1934.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

EIGHTH ANNUAL REPORT

OF

THE COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

FOR THE

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COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

EIGHTH ANNUAL REPORT FOR YEAR ENDED 30TH JUNE, 1934.

I. INTRODUCTION.

1. *General Scope of Council's Work.*—The increasing number of requests for assistance and advice received by the Council has made it clear that its services are becoming more and more in demand by the industries of the Commonwealth, and that there is now a general realization of the assistance which it is capable of rendering. When the Council was created in 1926 the Commonwealth Government began an organized attempt to help Australian industries through the services of scientific research, and by the *Science and Industry Research Act* 1920–26, the Council was empowered to undertake research work in connexion with or for the promotion of primary or secondary industries in the Commonwealth.

This was one of the first occasions on which any country had set up a single organization to carry out research work in relation to practically any branch of industry and applied science. One of the first tasks of the new Council was, therefore, to determine those fields of work in which efforts should first be concentrated, since obviously it was impossible to enter every field. It very soon became apparent that the most pressing needs were in connexion with the agricultural and pastoral industries. The control of important pests such as the prickly pear, the sheep blowfly and the buffalo-fly, which have spread so rapidly when removed from their natural habitat and from the factors which there kept them in check; the breeding of plants of economic value capable of being grown in the drier parts of the continent; the development of methods whereby greater quantities of Australian-grown perishable foods can be placed on the markets of the world; means whereby our timber resources can be utilized to best advantage; the examination and classification of our soils so that they may be profitably cultivated; the investigation of scