maintained approximately 3° C. above the final pasteurization temperature, the difference was not sufficiently great to prevent further precipitation of colloidal material after the second heating.

PUBLICATIONS.

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FRUIT COLD STORAGE RESEARCH.

Advisory Committee.—Mr. W. K. Dallas (Chairman), Sir Theodore Rigg, Messrs. H. G. Apsey, W. Benzies, F. R. Callaghan, J. T. Cross, F. W. Grainger, H. C. Heays, J. L. Mandeno, A. Powell, A. M. Robertson, H. E. Stephens, and L. W. Tiller (Secretary).

This report on fruit cold storage covers associated activities of the Dominion Laboratory, the Appleby Research Orchard, and the Plant Diseases Division of the Department of Scientific and Industrial Research, the Horticulture Division of the Department of Agriculture, and the Cawthron Institute.

REFRIGERATED GAS-STORAGE.

In continuance of its investigations into this aspect of storage, the Dominion Laboratory commenced work on the gas-storage of apples of the Jonathan and Sturmer varieties in the small-scale plant referred to in the annual report for 1937.

Temperatures adopted in the 1939 tests were 35° F., 38° F., and 42° F. At each temperature the following storage atmospheres were maintained: (*a*) 9 per cent. carbon dioxide, with 12 per cent. oxygen; (*b*) 6 per cent. carbon dioxide, with 15 per cent. oxygen; (*c*) 3 per cent. carbon dioxide, with 18 per cent. oxygen; (*d*) air; (*e*) air.

In treatments (*a*) to (*d*) the fruit was held in cabinets, and in these it was under approximately uniform conditions of relative humidity and air movement. In treatment (*e*) the fruit was held in the air of the storage chamber, where the relative humidity was much lower and the air movement greater.

Fruit of a standard commercial type and of known history, from the Appleby Research Orchard, was used for the work. Size-counts in both varieties were 163 and 180, corresponding to diameters of $2\frac{1}{2}$ in. to $2\frac{5}{8}$ in.

Jonathan.—The Jonathans were placed in storage on the 8th March, 1939. The stage of maturity was such that at 68° F. (20° C.) the average time for the fruit to reach its climacteric, or peak of respiratory activity, was ten to fourteen days.

For this variety the most suitable of the storage conditions tested appeared to be a temperature of 42° F. with an atmosphere containing 9 per cent. carbon dioxide with 12 per cent. oxygen.

Under this treatment the fruit at the first examination, at the end of eighteen weeks' storage, was found to be in hard, green condition. A sample removed from storage and maintained for two weeks at a temperature of 68° F. and a relative humidity of 90 per cent. remained in sound, firm condition.

A second examination was made at the end of twenty-eight weeks' storage, and the third at the end of thirty-seven weeks' storage. At this last examination the fruit upon removal from store was still firm, crisp, and of good flavour. At the end of the two weeks' treatment under the severe post-storage conditions of 68° F. and 90 per cent. relative humidity, only about 10 per cent. of the fruit had reached an unsaleable state.

These results suggest that it should be possible to gas-store Jonathans in excellent condition until about October or November. As the fruit varies from year to year, however, it is obviously necessary to repeat the work for confirmation.

A striking fact that has emerged is the complete absence of Jonathan-spot from the gas-stored fruit, whereas the controls stored in air showed a considerable amount.

Sturmer.—The Sturmers were placed in storage on the 19th April, 1939. Respiration measurements suggested that even at this date the fruit was very close to its climacteric and was therefore perhaps slightly too mature to give the best results in gas-storage.

Nevertheless, great improvement in the keeping of the variety was effected by gas storage; the most successful treatment was a temperature of 42° F. with an atmosphere containing 9 per cent. carbon dioxide and 12 per cent. oxygen.

Under these conditions the fruit kept without loss for twenty-eight weeks, and a portion then held for two weeks at a temperature of 68° F. suffered only a 2 per cent. wastage, due to fungus. At the same stage 30 per cent. of the air-stored control fruit was damaged, due mainly to severe scalding but partly to fungus.

After thirty-five weeks' storage a loss of approximately 6 per cent. was experienced, but this was again due chiefly to fungus, with a slight amount of breakdown becoming apparent. The further two weeks at 68° F. did not appear to increase appreciably the amount of damage. The fruit was still firm, crisp, and of very good flavour, and had the appearance of being freshly picked.

The results thus indicate that the Sturmer can be maintained in very good condition in gas-storage up till December. The work requires confirmation and is therefore being continued.

It is a highly significant fact that superficial scald, severe on the fruit cool-stored in air, was eliminated in storage atmospheres containing more than 3 per cent. of carbon dioxide. Fungous wastage was markedly retarded, and in atmospheres containing 9 per cent. of carbon dioxide was almost entirely suppressed.

Effect of Fertilizers on Storage Quality.

At the Research Orchard, studies of the effect of the manurial treatments applied to apples on the storage quality of the fruit have been continued, although the light crop in 1939 tended to increase the variability of the fruit available and so decrease the reliability of the results. The following summarizes the observations on the different varieties:—

Cox's Orange Pippin.—Owing to the extremely light crop in this variety, it was not possible to obtain a sample of fruit for storage tests.

Dunn's Favourite.—With this variety also a light crop interfered with the significance of the results. It was significant, however, that a heavy dressing of 4 lb. ammonium sulphate per tree, additional to a normal dressing of phosphate and potash, had induced a marked increase in susceptibility to breakdown in the fruit.

Jonathan.—It was again found that in the "off" year of the variety, nitrogenous dressings increased the amount of breakdown and fungous disease, the increases being roughly proportional to the amount of nitrogen used. Nitrogen and potash both appeared to increase susceptibility to Jonathan-spot, although the degree of damage was very slight.

Delicious.—All treatments have again been without effect on the storge quality of this variety.

Sturmer.—A feature of the behaviour of the variety this season was the high percentage of wilting that occurred in most samples. As a generalization, it can be said that wilt and breakdown occurred in inverse ratio one to the other, and this fact tended to keep the percentage of sound fruit fairly constant throughout treatments. Fruit from trees receiving nitrogen alone was very subject to breakdown but resistant to wilt. Phosphate treatment induced a large amount of wilt but reduced breakdown as compared with the untreated controls. The skin mottling to which the variety is subject was markedly increased by both nitrogen and potash but was reduced by phosphate.

Effect of Boron on Storage Quality of Apples.

(*a*) *Soil Dressings.*—The adverse effect of rather large applications of hydrated borax on the storage quality of the Jonathan apple was noted in the last annual report. Observations have been continued by the Cawthron Institute, and fruit from trees treated three years ago with 3 lb. borax per tree is still more subject to breakdown. Chemical analysis suggests that when the boron content of the fruit rises above 30 p.p.m. the storage quality of the fruit suffers.

(*b*) *Sprays.*—Two applications of both 0·1 per cent. and 0·25 per cent. borax sprays were made on Cox's Orange, Jonathan, and Sturmer varieties. The boron content of the fruit was markedly increased, but the storage quality of the fruit was not significantly affected.

Superficial Scald in Granny Smith Apples.

The Horticulture Division of the Department of Agriculture made a further test of the influence of pre-storage factors on the development of superficial scald on the Granny Smith variety, but the results were rendered somewhat inconclusive by the relatively low incidence of scald even in the control samples.

Fruit of a mid-April picking was almost free from scald, whereas some scald developed in fruit picked at the end of March. Delay between picking and storing did not have any consistent effect on the development of scald. Oiled wraps appeared to give some measure of control, more noticeable after the fruit had been out of store for a period.

Deep Scald in Jonathan Apples.

Tests at a number of different temperatures, singly and in combination, were made by the Horticulture Division to ascertain if lower temperatures could be used to check ripening of the Jonathan in storage without incurring damage from deep scald.

In some sections of the experiment a period of four to eight days at a temperature of 40° F. preceded subsequent storage at lower temperatures, but the period at high temperature proved insufficient to eliminate scald.

Further clear evidence was obtained that at the low temperature of 31° F. the Jonathan is extremely susceptible to deep scald.

Fruit picked in the first week of March was less susceptible to scald than fruit picked in the last week of March, but early picking is not recommended in preference to a higher storage temperature as a means of controlling deep scald.

Pre-cooling of Winter Cole Pears.

Temperature measurements made by the Horticulture Division during the cooling of sixteen lots, each of fifty cases, of pears showed that the fall in temperature was more rapid when the fruit was placed loose in open cases than when packed up as for delivery to market. With a final holding temperature of 31° F. the unpacked fruit required approximately 72 hours to fall 36° F., whereas the packed fruit required approximately 108 hours to fall 34° F. The unpacked fruit was

packed after it had fully cooled, and most of the fruit from the experiment was then sent overseas. An inspection of the fruit on arrival failed to indicate any differences in the results of treatments, and the whole consignment was reported as being in good condition.

A portion of each sample was hand-graded for comparison with the balance, which was machine-graded. No evidence of injury in machine-grading was obtained, and the saving of grading costs by use of the machine was approximately 50 per cent.

Wastage in Citrus Fruits.

On behalf of the Australian Commonwealth Council for Scientific and Industrial Research, experimental shipments of Washington Navel and Valencia oranges were stored and examined at intervals for wastage by the Plant Diseases Division. Detailed reports were forwarded from time to time to the Australian investigators controlling the experiments.

Examinations were also made of shipments of oranges from the Cook Islands on behalf of the Internal Marketing Division of the New Zealand Primary Products Marketing Department. One shipment from Rarotonga was found to contain 40 per cent. wastage, caused by the fungus *Phytophthora citrophthora*. A second shipment from Atiu showed up to 30 per cent. wastage, caused by the sour-rot fungus, *Oospora citri-aurantii*, introduced into the cases through the practice of including windfalls.

In addition to the above, the Plant Diseases Division undertook work with chemical treatments for the control of the two moulds, *Penicillium digitatum* and *P. italicum*, on lemons in storage. Fruits were artificially injured, inoculated with mould spores, and held in store. Unfortunately, the dry conditions under which the fruits were held prevented the development of mould, even in check fruits. Consequently, further work is held up until chambers in which temperature and relative humidity can be controlled are erected. Work on these is proceeding.

Visit of Dr. A. J. M. Smith.

In September, 1939, Dr. A. J. M. Smith, the noted Cambridge authority on refrigeration and biological engineering, was brought from South Africa to advise the New Zealand Government on matters connected with the development of refrigeration facilities for fruit. Every opportunity for investigation and conference was placed at his disposal, enabling him to supplement his previous knowledge and experience of refrigeration in New Zealand.

A most detailed and valuable report has been received on the minimum extensions immediately needed to enable the fruit industry to function more efficiently, and included also is a recommendation for the provision of badly needed cold-storage experimental facilities in one of the commercial plants. It is to be hoped that effective action can be taken along the lines indicated by Dr. Smith, as this would result in a marked improvement in the quality of fruit for both export and local markets, and would prevent much of the economic loss that is at present frequently and unavoidably incurred.

Future Experimental Programme.

In view of wartime exigencies, two developments projected for the 1940 season may be noted here.

One is the institution of a programme of orchard-storage experiments, designed to give information to enable the best methods of non-refrigerated storage to be adopted. If refrigerated space is required for meat and dairy-produce, very extensive use may have to be made of storage accommodation on the orchard, and it is essential that knowledge be available on the capabilities and limitations of this class of storage.

The other development is the erection of a semi-commercial-scale refrigerated gas-store. This will enable the promising results already secured on the small experimental scale to be tried out on an adequate bulk scale, and from this more extended experience the fruit industry can be given reliable and fully substantiated data on this improved method of storage. The result will be that the New Zealand public will receive a very much higher grade article, especially in the latter part of the year, and much wastage that now occurs will be eliminated.

TOBACCO RESEARCH.

Advisory Committee.—Sir Theodore Rigg (Chairman), Dr. E. Marsden, Messrs. W. K. Dallas, N. J. Adamson, L. J. Schmitt, H. L. Wise, Ian Hamilton, C. C. Nash, F. A. Hamilton, B. T. Rowling, J. F. Balck, J. M. Allan (Tobacco Research Officer and Secretary).

During the year five meetings of the Committee were held in connection with the work of the Tobacco Research Station. Further progress has been made with the equipment of the Station at Umukuri. A glasshouse, tool-shed, garage, and pumping-station have been erected and an irrigation plant installed. Arrangements have now been finalized for the erection of a laboratory building which will provide office and laboratory facilities for the work of the Station. The erection of this building should complete the more important requirements of the Station for the conduct of the field experimental programme.

Good progress has been made in carrying out an extensive programme of tobacco research. The investigations have been carried out partly at the Field Station at Umukuri and partly in the laboratories of the Cawthron Institute.

At Umukuri the work has comprised a great variety of subjects connected with the control of mosaic disease, the use of fertilizers, and the management of the tobacco crop. The experiments have included tests of steam sterilization of the tobacco-seedling beds, the value of direct sowings of tobacco-seed into the beds as compared with the pricking-out of glasshouse-raised seedlings, the value of different varieties of both air-dried and kiln-cured tobaccos, and studies dealing with lateralling and topping of the plants.

At the Cawthron Institute the investigations have included studies of tobacco-seed germination, the use of disinfectants for the treatment of tobacco-seed, chemical studies relating to quality in tobacco, the extraction of nicotine from tobacco, and a detailed soil survey of tobacco lands in the Motueka and Riwaka districts.

A field-day was arranged at the Tobacco Research Station early in February, but the attendance of growers was disappointing. The Committee has received with great regret the resignation of Mr. J. M. Allan, Tobacco Research Officer, who has been appointed Tobacco Advisor to the Department of Agriculture in Western Australia.

Report of Tobacco Research Officer.

On the whole, the past season was a favourable one for tobacco at Umukuri. A dry spell in November and cold weather in December adversely affected transplanting operations and the early growth of the plants. The weather improved in January and remained satisfactory throughout the rest of the season. Harvesting commenced on the 9th February and continued until the 19th April, when curing was completed. The entire crop was much improved over that of last season, good yields being obtained over all experimental and commercial areas. Approximately twelve thousand sticks were harvested from 13 acres and over one thousand sticks of air-dried tobacco from 1½ acres. Leaf quality is much above that of last season, and a considerably higher average price should be realized when the leaf is sold. The kilns were taxed to their utmost capacity, also the storage-room for leaf. If the same quantity of leaf is to be grown in future years, extra kiln and storage space will have to be provided. It has only been possible to harvest all leaf this season by overloading the kilns, and whereas such a practice enabled all leaf to be brought in from the field it necessarily had some detrimental effect on quality.

Fertilizer Experiments.

It is not possible to give the final results of the experiments until grading is completed and the plot yields are calculated, but certain trends were observed in some experiments which may be indicative of the results to be expected. In the experiment where the fertilizer was applied at rates equivalent to 600, 800, 1,000, and 1,200 lb. per acre there was a slight increase in growth with the two heavier applications of fertilizer. When the nitrogen and potash in the standard mixture were varied, double nitrogen markedly increased growth but the leaf produced was the heavier, ranker type that matured slowly. Double potash appeared to have the effect of hastening maturity, although there was not much indication of increased growth. When both nitrogen and potash were increased the best results were obtained. There was an increase in the growth of the plant, the leaves were of good quality but heavier bodied than in the standard treatment, and earlier maturity was obtained. When the nitrogen was reduced to half, the plants did not grow as large, the leaf was smaller, and the plants ripened off earlier. Reduced potash had a somewhat similar effect; and the same trend was noted but to a greater extent when both potash and nitrogen were reduced to half.

In the experiment designed to test the effect of applying part of the fertilizer broadcast, the best results were obtained when half was applied under the plants before planting and half broadcast along the row at the time of the first hoeing. When all was applied under the plant there was a tendency to earlier maturity with not quite as much growth. Where all fertilizer was broadcast at the time of the first hoeing the plants got a poor start and were late maturing, with considerably less growth than in either of the other treatments.

The most interesting results were obtained in the experiment designed to test the effect of low sulphur content and the inclusion of a percentage of chlorine in the fertilizer. There was no noticeable effect from the inclusion of chlorine in the mixture, but there was a marked difference when the sulphur content was reduced. The plants in the low-sulphur plots stood well above the rest and the leaf was of good quality and greater surface area.

Mosaic Investigations.

Mosaic has been much less serious over the entire area than last year, when infection exceeded 90 per cent. This season the infection averaged over all plots was approximately 30 per cent. In addition to a lower percentage of infection, the disease was much less destructive on the plants.

Where bed-raised and pricked-out seedlings were compared there was a slight improvement in growth in the former lot, but it was not as marked as in the previous year. The most noticeable difference was in the percentage of mosaic in the different treatments. Bed-raised seedlings showed 48 per cent. infection, confined for the most part to the topmost leaves, affecting comparatively few harvestable leaves. Where the seedlings had been pricked out into sterilized soil there was 64 per cent. infection, mostly confined to the tops, but with a greater number of plants affected all over. In the seedlings pricked out into unsterilized soil the mosaic percentage was mostly systematic, affecting many harvestable leaves.

Variety Trials.

In the variety trials the flue-cured variety, Moss Special, a variety very similar to, if not identical with, the locally grown variety "Special," was outstanding. Two strains of Hickory Pryor also gave promise of yields above the average. The variety Meadow Giant, obtained from Rhodesia, gave a high yield. This variety is very similar to odd giant plants occurring amongst the locally grown Harrison's Special. All plants have produced at least fifty leaves without coming into flower. Many of the plants are now 8 ft. high. The variety is promising as a breeding-type for crossing with other varieties with a view to increasing the number of harvestable leaves. The leaves of Meadow Giant are rather narrow, and it is desirable to get more width into the leaves before considering it as a commercial variety. In the air-dried variety trials the green variety Maryland Broadleaf was outstanding.

Collar-rot Disease.

Some trouble has been experienced with the collar-rot organism affecting plants in the field. This disease was confined to the heavier tobacco on the heavier soil types. The fungus penetrated through wounds on the stem and leaves, such as scars where leaves had been picked, in the leaf axils where laterals were removed, topping wounds, insect punctures, &c. The disease was manifested by light-brown patches appearing on the leaves and stems, the affected parts soon becoming soft and rotten. Infected leaves when placed in the kiln often showed little evidence of the disease, but under the ideal conditions for the growth of the fungus provided by the colouring temperature, when the kiln is kept at 90° F. with a saturated atmosphere, the fungus grew rapidly. The symptoms of the disease spread over most of the affected leaf and generally to all leaves in contact. On removal from the kiln at the completion of the cure, the affected leaf areas were seen as extensive brown, broken-down, lifeless areas, often covered with a white fungal growth. In some cases small black resting bodies produced by the fungus were to be seen around the edges of the affected areas. The highest temperature reached in the curing was not sufficient to kill the fungus, and when the leaf was removed from the kiln again and prepared for bulking, conditions were once again suitable for the growth of the organism. If such affected leaf is bulked the damage can be expected to spread in the bulk, affecting undamaged leaf with which diseased leaves come into contact.

Sand-drown of Tobacco.

Further tests have been made with dolomite (magnesium-calcium carbonate) and with magnesium carbonate, with a view to the control of a disorder which appeared to be identical with sand-drown of tobacco as reported from the United States of America. The indications of the previous season have again been confirmed, and sand-drown has been controlled in experiments carried out in the Graham Valley by the use of the above-mentioned magnesium compounds. Not only was chlorosis of the leaf prevented, but improvement in the height of the crop, the number of leaves, and the dimensions of the leaf was obtained as a result of the magnesium treatments. The result secured in the Graham Valley, taken in conjunction with the analytical data obtained by the Cawthron Institute in regard to the magnesium content of typical tobacco-leaves, suggests that magnesium compounds may prove beneficial over a considerable area of the Riwaka-Umukuri tobacco land.

CAWTHRON INSTITUTE REPORT.

Soil Survey of Tobacco Lands.

The mapping of soils in the Motueka and Kaiteriteri subdivisions, including areas at Sandy Bay and Marakau, has now been completed. Coloured maps showing the extent and distribution of all the main soil types such as sand, sandy loam, silt loam, clay loam, &c., have been prepared, and variations in subsoil texture indicated on the soil types by appropriate symbols. In addition, coloured maps are being prepared showing the distribution of soils suitable for tobacco. The soils have been grouped into four categories in order of suitability for high-grade tobacco-leaf.

The area covered by the soil surveys in the Motueka and Kaiteriteri subdivisions is approximately 10,000 acres, of which 1,080 acres were used for tobacco in the 1938-39 season. It is considered that an additional 1,300 acres not at present being used for tobacco are texturally suited for high-grade-leaf production. A fair proportion of this additional acreage, however, is used for hops and small-fruit culture.

In co-operation with the Department of Scientific and Industrial Research, arrangements were made with the New Zealand Aerial Mapping Co. for the aerial survey of the Motueka and Riwaka districts and the Motueka, Dovedale, and Moutere valleys. A series of photographs on a 20 chain to 1 in. scale is now available for these areas. The photographs will prove invaluable in expediting soil mapping in the Motueka, Dovedale, and Moutere valleys. At the same time, much valuable information concerning the utilization of the land for different crops is provided on the photographs.

Soil samples from the different types in the Motueka and Riwaka districts have been obtained, and these are being examined in the laboratory for texture and plant-food constituents.

Chemical Investigations.

Chemical Criteria and Tobacco Quality.—With a view to the correlation of chemical composition of tobacco with quality as defined by the manufacturer, a series of samples of Nelson leaf of different grades has been obtained for laboratory tests. In addition, Messrs. W. D. and H. O. Wills kindly presented several samples of high-grade imported leaf to serve as standards in the comparison of analytical data.

Much time has been spent in perfecting methods for the determination of sugars in tobacco. The clearing of the solutions prior to the estimation of sugars has presented many difficulties. The use of cadmium sulphate as a clearing-agent has been tested, with promising results.

Some twenty-three samples of Nelson leaf have been examined for reducing sugars and nitrogen contents. The amounts of these constituents varied greatly in different samples of leaf. A range in reducing sugars from 2·0 per cent. to 30·9 per cent. was found. The total nitrogen contents varied in different samples from 1·48 to 4·27 per cent. The ratio of reducing sugars to total nitrogen ranged from 0·5 to 20·9, there being a distinct tendency for good-quality tobacco to give a high ratio. Typical figures for poor- and high-quality tobacco are shown below :—

Sample No.	Quality Tobacco.	Total Sugars.	Total Nitrogen.	Ratio, Sugar/Nitrogen.
		Per Cent.	Per Cent.	
T 33	Good	20·03	1·93	10·3
T 35	Poor	8·73	2·60	3·3

Further samples must be analysed before conclusions can be drawn regarding the value of the sugar/nitrogen ratio in assessing tobacco quality.

Nicotine in Tobacco.—With a view to the manufacture of nicotine sulphate in New Zealand, estimations of nicotine have been made in typical samples of Nelson tobacco. In addition, determinations have been made of nicotine in samples of Turkish tobacco which is known to have a fairly high nicotine content. A typical figure for waste Nelson tobacco-leaf was 2·67 per cent. nicotine, while samples of Turkish leaf grown at the Research Station showed variations in nicotine content from 3·87 per cent. to 7·02 per cent. in the leaf and from 0·92 per cent. to 1·25 per cent. in the stalks. The nicotine content of the Turkish leaf was considerably lower than that reported by analysts from other centres. Soil type and manurial treatment doubtless influence greatly the nicotine content of this variety.

Industrial Recovery of Nicotine.—A report has been prepared on the possibility of establishing in New Zealand the manufacture of nicotine sulphate, and in collaboration with the Tobacco Research Officer and the Fruitgrowers' Chemical Co. at Mapua a series of experiments on the steam distillation of nicotine from waste tobacco has been carried out.

Estimations of nicotine in the distillate from these tests showed that a relatively large volume of distillate was required to remove the nicotine from the tobacco. It is possible that better results would have been obtained by distillation under pressure. An alternative procedure for the extracting of nicotine from tobacco by the use of organic solvents is now under consideration, and preliminary work on the distribution coefficients of nicotine between water and organic solvents is being carried out in the laboratory.

Moisture Uptake of Tobacco.—Considerable variation in the rate of absorption of water by tobacco and also in the final moisture contents has been found in different tobacco samples when introduced into a water-saturated atmosphere.

In some cases samples of tobacco-leaf have absorbed up to 90 per cent. of their weight of moisture, while in others the percentage increase in weight has been 51 per cent. only. In view of the importance of these observations to the manufacturer, further studies of moisture absorption at known humidities are being made.

Mycological Investigations.

Damping-off Fungi.—As in previous years, the mycologist regularly inspected the tobacco seedlings grown by Nelson nurserymen for commercial use. In certain cases considerable damage to seedlings was caused by damping-off fungi. The importance of thorough sterilization of soil as well as disinfection of boxes and glasshouses used for the propagation of tobacco seedlings must be again emphasized. No less important to success in the rearing of healthy plants free from disease is satisfactory ventilation of glasshouses and the maintenance of dry conditions on the floor of the houses.

Preliminary tests have been conducted with eight different chemicals, including organic mercury derivatives and cheshunt compound, with a view to their use in the seedling-boxes for the control of damping-off fungi.

Of the chemicals used, red copper oxide detrimentally affected the germination of tobacco-seed and therefore must be considered unsuitable for use in seed-boxes. The other chemicals exerted no detrimental effect on seed-germination, but no statement can yet be made concerning their value in the control of damping-off fungi.

Effect of Steam Sterilization of the Soil on Seed-germination.—The introduction of steam sterilization for the treatment of tobacco-seedling beds has raised the question as to the effect of such treatment on the germination of tobacco-seed.

In the case of tomato soils a resting period after sterilization has been recommended prior to the planting-out of tomatoes. Experiments were therefore initiated to ascertain the effect of steam sterilization on the germination of tobacco-seed in the case of a typical tobacco soil. Four sowings of tobacco-seed were made at weekly intervals on the sterilized soil, commencing one week after sterilization and extending over a period of one month. In every case a thick stand of tobacco seedlings was obtained, indicating that no advantage was secured by allowing more than one week's interval

from the time of steam sterilization to the actual sowing of the seed. The steam-sterilized soil gave superior results to the unsterilized soil. In the latter case germination of tobacco-seed was reduced, growth of seedlings was slow, and foliage colour was poor.

Seed-germination Tests.

As in former years, germination tests have been made of the seed used by the companies for commercial plantings. The tests showed a variation in different lines of seed from 63 per cent. to 94 per cent. germination. In addition, germination tests have been conducted on five varieties of seed stored for two years and on two varieties of seed stored for three years. The results showed 65 per cent. to 99 per cent. in the first case, and 93 per cent. to 96 per cent. germination in the second case.

Effect of Disinfection on Seed-germination.—The effect of both rectified spirit and absolute alcohol on the germination of tobacco-seed has been examined in collaboration with the Tobacco Research Officer. The results show that no harmful effect on germination is obtained by immersion of tobacco-seed in either of these disinfectants for periods of five to ten minutes. Even when the drying of the seed, after immersion in these reagents, was delayed for thirty minutes no significant decrease in germination resulted.

During the course of the tests, however, it was noticed that if the tobacco-seed was not properly aired after treatment with rectified spirit a marked reduction in germination occurred.

The following figures illustrate the importance of thorough airing of tobacco-seed after treatment with rectified spirit:

Treatment.	Percentage Germination.	
	End of First Week.	End of Second Week.
Seed aired	12	86
Seed not aired	2	49
Control (not disinfected)	3	73

Further experiments conducted with alcohol, silver nitrate, and Uspulun have shown that, provided airing and subsequent storage of treated seed are satisfactory, no adverse effect on germination results if the treated seed is held in storage for periods up to sixteen months.

Tobacco Wilt.—Several cases of wilt in tobacco have been observed in two localities during the present season. They appeared to be associated with low-lying areas where soil conditions were rather wet. The wilt is characterized by a yellowing of the leaves on the lower half of the plant. On individual plants, yellowing begins at the tip of the leaf and gradually advances to the leaf stalk, finally affecting the whole surface of the leaf.

Both bacteria and the fungus *Verticillium* occur in the affected plants, the former chiefly in the root and base of the stem and the latter in the stem and wilted leaves. No statement can yet be made as to the cause of the wilt.

PHORMIUM RESEARCH.

Investigations in connection with the phormium industry during the year were confined to two main activities:—

(*a*) Botanical investigations under the control of the Botany Division of the Plant Research Bureau. These are reported upon briefly on page 15.

(*b*) Mechanical Investigations: Work was concentrated upon improvement of the design of the washing-machines now in use in flax-mills, but after extensive trials were carried out the modifications made were found not to be feasible, and the work has therefore been discontinued.

The first installation of the flax-stripping machinery is now being made and will enable these locally designed and constructed machines to receive thorough testing under commercial conditions.

TIMBER PROTECTION RESEARCH.

Timber Protection Research Committee.—Mr. L. E. Brooker, State Advances Corporation of New Zealand (Chairman); Mr. R. L. Andrew, Assistant Dominion Analyst; Mr. F. J. A. Brogan, Assistant Secretary, Department of Scientific and Industrial Research; Mr. F. R. Callaghan, Chief Executive Officer, Plant Research Bureau; Dr. G. H. Cunningham, Director, Plant Diseases Division, Plant Research Bureau; Mr. H. C. Gayford, Chief Inspector, Housing Construction Department; Mr. N. A. Marris, Dominion Laboratory; Dr. D. Miller, Entomology Division, Plant Research Bureau; Mr. A. F. Clark, State Advances Corporation (Secretary).

The Timber Protection Research Committee, set up in June, 1938, by the Council of Scientific and Industrial Research to direct investigations relating to the preservation of timber from the attacks of insects and fungi, has had to devote special attention this year to the problem of termites in New Zealand. During the year the Committee arranged for the visit from Australia of Mr. F. N. Ratcliffe, of the Division of Economic Entomology of the Commonwealth Council of Scientific and Industrial Research, to report on the termite position in New Zealand. Mr. Ratcliffe presented a report on

Australian termites introduced into New Zealand, and the report, together with the comments of interested bodies, is being considered by the Timber Protection Research Committee with a view to making recommendations as to the steps that should be taken to implement Mr. Ratcliffe's recommendations.

The following is an account of the work that has been carried out during the year :—

Dominion Laboratory.

(1) The analysis of all samples of timber-treating liquids submitted by the State Advances Corporation for examination.

(2) Work on the development of a field test to differentiate between treated and untreated wood. A test involving the incorporation of a fluorescent material in the treating liquid and the subsequent examination of small particles of the wood, under ultra-violet light, has been proposed and investigated.

(3) Miscellaneous work, such as solubility tests on the ingredients used in the timber-treating liquids and the indexing of articles on wood preservation appearing in Journals received by the Laboratory.

Entomology Division, Plant Research Bureau.

The problems selected for study are concerned with :—

(1) *Anobium domesticum* (common house-borer).
(2) *Anobiid* sp. (large native borer).
(3) *Lyctus brunneus* (powder-post beetles).
(4) *Ambeodontus tristis* (two-tooth long horn).
(5) Termites (white ants).

At the present time attention is being given particularly to *A. tristis* and the termites, and to a less extent *Anobiid* sp. The others—*i.e.*, *A. domesticum* and *L. brunneus*—have been studied in detail in other countries, though a great deal needs to be done regarding them in relation to New Zealand timbers and timber structures, and their control.

In the case of termites the avenues of study are as follow (certain phases, marked with an asterisk, are being studied in co-operation with officers of the Australian Council of Scientific and Industrial Research) :—

(1) Survey of range and relative economic importance of species in New Zealand :
(2) Influence of climate on the geographic range of different species, with the object of ascertaining zones that are likely to remain termite-free :
* (3) The inroads of different species on different kinds, qualities, and conditions of timbers :
(4) Biology of the species, involving :

* (*a*) Systematics ; (*b*) seasonal history ; (*c*) rate of growth ; (*d*) season and time of swarming ; (*e*) location of reservoir colonies ; (*f*) time required to cause major structural damage ; (*g*) characteristic appearance of wood infested by species of termites, and specific characters of frass ; (*h*) relation to fungi, moisture, temperature, and general environment, such as types and regions of structures favoured (in co-operation with State Advances Corporation and Plant Diseases Division).

(5) Control :

* (*a*) Prevention of introduction of alien species and the check to spread of species already in the country ; * (*b*) modification of building technique ; * (*c*) treatment of timber ; * (*d*) destruction of colonies detached from buildings, &c.

In regard to *A. tristis*, the main points being elucidated follow largely those of termites.

Recommendations were made to the Department of Housing Construction covering modifications of building technique as soon as it became apparent that the Australian termite problem was of importance. These recommendations have since been confirmed by Mr. Ratcliffe.

Plant Diseases Division, Plant Research Bureau.

(a) Field Survey.

Studies have been made of decay of house timbers and eucalypt power-poles in the vicinity of Auckland City, caused by the common fungi and insects. Particulars are being collected covering the conditions under which each operates. Examinations have been made of timbers treated with various therapeutants in the field, and the efficiency of such as preservatives noted. A brief survey of the position of housing-timber diseases was made in Wellington and Christchurch.

(b) Laboratory Investigations.

Numerous isolations have been made of wood-destroying fungi common in New Zealand in house timbers and power-poles. These organisms, together with twelve wood-destroying test fungi supplied from the laboratory at Princes Risborough, England, have been grown in cultures in the presence of matai and rimu blocks to compare their wood-destroying properties. The purpose of this work is to ascertain the behaviour of our organisms as compared with those introduced from overseas, so that results can be compared with these standard test fungi. Attempts have also been made to isolate the fungi responsible for sap-staining in timber, but so far with small success. Cultures of all fungi collected in this manner are being propagated for testing of therapeutants as soon as a standardized technique has been evolved.

Work on insects has been confined to developing methods for producing quantities under laboratory conditions. Timber infested with *Anobium* was collected, information secured on the habits of this beetle during its short life after emergence, and methods developed for maintaining individuals until the egg-laying period. Studies are now being made on the most suitable species of timber upon which to raise quantities of the beetles artificially, and effects of age and moisture content of the timber on the life of the progeny.

Difficulties have been met in securing adequate numbers of *Ambeodontus* for test purposes, owing to the extended period of emergence of the beetle and its long life-cycle. For these reasons attempts are being made to evolve a larval test.

Work with termites has been limited to the endemic wood-dwelling species, *Calotermes brouni*. Several thousand nymphs have been established in glass jars and will be available for tests when equipment is available for treating sample blocks.

(c) Penetration Tests.

Use of water-insoluble organic therapeutants depends largely upon discovery of a satisfactory solvent which will carry the product well into the wood, preferably without the use of pressure equipment. Tests were made with seven petroleum oils covering a wide distillation range, together with methyl-ethyl-ketone, upon sap rimu and matai blocks. Irregularities in penetration of each material made it difficult to measure differences. None, however, penetrated more than 1/10 in. into surfaces with straight grain, although when the grain ran in slightly from the surface, penetration appeared much better owing to the liquids travelling along the vessels. These results are at variance with claims made by certain American workers.

State Advances Corporation.

Throughout the year the major portion of the field-work of the Timber Protection Research Committee has been undertaken by the Field Staff of the State Advances Corporation.

The work has been concerned firstly with the geographical distribution of the Australian subterranean termites (*Ambeodontus tristis*, *Anobium domesticum*), weevils, and the native dry-wood termite. Considerable data have been collected upon the Australian termites, and this information was made available to Mr. F. N. Ratcliffe during his visit to the Dominion. The study of the distribution of *Ambeodontus* and *Anobium* has revealed that both these insects are widespread, but there is a noticeable increase in the incidence of the former insect in the Taranaki Province.

Attention must be drawn to the great amount of damage which is being caused to houses by the native dry-wood termite, *Calotermes brouni*. In some cases this termite has shown that it is able to cause even more severe damage than the Australian termites, although, of course, its attack is less rapid. On the other hand, the detection of attack by *Calotermes brouni* is more difficult than that of a subterranean termite, and control methods are likely to be more difficult.

The distribution of the various fungi attacking house timbers is being actively investigated. It has been ascertained that the City of Christchurch probably shows a greater incidence of fungal infection than any other large city in the Dominion. Specimens have been sent to the mycologists for the purposes of identification and culture. Studies have also been made of building practice in relation to attack by both insects and fungi. The qualities and grades of timber in relation to their susceptibility to infestation have been similarly investigated. Supplies of timber infested by insects and by fungi have been forwarded from time to time as required to the two Divisions concerned. The Corporation provided the transportation for officers of the various Divisions when such was necessary.

LEATHER AND SHOE RESEARCH.

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

During the year the Director visited Great Britain, Canada, and the United States of America to renew direct contact with methods used overseas in research work and manufacturing methods. The trip was very successful, and much valuable information was obtained about the present methods of manufacture of leather and shoes. A report on the visit was forwarded to members of the New Zealand Leather Research Association.

LEATHER RESEARCH ASSOCIATION.

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

Observations on the Director's Visit Overseas.

English sole leather has a reputation throughout the world for its firmness, good wear, and resistance to water absorption. Investigations have been carried out in New Zealand on how these qualities are obtained, especially in relation to the use of astringent tannin materials. It is usually accepted that astringency is related to the size of the tannin molecule. Much work is being carried out in Britain on molecular size, and, although the knowledge is at present somewhat incomplete, practical tanners are talking in terms of size of molecules. The discovery of a method which will give maximum and minimum as well as the average molecular weights would be of the utmost benefit to tanners.

The use of astringent tannins (*i.e.*, those of large molecular size) raises the question of how they are to be absorbed by the leather, since it is more difficult for large particles to penetrate the leather. The question of scouring was discussed from the mechanical aspect and also the proper time at which this process should be carried out.

Methods of factory control were discussed in relation to the type of leather being made, the tanning-materials used, and the mechanical methods employed. There are many different methods of producing good sole leather.

The latest types of machines, and older types of machines with improvements, were seen in operation. Often it was found, as has been the case in New Zealand, that machines have to be altered or adapted to meet the requirements of local conditions. In New Zealand this is more difficult, as the mechanics who have specialized in this type of machinery are not available.

Great advances in upper leather have been made in Great Britain in recent years as regards both quantity and quality. From observations made on the trip it appeared to be definitely established that quality bears a direct relation to the care taken in regard to details and to the amount and quality of the work put into the processes. The investigation carried out in New Zealand on the "Tightness of the Grain of the Upper Leather" had aroused great interest in Britain, and discussing the practical application of this enabled much valuable information on the manufacture of upper leather to be obtained.

Climatic and economic conditions have developed the leather industry in America along lines different to those in Great Britain. The huge demand for leather has to be supplied by home production, and consequently methods have been evolved to deal efficiently and economically with large outputs.

One of the most important qualities demanded in American sole leather is flexibility. A system of tanning has been evolved which will produce flexible leather and at the same time maintain a standard of colour that is possibly higher than that required in other countries.

New systems of liming have been tried out with some success. The use of dimethylamine as a depilatory, on a works scale, was investigated. The chief disadvantage appeared to be an economic one.

The methods of stretching upper leather (viz., toggling, tacking, and pasting—were seen, and special attention was given to the last as this method has not as yet been successfully operated in New Zealand.

The use of rubber latex as a component in the finishing-material for upper leather was of great interest in view of the special qualities imparted to the leather.

Research Institutions.—The research laboratories of the British Leather Manufacturers, of the Tanners' Council of America, and of the Bureau of Standards were visited, in addition to the research laboratories of many large, well-known leather firms and firms connected with the leather trade.

One of the most important problems confronting the leather industry is the need for the development of physical tests and standards for leather. Chemical tests are valuable guides as to the uniformity and efficiency of processing, but give little or no indication of quality from the user's point of view.

Research Work.

The programme of research work carried out has of necessity been curtailed during the year. The main investigations are:

Cracking of Upper Leather.—An examination of samples of upper leather liable to crack suggested the following causes:

(1) Disease damage in the hide associated with damaged hair follicles.
(2) Lack of efficient scudding.
(3) Lack of softness for special purposes—*e.g.*, slipper work.
(4) Lack of plasticizer in the finishing-materials in relation to the amount of oil in the leather.

Factors affecting Absorption of Tannin.—When astringent tan liquors are being used, it is essential that the large-sized molecules of tannin shall be able to penetrate the leather. If conditions arise in which only the smaller-sized molecules, such as non-tans, can enter, the liquors will gradually become richer in astringent tannins, as was found to be the case under investigation.

Factors affecting Volume of Leather during Tanning.—The demand for thicker sole leather has necessitated that, as far as possible, the tanning processes should be such as will give the thickest possible leather. An investigation has been carried out on this problem, and within certain limits factors influencing thickness have been determined.

Tightness of Grain of Upper Leather.—The work on this problem has been continued with special reference to the properties of elastin. The results obtained demonstrate that the physical properties of elastin play a very important part in the mechanical treatment of upper leather during the processes of manufacture. It is quite possible, if these properties are not fully appreciated, to damage irreparably the upper leather by mechanical treatment.

General.

The usual routine work of the Laboratory dealing with the current industrial problems and factory control was carried out by the Assistant Director during the absence of the Director.

SHOE RESEARCH.

Advisory Committee.—Messrs. W. Denby, P. E. Edwards, W. S. Livingstone, R. O'Shea, W. Donovan.

Many materials besides leather are used in the manufacture of boots and shoes, and a knowledge of the properties of these materials is necessary if problems connected with their use are to be solved.

Special attention was given to problems of shoe-manufacture during the Director's visit overseas. Factories making fabric linings, cotton threads, linen threads, shoe finishes, and cleaning-materials, &c., were visited.

The principles underlying some of the processes in shoe-manufacture were discussed with machinery producers, and the problem of the efficiency of the machine in relation to the quality of the shoe was considered.

To face competition it may be necessary for the manufacturer to reduce costs. The co-ordination of all the efforts of a business in a suitable relationship to each other will materially reduce cost of production and increase output. This was strikingly demonstrated in some British shoe-factories turning out shoes to sell at popular prices.

One noticeable feature in both English and American shoes is the high average quality of the stitching of the uppers. This has a great effect in increasing the appearance value of shoes, and the possibility of effecting improvements in this connection in New Zealand was closely investigated.

Research Work.

Cleaning-materials.—During the course of manufacture shoes become soiled and have to be cleaned before the final polish is applied. The principles underlying cleaning methods, according to the nature of the material to be cleaned and the kind of extraneous matter removed, were used as a basis for the preparation of a general cleaning fluid. Particular preparations were recommended to deal with specific cases in which the general cleaner was not successful. Other factors which have to be considered when cleaning shoes were also investigated.

Pulling-over and Lasting.—Data were collected as to the amount of stretch imparted at the pulling-over and lasting machines. The results showed the necessity, when testing leather for stretch and crackiness, for a suitable instrument which will reproduce as nearly as possible the conditions at the lasting-machines and the pulling-over machines.

Stitching.—Tests have been carried out to demonstrate the effect on the strength and appearance of the seams produced by needles of different size and shape of point, and by the use of different sewing threads. The importance of the relation of the stretch of the leather to the stretch of the thread used has been demonstrated in connection with the strength of seams. This has a very important bearing on the breaking of threads in the seams during pulling-over and lasting.

Factory Problems.—The number of factory problems submitted during the year has been fully maintained. The fact that many pairs of shoes submitted for examination had been damaged by strong sulphuric acid or by burning shows either a lack of care or knowledge of the limitations of leather by the wearer.

HIDE AND PELT RESEARCH.

A method of testing the efficiency of the curing of hides and skins has been developed recently in America. From the preliminary tests which have been carried out in New Zealand it would seem possible, after sufficient data have been collected over a period of time, to determine whether a hide has been efficiently cured or whether it has been stored for a long period. It is intended, during the coming year, to determine what variations might be expected in hides from seasonal changes in temperature of curing and feeding of the animals.

WOOL MANUFACTURERS' RESEARCH ASSOCIATION.

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, Mr. W. L. Wood, Dr. E. Marsden (Secretary).

Director.—Professor F. G. Soper.

With the wool-textile industry working under very high pressure in its endeavour to meet both Government and civilian requirements, any investigations which necessitated mill trials and experiments or the use of mill equipment have had to be postponed temporarily, excepting those which could be carried out without interfering with output.

As a result of mill investigations, methods of increasing production and of control have been discussed with members and their staffs, and in a number of cases improvements have been effected. Woollen and worsted carding outputs have been increased, improvements have been effected in fibre control, in worsted drawing and spinning, and preliminary trials in woollen-mule and ring-frame spinning have revealed interesting results. Improved methods of chemical control for carbonizing and non-shrink processes have been introduced into sections of the industry, and simple control equipment secured for the mills concerned.

Periodic visits to all members' mills have been carried out.

One of the principal activities of the Association has been in its own laboratories, dealing with problems submitted by individual mills. The problems have included yarn and fabric faults, samples of substances to be analysed, and numerous technical inquiries. The faults have consisted of uneven dyeings, the diagnosis of which presents some of the most difficult problems in consulting work; stains, frequently traced to metals and mineral lubricants; damaged fabric caused by chemical and bacterial attack; and structural and other physical faults in fabrics.

Analyses have been carried out on samples of water, soaps, oils, and chemicals used by the industry. Amongst the inquiries dealt with by the Association have been those relating to the possibilities of alternative chemicals and dyes, and sources of supply; processing technique; new processes and equipment: and corrosion of metals.

Work has now been started to discover the possibilities of the wool-textile industry making more use, as a textile lubricant, of the abundant supplies of locally produced neatsfoot oil.

A survey of the possibilities of introducing into the country some form of textile education, which is sorely needed by the industry, was unavoidably interrupted by the outbreak of war. This will be continued as soon as possible.

Probably one of the greatest contributions the Association is making at present to the industry is in emphasizing the necessity of, and in showing the advantages to be gained through, stricter chemical and mechanical control during processing.

A monthly letter, which was circulated to the members until the end of 1939, has now been replaced by a quarterly bulletin. Some of the principal subjects discussed have been "Testing," "Variability in Woollen Carding," "Worsted Drawing and Spinning," "Woollen Batching Oils," "Wool Grease," and "pH Control in the Mill."

The resources of the British Wool Industries Research Association at Torridon have proved most valuable, and the generous help given, when consulted on many questions during the year, has been greatly appreciated.

RADIO RESEARCH.

Advisory Committee.—Professor J. Shelley (Chairman), Professor P. W. Burbidge (Auckland), Professor D. C. H. Florance (Wellington), Professor R. Jack (Dunedin), Professor F. W. G. White (Christchurch), Squadron-Leader E. M. F. Grundy (Air Department), Captain G. H. Heal (N.Z.S.C., Army Headquarters), Mr. E. H. R. Green (Post and Telegraph Department), Mr. J. R. Smith (National Broadcasting Service), Dr. M. A. F. Barnett (Dominion Meteorologist), Dr. E. R. Cooper (Department of Scientific and Industrial Research), (Secretary).

During the year Dr. Kreielsheimer took up his appointment as Research Physicist, working under this committee at Auckland University. Before arriving in New Zealand he spent some three weeks in Sydney making contact, through the kindness of the Commonwealth Radio Research Board, with the latest developments in that centre. Since May he has been working at Auckland mainly on cathode-ray direction-finding.

During this year also Mr. C. J. Banwell relinquished his position as a Research Physicist working under this committee at Canterbury University College and proceeded to England to gain experience in radio research there. On account of the outbreak of war, considerable difficulty has been experienced in continuing research uninterruptedly owing to staff changes.

The following is a summary of the work carried out during the year:—

(1) The Reception of Distant Signals Research.

(*a*) *Field Intensity Measurement.*—Some fifty photographic records of the intensity of Daventry broadcasts were made. The early records show pronounced fading fluctuations which were later reduced by damping; the transmissions (in the 15 Mc/s band with 50 kw. output) between 21 hours G.M.T. and 24 hours G.M.T. towards South America and New Zealand consistently exhibit a maximum at about 22.00 G.M.T., with a gradual falling off of intensity at 24.00 G.M.T. Between 01.00 G.M.T. and 02.00 G.M.T. there is a rapid rise in field strength of the 9·51 Mc/s transmission on bearing 224° E. to a maximum at about 04.00 G.M.T., after which the signal strength remains sensibly constant until about 06.00 G.M.T. Comparison of transmissions directed to Canada and New Zealand on 9·51 Mc/s showed a maximum for the average value of 250 micro-volts per metre (peak values of fluctuations exceeding 400 μ v/m). The accuracy of measurement of field strength was estimated at 18 per cent.

(b) Cathode-ray Direction-finding.—Receivers for this system have been completed, the modulation input was built, the aerial system surveyed, a field oscillator built, and a phase compensator designed and built. The whole of the apparatus was aligned, and photographs of ellipses were obtained recording the bearings of Berlin from broadcast transmission. It is intended to redesign certain parts of the apparatus.

(c) Distribution of Atmospherics on Different Wave-lengths.—A single receiver and recorder has been employed, relative determinations of the intensities of various wave-lengths being made by observations of different bursts of static. The static burst was recorded on a rotating drum, provision being made automatically for the wave-length of reception to be altered through a range of values for one complete rotation of the drum. The period of rotation was thirty minutes, for which twenty-five bursts per minute could be dealt with satisfactorily. The following conclusions relate to records taken on 15,000 metres:—

(1) There is in general greater activity by night than by day.
(2) Frequently the activity diminishes just before sunset and increases again during the night.
(3) During a quiet period of the day the activity consists of about ten bursts per minute, and during the night twenty-five bursts per minute.

(2) Ionospheric Research.

Research into the ionosphere is carried on principally at Canterbury University College, but absorption measurements are also made at Victoria University College. The automatic recording-equipment at Christchurch, which registers the critical frequencies of the F and E regions at hourly intervals, has been in continuous operation. An attempt is being made to relate the considerable amount of data being obtained to radio communication circuits. The following Radio Research Publications have been issued by this section:—

No. 4: "The Estimation of Wireless Transmission Data from Ionospheric Observations," by Professor F. W. G. White. (*N.Z. Jour. Sci. & Tech.*)

No. 5: "The Dispersion of Wireless Echoes from the Ionosphere," by Professor F. W. G. White. (*Proceedings of the Physical Society*, London.)

No. 6: "The Diurnal Variation of Absorption of Wireless Waves," by Professor F. W. G. White and F. W. Straker, M.Sc. (*Proceedings of the Physical Society*, London.)

No. 7: "The Antartic Zone of Maximum Auroral Frequency," by Professor F. W. G. White and M. Geddes, M.A., F.R.A.S. (*Journal of Terrestrial Magnetism and Atmospheric Electricity.*)

Data on auroral observations are being supplied regularly to the committee by the Director of the Carter Observatory, Wellington. Also regular reports of ionospheric data are being received from the National Physical Laboratory, Teddington.

SOCIAL SCIENCE RESEARCH BUREAU.

Since its establishment, the Bureau has collected a large amount of data relating to the standards of living of workers in three selected industrial groups—namely, dairy-farmers, boot and shoe operatives, and tramway employees.

Standards of Life of Dairy-farmers.

The material for the dairy-farmers' survey, which was collected in the summer of 1937–38, has now been analysed and the results incorporated in a bulletin which is to be published during the coming year. The bulletin will contain information on a variety of topics connected with the standards of life of the industrial group with which it deals, covering such topics as housing, household budgets, work, home amenities, and leisure-time activities.

Standards of Life of Urban Workers.

The information gathered by the Bureau in the latter part of 1938 concerning the standards of life of two selected groups of urban workers—viz., operatives in boot and shoe factories and tramway employees—has now been coded, and its analysis has formed the major task of the Bureau during the past year. The experience gained in the analysis of the data from the dairy-farmers' survey has been of great assistance.

The reports on these urban surveys are being written up in sectional form, each section being complete in itself. Three of these sections have been completed, and the work on others is well forward.

These sections deal with work and wages, insurance against sickness and other emergencies, leisure-time activities, and spending-habits.

The work will form a valuable base-line for sociological studies in New Zealand.

RESEARCH WORK AT AGRICULTURAL COLLEGES.

Grants were made by the Department during the year to Massey Agricultural College and to Canterbury Agricultural College for a number of projects, which are reported on below.

CANTERBURY AGRICULTURAL COLLEGE.

Subterranean Clover.

Subterranean clover is felt to be capable of playing an important part in increasing the carrying-capacity and fertility of much of the lighter lands of Canterbury, and at Ashley Dene 72 acres were set aside for a series of establishment trials and sheep-grazing experiments. Four fertilizer treatments, replicated, were arranged as follows:—

A. 1 cwt. super. alternating with 5 cwt. lime.
B. 2 cwt. super. annually.
C. 1 ton lime (initial) plus 2 cwt. super. annually.
D. 1 ton lime (initial) plus 2 cwt. super. plus 1 cwt. potash annually.

The various areas were grazed, a flock of 140 four-toothed Corriedale ewes being used in the trials.

Very unfavourable weather conditions prevailed during the whole of the establishment period in the previous year and again during the early autumn period of the present year, so that to date a really dense clover sward has not been developed.

The results of the grazing trials to date give information as summarized in the following table:—

Treatment.	Ewes, per Acre.	Stocking Ratio.	Actual Production Ration.
A	$1\frac{1}{2}$	100	100
B	2	133	123
C	$2\frac{1}{2}$	166	154
D	$2\frac{1}{2}$	166	154

It is seen that treatments C and D have to date given a 50-per-cent. increase in production over treatment A, which is considered the minimum fertilizer application which should be given to a stand of subterranean clover.

The trials to date have also indicated that no real advantage occurs in this light type of soil when dressings in excess of 5 cwt. per acre of lime are applied.

Sheep-dip Investigations.

L. Morrison.

Following the receipt of a grant from the Christchurch Gas Co., collaborative investigations were commenced with a view to ascertaining the possibility of manufacturing an efficacious dip comprised largely or entirely of locally produced materials. Trials of various dips and the purely entomological parts of the researches were carried out at the College. Preliminary work indicated the impossibility of carrying out tests adequately in portions of the fleece, and so a series of small paddocks to accommodate the various units of an experimental flock were constructed. These were infested with keds (*Melophagus ovinus*) and lice (*Bovicola ovis*) and have been treated in dips of various compositions. Interim results indicate that all of the preparations containing arsenites, phenols, and rotenone were effective against adult keds, but in order to be thoroughly effective the toxic influence should be protracted sufficiently long to deal also with the keds which emerge from the pupæ. Incomplete trials to date indicate that derris possesses value for giving this delayed action.

Stem Insects of Cereals.

L. Morrison.

Work has been continued on stem-weevil infestation of wheat, special attention being devoted to studies of the different degrees of resistance to attack of the various varieties commonly grown. Though results were not quite definite, there are indications that Hunters, Cross 7, and some of the newer varieties developed by the Wheat Research Institute possess a somewhat higher degree of resistance than other varieties. Investigations on the Hessian fly have now almost been completed.

Cocksfoot Midge.

Cocksfoot midge has been kept under general watch with a view to accumulating further particulars regarding its life-history under New Zealand conditions. It has been found that the insect is on the wing between the end of October and the end of March in Canterbury. It has not been possible to determine the economic importance of this insect, which appears to infest roadside cocksfoot to a much more serious extent than that growing in open fields. Information is being gathered relative to the actual seed loss caused by the depredations of the midge.

MASSEY AGRICULTURAL COLLEGE.

MOLE DRAINAGE.

A. W. HUDSON.

During the autumn of 1939 Mr. Hopewell, Drainage Research Assistant, was engaged in studying the nature of the cracking associated with the blade slit and mole channel and various aspects of these connected with breakdown in moles. Measurements and photographic records of this work have been obtained.

Observations have also been made on moles having falls ranging from about 1 in 10 to 1 in 4, and drawn two years previously, to determine the influence of fall on scour in the floor of the channel.

Several plugs of new design have been tried with the object of getting further information on means of preventing the blade slit being sealed at its point of junction with the roof of the mole channel. These studies also aim at determining the effect of maintaining continuity between the blade slit and the mole channel compared with the sealing action of the old type of plug on the blade slit.

The fin plug designed in 1939, while serving to keep the slit open, has the disadvantage that a considerable amount of breakdown from the roof of the channel takes place when the clay re-wets in the year following pulling.

A new torpedo-plug combination, in which the blade extends behind the plug and prevents the slit from closing, shows considerable promise, and its use, so far as can be determined at present, is not accompanied by the undesirable action of the fin plug. Modifications of this design are still under trial.

The new method of joining minor to major moles, which was devised last year, has been the subject of further trials which will be examined each year, for a number of years, to ascertain the permanency of this type of junction.

It has been found possible to join minor to major moles, without the former being completely blocked, by making the angle of junction about 30°, providing the minors and majors are pulled at the same depth. Whether this procedure will stand the test of practical conditions is at present the subject of a trial laid down last November. Further trials will be carried out in the coming season. If effective under practical drainage conditions, this method will save a considerable amount of labour under conditions to which it is suited.

When the major mole is at right angles to the minor, the latter is completely and equally blocked on both sides of the major. Pulling the major at an angle of 45° results in a thinning of the blockage in the minor on the side from which water passes from the minor to the major. As the angle of junction is still further reduced to one of 30°, the minor, although reduced in diameter on the side from which water passes to the major, has a small but clear passage left. The point to be determined by future investigation is whether this passage will persist or become so reduced in size as to be ineffective.

Valuable evidence has been obtained regarding the silting-up of moles as influenced by the time of pulling in relation to the wetness of the ground and the incidence of rain falling following pulling. Contrary to the generally accepted ideas that a heavy fall of rain following pulling is desirable from point of view of flushing the channels, it appears that such conditions are a decided disadvantage and may cause rapid silting up.

It would appear that pulling moles late in the spring is preferable to winter or early spring pulling. It is proposed to make an intensive study of time of pulling in relation to soil and climatic conditions in the coming season. The point appears to be highly important. Its influence on experiments laid down in 1938 is such that at least one of these experiments will have to be repulled.

Work is proceeding on the design and construction of automatically recording flow-meters and rain-gauges requisite for the full experimental study of mole drainage.

During October a visit was paid to Southland, and valuable first-hand information regarding methods adopted there was obtained.

ROOT DEVELOPMENT STUDIES.

W. A. JACQUES.

Studies have continued on the mapping of the root forms and distribution of roots in different soil conditions of a range of pasture plants. No striking differences were found to occur in root systems of rye-grass and white clover when fertilizers were placed at different levels in the soil. Chemical investigations into the storage of plant food in roots revealed that food stored as sugar varied in accordance with the treatment of the foliage and that certain "white roots" appeared to contain the greater portion of the total food reserves. Some initial useful information on the rate of root-system development following different intensities of foliage cutting has been secured with cocksfoot and different types of rye-grass. This work needs repetition to enable the results to be confirmed.

Plants of selection 507, crested dogstail, have been grown in larger quantity and the seed gathered therefrom handed over to the Grasslands Division for further multiplication and testing. This line represents the best type of crested dogstail selected after a number of years of trials.

WOOL METROLOGY.

P. R. MCMAHON.

During the year statistical analysis of results accumulated at the Massey Agricultural College has been continued, and, in addition, the work has been extended to cover other features of sheep-production. Although gross medullation, obvious to the hand and eye, materially reduces the economic value of a clip, other features of wool-production, such as fleece weight, yield, general character, and staple length are capable of more intensive exploitation by the breeder in his endeavours to secure increased

returns. Exploratory work on these aspects of wool-production, their inter-relationships with each other and with the environment, their inheritance, and their possible association with mutton conformation and breed type in the Romney has been commenced.

The results obtained are treated under the following heads :—

(*a*) Medullation Research.

Investigations on the measurement and recording of medullation in Romney fleeces, commenced some years ago and interrupted from 1935 to 1938, have been resumed with a detailed study of sampling and grading technique, sources of error, and a general survey of environmental factors affecting the manifestation of medullation. In addition, a search has been made of records accumulated by the Massey Agricultural College Fleece Testing Department with a view to obtaining information relating to the intensity of the inheritance of this important wool characteristic, thus enabling the cost, in power of selection, of breeding for freedom from medullation, to be estimated.

Statistical analyses of the available records revealed that data could be collected by different observers without introducing error. Errors arising through the sampling of fleeces were found not to influence the grading of a sheep by more than one grade, which was not very serious, and sampling at five points in the fleece gave results substantially as correct as when six samples were chosen.

It has been found that seasonal influences have played a greater part in the occurrence of medullation than was suspected, and 40 per cent. of the total medullation may be attributed to season and 60 per cent. to the individuality of the animal. To get a true measure of the variations due to the individuality of sheep it is essential that these be maintained under precisely the same conditions.

No clear evidence has yet been secured to indicate whether medullation is inherited. In a flock comprised of animals whose fleeces show little medullation, improvement is likely to be very slow; indeed, so slow as not to justify attention being devoted to improvement. If, however, rams showing a high degree of freedom from medullation are used with low-testing ewes, their progeny will show sufficient improvement in their fleece characters to make the effort economically sound.

The presence of halo hairs in the wool of the lamb is no indication of the degree of medullation which will occur in the mature fleece, nor can the claim that medullated fleeces are the heaviest be substantiated. Nevertheless, there is evidence that seasons of heavy average fleece weight are those also in which the degree of medullation increases. Some breeders claim that medullation is associated with big sheep, but an analysis of data collected did not support this, though it revealed a strong relationship between body weight and fleece weight. Another claim that medullation is associated with the strong constitution necessary for hill-country sheep was tested out in a flock of 700 Romney ewe hoggets and could not be substantiated.

(*b*) Halo Hair Investigations.

Analyses of records of data derived from the fleece coats of some 700 lambs show that simple selection against halo hairs would be almost immediately effective in reducing the amount of medullation. The results also show that the wool characters of the britch areas are the most strongly inherited.

(*c*) Fleece Weight and Quality Investigations.

Examination of fleece weights in a flock showed that the standard deviation for weight of fleece within count groups was of the order of 1·25 lb., which is surprisingly high. Now, as the fleece weight of any sheep remains fairly constant in successive years, and therefore, if the young ewe flock was culled on account of fleece weight, the average of the flock would fairly steadily increase, and, seeing that fleece weight is a fairly strong hereditary character, with the use of progeny-tested rams it would be possible, within a comparatively short period, to increase the average fleece weight by as much as 2 lb. per sheep.

Considerable attention, therefore, is being paid to fleece weight, at the present time, in order to determine what relationships, if any, exist between other fleece characters such as count, general character, length of staple, medullation, age of sheep, and environmental conditions. Such information, when available, will enable an accurate forecast to be made of the effect of intensive selection for any one character, such as fleece weight, on the remainder of the fleece.

(*d*) Yield-determination Investigations.

Although prices are quoted for wool as so much per pound in the grease, these are calculated from the estimated clean scoured yield. To determine the yield of a fleece is almost as important, therefore, as to determine the weight of a fleece and, with the temporary assistance of Mr. J. Godfrey, attempts are being made to secure a micro-method for determining yield which can be applied to samples cut for medullation estimation. If this work is successful we will be in the position to place in the hands of the breeders the means whereby complete recording of the wool quantity and quality can be achieved and, if these be utilized in practice, there seems to be no reason why the spectacular improvements effected by the dairy breeder should not be duplicated in the sheep industry.

(*e*) Relationships between Wool Characters and Body Conformation.

Even for hill-country farms the importance of wool in the production of total gross income is only of the order of 50 per cent., the remainder being made up from the sale of surplus stock. Since returns from the sale of surplus stock are dependent in large measure on characteristics of the animal apart from its wool, it is necessary that wool characters be considered in relation to mutton conformation and breed type. If correlations between fleece and carcass exist they must manifestly be of importance in any programme designed to promote increased returns.

From investigations on the connection between mutton and wool characters, there would appear to be a tendency for animals graded in higher classes for mutton conformation on the hind quarter to carry fleeces of higher grade and quality.

(*f*) Wool Survey Preliminary Investigations.

Although many breeders have definite ideas as to the type of Romney crossbred wool suited to a given type of country, these opinions are sometimes diametrically opposed, and it is hoped that a wool survey can be made to establish as definitely as possible the most suitable types of wool to be grown on different types of country. With this end in view a preliminary survey has been made of the interrelationship of the factors affecting returns for fleece wool by examining 700 fleeces grown on rich Kairanga dairying land, 1,000 fleeces grown on first-class papa-limestone Taihape hill country, and 2,000 fleeces grown on medium to poor quality hill country in the Manawatu district.

Analysis of the data is not yet complete, but some very important relationships are already becoming evident, such, for example, as those between fleece weight and count, fleece weight and staple length, and fleece weight and general character. Fleece weights become heavier by approximately 0·5 lb. for each increase in count in the series 48's, 46's, 44's, 40's, although there is some indication that this does not hold for younger sheep grown on the Taihape country examined. In all cases, however, there is a marked correlation between fleece weight and staple length, and between fleece weight and general character.

(*g*) Constructive Breeding.

In conjunction with Dr. F. W. Dry, an attempt is being made to secure funds to establish a high-quality wool flock along similar lines to those which Dr. Dry has found effective in breeding for bad wool.

(*h*) Manufacturing Experiments.

Quantities of wool differing only in medullation grade and coming from known positions on the animal are being prepared with a view to their being submitted for valuation to an independent authority. In addition, arrangements are in hand for a large scale manufacturing test in collaboration with the Wool Manufacturers' Research Association at Dunedin. The importance of this work cannot be overestimated, since it is aimed to provide the sheep industry with exact knowledge of the requirements of the wool-manufacturer.

PHYSICAL TESTING LABORATORY.

Director: Dr. E. R. Cooper.

The Physical Testing Laboratory was established during the year as a new Division of the Department with the object of bringing together in one organization the Department's staff and facilities for physical research and testing. The functions of the Laboratory are briefly as follows:—

(1) To undertake physical research for the Department of Scientific and Industrial Research and for other Government Departments as required.
(2) To undertake miscellaneous physical tests for various Government Departments.
(3) To undertake physical tests necessary for the formulation and application of industrial standards.
(4) To form a nucleus for a National Standards Laboratory in New Zealand to maintain primary reference standards of measurement.
(5) To design, construct, and repair instruments for physical, geophysical, and chemical investigations within the Department of Scientific and Industrial Research.

The Laboratory, with which is included an instrument workshop, has begun its work at 54 Molesworth Street. The nucleus of the staff had previously been working, under very cramped conditions, at the Dominion Observatory, where it was concerned with the maintenance of observatory equipment; a considerable amount of physical research and testing was also carried out. At the new premises in Molesworth Street there is a large workshop and two rooms which serve as laboratories.

The workshop is equipped with lathes, drill, and milling machine so that precision-instrument work can be performed, but at present in no great quantity. It should be pointed out that it is not the function of the Laboratory to construct instruments in bulk, but only to carry out the initial experimentation necessary to produce a model instrument which could then be copied if desired.

(1) Present Facilities.

The facilities at present available at the Laboratory include equipment for the following purposes:—

General Physics.—Calibration of volumetric apparatus; measurement of small intervals of time; measurement of small dimensional changes—*e.g.*, strain in structural members to 10^{-5} in., the shrinkage of concrete; measurement of mechanical vibrations in buildings; measurement of air movement; determination of elastic constants of metals; the testing of cloth, &c.

Heat.—Temperature measurement to 750° C., shortly to be extended to 1,400° C.; calibration of thermometers from —80° to 400° C. by direct comparison with sub-standards covering this range; thermostatic control and humidity control; thermal insulation measurements on building-materials, including refrigerator insulants, range to be extended shortly to 0° C. and at mean temperatures up to 1,600° F. Apparatus will shortly be available for the determination of the temperature expansion coefficients of metals and refractories.

Light.—Photometric equipment and sub-standard lamps for measurement of candle-power and lumen output by bench photometer (equipped with Lummer-Brodhun contrast photometer cube) and photometric integrator respectively; portable photometer for rapid measurement of illumination *in situ*; photoelectric cells for light measurements covering range from infra red to ultra-violet; calibration of ultra-violet lamps.

Electricity.—General electrical measurements; calibration of D.C. and A.C. ammeters and voltmeters by direct reference to standard resistances and Weston cell; standard resistances with temperature control covering range 0·02 ohm to 100 ohms; calibration of wattmeters; measurement of magnetic properties of materials; determination of radioactive indicators. Special electrical measurements can be undertaken if required.

(2) Summarized Report on the Year's Activities.

(*a*) *Examination of Possible Substitutes for Cork for Insulation Purposes.*

The following table shows the thermal conductivities of various materials:—

Thermal Conductivities of Pumice, Flax, and Cell Concrete in B.T.U/Square Feet/Inch/°F./Hour.

	Undried.	Dried.	Mean Temperature of Specimen.
Pumice (loose) particle size not exceeding $\frac{1}{2}$ in.	1·3	..	8° C.
,, $\frac{3}{8}$ in.	1·4	..	,,
,, $\frac{1}{4}$ in.	1·5	..	,,
,, $\frac{1}{8}$ in.	1·5	..	,,
Pumice (loose) particle size between $\frac{1}{2}$ in. and $\frac{1}{4}$ in.	1·1	..	,,
,, $\frac{3}{8}$ in. and $\frac{1}{8}$ in.	1·2	..	,,
,, $\frac{1}{4}$ in. and $\frac{1}{16}$ in.	1·2	..	,,
,, $\frac{1}{4}$ in. and $\frac{1}{8}$ in.	..	1·0	,,
Pumice concrete particle size between $\frac{1}{2}$ in. and $\frac{1}{4}$ in.	2·3	..	45° C.
,, $\frac{1}{4}$ in. and $\frac{1}{8}$ in.	2·0	..	,,
,, $\frac{1}{8}$ in. and $\frac{1}{16}$ in.	2·5	2·0	,,
Flax waste packed at optimum density 5 lb./cu. ft.	..	0·5	,,
Cell concrete of density 18·9 lb./cu. ft.	..	1·2	,,

The conductivity of cork is about 0·3 in the above units.

The thermal conductivity of pumice concrete, which consists of pumice fragments bonded together into a concrete, can be reduced by 20 per cent. by efficient drying. The moisture-absorbing properties of these materials have also been investigated.

(b) Distribution of Artificially Radioactive Materials in Plants and Animals.

(i) *Manganese.*—Radioactive manganese* obtained by deuteron bombardment of iron in a cyclotron was injected into a Sturmer apple-tree at the Plant Division Diseases Laboratory, Auckland, and the distribution after one month was tested by means of an ionization chamber specially designed by Dr. Marsden. The tree was divided into portions, dried, and pulverized. The tests were made, and then repeated after the various portions were ashed. The process of ashing was shown to have negligible effect on the Mn content. The Mn was subsequently recovered chemically. When the results were reduced to milligrams of Mn per gram of dried material it was shown that the Mn became concentrated in the leaves and tips of the branches.

(ii) *Cobalt.* Diseases of stock in New Zealand of the bush-sickness type have been shown to be due to a deficiency of cobalt in the soils and pastures, and to be cured by supplying the deficiency of that element. Little or nothing is known, however, of the metabolism of cobalt in the animal body, and it was thought that the administration of radioactive cobalt might throw some light on this problem. Dr. Marsden and Mr. Watson-Munro, in collaboration with Dr. Filmer, Acting-Director of the Animal Research Division, Department of Agriculture, initiated experiments during the year in which selected sheep were injected with a solution containing radioactive cobalt.* From these experiments, which were carried out under the direction of the Cobalt Committee, interesting preliminary data have been obtained, but further confirmatory work is required, and it is hoped to carry this out during the coming year.

(c) Facial Eczema: Physical Investigations.

Routine measurements of soil temperature, soil moisture, and solar radiation have been instituted on behalf of the Department of Agriculture at the Ruakura Animal Research Station, and an officer temporarily appointed to do this work at Ruakura is directly under the supervision of this Laboratory. The meteorological observatory at Ruakura has been placed on a new site and its daily observations extended to include continuous measurement of soil temperature at 4 in. and 8 in. depths and of total solar radiation. Daily measurements of soil moisture are also being made by an electrical method. Continuous observations of red and blue solar radiation have been made this year, and valuable comparisons of these with total solar radiation are now available. It is intended to erect apparatus for the continuous measurement of ultra-violet solar radiation, also an evaporimeter for the measurement of evaporation. As part of this work there have this year been issued to the Department of Agriculture fortnightly reports on air and earth temperatures; the importance of these data in relation to facial eczema was established by an examination of the data on air and earth temperatures available for the North Island from 1915 to 1939. It was shown that outbreaks of facial eczema occurred in those seasons when air and earth temperatures and vapour pressure were abnormally high. The object of the fortnightly reports prepared this year was therefore to warn farmers of abnormal weather conditions which, to date, have been associated with the disease.

Full information on this section of the work will be published in the June issue of the *New Zealand Journal of Science and Technology* (Agricultural Section).

(d) Tests for other Government Departments.

(i) *Public Works Department.*—An examination of the vibrations transmitted by various machines in the Government Printing Office to the building in which they are housed was made in collaboration with the Public Works Department. This investigation was undertaken to derive design data for the proposed new Printing Office.

Six 1,000 watt lighthouse lamps were submitted for test. The candle-powers of these lamps were measured in specific directions by means of the bench photometer. The lamps are to be run under service conditions for one thousand hours and then retested to discover their loss of efficiency.

(ii) *Railways Department.* Experiments were made to discover the maximum temperatures existing under working-conditions on the inner surfaces of the concrete walls and floor which, situated below floor-level, enclose the flue of the Sesci furnace.

A gauge has been designed and constructed to measure the strain, correct to 0·00001 in., existing between points 1 in. distant on a welded steel arm when this is subjected to stress in the Avery testing-machine at the Hutt Railway Workshop. The work is being done in collaboration with the Chief Engineer, Railways Department.

(iii) *New Zealand Standards Institute (Department of Industries and Commerce).*—The strengths and moisture-free weights of samples of plaster-board manufactured by various firms in New Zealand were tested for the purpose of drawing up a standard specification for such boards. Tests were also made of the comparative bending strengths of seven different types of steel fencing-posts.

(iv) *Defence Department.* A considerable amount of work has been done for the Defence Department, including the testing of materials, and the design, construction, and repair of instruments.

(v) *Miscellaneous Investigations.*—(*a*) X-ray Examination of Delicious Apples for Mouldy Core: X-rays were generated at voltages ranging from 40 kv. to 85 kv. with a platinum anticathode. The shadow produced by the apple was examined on a zinc sulphide fluorescent screen placed about 18 in. above the X-ray tube. Under these conditions the detail observed on the screen was judged to be clearest when the screen was in contact with the fruit. After some practise it became possible to recognize apples badly affected with mouldy core, but to do so it was essential to be able to rotate

* Supplied to Dr. Marsden by courtesy of Dr. Seaberg and Dr. Livingood, of the University of California.

the apple in the X-ray beam. The method was not considered of commercial value. The co-operation of Mr. J. M. Graydon (Messrs. Watson Victor, Ltd.) and the Superintendent of the Public Hospital, Wellington, is gratefully acknowledged.

(*b*) Control of Conditions obtaining in a Cheese-curing Room: Some help was given by the Laboratory to the Dairy Research Institute in this connection. An experimental curing-chamber was built to control humidity and temperature, and to produce air movement of a definite amount past the cheese.

(3) Publications.

The system of issuing bulletins has been adopted by the Laboratory, and the following were issued this year:—

No. 1.—"The Flexural Strengths, Elastic Limits, and Moduli of Elasticity of some Fibrous Boards," by C. N. Watson-Munro. *N.Z. Jour. Sci. & Tech.*, *21*, 101B.

No. 2.—"X-ray Detection of Mouldy Core in Delicious Apples," by L. W. Tiller and E. R. Cooper, *N.Z. Jour. Sci. & Tech.*, *21*, 168A.

No. 3.—"Climatic Factors relating to Outbreaks of Facial Eczema in New Zealand," by E. R. Cooper and D. Walker. To appear in June, 1940, issue of *N.Z. Jour. Sci. & Tech.*

(4) The Maintenance of Primary Reference Standards, and their Application to Industrial Standards.

Liaison has been established with the standards organization of the Council for Scientific and Industrial Research, Australia, and it is hoped, as soon as it is practicable, to establish a sub-testing station at Wellington, under the direction of the Department of Scientific and Industrial Research, equipped with sub-standards of special importance to New Zealand manufacturers.

(5) Design and Construction of Instruments.

The workshop has been very active, and is satisfying numerous and varied demands by the branches of the Department. Skilled instrument mechanics are few in New Zealand, and cadets are therefore being trained in the workshop so that eventually a team of mechanics with the requisite background of scientific knowledge will be obtained.

Some of the major items of instrument construction which have engaged the workshop staff this year are detailed below. In addition to this work, however, innumerable small items of instrument repair have been dealt with, and the service rendered has undoubtedly proved very useful to the various departmental laboratories. Radiation solarimeters for facial-eczema investigation, Ruakura; time chart exhibited by Dominion Observatory at the Exhibition; N.P.L. type, thermal insulation apparatus; two needle valves and flowmeters; millivolt potentiometer for field use; voltage doubler; voltage stabilizer; balloon rollers; switch panel; set of switch arms; repair of 100 binoculars; strain gauge to measure 0·00001 in.

DOMINION LABORATORY.

Director: W. Donovan.

The Dominion Laboratory is an institution combining the functions of a Chemical Service and a Chemical Research Laboratory. For many years it has carried out the chemical work required by all Government Departments, except Agriculture and to some extent Railways, in the course of their administration, and, in covering the wide field involved, has built up a staff with special knowledge in many branches of chemistry, and a well-chosen reference library. This, and the accumulation of varied and valuable equipment over the years, has put the Laboratory in an excellent position for undertaking the chemical portion of such researches as those on kauri-gum, phormium, active principles of plants, and spray treatment. The Coal Survey Section is engaged principally in research, and the Gas Storage and Chemical Engineering Sections entirely so. A Spectrographic Section is well equipped for routine determinations and for research. The specialized knowledge of one section is often very helpful to another, and the staff of the entire Laboratory works in fullest co-operation. The main Laboratory is situated in Wellington, and there are branches in Auckland, Christchurch, and Dunedin.

Work for Government Departments.

During the year 25,997 samples were examined for thirty-three Government Departments. The figures for the various centres are—Auckland, 11,218; Wellington, 7,541; Christchurch, 4,844; Dunedin, 2,394: Total, 25,997.

A test for the efficiency of the pasteurization of export butter is carried out in the Auckland Laboratory, but not in the other branches, and this has helped considerably to swell the Auckland total. The work for the majority of the Departments has followed the usual lines during the year, and there is nothing special to report regarding that undertaken for Customs, Labour, Main Highways, Post and Telegraph, Prisons, and many others.

Defence.

For this Department there were numerous examinations of ammunition components, and a report was furnished on water-proofing of tents. Water and milk supplies to military camps have been tested.

Department of Health.

Milk.—A total of 13,142 samples of milk were submitted by Inspectors of Health at the four Laboratories, and examined for compliance with the regulations. In Auckland there was a marked increase in the number of samples containing added water. In Wellington the proportion of milks not complying with the standard was about the same as in the previous year, and may be regarded as satisfactory. The Government Analyst at Dunedin reports: "The number of milk-samples taken shows a further considerable increase over those taken in the two preceding years. The proportion of watered and stale milks and of milks slightly below the standard was considerably lower than in 1938, while the proportion of samples deficient in fat increased slightly. No preservatives were detected in any of the samples." The Government Analyst, Christchurch, reports close co-operation with the Departments of Health and Agriculture, which has led to a steady improvement in conditions on farms and dairies. The percentage of unsatisfactory samples is reported as small, and the opinion is expressed that, "Provided adequate sampling is maintained, defects in the supply can be quickly located and remedied." The experience of all the centres would confirm this opinion.

Particular attention has again been paid to the purity of milk supplied to school-children, and to the efficiency of pasteurization.

Water. Regular examination of water from town supplies and other sources, for domestic use, was continued during the year. In all, 556 samples were submitted, including some from military camps.

Foodstuffs. Foodstuffs examined were again in considerable numbers and great variety. There was an extensive search for preservatives, which were found to be illegally present or in excessive amounts in some prepared meats. In Auckland, whole-meal flour and whole-meal bread were subjected to critical survey. In general, the foods examined complied with the Regulations.

Drugs and Medical Preparations.—These comprised camphorated oil, lime water, olive oil, ointment, tincture of iodine, tablets, and preparations of various descriptions. Christchurch reported extravagant advertising in connection with goitre remedies and a wheat-germ food. The position regarding improper advertising is very unsatisfactory.

Special Investigations.

Atmospheric Pollution, Waiuta.—An investigation was commenced of atmospheric pollution at Waiuta, resulting from the roasting of arsenical pyrites. Alterations to the plant for the treatment of waste gases have been made, and further improvements are under consideration.

Dunedin City Baths. An investigation of eye-infection at the baths revealed that the trouble was not due to excessive chlorination, as had been supposed, but to insufficient control of the pH of the water. When this was increased from 3·8 to 7·2 the trouble disappeared. A marked improvement in the clarity of the water also resulted.

Canning of Toheroas.—Following a complaint from Great Britain that excessive amounts of tin, lead, and zinc had been found in New Zealand canned toheroas, and that copper and arsenic were also present, careful analyses were carried out in Wellington. The proportions of metals found were not higher than normal for shell-fish generally, and the high figures obtained in Great Britain were not confirmed. Inspection of the canneries revealed no likely source of metallic contamination, and it seems evident that, where reasonable care is taken, canned toheroas do not contain metals in injurious amounts.

Succinic Acid in Beer.—Succinic acid is a normal product of fermentation, but, being in small quantity, is seldom detected in the routine examination of beer. It was present in one sample in sufficient quantity to interfere with the determination of preservative. A short investigation followed, and a note on the subject has been forwarded to the *Analyst*.

Industries and Commerce.

The materials examined for the Department of Industries and Commerce were commercial products having a relation to New Zealand industries, and were submitted chiefly by the Technical Advisory Officer.

Mines Department.

The Mines Department is concerned, directly or indirectly, with all the mineral work carried out in the Dominion Laboratory. Prospectors' samples were again few in number, and of comparatively little value. The possibility of the development of deposits of non-metallic minerals is being more generally recognized, and special attention has been given to uses of bentonite, feldspar, serpentine, and various types of clays. The most outstanding work on the mineral side has been the regular analyses of Onekaka iron-ore and Patea black sand, for the Iron and Steel Department. Iron was determined in 1,142 samples, and fuller analyses made when required. Twenty-six samples of limestone adjacent to Onekaka were also analysed, and one sample of dolomite from Mount Burnett. Forty-six mine airs from various collieries were analysed. The Department has been active in support of the work of the Coal Survey detailed below.

Police.

The most interesting investigation for the Police was carried out at Auckland, the problem being that of identification of clay, in connection with a case of arson in which human remains were found after the fire. A heavy claim for insurance was involved, and it was suspected that the remains were those of a body obtained by robbing a grave. For proof it was essential that the grave be located. Clay found on a shovel left by the accused was compared with clay from twenty-eight cemeteries in the district, and, as a result, one cemetery was selected for closer investigation. Examination of clays from different parts of this cemetery narrowed the search down to a certain area. Exhumation of the only grave in this area of a required date revealed an empty coffin.

As far as can be ascertained, an entirely novel method was used in the examination. The clay on the shovel contained four varieties of diatoms, and counts of these enabled the grave to be located. Confirmatory evidence was obtained from surface factor of the clays, true specific gravity, sedimentation test with particle count, and malachite-green absorption.

Gas-inspection.

The major town gas-supplies of the Dominion were tested regularly throughout the year for calorific value, purity, and pressure. With one or two exceptions for which there was adequate explanation, all complied with the regulations on every occasion. Gas-meters tested totalled—Christchurch, 3,841; Auckland, 5,629; Wellington, 12,518.

Research.

Chemical Engineering Section.

The semi-commercial seed-dryer referred to in the last annual report of the Department proved successful in operation, and drawings for a commercial unit to treat 5 cwt. per hour have been prepared. An inexpensive experimental sample drying-plant was designed for the Plant Chemistry Laboratory, and is quite effective for the purpose. At the request of the Air Department, the Assistant Chemical Engineer was sent to Australia to investigate the operation of the C.F.R. engine for determining the knock rating of aviation fuels, and one of these engines is now installed at the Laboratory. Tests of aviation fuel supplied to the Government are now regularly carried out. Since the outbreak of war the staff has been fully occupied, in association with officers of the Public Works and Transport Departments, with work relating to the use of producer gas as a substitute for petrol for motor-vehicles. This has involved the thorough testing of producers already on the local market, and the design of one of simplified form, also the examination of various fuels available. The investigation has been greatly facilitated by the co-operation of the Director of the Wellington Technical College in granting the use of the College dynanometer, and providing facilities for its operation.

Coal Survey.

Details of the organization of the Physical and Chemical Survey of the coal resources of New Zealand were published in last year's annual report. The field staff has proceeded during the year with geological surveying and sampling programmes in the Greymouth coalfield covering the Liverpool, Strongman, Paparoa, Wallsend, Dobson, and a number of smaller co-operative mines. The Coal Survey Laboratory staff has been engaged on full analyses of the samples forwarded, and has at the same time conducted investigations into a number of survey and general problems.

An investigation was made as to the suitability of certain fuels for dust-firing. Float and sink tests were carried out to determine the washing characteristics of Liverpool coal. Twenty-one samples of Liverpool slack (minus ½ in.) from various parts of the mine were analysed to study variations in ash content. A number of ash-fusion-point determinations and ash-analyses have been made on various coals in an endeavour to investigate some of the factors responsible for clinker formation. A report was made on the distribution of sulphur in the products of carbonization.

Contact has been maintained with the Iron and Steel Department regarding supplies of coal suitable for making metallurgical coke. If supplies are to come from local sources, drastic conservation of the Dominion's low-sulphur coals would appear necessary.

Some work has been carried out relating to the fuller use of local coals in the gas industry, and cases of complaint investigated. The reactivities of charcoal and coke from various sources are being investigated in order to determine their suitability for use in portable producer plants.

Gas-storage of Fruit.

Investigations have been commenced this year on the gas-storage of apples of the Jonathan and Sturmer varieties. The results obtained have been very encouraging and indicate that gas-storage gives considerable improvement in the keeping-qualities of these varieties as compared with ordinary cool-storage. A fuller account of this work appears under "Fruit Cold Storage Research."

Paint.

Increasing use is being made of the facilities available at the Dominion Laboratory for the examination of paints and related materials. Numerous analyses were carried out for the Department of Housing Construction, the State Advances Corporation, Public Trust, Public Works, Post and Telegraph, and Railways Departments. Most of these Departments now purchase to specification, and it is satisfactory to note that, as a result of regular analytical control, there has been a very decided improvement, compared with the previous year, in the quality of the paints purchased.

The most severe handicap to the testing of paints is the lack of reliable methods for the analysis of the more modern types of vehicles, but information and experience in this direction are being gradually acquired. In this connection a standard brushing-out test was introduced during the year, and has proved very useful.

Several cases of paint failure were investigated. The examination of paint-scrapings in one instance led to the conclusion that the rapid "fading" of the paint film was a chalking effect, probably due to abstraction of oil from the finishing coat as a result of improper priming or undercoating treatment. Titanium, a notoriously bad chalking pigment, was present, but not in excessive amount, and could hardly have been responsible for the failure. The use of small amounts of titanium appears to be on the increase, and its use, in limited amount, is permitted by at least one Government Department, though it is usually not looked upon with favour owing to its chalking tendencies when present as a major constituent of ordinary linseed oil paints.

During the year a tentative "Specification for Ready-mixed Paints for Finishing Coats for Woodwork (Light and Cream Tints)" was decided upon, after consultation with several manufacturers, by the Wellington Interdepartmental Committee for Paint Investigation. Using this specification as a basis, house-painting trials upon several pigment-oil combinations were initiated, all the materials used in the investigations being subject to careful analytical control.

The Laboratory has co-operated with the Public Works Department in the development of priming and finishing paints for steelwork, and has examined aluminium paints and micaceous iron-ore samples of different origin for the Railways Department. It has again been possible to give assistance to the Standards Institute in the development of standards for paint material.

Several cases of gross adulteration of paint were met with, and in one instance the use of an inferior grade of linseed oil. Lithopone was found in several undercoating and finishing paints, but is not regarded as an ideal pigment for exterior use. The necessity for continued investigation into paint is fully demonstrated.

Building and Constructional Materials.

Investigations into materials used by the building and allied industries were continued during the year. For the Department of Housing Construction tests were made on roofing tiles, concrete, cement plaster, wallboard, distemper, galvanized wire, and roofing iron.

In connection with the issue by the New Zealand Standards Institute of a "New Zealand Draft Standards Specification for Reinforced Concrete Pipes," a comparison was made of the American, British, Australian, and New Zealand methods for the determination of water-absorption, as a result of which it was possible to make recommendations as to the best procedure to adopt. Preece tests on galvanized fencing-wire and on wire-netting were made for the Fencing-wire Sub-committee of the Standards Institute, while assistance was given to the Public Works Department in the development of a mandril test for the quality of the zinc coating on crimping wire.

A report on the condition of cement asbestos pressure water-pipes that had been in service for some years was made for the City Engineer, Christchurch. The work was made necessary owing to disturbing reports from elsewhere as to the deterioration of this type of material, but the investigation showed clearly that, from the chemical aspect at least, there was no evidence of appreciable deterioration of the pipe, either on the inside or outside.

For the Lyttelton Harbour Board samples of mud from the harbour-reclamation works were examined, with special reference to suitability for the manufacture of Portland cement or bricks. Work on the evaluation of clays and other ceramic materials was continued.

Corrosion.

For the Public Works Department an examination of mineral waters from the Taupo district was made in order to ascertain whether or not they would be harmful to Portland cement concrete.

An examination of the condition and composition of concrete from the flue-casing and recuperator in the Sesci furnace at the Hutt Workshops foundry was made for the Railways Department.

Several corrosion problems were investigated. These included three cases of corrosion of lead-cable sheathing for the Post and Telegraph Department; the corrosion of a Diesel-engine cooling-system by circulating water for the Public Works Department, and corrosion of Alclad aircraft parts for the Lockhead Aircraft Corporation.

At the request of the Public Works Department visits were paid by a member of the staff to Temuka, Waitaki, and Napier in order to investigate the possibility of deterioration of concrete structures, such as dams, irrigation channels, and concrete pipes, by waters containing aggressive carbon dioxide in solution. Tests were carried out on the spot and samples collected at each locality for examination at the Laboratory. In no instance was evidence obtained that would indicate possible danger of excessive attack of the water on concrete.

Spectrograph Section.

Experience in the use of the quartz spectrograph has indicated the methods most suitable for local requirements, and the application of these methods, in conjunction with general laboratory work, has continued on the lines mentioned in last year's report. With the facilities now available better use can be made of the small visual spectrometer, and in several cases a rapid qualitative examination with this instrument has given sufficient information. Corrosion problems continue to require investigation, and considerable work was done in a case of corrosion of aluminium in aircraft. It was found that a more rapid method of determination of strontium for rock analysis was desirable, and, instead of using pellets, a drop of solution containing potassium sodium tartrate as spectroscopic buffer, dried on in a cup in a copper electrode, was subjected to spark excitation.

A spectrographic examination of samples of "fused" pine-needles indicated that this condition might be due to a deficiency disease, but as a sample of diseased needles from only two areas were compared with healthy samples from four areas further work is required to test the conclusions. Work was continued on the determination of minor elements in standard samples of pastures. In preliminary work, comparison of the results by spectrographic and chemical methods for cobalt, copper, and manganese showed on the whole good correlation. Determinations of seven minor elements have been made on the pasture samples, and preliminary results obtained for another seven.

A paper on the equipment, technique, and applications of spectrographic analysis in the Dominion Laboratory has been published in the *New Zealand Journal of Science and Technology*.

Kauri-gum.

Investigations carried out in England have resulted in the development of a successful process for the purification of kauri-gum of low grade. This pure uniform product has been produced in three grades, and further studies of its properties at the Paint Research Station, Teddington, followed by practical commercial trials in England, have shown it to be entirely suitable for use in high-grade varnishes. It has also been shown to possess properties which make it specially suitable for use in mat surface lacquers and in spirit-type varnishes employing certain lesser known solvents. The position now is that if the purified material were produced continuously in commercial quantities a good demand for it would probably be found; on the other hand, failure to exploit the process will probably result in further decline in the kauri-gum industry and the ultimate permanent burying of large quantities of gum through the development of the gumlands for farming purposes.

Phormium tenax (New Zealand Flax).

The chemical examination of a number of varieties of fibre has been completed. Certain differences have been revealed which would indicate that some of these varieties are likely to yield fibre possessing greater durability than others.

Phormium Fibre as Reinforcement for Plaster Wall-boards.

When commercial grades of phormium fibre are use for fibrous-plaster wall-boards stained areas appear on the surface of the boards. It has been shown that the staining is caused by excessive amounts of water-soluble substances in the fibre due to incomplete washing at the time of milling. The occurrence of the staining might be aided by the use of alkaline retarders used in the plaster mixtures.

If the fibre is well washed at the time of stripping or, if fibre as at present produced is soaked in a weak alkali bath, such as ammonia, ammonium carbonate, or sodium carbonate, and then washed in water, it will not cause staining in plaster boards.

Ragwort.

The alkaloid content of ragwort from areas near Hamilton, the Hutt Valley, and Southland has been determined at regular intervals in order to ascertain whether certain seasonal fluctuations, previously observed, are of a regular nature each year.

Samples of large rosettes from Southland, collected during the period July, 1939, to March, 1940, had an alkaloid content comparable with samples from the North Island areas. These Southland samples, therefore, possess a considerably higher toxicity than did samples obtained from Southland during the last four months of 1937.

Further comparisons have been made between fresh ragwort and similar material included in an ensilage stack and recovered eight months later. The alkaloid content of various samples decreased by amounts varying from 50 per cent. to 60 per cent. of the total. Similar experiments in 1937 showed a decrease of about 90 per cent. in the alkaloid content four months after the making of the ensilage. It seems probable that the decomposition of the alkaloid depends on the type of ensilage and the method of making. Experiments on similar lines are being made with ragwort hay.

Analyses have shown that plants collected in December, from the rosette to the early flowering stage, all contained 0·2 per cent. of alkaloid in the leaves; plants in full flower at this time contained 0·17 per cent. in the leaves (values expressed on dry weight). The alkaloid content of all leaf samples was about one-third higher than that of the stalks. Ragwort seeds contained only 0·04 per cent. alkaloid.

A supply of the pure alkaloid is being accumulated with a view to carrying our feeding trials on farm animals.

Medicinal Plants grown in New Zealand.

Digitalis purpurea. Material collected from the Hutt Valley was assayed by the chemical method of Knudson and Dresbach and gave the following results (expressed in International units per gram of dry powder): Leaves, 9·8 to 10·3 units; flowering stalks, 14·0 units. Digitalis of the British Pharmacopœia contains 10 units per gram.

Datura stramonium.—Material growing in Wellington contained 0·34 per cent. of alkaloids calculated as hyoscyamine. The stramonium of the British Pharmacopœia contains not less than 0·25 per cent. of alkaloids calculated in the same manner.

Gentiana corymbifera.—This plant is a native of New Zealand and has been compared with the official *Gentiana lutea.* From the young roots the extractives either with alcohol or water amount only to some 20 per cent., but the aqueous extract is about three times as bitter as an extract from the same weight of the official drug. The native species contains a new glucoside which is being examined further.

Spraying Materials.

Analyses have been carried out as a check on the quality of certified spray products. In all cases samples conformed to the requirements. Derris samples were tested for ether extract and for rotenone; the latter was determined by extraction with cold chloroform, crystallization from carbon tetrachloride, and purification with alcohol. Three samples submitted contained only 0·06 per cent. rotenone, and the crystallization of the rotenone from these three samples could only be obtained after addition of pure rotenone. Other samples varied from 0·2 per cent. to 1 per cent. of rotenone.

Further work was carried out on sixty samples of pyrethrum flowers, the content of pyrethrins I and II varying from 0·4 per cent. to 1·8 per cent. Mercury seed dusts were also examined.

Analyses of samples of colloidal sulphurs (original sulphur content of 25 per cent.) which were collected in orchards served to show that there is a grave risk of inadequate mixing of bulk samples in orchard practice. One sample taken from a half-emptied keg of colloidal sulphur showed 55 per cent. of sulphur, while another sample from a previously unopened keg which was shaken for one minute, gave a sulphur content of 22·5 per cent. Hence adequate mixing prior to use in the orchard is a very important factor in securing satisfactory control.

Thermal Regions, White Island.

During April, two members of the staff made a visit to White Island, again in co-operation with Dr. P. Marshall. On this occasion five days were spent on the island. Samples of gases, condensed steam, and waters were brought back for analysis. A method had been devised for collecting samples of gas from fumaroles, and this was found to work satisfactorily. The presence of hydrochloric and hydrofluoric acids in the magmatic steam, as indicated by the analyses of samples from fumaroles, would make difficult the utilization of steam obtained by boring for the evaporation of sea-water to produce salt.

Library.

Facilities have been considerably improved during the year by the provision of another room to house bound volumes of periodicals. The former congestion has been to a large extent relieved, and facilities for reading and writing provided for the staff.

Accessions for the year have been fewer than usual, both owing to restrictions in funds and to the fact that a large proportion of foreign literature is no longer available. Books received during the year total about 100, while the number of periodicals (including annual reports and bulletins) regularly received is 91.

The subject index of articles from journals, books, periodicals, and other information now amounts to over seven thousand entries. The compiling of a catalogue and shelf-list is being undertaken.

A monthly list of publications received in the library is now circulated to all members of the staff.

Increased co-operation has been made possible between the Laboratory library and that of Head Office following on the appointment of a librarian to the latter.

Service on Committees and Consulting Work.

Several senior members of the staff represent the Laboratory on various inter-departmental committees, according to their specialized knowledge, and undertake their full share of the work and responsibility involved. They also deal with numerous requests for information on scientific and industrial matters, many from the general public, and furnish reports when required. In such work the library is proving invaluable.

GEOLOGICAL SURVEY BRANCH.

REPORT OF DIRECTOR (Dr. J. Henderson).

During the year ended 31st March, 1940, official visits were made to Onekaka, Greymouth, Charleston, Lyell, and Reefton. A summary account of the Alpine mine at Lyell appears in this report.

Mr. M. Ongley worked with Dr. Lillie in the Dannevirke district. Later he visited Tokatoka, North Auckland, and collected samples from critical sections in the Gisborne and Hawke's Bay regions; summary accounts of the results of his work are included here.

Dr. J. Marwick completed the manuscript of, drew illustrations for, and supervised the preparation of the photolithographic drawings of the maps to accompany the bulletin describing the Te Kuiti Subdivision now in the press. He named the fossils of many collections made by the field officers. With Dr. Finlay, he wrote an account of the subdivision of the New Zealand Tertiary and Cretaceous rocks.

Dr. H. J. Finlay made many determinations of the foraminifera in samples sent in by the field officers and by oil companies. He also prepared descriptions of key species of foraminifera found in the Cretaceous and Tertiary formations of New Zealand.

Dr. C. O. Hutton worked chiefly on the rocks and rock slides of the Otama intrusive mass of the Wakaia Subdivision. He visited the area and collected samples from critical points.

Mr. H. E. Fyfe, assisted by Messrs. R. J. Bagge, M. Gage, W. E. Hall, and others, continued the detailed mapping of the Greymouth coalfield. Unfavourable weather again greatly hampered field-work, which it is hoped to complete next season.

Dr. A. R. Lillie extended geological mapping over unexplored parts of the Dannevirke Subdivision. The examination of this district, begun in 1936, has been greatly delayed owing to long leave being granted to several of the officers engaged. The field-work will probably be finished next season.

During the winter Mr. R. W. Willett worked on the manuscript of the Glenorchy Bulletin, which is now well forward. In November he began field-work in the Orepuki Subdivision, a district containing deposits of alluvial gold, coal, and oil-shale. With Mr. Wellman, he prepared a report on the oil-shale, which is shortly to be published in the *New Zealand Journal of Science and Technology*.

In an endeavour to bring the Geological Survey into closer touch with the economic problems of the day, officers of the Survey have examined a number of deposits of mineral substances likely to be of use in New Zealand industries, though not themselves of high intrinsic value. Mr. E. O. Macpherson, after preliminary investigation, recommended that the bentonitic clays of the Porangahau district be trenched and sampled, a work carried out by Mr. R. G. Coventry. Mr. Macpherson also examined deposits of white-burning feldspathic clays at Kaka, in Nelson, and these Mr. B. L. Taylor is now prospecting and sampling. Other deposits examined are those of manganese ore near Auckland and the barite-fluorite deposit near Baton Saddle. Mr. Macpherson also traversed the east shore of D'Urville Island and the coast of Croixelles Harbour in search of chromite, and prepared a reconnaissance map showing the distribution of serpentine on the former. He visited Waihi, Thames, Manukau North Head, and Great Barrier Island.

Mr. J. Healy mapped in detail, and prospected by boring, the sulphur deposits at Rotokaua, near Taupo. His report is to be published in the *New Zealand Journal of Science and Technology*. During the winter he worked on the manuscript of the bulletin describing the Wakaia Subdivision.

Other officers examined deposits of commercial or possible commercial value. Mr. M. Gage studied the iron-ores of Onekaka, and advised prospectors for gold deposits in their work near Brunner and in the Big River area, Reefton. Mr. Fyfe visited the Alphine Mine at Lyell, and the mica deposit at Charleston. Mr. Willett reported on fuller's earth, near Gore, and collected sands to be tested for stream tin at Manapouri. Dr. Hutton took samples of copper-bearing schists outcropping in Kawarau Gorge.

Mr. N. Modriniak carried out geophysical work at Onekaka, where, by seismic methods, he determined the depth of the ore-deposit at a number of points. He also examined dam-sites on the Waikato River at Karapiro, near Cambridge, and at Ohakuri, near Atiamuri, using seismic and magnetic methods.

Mr. H. W. Wellman investigated, by means of seismic and magnetic methods, the oil-shale deposit at Orepuki. During the winter of 1939 he prepared the maps of the Glenorchy Subdivision from aerial photographs and got ready the field-sheets of the Orepuki district.

Mr. A. W. Hampton prepared the photolithographic drawing of the eleven maps to accompany the Te Kuiti Bulletin. He also made plans, sections, and graphs and did much other miscellaneous draughting, including the preparation of a large-scale map for the Centennial Exhibition, mentioned later.

Mr. D. H. K. Ross attended to the different sections of the office work, as well as to the library. He also prepared, chiefly in his own time, the numerous photomicrographs illustrating Dr. Finlay's accounts of the foraminifera.

Last year the thirty-third annual report of the Geological Survey was issued and Bulletins 38 and 39 published. The head office of the Department published Geological Memoir No. 5 by C. O. Hutton, containing an account of the geology of part of western Otago. Members of the staff wrote the following papers that appeared in the *New Zealand Journal of Science and Technology*: "The Titaniferous Ironsands of Patea, with an Account of the Heavy Residues in the Underlying Sedimentary Series"; "Optical Properties and Chemical Composition of Two Micas from Westland"; and a review on R. C. Evans' "An Introduction to Crystal Chemistry," by C. O. Hutton; and "A Glacial Valley, Mount Aurum, Skippers Creek Survey District" and "The Invincible Quartz Lode," by R. W. Willett.

To the "Transactions of the Royal Society of New Zealand," H. J. Finlay contributed "New Zealand Foraminifera: Key Species in Stratigraphy" (three parts); H. J. Finlay and J. Marwick, "The Division of the Upper Cretaceous and Tertiary in New Zealand"; C. O. Hutton, "The Bob's Cove Tertiary Beds and the Moonlight Thrust-fault"; and M. Gage, "The Physiography of the Makara and Karori Valleys." J. Henderson prepared a paper on "Underground Water in New Zealand" that was presented at an assembly of the International Union of Geodesy and Geophysics, held at Washington in September, 1939, and another on "Metasomatic Alteration of the Country of the Auriferous Quartz Lodes of New Zealand" appeared in abstract in Vol. 24 of the "Proceedings of the Australasian and New Zealand Association for the Advancement of Science." He also revised a pamphlet on "The Mineral Deposits of New Zealand" for distribution at the Centennial Exhibition.

The time of several officers was much occupied by work for the Centennial Exhibition. Dr. Marwick spent several months on a scale model of the Rotorua–Taupo region: Dr. A. R. Lillie assisted in this, and Mr. W. H. V. Baker especially had much to do with all parts of its preparation. To illustrate the work of the Geological Survey, Dr. Marwick got together a series of photographs, most of which were taken by Mr. D. H. K. Ross. Mr. A. W. Hampton spent four months in compiling, draughting, and colouring the large-scale geological map of New Zealand that was exhibited, and in preparing data for the forthcoming Centennial Atlas.

DANNEVIRKE SUBDIVISION.

By A. R. Lillie.

Between October, 1939, and March, 1940, the writer mapped in detail some 160 square miles. Since the regions mapped comprise two distinct areas, that of Pourerere to the east of Waipawa and the survey districts of Mangaotoro and Tahoraiti east of Dannevirke, they are discussed separately.

Mangaotoro and Tahoraiti Survey Districts.

The dominant topographic features of this area are the Waewaepa Range, formed of greywacke, and the adjoining Puketoi Range, of sandstones and limestones. The valley of the Mangaotoro separates these two. To the north of the Puketois the isolated mass of Tuturewa, bounded by the deep Mangamaire Stream to the south and the Mangahei Stream to the north, dominates lower surrounding country. The massifs of Paeroa and Ahiweka to the north of the Mangapuaka River mark the southern limit of Takapau Survey District, where the relief is much more pronounced. To the east of the Puketois, Tuturewa, and Ahiweka there is a broad depression occupied chiefly by Ihungia mudstones and separating these hills from the Whangai Range.

A dissected plateau at a height of approximately 900 ft. occurs east of Dannevirke; it has not been traced to the south. A broad terrace at an approximate level of 650 ft. at Dannevirke slopes gently to the Manawatu, where its height is about 600 ft. At points near Dannevirke it can be seen that there are a main terrace and a less marked intermediate terrace some 20 ft. or 30 ft. higher, but the intermediate terrace appears at points to grade into the main terrace. The main terrace can be traced for many miles following the Manawatu and its tributaries. Thus it can be traced far up the Mangamaire Stream into the Tinakire Stream and along the valley flats of the Mangaotoro River. This terrace represents a fairly long period of still stand. There are other lower terraces along the Manawatu and its tributaries, but none of any importance.

Structure.

The syncline of Ihungia mudstones to the west of the Whangai Range is bounded by an anticlinal "high" of Cretaceous rocks, forming a continuation of the Tinui beds mapped by Mr. Ongley in the Eketahuna Subdivision. The Cretaceous, steeply dipping or often vertical beds, in this anticline appear on the map as two long tongues projecting northwards from the south limit of the subdivision. The eastern tongue is continued to the north of the Weber Road by a narrow inlier of Cretaceous shales. The western tongue is not found north of the road, but must be represented by a fault, since part of the Tertiary sequence present in the south appears to be cut out there.

To the west of the anticline succeed beds which, striking usually N. 35° W., dip westwards. They range in age from Tutamoe to Petane and the upper members form the summits of Oporae and Tuturewa, which are continuous with the westward dipping beds of Ahiweka. These beds form the eastern limb of the syncline which is marked in the country to the south-west of Ahiweka. This syncline is continued through Tuturewa to the vicinity of Oporae, where, about a mile and a half north-west of that summit, it is again to be seen, now relatively shallow. There a slight fault occupies the synclinal axis. This syncline is bounded to the west by a fault (Fault A), which in the Mangapuka Stream brings easterly dipping Te Aute limestone against Tutamoe sandstones with a strong westerly dip. On the Oporae massif the same fault has a negligible throw, but occupies an anticlinal crest in the Petane limestones. To the east of Paeroa another shallow syncline succeeds and is visible in the Petane beds. The western edge of this syncline is sharply turned up and a greywacke mass some one mile and a half long and a quarter mile wide is faulted (Fault B) against the Petane limestones. This Fault B is a continuation of the Rangitoto Fault mapped by Quennell in south-western Takapau Survey District. Beds ranging in age from Ihungia (barely visible) to Petane are faulted against the western side of this greywacke mass. The faults bounding the eastern and western edges of the greywackes coalesce and continue to the south-west as a main fault-zone (B) running west of Tuturewa Road. Thence it continues parallel to the Mangaotoro River down the eastern edge of the Waewaepa Range, where it separates the greywackes from the Petane beds that form the Puketoi Hills. The outcrop of Waewaepa greywacke gives at its northern extremity a thin-pointed outline on the map, and a branch of Fault B may also run for some distance along the western edge of the greywackes. Farther south, however, this fault is replaced by a stratigraphic contact between Opoiti conglomerate and greywacke.

Another branch of the Rangitoto Fault (Fault C) diverges westwards to the north of Paeroa, and after running south-west and west-south-west crosses the Manawatu River twice and later reaches the western edge of the Waewaepa greywacke. West of Fault C come marked dip-slopes of Te Aute and Petane beds which give place to a minor syncline and anticline visible in the Manawatu in the vicinity of the Otope Road junction.

As a rule the strike of the beds in the region is approximately N. 30° E. The faults are high-angle reverse faults dipping westwards, and tend generally either to follow the direction of strike of the beds or to run suddenly south-west, transverse to the strike.

Stratigraphy.

Mesozoic (?) Greywackes.—The greywackes of this area are usually indurated, of fine grain and always much weathered. They are cut by joint and shear planes which are covered by thin films of manganese oxides. Bands of fine red chert occur occasionally, and at one locality a thin band of softer yellow mudstones has been observed. No fossils have been found to date.

Cretaceous Series.—The Cretaceous, found north and south of the Weber Road near the Mangatuna Road, is represented by chocolate shales, weathering light grey, which enclose large concretions of hard grey limestone with a honey-coloured weathering. These beds distinctly resemble the Waipawa shales. Occasional beds of glauconitic sandstone are enclosed within the beds of shale.

Bortonian Series.—Adjoining the Cretaceous rocks are sandy dark-grey mudstones of a facies resembling that of the Ihungia. Pyrite nodules are abundant in some parts of the formation and bands of greensand also occur. The mudstones have yielded a Bortonian microfauna. The thickness is probably between 300 ft. and 500 ft.

Ihungia Series.—In the vicinity of the Mangatuna Road junction the Bortonian mudstones pass up into yellow calcareous mudstones which somewhat resemble those of the Weber formation. Dr. Finlay, however, has found that these mudstones contain a microfauna different from that of the Weber and probably representing a special facies fauna of the Lower Ihungia. These calcareous mudstones are not more than 100 ft. or 200 ft. thick. At some localities a sandy limestone band replaces the mudstones, and where present forms a fair marker of the Bortonian-Ihungia boundary. This limestone contains a fauna of pelecypods and abundant corals, which are also to be found in the adjoining mudstones both above and below. At a slightly lower horizon than the coralline limestone there is a similar limestone band containing abundant brachiopods, but this band is less continuous. The Ihungia mudstones above the coralline marker are rather sandy, and there is a passage into the sandstones of the Tutamoe.

Tutamoe Series.—The Tutamoe consists of massive soft grey sandstones. Occasional sandy limestone bands have yielded a good fauna including abundant *Struthiolaria callosa*. The thickness is about 1,200 ft. On the western side of the Cretaceous anticlinal "high" already mentioned a good stratigraphical contact between chocolate shales of the Cretaceous and a sandy limestone with Tutamoe fauna has been observed. The presence of Bortonian on the eastern side of the anticline not far from this contact indicates an extensive overlap of the Tutamoe formation.

Mapiri Series.—It has not been possible to separate the Mapiri formation in this region. It is possible that part of the sandstones classified as Tutamoe and Opoiti are of Mapiri age.

Opoiti Series.—Soft, grey sandstones resembling the Tutamoe have yielded Opoiti faunas. These sandstones are sometimes finely banded, and bands of shelly limestone occur near their base. One of these bands containing greywacke fragments has occasionally been located at the base of the formation overlying the Tutamoe sandstones. On the western side of Waewaepa Range near Otope Stream a sandy conglomeratic limestone rests in direct stratigraphic contact on the greywackes which present an erosion plane dipping westwards at approximately 20°. The Opoiti Series is usually from 1,000 ft. to 1,300 ft. thick.

Te Aute Series. At the base of the Te Aute Series there is a coarse, sandy, shelly limestone yielding, as a rule, a good fauna. The lower part of the limestone band contains abundant pebbles of sandstone, mudstone, and greywacke. Rarer pebbles of calcareous conglomeratic, worm-bored sandstone are derived from the Opoiti and are evidence of strong local erosion of that formation. The Te Aute limestone band varies from 20 ft. to 50 ft. in thickness, but is, in places, represented by less calcareous and less fossiliferous coarse, yellow sandstones. The limestone band is covered by soft, grey sandstones with an orange, weathered surface.

In the eastern part of the region near Oporae the Te Aute appears to be about 1,000 ft. thick, but west of the Waewaepa Range the Te Aute Series attains an approximate thickness of 2,500 ft. and a second limestone band is strongly developed some 500 ft. above the basal limestone.

Petane Series.—Petane rocks are similar to those of the Te Aute Series. East of the Waewaepa Range there are three marked limestone bands, ranging in thickness from 30 ft. to 60 ft. and separated by soft grey sandstones; the series is approximately 2,000 ft. thick. West of the Waewaepas there is only one good shelly limestone band, regarded as the base of the formation. There are also some poor local developments of shelly limestone. Between the basal limestone and the Mangatarata beds there is approximately 800 ft. of Petane beds.

Mangatarata Series. The first appearance of white pumiceous sandstones above the Petane beds is regarded as the beginning of the Mangatarata Series, which consists of grey silts and current bedded pumiceous sandstones interbedded with greywacke gravels.

Pleistocene and Recent. The gravels of the high plateau and main terrace are presumably of Pleistocene age. The later gravels of the low terraces are Recent.

Economic Geology.

The silica sands in the Mangatarata beds have been used in foundry work. The pumiceous silts of these beds could be used in sandsoaps or as a filler in bituminous surfaces.

The shelly limestones of the Te Aute and Petane could be used for agricultural purposes, but are not of high grade.

The gravels of Pleistocene and Recent age are much quarried for road-making material.

Faint oil indications are known only in the region adjoining the Whangai Range. The overlap of Opoiti beds on the greywackes in the Waewaepa Range makes the chances of finding oil-bearing bed in the Dannevirke basin highly problematical.

Motuotaraia North-eastern and Pourerere Survey Districts.

Structure.

East of the Tangatupara Ranges there is a broad synclinal depression of Ihungia mudstones representing the northern continuation of the Akitio Syncline. Between the Whangai argillites of the ranges and the Ihungia mudstones the Wanstead formation is usually present, but longitudinal faulting has obscured the stratigraphical relations.

Some three miles east of the ranges the syncline is interrupted by an anticline which runs north-north-east across Pourerere north-west. This anticline discloses Bortonian bentonite and greensands south of the Kerrytown Road - Farm Road junction, but farther north the special facies of the Lower Ihungia, in the form of yellow calcareous mudstones, appears. The anticline crosses the Pourerere Road where it cuts a low ridge formed of Wanstead and Whangai formations. East of the anticline the Ihungia mudstones reappear dipping gently west or flat-lying. They are capped by Tutamoe sandstones, which form the prominent summits around Omakere Station—namely, Omakere Hill, Trig. C, Trig. A, and Trig. X.

The region between these summits and the coast is very complicated and requires a closer study in the light of micro-faunal evidence. There is an axial rise towards the north and perhaps several cross-faults with an approximate east-west orientation bringing older beds to the surface in the north. One and a half miles west of Clareinch Station the Ihungia mudstones assume a westerly dip, and Cretaceous beds appear to the east, forming a complex anticline. These Cretaceous beds are clearly visible in the upper part of the Mangakuri Stream, but both their structure and stratigraphy is obscure. The rocks are generally faulted and sheared, and slumping hides many of the critical contacts. There appear to be formations exactly resemblimg the Whangai, the Tapuwaeroa, and the Raukumara, as well as bentonite in this anticline. The Cretaceous beds are overlain by the yellow calcareous mudstone facies of the Lower Ihungia.

Along the Mangakuri Road a fault-zone separates the anticline from a thin strip of Ihungia mudstones, but another anticline of Cretaceous mudstones and bentonite again occupies all the country to the east between the road and the coast. The Cretaceous beds can be traced as far as Pourerere, where mudstones, presumably of Ihungia age, are faulted against the eastern margin of the Cretaceous.

The country to the south and south-east of Clareinch Station is occupied by Ihungia mudstones. The presence of gas-springs and earthquake traces at Roundaway Station on the Pourerere Road marks the continuation of the Pourerere fault-zone noted on Mangakuri Road. Thence the Pourerere Fault must extend along the western edge of Frenchman's Cap, where it has a downthrow to the east. A transverse east-west fault with a downthrow to the south probably runs towards the coast from the north of Frenchman's Cap. This outstanding hill is formed of hard, shelly conglomerates and calcareous sandstones of Tutamoe age, which have a steep easterly dip. Succeeding these beds to the east of the summit are softer sandstones and mudstones of Tutamoe age and Mapiri mudstones, which are difficult to distinguish lithologically from the Ihungia. A marked anticline of Tutamoe sandstones reappears about two miles east of Frenchman's Cap.

Stratigraphy.

Raukumara Series.—In a stream some 110 chains north-north-west of Clareinch Station massive dark blue-grey mudstones have yielded abundant *Inoceramus*. These are similar to the *Inoceramus* found in the Whangai Range, and Dr. Finlay reports a microfauna similar to that of the Mangaotane mudstone.

Tapuwaeroa Series.—The lowest part of the beds, here classed as Tapuwaeroa, are well exposed in Mangakuri Stream, 105 chains west of Clareinch Homestead. They consist of greenish white argillite that weathers to a rusty colour, and bands of jade-green sandstone, all intricately folded and sheared. These beds are overlain by carbonaceous sandstone and mudstone with occasional bands of breccia made up of fragments of white argillite. At another locality similar beds pass up into a fine-grained conglomerate containing *Ostrea lapillicola*. Cannon-ball sandstone also occurs. The group, as a whole, is characterized by bands of carbonaceous mudstone and current-bedded grey sandstone and particularly by fine-grained conglomerate of greywacke and metamorphic rocks containing *Ostrea lapillicola* and many fragments of *Inoceramus*.

Wanstead Series.—This consists of fine grey mudstones and bentonitic clays.

Ihungia Series. The special calcareous facies of the lower Ihungia is often present. The higher parts of the Ihungia consist of fine dark grey mudstones.

Tutamoe Series.—Tutamoe microfaunas are recorded by Dr. Finlay from mudstones somewhat lower than the first marked sandstone bands of the Tutamoe. The more characteristic Tutamoe consists of bands of hard sandstone interbedded with mudstones. The sandstones vary in texture from coarse to fine, and there are occasional conglomerate bands. These sandstones have usually a calcareous cement and contain abundant *Amphistegina*. The upper part of the Tutamoe consists of softer grey sandstones.

Mapiri Series.—Bands of pumiceous white sandstone occur at the base and are covered by mudstones similar to those of the Ihungia.

Economic Geology.

The hard Tutamoe sandstones have been quarried for road-making purposes at Frenchman's Cap and beside the Pourerere Road about 140 chains north-east of Omakere Station. These quarries are no longer worked.

Near Roundaway Station on the Pourerere Road there is an old gas-spring which gave a regular discharge for one year after the Murchison earthquake. Earthquake traces 8 ft. to 9 ft. deep were found on this site at the time of the Napier earthquake, and occasional slight discharges of liquid mud still occur.

There is a very large deposit of bentonite along the coast east of Clarcinch Station and north of Poanui Point. Samples taken from this deposit indicate the presence of high-grade material.

OREPUKI SUBDIVISION.

By R. W. Willett.

Field-work was commenced in the Orepuki Subdivision in November, 1939, and by March, 1940, an area of some 180 square miles had been mapped in detail, comprising the entire Longwood Survey District. Adverse weather conditions and heavily bushed country greatly hampered the progress of the survey. Special attention was given to a detailed examination of the Orepuki oil-shale deposits, this work being assisted by seismic and magnetic surveys.

Topography and Structure.

The outstanding topographic feature of the area is the Longwood Mountains, a rounded, flat-topped mass, extending north and south through the eastern part of Longwood Survey District. They range in height from 2,300 ft. to 2,850 ft. Near the northern end the headwaters of the Waimeamea River rise in a low saddle between the Longwoods and Hekeia or Bald Hill, a rounded isolated knob in the extreme north of the area. To the west they are flanked by low flat-topped hills and ridges and extensive river terraces. Along the western base of the Longwoods the Waimeamea River flows south to Te Wae Wae Bay and separates the main mountains from the foothills to the west. Towards the south the Longwood Mountains terminate in a group of low hills occupying the Pahia-Riverton area and forming the coast-line—namely, Round Hill, Pahia Hill, Ruahine Hill, and Oraka Hill.

In the Orepuki area an extensive terrace extends from the coast to the base of the Longwoods, a distance of about three miles. This terrace extends north along the base of the Waihoka foothills and joins the terraces of the Waiau valley, and eastward skirts the coastal hills as far as the Aparima River.

In the lower Waiau Valley are well-preserved and extensive terraces at heights of 35 ft., 50 ft., and 85 ft. that skirt the base of the foothills and the edge of the Waiau River's flood-plain. These terraces meet the coastal terraces at a point a mile north-west of the mouth of Grindstone Creek and form a cliff some 170 ft. high. The streams have cut fairly wide channels in the higher terrace (85 ft.) and have entrenched themselves in narrow channels in the lower terraces. This rejuvenation of the streams can be seen to advantage where the terraces merge, a narrow, deep channel cut in the bottom of the wide upper gully. The coastal terrace extends from Waiau mouth to Monkey Island at the southern end of Te Wae Wae Bay, and ranges in height from 40 ft. to 170 ft. Remnants of a coastal terrace, 30 ft. to 45 ft. in height, can be seen around the headlands and bays between Pahia Point and Colac Bay. Generally the terrace rises from a wide wave-cut platform, which, south of Orepuki, is a prominent feature of the coast-line. The wave-cut platform is always covered with a veneer of rounded igneous boulders, with here and there partly consumed stacks and several almost-stacks. In several places beach gravels are to be found on the terrace remnants. The wave-cut platform is in weathered igneous rocks, except in Te Wae Wae Bay, where the harder sandstones of the Orepuki Series form the platform. Likewise, in the case of the coastal terrace where the soft Orepuki Series have eroded away, the cliffing has been continued on the weathered igneous complex, large unweathered cores being left as boulders resting on a wave-cut platform. In the past the rapid retreat of the cliffs, composed of non-resistant clays and sandstones, has been responsible for the rejuvenation of the main streams, such as the Grindstone Creek, Deep Creek, Waimeamea River, Taunoa Stream, Falls Creek, and Kemp Creek.

The structure of the area is by no means clear, especially in the Orepuki district, where exposures of the Tertiary beds are few. The evidence suggests that the Tertiary beds were laid down on a comparatively level surface cut on the igneous complex, and later folded into a series of synclines and anticlines along a north-south axis. The hypothesis is supported by evidence obtained from geophysical surveys. The Tertiaries were then reduced to a gentle sloping erosion surface, upon which the Orepuki Series was deposited. Along the contact of the Tertiary rocks and the igneous complex, the dips on the basal coal-measures are fairly regular, and, near Orepuki, there is nothing to support the suggestion that it is a fault contact, nor is there any evidence of an overlap on to the granite. The Orepuki Series extend over the Tertiary surface and overlap on to the igneous complex, resting on the fairly

flat surface cut in the complex where the Tertiaries are missing, as, for example, in the area south and east of Orepuki. Two fairly strong north-north-east-striking faults have been observed, one in the Tertiary rocks at the mouth of Grindstone Creek and another along the course of Fryer Creek, where the Waimeamea Series have been faulted against the granite. Macpherson (1938) describes a recent fault striking north-north-west and affecting the Orepuki Series at Round Hill. Exposures along this fault are now obscured by tailings and numerous slips, but from the evidence that can be obtained it appears that the fault controlled the course of the Ourawera Stream after the lower members of the series were laid down. The upper sandstone layer appears to be continuous across the fault. Where the fault was exposed by gold-mining operations the old miners state that it was a clean-cut wall in the igneous basement.

Along the eastern slopes of the lower Waiau Valley the foothills appear to be remnants of higher terraces, 300 ft., 350 ft., 500 ft., and 650 ft. The Tertiary beds are probably faulted against the granite, though the evidence is by no means conclusive. The course of the Waimeamea River seems to be controlled by the original folding direction, its valley being a continuation of the main syncline at Orepuki.

Stratigraphy.

Waimeamea Series.—Blue mudstones, carbonaceous mudstones, the Orepuki oil shale, and brown coal make up the basal Tertiary beds in the area. The mudstone contains a few marine fossils, together with well-preserved leaf impressions, and in the upper beds there are numerous calcareous concretions. The shale, about 4 ft. thick, rests on 10 ft. to 20 ft. of hard brown coal which in turn rests directly on the basal igneous complex. These beds are exposed in the Waimeamea River, Stony Creek, and the Taunoa Creek. Two small outcrops of coal were found near the contact with the basement at the head of Mary Ann Gully. The total thickness of these beds is about 500 ft.

Taunoa Series.—A thin conglomerate band of igneous cobbles and some white argillite cobbles separates this series from the underlying Waimeamea Series. This conglomerate band is exposed in Taunoa and Stony Creeks, where the Taunoa Series is best seen. The rocks are a thin band of mudstone passing up into a hard, well-compacted fossiliferous sandstone. The fossiliferous sandstone outcrops in the lower Waimeamea River, as well as in the previously mentioned streams. The thickness of the Taunoa Series is probably about 500 ft., and, together with the Waimeamea Series, they make up the Tertiary rocks of the Orepuki district. These rocks are important from the economic point of view as they contain the oil-shale deposits and coal-seams of this district. Pending an examination of the fossil evidence, no age has been assigned to these rocks.

Waihoka Series.—Extending north-west from the mouth of Grindstone Creek for about a mile along the coast are numerous exposures of a richly fossiliferous fine-grained, light blue, marly mudstone, dipping west-north-west at 23°. They contain large calcareous bands along the bedding-planes, which are especially well shown at Grindstone Creek. Here a fault has thrown down against the mudstone a sandstone containing similar calcareous bands. Between the sandstone and the mudstone is a thin gritty band, containing numerous large foraminifera. These beds continue up the Waiau Valley, being exposed in Saddle Creek, Holly Burn, and Arthur Creek, where they are overlain by a hard gritty sandstone and in places show thin lignite seams with leaf impressions. The dips in the Waiau Valley are rather irregular, but are generally to the south-east and suggest faulting.

Orepuki Series.—A thickness of some 400 ft. of unfossiliferous sandstone, carbonaceous sandstones and silts, poor lignite beds containing large quantities of partly carbonized timber and lenses of heavy conglomerates and gravels, directly overlie the Waimeamea and Taunoa series with marked angular unconformity throughout the district adjacent to Orepuki. At the base of the Orepuki Series there is a well-consolidated conglomerate composed of weathered, rounded igneous pebbles. The Orepuki Series forms the coastal terrace from the Grindstone Creek to Monkey Island, and patches are found forming terrace remnants along the coast south of Monkey Island. They extend inland to the base of the Londwoods and east to Colac Bay. Occurrence of the fresh-water mussel *Diplodon* in the sandstone at Round Hill has been noted. Throughout this series occur the gold deposits that have been profitably worked for the past sixty years. Associated with the gold is a considerable amount of platinum, which is saved along with the gold. Park (1921) placed the age of the Orepuki Series as Pleistocene, though the sandstone at the base may be older, for there is a strong unconformity between it and the lignitic beds and sandstones above, but any attempt to give these beds an age is hampered by the lack of fossil evidence and by the fact that they are peculiar to the Orepuki area.

Late Pleistocene and Recent.—The terrace gravels of the Waiau Valley form late Pleistocene deposits and the fine and even-textured clay deposit over the Orepuki can probably be classed as such. This clay formation, ranging from 10 ft. to 15 ft., covers the Orepuki Series evenly and contains a few wind-facetted pebbles. Where it is well exposed, as in the old workings at Orepuki, it exhibits a vertical jointing characteristic of loess deposits. The Recent deposits are largely represented by the wide flood-plain of the Waiau River, together with the widespread tailings and alluvium from the old gold workings at Orepuki and Round Hill.

Igneous Rocks.—The basement rocks in the area consist of granites, diorites, gabbros, and norites of a large igneous complex. The Longwood Mountains and all the coastal hills are made up of rocks of this igneous complex. The surface cut in these rocks upon which the Tertiaries rest is deeply weathered and fairly soft, a feature characteristic of the basement throughout the district. Along the coast from Monkey Island to Colac Bay there are magnificent exposures of the rocks of the igneous complex, exhibiting strong joint systems with numerous basalt dykes. These coastal rocks are largely gabbros, diorites, granites, and norites, but, pending detailed petrographic work, these are purely field classifications. The dominant joints are in two groups—one with strikes lying between 90° and 107°, and the other with strikes between 32° and 48°. The less prominent joints fall into four groups, of which the general strikes are 15°, 65°, 315°, and 340° respectively. Differential weathering is a feature, the granitic rocks weathering faster than the norites, with the result that norite boulders cover the wave-cut platforms and occur on the coastal ridges, and on the summit of the Longwoods.

Economic Geology.

Gold. The gold-bearing gravels and silts of the Orepuki Series have been worked extensively during the past sixty years over an area extending from Waimeamea River to Ourawera Stream at Round Hill. In past decades a considerable amount of work was done on the black sands on the beach of Te Wae Wae, but to-day these activities are confined to two or three parties. At Orepuki there are at present four parties carrying out sluicing operations, while at Round Hill extensive work is being carried out by the Round Hill Gold Mining Co. with considerable success. The gold is fairly evenly distributed through the entire Orepuki Series, there being no particular auriferous formation. In the Orepuki district the bottom is generally the Waimeamea or Taunoa Series, locally known as the "papa" bottom, and in the Pahia - Round Hill area the weathered igneous complex forms the bottom, termed the "diorite" bottom by the local miners. All parties working in the area are receiving a good return for their labour, and there is no reason why there should not be more activity than there is at present.

Coal.—At the base of the Waimeamea Series, immediately below the oil shale, is 10 ft. to 20 ft. of hard brown coal. This coal has been worked in the past at several places in the district, just east of the Waimeamea River, near Taunoa Creek, and at the shale-works where coal was obtained during the shale-mining operations. A small open-cast mine is at present working on the banks of the Waimeamea River, producing enough to supply a part of the local market. In the Orepuki area there is an extensive coalfield that should be of considerable importance in the future. This field is bounded by the Waimeamea River in the north and by Falls Creek in the south.

Oil Shale.—A fuller report on the work carried out on the Orepuki Shale deposits will appear in the *New Zealand Journal of Science and Technology*. In 1899 the New Zealand Coal and Oil Co. erected works and began mining the shale on the eastern bank of the Taunoa Creek, about two and a half miles from Orepuki. A drive was put in for a distance of 900 ft. down the dip of the shale, which is here 25° south-south-east. Some 14,000 tons of shale was obtained during the period the works were in operation. Shale was also mined on a small scale at the Waimeamea River, where the outcrop is only 8 in. thick, and near the shale-works it was obtained by sluicing. In the main mine the shale was 4½ ft. thick, which is the average thickness in the area adjacent to the works. In the year 1908 the New Zealand Coal and Oil Co. had four bores put down on their property, along a line running north-north-west from the shale works and on the southern bank of the Taunoa Creek. The depths obtained from these bores agree with both the geological and geophysical evidence. Samples from boreholes were treated, and the following table gives the borehole information and the treatment results:—

Bore.	Depth of Top Shale.	Thickness.	Gallons Crude Oil per Ton.	Ammonium Sulphate, Pounds per Ton.
	Ft. in.	Ft. in.		
1	180 6	4 6	45	21·9
2	287 0	4 9	36	25·55
3	375 6	4 8	45	31·0
4	479 3	4 3	45	28·30

These tests were carried out by Ronald Johnstone and Son, of Glasgow. An estimation of the amount of shale available is given in the more comprehensive report referred to above.

Other Economic Deposits.—There is no limestone of any value in the area discussed in this report. The fine-grained, marly mudstones that occur at Waihoka may be of value to the cement-making industry. Road-metal can be obtained in unlimited quantities from the gravel terraces and flats of the Waiau Valley, but there are no exposures of the igneous complex suitable for quarrying.

COAL RESOURCES SURVEY.

By H. E. Fyfe, M. Gage, and W. E. Hall.

Field-work.

In the later part of the 1938–39 season, field-work continued in the same areas as were described in last year's annual report. Preliminary traverses were run along the ridge between Brunner and Mount Davy mainly for the purpose of tying in the earlier detailed work of H. A. Ellis in the Coal Creek basin. This enabled his survey, with additions by the present survey, to be incorporated in the new plans. Traverses were run in the headwaters of branches of Coal Creek rising on the Mount Davy ridge, and on the spurs between them. In Seven-mile Stream geological observations were made in and around Moody Creek, and Baddeley and party leases in connection with mining problems. During the winter months the Coal Creek basin was triangulated and many points were fixed along the Brunner-Blackball side of the coalfield in preparation for geological work. Weather conditions did not permit completion of the observations until well into the present season. Also during the winter some geological prospecting was done in the Williams and party, Hunter and party, and Moore and party areas. At the commencement of this season survey lines were cut along streams and ridges at Roa, and surface prospecting was done in anticipation of geological work.

The field-work is not yet sufficiently advanced to permit definite correlation between two areas, for each of which the stratigraphic sequence is satisfactorily established. In the following account, therefore, these areas, which are separated by a line running roughly from Blackball Peak to the outfall of Cavern Creek, will be referred to as the north-western and south-eastern areas respectively.

South-eastern Area.—The Brunner coal-measures have been studied on the western slopes of Mount Davy in the Seven-mile and Coal Creek valleys. The outcrops of different members of the Paparoa measures were traced in the Seven-mile valley for correlation purposes, for information about faults, and to assist in selecting sites for deep drilling. The detailed work is largely complete except for the area west of Spring Creek and immediately north of the Seven-mile Stream. The Survey has advised on geological matters concerning the Liverpool State Colliery and several co-operative mines, reports and plans having been prepared in this connection.

North-western Area.—With consideration given to the geological aspect of mining difficulties, detailed correlation of seams and the elucidation of faulting continued in this area. During the early part of this season the mapping of the south side of the lower Ten-mile valley was completed and attention has since been concentrated on Griffiths, Nine-mile, and Kiwi streams. The main traverses along creeks and ridges having been completed, the detailed mapping of intervening areas is in progress. Special attention is being directed to faulting and structural problems in the vicinity of the Strongman State Mine.

Brunner Area.—Geological work has recently been commenced in this area as a preliminary to geophysical experiments aimed at the elucidation of the fault system.

Structure.

South-eastern Area.

The Seven-mile valley, Coal Creek, and the south-western spurs of Mount Davy afford a generalized section across the coalfield, showing two north-north-east-striking asymmetrical anticlines separated by a complex strongly faulted depressed zone. To the east of these structures a comparatively undisturbed dip-slope capped by Brunner beds extends to the crest of the Mount Davy–Brunner ridge. The southern portion dips evenly westward, but northward the strikes swing in a broad arc so that on Mount Davy and in Davy Creek the dips are to the south-west; a broad intensely faulted area with widespread deep talus separates the northern end of the structure from an anticlinal structure to the west. All these structural units are more or less disturbed by normal and compressional faults, the former with displacements of up to several hundred feet.

The axis of the western anticline crosses the Seven-mile Stream at Moody Creek Mine, passing northward along the slopes west of Spring Creek; but southward it has been mapped only as far as Coal Creek, passing close by Trig. A. Disrupting the broad western flank the Dunollie Fault has a downthrow to the west of up to 150 ft. Other faults with displacements of from 12 ft. to about 50 ft. are known, having been encountered in the old Point Elizabeth State Colliery and neighbouring co-operative mines. From the Moody Creek Mine a fault appears, increases to about 12 ft. of throw, and dies out within a distance of about 3 chains. All the more important faults strike between north and north-east. On the steep east-dipping limb of the fold, close-spaced faults break up the terrain into narrow blocks such as that in which Baddeley and Party worked an exceedingly steep seam. The old east-dip workings of the Moody Creek Mine are similarly situated on the steep east limb.

The synclinal area to the east is so disturbed that it is better to regard it as a complex depressed and faulted belt. From Coal Creek it crosses the divide into the Seven-mile valley near Bend Creek, thence up Spring Creek and over the saddle into the watershed of Bishop Creek. This fault has been referred to in previous reports as the Spring Creek fault-zone. Within the disturbed zone, but apparently free from serious faulting, one west-dipping block extends eastward from the Runanga water-supply tunnel for about 16 chains. Its eastern margin is a sharp flexure producing steep north-easterly dips. A short distance farther to the east, there is a fault, which, although obscure, undoubtedly has a considerable upthrow to the east, and beyond which lies another west-dipping block about 3 chains wide. These are the easternmost blocks containing workable members of the Point Elizabeth coal-measures—that is, the uppermost Paparoa seams—and are to be developed by Currie and party from the Seven-mile side. The area of workable coal is restricted by the faults and by the barrier required to be left to protect the waterworks. In this vicinity the trend of structures, including faults, has swung west of the meridian.

Eastward from the depressed zone is the west flank of the adjacent anticline broken by faults, mostly normal, of the dominant north-east system. The crest of this structure can be followed from Batty Creek northwards across Coal Creek, the Seven-mile Stream, and on the intervening ridges. Thence northward it parallels the meridional reach of the Seven-mile Stream. It maintains its identity as a generalized structure through the Liverpool State Mine and beyond to the northern margin of the coal-measures in Otto Creek, although considerable complexity appears in this northern area. The Denston Fault, which bounds the Binn's Section of the Liverpool Mine to the west, is probably identical with a fault west of Hunter and party Seven-mile workings, but it has not been detected south of the Seven-mile Stream. The area west of the Denston Fault appears to be too broken by close-spaced faults and too uncertain as regards coal content to be attractive to co-operative miners. The crest of the eastern anticline is disturbed by a small compressional fault at Tyson Creek; this was investigated in detail during the selection of a site for a deep borehole. One of a group of north-east-striking faults east of the structural crest crosses Williams and party lease, but from surface observations in Coal Creek and on cliffs above the mine it is anticipated that this fault, if not entirely absent, will be of small throw in the new workings. In addition to the main north-east fault system, an east-west set of fractures are chiefly known from the mine workings, but appear to be generally of small displacement. This field generalization was applied to faulting problems in Williams and party Mine, the party being persuaded to prospect through an east-west fault, thereby proving it to have displaced the seam by an amount little more than the height of the coal.

In the Coal Creek area a sharp asymmetrical syncline, broken by the important Saddle Fault, separates the eastern anticline from the broad dip-slopes of Mount Davy. The Saddle Fault, actually a group of closely spaced faults, is analogous to the Spring Creek zone, but on a smaller scale. It was not picked up in Batty Creek, but appears a little to the east of Trig. MM, crosses Coal Creek near the junction with Coulthard Creek, and apparently passes obliquely across the Seven-mile - Coal Creek divide, thence across Davy Creek, and forms the eastern boundary of the Liverpool Mine block.

North of Davy Creek the broad west-dipping monocline referred to earlier terminates, and east of the Liverpool block the country is faulted and closely folded as far as the north-east corner of the coalfield. A fault with a downthrow to the west, of the order of 200 ft., crosses the south-west spur of Mount Davy and Davy Creek, but has not been identified farther to the north-east. Southward it must rapidly die out between Herd and Coulthard creeks.

North-western Area.

The most notable structure of this area is an open syncline approximately 50 chains wide which passes through the central part of the Strongman State Mine workings and strikes about due north. This structure is well established from observations taken in the mine workings and from outcrops in Nine-mile Stream, in Griffiths Creek, and to a less extent from outcrops on the south side of Ten-mile Valley. It is noteworthy that this structure differs in trend from the main faulting system of the field which strikes approximately between 25° and 30° east of north. The smaller short folds that occur sporadically through the area approximate more nearly the strike of the faulting system. The north-easterly-striking fault system is the most consistent structural feature in this area. The faults have been traced from Ten-mile Stream southwards to Kiwi Creek, and in general decrease in throw in this direction. On the other hand, the Transformer Fault, where it cuts off the James seam south of Cannell Creek, has increased its throw. It is possible that this fault, and others of this area, do not persist as single fractures, but that they are distributed by subparallel displacements. Faults transverse to the main system are of a much smaller order, but are important in mining operations and therefore have received considerable attention. "Splits" from main faults are occasionally encountered, many having considerable throw and diverging at a low angle so as to be difficult to distinguish underground from the principal fault. An example is the "90 ft. Fault" which intersects the main drive of the Strongman State Mine about 26 chains from the entrance. It appears to join the Armstrong Fault a few hundred feet north, whereas to the south both faults die out very rapidly and appear to be represented across Kiwi Creek merely by minor folding of the strata.

The evidence so far collected shows that compressional faulting is subordinate to tensional. In the absence of key beds it is not always possible to determine the type of fault. The supposedly greater crushing of strata adjacent to compressional faults is not reliable evidence of compressional faulting in the strata of the Grey coalfield, for folding of incompetent beds between competent ones, as demonstrated in a small outcrop or in mine workings, though perhaps suggestive of compressional faulting, may result from normal faulting.

Coast Faults.—Along the coast between Nine-mile and Ten-mile creeks there is a series of normal faults, generally striking north-east, with westerly downthrow. One example is to be seen on the west side of the main-road bridge crossing the Nine-mile Stream. Another crosses the main road just after it turns east into Ten-mile Valley, showing the Island Sandstone downfaulted to the west of the Brunner Conglomerate.

Fred Fault. This fault has a north-west dip of approximately 70°. It enters the area at Fauth and party Mine in the Ten-mile valley and cuts off these workings on the west side. Traversing the east side of Moors and party workings in the James seam, it crosses the Strongman Mine Road 40 chains from the coast, where the Island Sandstone is again seen downfaulted against Brunner Conglomerate. Southward, it forms the western boundary of the James State Mine, the throw being estimated at probably over 100 ft.

Griffiths Creek Fault.—This fault is first definitely traceable where the Strongman Mine Road crosses Griffiths Creek, Island Sandstone being downthrown to the west of Brunner Conglomerate. This fault, or a related fracture, cuts off the James State Mine workings to the east.

A1 Fault.—This fault is deduced from stratigraphic evidence in Ten-mile Valley, where it appears to displace the coal seams to the extent of 150 ft. It is next to be observed crossing Griffiths Creek, where it is apparently dying out, as it is not seen displacing the Brunner Conglomerates which cap the ridge to the south. However, about 3 chains east of this point where it should cross the ridge, there is another fault which may have replaced the A1 Fault, though it is indicated only by fractures in Griffiths Creek. It crosses Nine-mile Stream in the vicinity of the road bridge about 20 chains west of the mine entrance.

Hunter Fault.—This is not well established, but the mapping suggests that a mudstone stratum and a coal-seam have been displaced about 300 ft. The fault appears to be of no great length, for it does not occur on the ridge south of the Ten-mile Stream.

Transformer Fault.—With a westward downthrow of about 300 ft., this fault cuts off the Hunter and party seam to the east and the Armstrong and party (Strongman State Mine) seams to the west. A change of vegetation on the crest of the ridge south of the Ten-mile valley may indicate its approximate place. It is to be seen on the ridge south of Griffiths Creek, where the Brunner Conglomerate is downthrown against the underlying sandstones; thence it crosses the main drive of the State Mine near the entrance. On the ridge east of Trig. GG, the Brunner Conglomerate is downthrown to the west of the sandstones. South-westwards, across the headwaters of Cannell Creek, the displacement of the James seam is tentatively given as 500 ft. Contrary to the general rule in the area, the throw on this fault is greater to the south than to the north. It is possible that, like others in the field, it may die out and its displacement be taken up by other nearby faults.

Armstrong Fault.—Crossing the Ten-mile Stream about 15 chains downstream from Doherty Creek junction, this fault cuts off Armstrong and party workings to the east. It is seen in the Nine-mile Stream and the cliffs above and to the north of the State Mine workings. In the State Mine workings there are two faults which intersect the main drive at respectively 21 chains and 23 chains from the entrance, and these probably represent a bifurcation of the Armstrong Fault. In the Armstrong and party area this fault has a downthrow of about 300 ft. to the west, but it dies out southward before reaching Kiwi Creek, beyond which the west branch is represented by a steep roll and the east by a small, gentle syncline.

Doherty Fault.—This fault, which dips northwestward at about 60°, crosses Ten-mile Stream 2½ chains above Doherty Creek junction, where the lower mudstone is downfaulted westward some 600 ft. against the Paparoa Basal Conglomerate. Farther north, where it displaces Bishop Creek and Strongman seams, the throw is difficult to estimate on account of another fault which appears to be a fracture diverging from it, striking sub-parallel on its eastern side. This split, the Point C Fault, is thought to have a westward downthrow of about 140 ft. Thence southwestward Doherty Fault crosses Nine-mile Stream about 7 chains downstream from Borehole No. 6, where its throw is considerably less than 600 ft. In this vicinity nearby parallel fractures probably take up the displacement of the fault. It is seen in the cliffs on the south side of Nine-mile Stream, and it traverses the State Mine workings as a steep roll displacing the strata about 20 ft. downward to the west. Immediately east of this point a small parallel fault, or a split from the dying-out Doherty Fault, downthrows the strata about 12 ft. to the west. The Doherty Fault has not been found to cross Kiwi Creek.

Smaller Faults of the North-east-striking System.—There are several smaller faults belonging to this system which have been traced for short distances only. Among these is the fault that cuts off the Kaye and party seam to the west with a westward downthrow of about 100 ft., and the small fault about 6 chains north-west from Trig. C that strikes towards the headwaters of Kiwi Creek and has a downthrow to the west of about 20 ft.

Stratigraphy.

As explained in earlier annual reports, the absence of fossils necessitates lithologic correlations. At this stage of the work it is not yet possible to give a final account of the succession over the whole area, as several important matters are still in doubt. There is no complete section of the coal-measures west of the Paparoa Divide; the upper part has been established in the south-eastern area and the lower part in the north-western area, and correlation between the two is difficult. The following stratigraphic section is based on field observations of the most complete sections and bore-hole data; where information is lacking inferences have been made from cross-sections:—

South-eastern Section.	North-western Section.
Calcareous mudstone (Kaiata beds)	Calcareous mudstone.
Calcareous sandstone (Island Sandstone)	Calcareous sandstone.
Coal-measures (Brunner, James)	James coal-seam.
Conglomerates (Brunner Conglomerates)	Conglomerates.
Unconformity.	*Unconformity.*
Coal-measures (Point Elizabeth seams)	Sandstones and coaly sections.
*Massive mudstone	*Massive mudstone.
Coal-measures (Moody Creek, Binn's, Kimbell, &c., seams)	Coal measures (Strongman and Bishop Creek seams).
*Massive mudstone	Massive mudstone.
Coal-measures (Morgan seam)	Thin coal-measures.
	Conglomerates (Basal Paparoa).
	Unconformity.
	Greywacke, argillite (Greenland Series).

* It is uncertain which of the mudstones in the south-eastern section is to be correlated with the upper massive mudstone of the north-western section.

The unconformable contact at the base of the Brunner Conglomerate that has been observed in the Seven-mile - Dunollie area is also to be seen just below Trig. C to the east, and less plainly on the ridge east of Trig. WP.

Another break in the succession is suspected at the base of the series of sandstones and conglomerates that underlies the lower Strongman State seam (Armstrong and party lower seam), and overlie the Bishop Creek seam. Very little can be said about this probable break, which is deduced from the different thicknesses of the stratigraphic column in measured sections, from the suggestion that the smaller faults in the underlying strata do not displace the upper beds, and from the fact that the conglomerates contain water-worn coal pebbles.

As indicated above, correlation of the stratigraphic positions of the two massive mudstones in the south-eastern area with those of the north-western area is uncertain. Consequently there is some doubt as to the correlation of the Dunollie-Rewanui seams with the Nine-mile - Ten-mile seams. It is to be hoped that this matter will be cleared up by the deep bore-hole that it is proposed to drill at the Tyson Creek - Seven-mile junction, and in the course of field-work between Spring Creek and the Nine-mile. Samples of the several mudstones have been forwarded to the Petrologist in the hope that heavy mineral determinations may help in the correlations.

Coal-seam Correlations.

South-eastern Area.

In the Paparoa coal-measures attention has been directed mainly to the seams between the Kimbell and the Binns Section seams at Rewanui, which form a well-defined group of coal-measures below the upper mudstone of the area. It is established that the Binn's Section workings are in an upper seam of these measures, the Liverpool No. 3 Extended Section being in the same seam as that mined by Hunter and party and Williams and party. Seams in this group are mined by O'Brien and party; lower still is a seam formerly mined by Sparke and party and in the Liverpool No. 4 Section. The Kimbell seam, now also being worked by Sparke and party, is the lowest member of this group.

The same set of coal-measures is being developed in Moody Creek Mine near Dunollie at a point where the upper members of the group crop out in the core of the western anticline. It is impossible to suggest a detailed correlation of the seams at Moody Creek with those of the Rewanui area, and it is likely that no individual seam is continuous between the two areas, but rather that the coal occupies extensive, over-lapping lenses.

At the top of the Paparoa beds are the Point Elizabeth seams, once worked by the old State Colliery at Dunollie. Small fault-bounded blocks containing these seams have since been mined by Boote and party, Guy and party, Baddeley and party, and others. Eastward from Bend and Spring creeks these seams rapidly diminish to unworkable heights, and on the south bank of Seven-mile Stream cut out at about 20 chains east of the Runanga water-supply tunnel, and extend beneath Ikes Peak as thin stony seams. These seams should be prospected for, beneath the James Mine workings, by at least one bore.

The Brunner measures in the Seven-mile area contain one productive seam developed at Dunollie by the James and the old Point Elizabeth No. 4 mines, and by Currie and party, Smith and party, and Duggan and party. Across Coal Creek basin this horizon is unproductive until the Brunner mining area is reached. The measures are continuous from Dunollie to Mount Davy, where they contain at least four thin seams, the highest averaging about 2 ft. 6 in., although attaining 5 ft. locally. The seams are noteworthy for their persistence throughout the field, although over large areas they thin to 1 ft. 6 in. or less, of dirty and splinty coal. A large area of Brunner measures outcrops at shallow depth between Dunollie and the coast. It is anticipated that the coal in this area, besides having the characteristic high sulphur content and lenticular stony bands, will make and thin rapidly and that numerous small faults and rolls will intersect it.

North-western Area.

The workable coal in this area lies between the two mudstone horizons, the principal seams being the two Strongman State Mines seams, and the Bishop Creek seams. The State Mine seams, with an average interval between them of 100 ft., underlie the upper mudstone and crop out in the cliffs on the south side of the Ten-mile valley, where they are both worked by Armstrong and party. Many outcrops show a thickness of as much as 20 ft. of coal.

The Bishop Creek seam is about 300 ft. stratigraphically below the lower State Mine seam. From Otto Creek to the Kaye and party Mine, different outcrops show a height of from 10 ft. to 18 ft. of coal, but between this mine, where it averages 10 ft., and Doherty Creek, where it is 13 ft. thick, this seam thins to 1 ft. 9 in. Since the correlation here is based on stratigraphic intervals it is possible that the seam does not represent one continuous horizon between these points.

The stratigraphic position of the seam being worked by Hunter and party between the Transformer and Hunter faults is somewhere between the Bishop Creek and the Fauth and party seams. It ranges considerably in height but averages about 6 ft.

Other seams of less extent are the Fauth and party seam and the low seam worked by Hunter and party just west of the Hunter Fault. The former seam is of varying quality, but its height ranges up to 10 ft. of clean coal. These two seams are nearly on the same horizon, but as all the seams in this locality are extremely lenticular it is unlikely that these two are extensive.

There are other seams which locally attain 10 ft. in thickness, but none of these has as yet been considered of sufficient extent to be worked. Below the lower mudstone, and of wide lateral extent, is a 10 ft. band of coal interbedded with sandstone, but in no place yet seen does the coal attain sufficient height to be workable.

Sampling.

To-date some 130 pillar samples have been taken from the chief mines of the Greymouth and Westport coalfields, and analyses of these are now nearing completion. Run-of-mine sampling is under way, the chief producing mines of the Greymouth field having been sampled. During the coming winter run-of-mine samples will be taken from the chief mines of the Westport, Kaitangata, Ohai, and Huntly fields.

PALÆONTOLOGICAL WORK.

By J. Marwick.

A good deal of time was spent last year in preparing exhibits for the Centennial Exhibition. A 9 ft. by 6 ft. relief model was constructed to show the geology and topography of the Rotorua-Taupo-Ruapehu district. Samples of rocks illustrating the different formations outcropping in the district accompanied the model. A series of about fifty photographs was also prepared to show the work of the Geological Survey. These, with explanatory captions, were copied on to a 35 mm. film strip, which was shown by an automatic projector on to a glass screen. Both of these exhibits were placed in the Mines Department Court.

The writing of Bulletin 41, "The Geology of Te Kuiti Subdivision," was completed and the illustrations prepared for the printer.

With Dr. Finlay, a paper on the Stage Divisions of the Tertiary of New Zealand was written for the Pacific Science Congress, held in San Francisco last August. Later, this paper was considerably elaborated and expanded to include the Cretaceous, and is to be published in the June issue of the "Transactions of the Royal Society of New Zealand."

The molluscan collections obtained by Dr. Lillie in the current survey of Dannevirke Subdivision have been given a preliminary examination.

At the request of Dr. Teiichi Kobayashi, some of the syntypes of the trilobite *Oggygites hectori* Reed were sent to him at the Imperial University of Tokyo. These fossils were collected from rocks on the Taylor-Wangapeka watershed, considered by their collector, Mr. E. O. Macpherson, to belong to the Mount Arthur Series. Dr. Kobayashi reports that they belong to the Asiatic genus *Taihungshania* and so are "Arenigian (Lower Ordovician) instead of Upper Ordovician as formerly suggested."

MICROPALÆONTOLOGICAL WORK.

By H. J. Finlay.

Samples sent in by field officers have come mostly from Dr. Lillie, in the Dannevirke area, and have ranged from Raukumara Cretaceous to Nukumaruan Pliocene. As usual, the Pliocene faunas have been rich, but much more difficult to distinguish than older ones. The most puzzling faunas have been from beds mapped as Lower Ihungia, but which evidently represent a very distinct North Island facies of the South Island Upper Ototaran and Waitakian. Numerous samples from B. W. Collins have also been determined, for his account of the Motumau area.

Mr. M. Ongley has lately re-collected from several type sections, and the numerous faunas determined have clarified many points. The type Weber is now known to be definitely Whaingaroan (with *Rotaliatina*, *U. maynei*, &c.), the only other fauna at Weber being Whangai. The type Wanstead is uniform throughout the section and contains no lower Bortonian forms. The Wheao Stream and Waikohu River sections gave definite knowledge of the Wheao as equivalent to lower Ihungia, the faunas above and below the igneous conglomerate being indistinguishable. The Mangatu and Waikura streams sections were unsatisfactory.

Numerous samples have been examined and faunal lists made up in connection with the Te Kuiti Bulletin, now in press.

Samples from the major oil companies have taken up much time. The Shell Company of New Zealand has forwarded many odd samples of well-preserved rich faunas from Hawke's Bay for making up reference slides, and sections have been examined in conjunction with Dr. Büning, notably one through lowest Opoiti into Mapiri. Many rich faunas from the Westland "Blue Bottom" have cleared up the confusion surrounding this thick and homogeneous deposit; most of it is now known to be Awamoan with a rather thin layer of Hutchinsonian below, and a much larger amount of Opoitian directly above (and some poorly fossiliferous Waitotaran), the intermediate Taranakian being missing, except at Kapitea Creek. Examination of Dr. Bossard's Taranaki collections for the Vacuum Oil Co. is continuing, and a recent visit was paid to Gisborne to discuss micro-faunas with J. M. Dorreen (Vacuum Co.), and to examine the whole of their mounted collections. The Superior Oil Co. have recently asked for collaboration in foram work, and intensive study of the Pliocene faunas with Mr. Wheatley has already begun.

Valuable foreign material has been sent in during the year, and is mostly mounted up. Mrs. F. B. Plummer has sent much fine type material from the Austin, Taylor, Navarro, and Midway formations; P. W. Jarvis, a good suite from various well-known Trinidad localities; H. G. Schenck, two Californian Miocene lots; W. F. Nuttall, some type material from the Mexican Mendez and Aragon; and W. J. Parr and F. Chapman, some slides of Australian species. Paratypes of species described in "Key Species No. 1" have been sent to J. A. Cushman and W. J. Parr, a slide of 100 key species to the Otago University, and other exchange material prepared.

PETROLOGICAL AND MINERALOGICAL WORK.

By C. O. Hutton.

Considerable progress has been maintained in the development of a rock and mineral museum, and nearly six thousand specimens are now readily available. A number of these specimens have been sectioned and catalogued, but classification cannot be completed until a great many thin sections have been made. Special collections of New Zealand ores and economic minerals are being assembled and made available in separate cabinets. In this collection are many very fine specimens from old prospecting and mining localities that have, by this time, been worked out or fallen into disuse. Further, most of the rock specimens described by Professor Sollas and A. McKay in "The Rocks of Cape Colville Peninsula, New Zealand," are now available. Development of the foreign collections of rocks and minerals has been continued, and the value of these collections has been greatly increased by recent gifts. In this connection thanks are due to Mr. K. C. Church, of the Broken Hill Proprietary Co., Ltd., for a case of fine ferrous minerals from the iron-mines of Iron Knob and Iron Monarch, South Australia. Dr. F. J. Turner, University of Otago, very generously forwarded rocks that were collected recently by him in America; noteworthy in this collection are some specimens from the famous Crestmore locality, in Riverside County, California. Another valuable addition is a specimen of crocidolite, from the Hammersley Range, Western Australia.

Material that was collected at Patea, in South Taranaki, last year has been investigated and the results published.

The petrological investigation of the metamorphic and intrusive rocks of the Wakaia Subdivision has been continued, and it is now possible to state that the greywackes and schistose rocks of this area can be subdivided into three subzones of the chlorite zone—viz., Chl. 1, Chl. 2, and Chl. 3. Further mapping and collecting were carried out in this area during February and March, and this work has shown that granophyres are very plentifully distributed throughout the Otama pluton. Work on the rocks of this region is temporarily suspended pending the cutting of thin sections. While in the field this year, extensive collections were made from the conglomerates at the base of the Clinton Series at a point eight chains west from Popotunua Hill (60 chains north-west from the Clinton Railway-station), and at Albert's Cap, one mile east of Waiwera Railway-station. A study of these boulders has been commenced.

Collections were also made from a small intrusion mapped by Mr. M. Ongley (1939) during a survey of the Kaitangata - Green Island Subdivision. This intrusion, situated three miles and a half south-south-west of Balclutha, is composed entirely of granophyre. A suite of the lavas from Timaru and surrounding districts was collected for the museum, at the beginning of this year.

With Dr. F. J. Turner, the occurrence was investigated of some very coarsely porphyroblasic schists outcropping in a deep meander of the Waikouaiti River, about twenty-five miles north of Dunedin.

During the examination of the Western Otago schists the occurrence was observed of native copper in a biotite-bearing green schist from Nevis Bluff, Kawarau Survey District. After completing field-work at Otama this locality was visited and some sampling of the green-schist zone at Nevis Bluff was carried out. Thin section information and analytical data are not yet available.

Mr. R. W. Willett forwarded samples of beach sand and Tertiary sandstones from Lake Manapouri for investigation of the heavy minerals, with special reference to cassiterite. Heavy residues were prepared, but cassiterite could not be identified with certainty in any of the preparations. Analytical data is not yet available.

In company with an officer of the Department of Housing Construction, possible dam-sites on the eastern side of the Hutt Valley, opposite Taita were visited. The proposed sites were situated on spurs, at a point where they flattened out considerably before dropping steeply towards the valley-floor. The country rock is much shattered and closely-jointed greywacke and is covered by a very deep mantle of weathering products.

At present, work is being carried out with a view to finding ways of utilizing glauconitic greensands as a source of potash and as a potash fertilizer. So far it has been found that electromagnetic methods may be used to produce a 90 per cent. to 95 per cent. glauconite product. Qualitative experimental work has shown that, on roasting and subsequent treatment with 1 per cent. hydrochloric acid, considerable potash can be obtained from glauconite. Several pure glauconite samples are being separated from greensands for complete chemical analysis.

Routine determinations of rock and mineral specimens forwarded to the Survey Office have occupied a considerable time.

Several requests have been made for representative collections of New Zealand rocks and minerals, two of these coming from America, one from England, and two from New Zealand. Some time has been spent packing the type material at present available.

GEOPHYSICAL WORK AT DAM-SITES, WAIKATO RIVER.

By N. Modriniak.

Geophysical work at the Karapiro dam-site, on the Waikato River, a few miles upstream from Cambridge, was begun in December, 1939, and finished in February, 1940. Seismic refraction and electric potential drop-ratio methods were used. The basal rock, greywacke probably of Mesozoic age, outcrops in the river-bed, but deposits of pumiceous silt, sand, and gravel conceal it on the banks. The object of the survey was to determine the thickness of this drift at and near the dam-site. In addition, along several traverses the depth to which the greywacke is weathered and the approximate position of shear planes were ascertained.

At Ohakuri, near Atiamuri, work has been proceeding for some time, and is now well advanced.

GEOPHYSICAL WORK AT OREPUKI.

By H. W. Wellman.

Geophysical work at Orepuki was begun in December and continued till March. The seismic refraction method was used, but as the thickness of strata was more than expected and beyond the capacity of the apparatus available, a magnetic survey was also carried out.

The Tertiary beds containing the shale near their base rest on a complex of basic igneous rocks, and by means of changes in the magnetic intensity at the surface a rough idea of the shape of the shale basin was obtained. Geological data and seismic lines near the edge of the basin confirmed the results. These, however, must be checked by extensive boring to prove the depth of the basin and the thickness of the seam of shale.

ALPINE MINE, LYELL.

By J. Henderson.

In November, 1939, the writer, with Messrs. G. W. Lowes, and E. Collier, of the Mines Department, and H. E. Fyfe, of the Geological Survey, examined the adits driven on Reid's Reef, and inspected the greater part of No. 7 adit of the Alpine Mine. As the report will be published later, it is enough to state here that the Alpine lode appears to be in a fissure on the axial plane of an anticlinal structure, and that a study of the available reports and plans do not suggest that the ore-shoot was faulted, but rather that the ore decreased in value in depth.

TOKATOKA DISTRICT.

By M. Ongley.

Under the guidance of Mr. G. E. Hyde, five days were spent examining the Tokatoka property of the Northern Oilfields, Ltd. This is in the Dargaville-Rodney Subdivision described by H. T. Ferrar in the Geological Survey Bulletin 34.

New information has been gained by following the suggestion of Mr. E. O. Macpherson and mapping the Onerahi Series of Ferrar in two parts, the shale below and the limestone above. This showed that the limestone and shale are in belts trending east, and as the shale is the lower bed the belts of shale represent structural highs. These folds are transverse to the main north-trending structure of the district as mapped by Ferrar and confirmed by Mr. W. M. Jones's magnetic work. Not nearly enough detailed geology was done to show the relations of the folds, or even the thickness of the beds involved.

No definite indication of oil was seen. The conglomerates, grits, and greensands at the base of the Onerahi Series are assumed to be the reservoir beds. These are the well-known Pahi Greensandstone, one of the classic geological formations of New Zealand, visited and investigated many times by geologists, none of whom has ever mentioned it as petroliferous.

Dr. Finlay reports that microfaunas from supposedly five different hydraulic limestones penetrated, show that they are all of Upper Bortonian age, the last hundred feet possibly Lower Bortonian; the Cretaceous was not reached.

MANGANESE DEPOSITS, MANUKAU COUNTY.

By E. O. Macpherson.

Three deposits of manganese ore were examined in Manukau County during November, 1939. These occur at—(1) Mrs. Longshaw's Farm, about three miles east from Bombay Post-office (Block 10, Opaheke Survey District); (2) Mirandite Products, Ltd. (Block XIV, Wairoa Survey District); and (3) Piggot's Farm, Moumoukai (Otau Parish, Block XIV, Wairoa Survey District).

The Bombay deposit has produced 550 tons of manganese ore. Of this, 450 tons was sold to Challenge Phosphate Co. and 100 tons is bagged and stacked on the property. This deposit is now exhausted.

The manganese claim owned by Mirandite Products, Ltd., has been prospected by cuts and drives; it strikes nearly north, and dips west at 65°. The thickness ranges from 5 ft. to 20 ft. and the ore-body has been reasonably well proved for 170 ft. along its trend. During 1938, 90 tons of high-grade ore was exported to Melbourne from this claim, mainly for use in the battery industry; ore below a definite grade is unsuitable and is left at the mine. Two more drives lower down the hill-slope would prove the reserve of mixed-grade ore here, and if the ore in these drives maintains a general thickness of 13 ft. for 170 ft., with 50 ft. of backs, there may be 10,000 tons to 12,000 tons of mixed-grade ore in the deposit.

The deposit on Piggot's Farm, Moumoukai, has been developed by Mr. W. S. Miller, of Khyber Pass, Auckland, who has extensively prospected the ore-body and constructed transport facilities to get the ore to the road. A good deal of prospecting has been carried out, but the downward continuation is not proved, and at least three prospecting-drives should be put in from the south-western side of the ridge, far enough down the slope to prove at least 50 ft. of backs. Estimates of tonnage are tentative until this driving is done, but, assuming, as may reasonably be done, that the ore persists down for 50 ft., the deposit should contain from 25,000 tons to 30,000 tons of mixed-grade ore.

BENTONITE NEAR PORANGAHAU.

By E. O. Macpherson and R. G. Coventry.

Three months were spent mapping and sampling the more promising bentonite deposits in Hawke's Bay. The deposits on Stoddart's and Hunter's Farms, Porangahau, were sampled, and tentative estimates of the tonnage of higher grade bentonite have been made. At present this work is being checked; it will then be possible to give an estimate of the quantities of higher-grade bentonite at these localities.

CHROMITE, SERPENTINE AND NELSON.

By E. O. Macpherson.

For two days in December, 1939, the distribution of the serpentine belt through Croixelles Harbour and D'Urville Island was studied, and points along the south-east coast of D'Urville Island were selected where serpentine could be readily quarried and shipped should it be required by the fertilizer industry.

The dump of chromite in Onetea Bay was located and sampled. Here about 40 tons of chromite-ore is stacked on the foreshore in the south-west corner of the bay about 20 ft. above high-water mark. Chromite-ore was also seen on the rocky foreshore a mile and a half north-east from Kakaho Point and south from Pakihau-o-kiwi along the north-west coast from Croixelles Harbour. On Te Ahau Point, two miles north from French Pass, masses of chromite-ore are scattered along the rocky foreshore. At Hapuku Rocks, on the east coast of D'Urville Island, small fragments of chromite-ore were picked up on the beach. In general, the chromite is of low grade.

BARITE, BATON SADDLE, NELSON.

By E. O. Macpherson.

Two days were spent in this locality during December, 1939, and a deposit of barytes previously described by Professor Park (*Rep. Geol. Explor.*, No. 20, 1890), was relocated. The deposit is 70 chains from the road at Baton Saddle on a bearing from the saddle of 198° and 1,800 ft. above sea-level. The outcrop is not conspicuous, being almost covered by fern and second growth. This deposit had previously been described as fluorspar, but at the outcrop the main bulk of the material is barite, with occasional crystals of pale, greenish fluorspar scattered through the ore. The outcrop stands out slightly on the slope as a narrow ridge 60 ft. long, trending about 130°. The width is about 35 ft. at its widest part, but appears to taper away at both ends. Several exposures indicate that the deposit is 20 ft. thick, and there is about 500 tons of the material showing on the surface.

SULPHUR AT ROTOKAUA.

By J. Healy.

Between November and March the sulphur deposits at Rotokaua were examined in detail and prospected by boring. Patches of sulphur occur over an area of 480 acres. In all, 424 bores were sunk to an aggregate depth of 4,404 ft. and forty-two representative samples were prepared. This work showed that the deposits are superficial, being of recent origin and still in process of formation. The total estimated sulphur is about 4,800 tons, of which perhaps 3,000 tons is reasonably accessible.

DOMINION OBSERVATORY.

Acting-Director: R. C. Hayes.

REPORT FOR THE YEAR ENDING 31st DECEMBER, 1939.

Buildings and Grounds.

The Observatory buildings have been kept in good order. The grounds have been attended to periodically by the Wellington City Council.

Time Service.

Control of Standard Clock. During 1939 a total of 461 short-wave radio time signals was received from abroad, for checking the standard mean time clock. Conditions permitted of more regular daily checking than in the previous year, and this resulted in an improvement in the accuracy of outgoing time signals.

Following the outbreak of war it was considered advisable to revive the practice of taking local transit observations at intervals. This is an emergency measure in order to be prepared for possible interruptions in the overseas radio time signals.

Time Signals sent out. Time signals have been sent out as previously, the following service being provided:—

(1) Time signals by radio (sent automatically by the Observatory signal clock):

(*a*) Through Wellington Radio Station ZLW, daily at 10 h. 30 m., a.m., N.Z.M.T. (= 23 h. G.M.T.). In transmitting these time signals the Observatory's call sign (ZMO) is used.

The following table shows the order of accuracy of the ZLW signals during the year 1939:—

Number of times error did not exceed 0·25 sec.	348
Number of times error between 0·25 and 0·50 sec.	16
Number of times error between 0·50 and 1·00 sec.	1
Number of times error greater than 1·00 sec.	0
Total number of signals sent out	365

Corrections to individual signals can be obtained on application to the Observatory.

There were partial failures of the ZLW signals on 3rd May, 4th May, and 9th October, resulting from trouble at the radio station; and on 28th December, due to a fault in the line from the Observatory to the radio station.

(*b*) Through the National Broadcasting Service Station 2YA daily at 10 h. 28 m., a.m.; 3 h. 28 m., p.m.; and (except Sundays) 7 h. 28 m., p.m., and 10 h. 28 m., p.m., N.Z. Civil Time. Station 2YA is responsible for the actual broadcasting of these signals.

(2) Time signals by telegraph (automatic)—

To the General Post Office and Railways Department, at 9 h. daily (except Sundays).

(3) Time signals by telephone (non-automatic)—

Time was given frequently in response to telephone calls. Towards the close of 1939 there was a marked increase in the number of calls, due mainly to more frequent calls from the Army Department. The stopping of electric clocks due to power trouble is generally followed by numerous calls for correct time. This was the case particularly in January, when severe westerly gales caused frequent power failures.

Public Clocks:—

The Government Buildings and General Post Office clocks have been checked daily at 9 h., a.m. The maximum errors of the Government Buildings clock observed during 1939 were 30 seconds fast and 69 seconds slow, the latter due, apparently, to an error in setting the clock to summer-time on 25th September; and of the General Post Office clock, 8 seconds fast and 4 seconds slow.

The synchronous electric clock was checked daily at 9 h., a.m. and 4 h., p.m. The maximum variation observed during the year 1939 was 27 seconds, which occurred during a period of 38 days. The longest uninterrupted run of the clock was 41 days, and during this period the maximum variation observed was 25 seconds.

Clocks and Chronometers.—During the year No. 2 Sidereal clock, No. 3 Mean Time master clock, and No. 5 signal clock were overhauled by the Post and Telegraph Department. No. 5 signal clock was also fitted with a six-dot contact wheel in the workshop of the Department of Scientific and Industrial Research. A second-hand ship's chronometer was purchased for use in time keeping at seismograph stations.

Electric Circuits.—During the latter part of the year considerable progress was made with the overhauling of the electric circuits, particularly those connected with the time service.

Astronomy.

The establishment of the Carter Observatory early in 1939 relieved the Dominion Observatory of all astronomical work (except observations necessary for carrying on the time service).

Arrangements were made for the astronomical section of the Dominion Observatory Library to be made available to the Carter Observatory, on loan. Certain astronomical equipment, such as telescopes, &c., and the radio apparatus of the two aurora stations in Southland, have also been taken over by the Carter Observatory, on loan.

In accordance with regulations, the aurora radio stations ceased operating immediately on the outbreak of war.

The Dominion Observatory tower room has been made available to the Carter Observatory, for use as a temporary library.

Seismology.

Seismic Activity in New Zealand in 1939.—Sesmic activity, on the average, showed a decline during the first six months of 1939. A slight increase occurred from July to November, after which a decline was again indicated. As compared with the previous year, more shocks were reported felt in the North Island in 1939, but slightly less in the South Island. In all, 157 shocks were reported felt in some part of New Zealand in 1939, as compared with 132 in 1938. On the other hand, the maximum intensity in 1939 was only R.-F. 7, as compared with R.-F. 8, in 1938.

The activity in 1939 may be summarized as follows :

(1) Fairly frequent local activity extending from Whakatane to the Rotorua and Taupo regions, probably associated with volcanic activity. The strongest shocks occurred in June and reached a maximum intensity of R.-F. 5, at Whakatane. Some shocks, originating at depths of from 100 km. to 300 km., have been located beneath part of the thermal regions. Some of these shocks show very irregular distribution of surface intensity, being felt at isolated spots far removed from their epicentres. Although not considered to be directly connected with the volcanic activity, shocks at similar depths have been recorded beneath volcanic regions in other countries.

(2) Occasional activity, centred in the East Cape - Gisborne region, with a strong shock (R.-F. 6) on 4th July (No. 29 on map).

(3) Fairly continuous activity in various parts of Hawke's Bay, with a particularly strong shock in the southern part of the district on 24th February. This shock reached intensity R.-F. 7, the maximum recorded in New Zealand during the year (No. 9 on map).

(4) Activity in the Wanganui-Rangitikei region, concentrated around two dates—*i.e.*, 13th May and 3rd November. On each occasion there was a group of shocks, the strongest of which reached intensity R.-F. 5–6 at Wanganui (Nos. 22, 23 ; and 49 – 53 on map).

(5) Some activity in the north-west Nelson and Buller regions, almost wholly confined to the first seven months of the year. The strongest shock (R.-F. 6) occurred on 10th February (No. 7 on map).

(6) Very occasional shocks in Canterbury during the second half of the year, with a strong one (R.-F. 6 at Hanmer) on 26th July (No. 34 on map).

(7) Activity in the south-western region of the South Island from January to April, and again from August to November. There were notable shocks on 11th February (No. 8), 5th March, and 1st September (No. 41). Three shocks in this region reached a maximum intensity of R.-F. 6, while a large number of minor ones were recorded by the seismograph at Monowai in January.

(8) A number of shocks originating in a submarine belt from 50 miles to 100 miles off the east coast of the North Island. Most of these were recorded after the beginning of August, when a Wood-Anderson seismograph was installed at Tuai, in northern Hawke's Bay. It would appear, therefore, that the new seismograph at Tuai has revealed a considerable amount of activity in this submarine region, which was not evident before. Some of the shocks were sufficiently intense to be felt in parts of New Zealand. One on 15th May was felt with intensity R.-F. 5 at Opotiki and Tolaga Bay, and one on 31st December was extensively felt in the North Island, with maximum intensity R.-F. 5 (No. 59 on map).

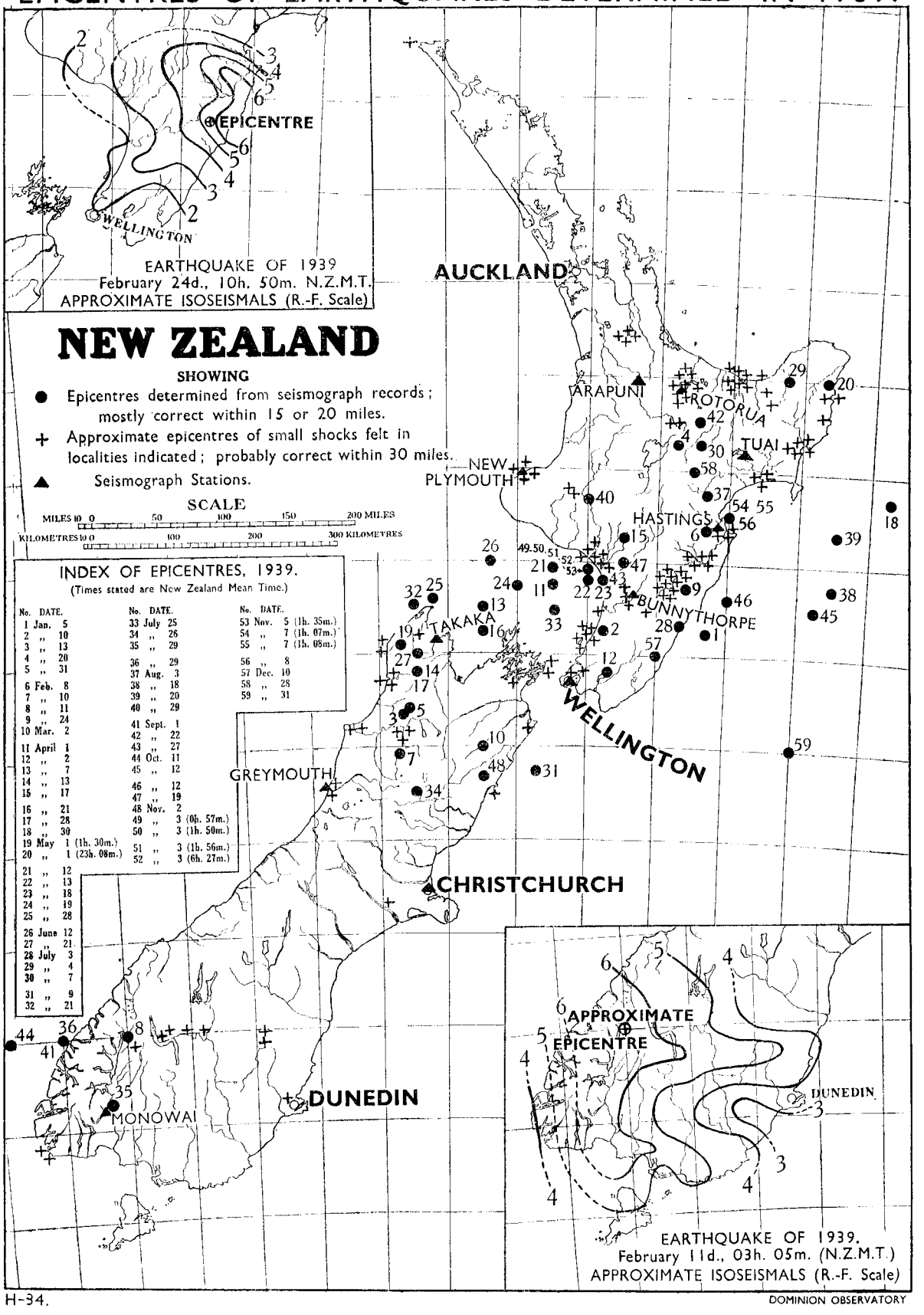
(9) Other minor activity occurred as follows :—

(*a*) A slight shock reported from Cape Maria van Diemen on 22nd December.
(*b*) A few slight shocks felt at Morrinsville.
(*c*) Very occasional shocks in Taranaki, the maximum intensity being R.-F. 5.
(*d*) Spasmodic activity in the Wairarapa–Wellington region.
(*e*) Occasional shocks centred in Marlborough, the maximum intensity being R.-F. 5.

The accompanying map shows the epicentres of earthquakes determined in 1939. The black circles, having an index number, represent epicentres determined from seismograph records. These are mostly correct within fifteen or twenty miles. The crosses indicate the approximate positions of small felt shocks, which could not be definitely located by instrumental records.

Information regarding the felt effects of earthquakes has been supplied by officers of the Post and Telegraph Department, officers of the Marine Department, and several private observers. In all there are about 120 non-instrumental reporting stations.

EPICENTRES OF EARTHQUAKES DETERMINED IN 1939.



INDEX OF EPICENTRES, 1939.

(Times stated are New Zealand Mean Time.)

No.	DATE.	No.	DATE.	No.	DATE.
1	Jan. 5	33	July 25	53	Nov. 5 (1h. 35m.)
2	,, 10	34	,, 26	54	,, 7 (1h. 07m.)
3	,, 13	35	,, 29	55	,, 7 (1h. 08m.)
4	,, 20	36	,, 29	56	,, 8
5	,, 31	37	Aug. 3	57	Dec. 10
6	Feb. 8	38	,, 18	58	,, 28
7	,, 10	39	,, 20	59	,, 31
8	,, 11	40	,, 29		
9	,, 24	41	Sept. 1		
10	Mar. 2	42	,, 22		
11	April 1	43	,, 27		
12	,, 2	44	Oct. 11		
13	,, 7	45	,, 12		
14	,, 13	46	,, 12		
15	,, 17	47	,, 19		
16	,, 21	48	Nov. 2		
17	,, 28	49	,, 3 (0h. 57m.)		
18	,, 30	50	,, 3 (1h. 50m.)		
19	May 1 (1h. 30m.)	51	,, 3 (1h. 56m.)		
20	,, 1 (23h. 08m.)	52	,, 3 (6h. 27m.)		
21	,, 12				
22	,, 13				
23	,, 18				
24	,, 19				
25	,, 28				
26	June 12				
27	,, 21				
28	July 3				
29	,, 4				
30	,, 7				
31	,, 9				
32	,, 21				

The following is a monthly summary of earthquakes reported felt during 1939:

Month, 1939.	Number of Earthquakes reported felt.				Maximum Intensity (R.-F.).	Locality of Maximum.
	North Island.	South Island.	Both Islands.	Whole of New Zealand.		
January	17	9	1	25	5	Gisborne, Brothers Lighthouse, Puysegur Point.
February	6	5	0	11	7	Southern Hawke's Bay.
March	6	4	0	10	4	New Plymouth, Farewell Spit, Otago, and Southland.
April	10	6	1	15	5	Brothers Lighthouse, Kahurangi Point.
May	18	2	1	19	6	Wanganui.
June	5	1	0	6	5	Whakatane.
July	9	8	1	16	6	Opotiki, Hanmer Springs.
August	7	1	0	8	6	Cromwell.
September	4	0	0	4	4	Wanganui.
October	12	4	1	15	6	Naseby.
November	14	4	1	17	5	Wanganui, Cape Jackson.
December	9	4	2	11	5	Wanganui.
Totals	117	48	8	157	..	

The following list gives some particulars of the most important New Zealand earthquakes in 1939:—

New Zealand Mean Time of Shock.	Approximate Epicentre.		Maximum Intensity (R.-F.).	Remarks.
	Latitude S.	Longitude E.		
1939. d. h. m.	°	°		
February 10 20 07	42·1	172·3	6	Felt in north-west portion of South Island, with maximum at Murchison.
February 11 03 05	45	168	6	Felt widely in southern part of South Island, with maximum at Milford Sound and Tuatapere. Deeper than normal (see inset map).
February 24 10 50	40·3	176·4	7	Felt in southern half of North Island, with maximum in southern Hawke's Bay (see inset map).
March 5 08 16	(Milford Sound Region)		4	Felt fairly extensively in southern half of South Island.
May 13 02 25	40·2	175	5–6	Maximum intensity about Wanganui; also felt slightly about Cook Strait.
July 4 00 51	38	177¾	6	Felt in East Cape district and in Hawke's Bay. Probably deeper than normal.
July 26 05 16	42½	172½	6	Maximum intensity at Hanmer Springs; also felt at Christchurch.
August 29 15 31	39⅓	175	5	Felt in most parts of Taranaki, with maximum at Whangamomona. Also felt at Wanganui.
September 1 01 51	45	167	6	Felt generally in Otago, and in parts of Southland, with maximum at Milford Sound and Cromwell.
November 3 00 58	40·1	175·0	5–6	Felt in southern part of North Island and about Cook Strait, with maximum at Wanganui.
December 10 06 26	41	176	4	Felt in southern part of North Island and about Cook Strait, with maximum at Castlepoint.
December 31 06 42	42	178	5	Felt in eastern and southern parts of North Island, with maximum at Wanganui. Probably deeper than normal.

Seismograph Stations.—The following table shows the number of earthquakes recorded at the various seismograph stations for each month of the year 1939. The stations are classified according to the type of seismograph. Class I stations possess sensitive local recorders of Wood-Anderson type: Class II, local strong-motion recorders, mostly of Jaggar type; and Class III, teleseismic instruments of varying sensitivity.

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.
Class I.													
Tuai	..	..	..	..	..	..	..	14	18	25	16	14	87
New Plymouth ..	16	13	17	13	10	8	13	8	9	14	19	9	149
Wellington	31	23	19	25	17	15	22	19	24	23	28	19	265
Christchurch ..	24	6	9	9	4	3	12	22	10	11	12	3	125
Class II.													
Rotorua	0	0	0	..	..	..	..	..	10	0	3	0	13
Tuai	0	1	0	0	1	0	1	..	..	..	..	..	3
Stratford	0	0	0	..	..	..	..	..	..	..	..	..	0
Hastings	1	6	0	1	3	0	3	3	5	2	4	1	29
Bunnythorpe ..	0	1	0	0	0	0	1	0	0	2	0	2	6
Takaka	0	0	0	0	0	0	0	0	0	0	0	0	0
Greymouth	0	0	0	0	0	0	0	0	0	0	0	0	0
Monowai	22	6	3	2	0	0	3	1	3	6	1	0	47
Class III.													
Arapuni	4	2	8	7	6	2	3	5	5	9	13	14	78
Wellington	32	25	22	27	29	20	19	27	8	12	14	19	254
Christchurch ..	36	22	24	33	29	16	10	6	3	22	18	18	237
Chatham Islands ..	1	0	0	0	0	2	0	0	0	0	0	3	6

The installation of a Wood-Anderson seismograph at Tuai has proved of great value in locating and studying earthquake activity in and around the North Island.

The Jaggar station at Stratford was closed on 31st March. Other stations have carried on as previously.

Records from Rotorua were interrupted at times owing to clock trouble. Towards the end of December recording was interrupted at both Tuai and New Plymouth owing to technical trouble.

In August the Milne-Shaw seismograph, No. 36, was lent to the Magnetic Observatory, Christchurch, for the purpose of investigating microseisms and for testing the conditions for seismographs of high sensitivity at Greymouth and Monowai.

The Imamura strong-motion seismograph at Wellington was overhauled in October, and re-erected in the Centennial Exhibition.

Measurement of Tilt.—The Ishimoto tiltometer has continued recording the E-W component of tilt; the N-S component being recorded by the Milne-Shaw seismograph. Tilt records are now available over a number of years, and are being subjected to an intensive study.

Seismological Research. The following research work has been pursued during the year by various members of the staff:—

Mr. R. C. Hayes—(1) Correlation of earthquakes and rainfall in New Zealand.
(2) Study of local earthquake record types.
(3) The direction of the initial movements of earthquakes as recorded at Wellington.

Mr. W. M. Jones—(1) Investigation of local earthquake waves and crustal structure.
(2) Results of Geophysical Survey work in North Auckland.

Mr. C. N. M. Watson-Munro—(1) Measurement of vibrations due to the Printing Office machinery, using some of the Geophysical Survey apparatus. This work was undertaken at the request of the Public Works Department, which was furnished with a comprehensive report on the results.

Assistance in seismological research has been given to the following voluntary workers: Dr. K. E. Bullen, of Auckland; Dr. L. Hastings, of Wellington; Mr. R. D. Thompson, of Stratford; and Mr. L. A. C. Warner, of Wellington.

General.—Three papers, by R. C. Hayes, on seismology in New Zealand and the Pacific, were sent to Dr. B. Gutenberg for presentation at the Sixth Pacific Science Congress, at San Francisco, in July–August, 1939.

A report on seismology in New Zealand during the years 1936–1937 1938 was prepared and forwarded to the Secretary of the Seismological Section of the International Geodetic and Geophysical Union for the Seventh General Assembly of the Union at Washington in September, 1939.

A number of original seismograms were lent to seismologists abroad, for the study of special earthquakes.

Workshop.

The workshop continued to carry out instrument work for this Observatory, as well as for other branches of the Department. In addition to maintenance-work, a new seismograph recorder was completed early in the year.

In September the control of the workshop was transferred to the newly formed Physical Testing Laboratory, and the staff and equipment moved to more spacious premises in Molesworth Street during November.

Centennial Exhibits.

The Dominion Observatory was allotted space for exhibits in the Government Court of the Centennial Exhibition, and exhibits, illustrating seismology and time-service work, were prepared and installed.

Publications.

The monthly seismological bulletins E. 81 to E. 91, covering the period 1938 December to 1939 October, were published during the year 1939. Owing to circumstances arising out of the war it was necessary to suspend publication of the "E" bulletins, after the October number. These were replaced by a series of provisional bulletins, forming a separate series, in continuation of a series of provisional bulletins which was published from 1929 to 1936. The provisional bulletin for 1939 November (P. 93) was issued on 20th December.

The following special bulletins were also issued during 1939:—

Bulletin 138 (S.-54).—Earthquakes in New Zealand in 1937 (reprinted from New Zealand Official Year-Book, 1939).

Bulletin 139 (T.-14).—Mean Time and Time Service (reprinted from New Zealand Official Year-Book, 1939).

Bulletin 140 (S.-55).—A Method of Calculating New Zealand Epicentres (K. E. Bullen).

Bulletin 141 (A.-54).—The Photographic Determination of the Height and Position of Aurorae in New Zealand (M. Geddes).

Bulletin R.-24.—Annual Report of the Dominion Observatory for the year 1938.

Bulletin T.-15.—Mean Time and Time Service Arrangements (reprinted from the "New Zealand Nautical Almanac, 1940").

Bulletins are now numbered separately in four series—Astronomical (A), Seismological (S), Time Service (T), and Annual Reports (R). A complete list of all Observatory bulletins to date was prepared and published in September.

The article on "Earthquakes in New Zealand" published in the "New Zealand Official Year-Book" was revised for the 1940 Year-Book, and the articles on "Time Service, &c." were revised for the 1940 editions of the Year-Book and the "New Zealand Nautical Almanac."

Staff.

Consequent on the establishment of a Physical Testing Laboratory, certain officers were transferred to it from the Observatory Staff. The workshop of the Laboratory still carries out instrument work for the Observatory, and arrangements have been made for one of the staff to be available at any time to assist with miscellaneous work.

MAGNETIC OBSERVATORY, CHRISTCHURCH.

Director: H. F. Skey.

SUMMARY OF OPERATIONS FOR THE YEAR ENDED 31st MARCH, 1940.

During the year the usual magnetic seismological and meteorological observations have been made.

Terrestrial Magnetism.

The Eschenhagen magnetographs at Amberley Substation and the Adie and La Cour magnetographs have been kept recording continuously. Twice monthly absolute magnetic observations have been made at Amberley, and from these and hourly measurements of the magnetograms the mean hourly values of D, H, and Z have been computed and tabulated. The mean monthly values of the magnetic elements obtained from the mean hourly values for all days of 1939 are—

1939.	D.	H.	Z.	ϕ
	° ′			° ′
January	18 20·9E.	22284γ	55187	−68 00·7
February	18 22·2	22262	55187	68 01·9
March	18 23·8	22253	55193	68 02·5
April	18 24·2	22236	55192	68 03·4
May	18 24·9	22238	55207	68 03·6
June	18 25·5	22254	55216	58 02·9
July	18 25·5	22251	55204	68 02·9
August	18 25·4	22248	55205	68 03·0
September	18 25·9	22257	55203	68 02·5
October	18 25·9	22247	55200	68 02·9
November	18 26·0	22266	55193	68 01·8
December	18 26·6	22270	55208	68 01·9
Year	18 24·7	22255·3	55199·7	68 02·50
Δ from 1938	+5·9	−8·0	−2·1	−00·30
	Y.	X.	T.	G. c.g.s.
Year	07029·4γ	21116·1γ	59517·3γ	0·35455
Δ from 1938	+45·3γ	−19·7γ	−1·0γ	−0·00004

A slight diminution in the mean annual value of G is still shown. T and H have diminished somewhat less than usual, and the east component Y has increased somewhat more than usual.

The local data of International Character Figures for all days have, as usual, been furnished to De Bilt for inclusion in their international publication. In *Terrestrial Magnetism and Atmospheric Electricity* for December, 1939, a method of evaluating a three hours' index of geomagnetic activity is described, as provisionally adopted by the International Association of Terrestrial Magnetism and Electricity at Washington, D.C., United States of America, at the September meeting, and is to be adopted for a trial at as many observatories as possible for the years 1940–42; the co-operation of all observatories is requested.

In December the Observatory was visited by Mr. Fitzsimmons and Mr. Wiener, of the scientific staff of the present United States (Byrd) Antarctic Expedition. At Amberley all facilities were provided for comparing and standardizing their dip and total force equipment. Only a few days were available for the work, but their constants were correctly obtained, and after computation at the Observatory copies of the data and results have been forwarded to the United States Coast and Geodetic Survey. At their urgent request a dip circle (147) with two needles was lent to the Expedition to help in their survey work in Antarctica. Valuable scientific results may be expected from this Expedition.

Electric Potential Gradient.

The Bendorf electrograph has been kept in operation, and its records partly reduced. Owing to pressure of necessary work, the tabulation of the hourly values has not been completed.

Seismological.

Throughout the year further valuable data have been obtained as to genesis and propagation of earthquakes from distant sources by continued registration on the Galitzin recorders, which give essentials for this purpose by recording movements in three components of direction. A single component Wood-Anderson seismometer, which is designed to detect all but very small, though quite significant, near shocks, registered distance of the main shocks in and near New Zealand. Early in 1940 a flurry of small shocks arising from regions about twenty miles from Christchurch was detected. It is unusual for seismic activity to occur so close to Christchurch. Its proximity to a large centre of population shows the desirability of having apparatus capable of fixing three essentials of location for such regions—viz., the depth, together with distance and direction from Christchurch. Lately, sites near Greymouth and Lake Monowai were tested as to their suitability for installation of Wood-Anderson seismometers. Such installations at these places will greatly improve the network of sensitive stations essential for accurate delineation of active regions in New Zealand. Besides undertaking these tests, Mr. Baird submitted for publication a paper prepared conjointly with Mr. C. J. Banwell on small undulations or oscillations of air pressure whose existence and close relationship with a baffling type of periodic ground unrest, called microseisms, they had discovered early in 1937.

Cosmic Ray Meter.

Continuous records have been obtained from the cosmic ray meter, and reduced measurements have been forwarded periodically to the Carnegie Institution of Washington. The results obtained at Christchurch have proved to be of great value to that institution in their investigation dealing with the world-wide changes in the cosmic ray intensity and their connection with variations in magnetic activity. Owing to the proximity of Christchurch to the belt of maximum auroral frequency, results obtained at this station should prove extremely important in the future.

An analysis was made of the "bursts" of ionization recorded in 1937 and 1939 to trace any dependence of their frequency and size on barometric height. No such effect was found. It was found, however, that the frequency distribution of the bursts for these two periods conformed to the law $R(N) = \frac{A}{N^s}$, adopted by Montgomery and Montgomery for showers, where R(N) dN is the number of bursts containing numbers of particles between N and (N + dN). Although two different ionization chambers were used during these two years, the values of A and s obtained were very concordant, and the latter was of the same order as the theoretical value given by Montgomery and Montgomery for showers produced under the same amount of lead shielding—*i.e.*, 12 cm.

METEOROLOGICAL BRANCH.

Consequent on the outbreak of war, the Meteorological Branch of the Department, together with the Apia Observatory, was transferred to the Air Department for the duration of the war.

The report of the Meteorological Branch during the past year is contained in the annual report of the Air Department.

RESEARCH SCHOLARSHIP.

A National Research Scholarship was awarded to Mr. A. T. Johns, of Canterbury University College, for the purpose of carrying out a biochemical investigation on pig fat. The research will be related to the important subjects of the growth of pigs and bacon quality.

IMPERIAL AGRICULTURAL BUREAUX.

The Imperial Agricultural Bureaux were established to act as clearing-houses for the interchange of information between research workers in various fields of agricultural science throughout the world, but more particularly within the various countries of the British Commonwealth.

In New Zealand co-operation with the Bureaux is maintained through the Department of Scientific and Industrial Research, for which purpose there is a special liasion officer. In addition, contacts with individual Bureaux and the appropriate fields of research are maintained by official correspondents, who deal with specific inquiries. The following is the list of Bureaux and the official correspondents in New Zealand:—

Bureau.	Official Correspondent.
1. Soil Science	Dr. L. I. Grange, Director, Soil Survey Division, Department of Scientific and Industrial Research.
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, Wheat Research Institute, Christchurch.
5. Pastures and Forage Crops	Mr. E. B. Levy, Director, Grasslands Division, Palmerston North.
6. Horticulture and Plantation Crops	Mr. W. K. Dallas, 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, Entomology Division, Plant Research Bureau, Cawthron Institute, Nelson (joint correspondents).
9. Forestry	(To be appointed.)
10. Dairy Science	Dr. H. Whitehead, Dairy Research Institute, Palmerston North.
New Zealand Liaison Officer for Imperial Agriculture Bureaux.	Mr. F. J. A. Brogan, Department of Scientific and Industrial Research, Wellington. (Acting.)

PUBLICATIONS.

The monthly publication of the *New Zealand Journal of Science and Technology* has been continued during the year. The alternate numbers have been devoted to two different classes of papers. Section A of the *Journal* is composed entirely of agricultural science articles, while Section B deals with a variety of subjects, including chemistry, physics, geology, seismology, economics, and industrial technology.

The following is a list of bulletins issued during the year:—

No. 74: "Some Ground-wave Field-intensity Measurements taken in New Zealand," by G. Searle.
No. 76: "Soils and Agriculture of Part of Waipa County."
No. 77: "Maintenance of Vegetative Cover in New Zealand, with Special Reference to Land Erosion."
No. 78: "Diamond-back Moth Investigation in New Zealand," by P. L. Robertson.
No. 79: "The Grasslands of the North Island of New Zealand," by E. A. Madden.
No. 80: "The Curing and Colouring of New Zealand Lemons," by J. B. Hyatt and O. H. Keys.
No. 81: "Sixth Annual Report of the Wheat Research Institute."

Approximate Cost of Paper.—Preparation, not given; printing (925 copies, including graphs), £140.

By Authority: E. V. Paul, Government Printer, Wellington.—1940.

Price 2s.]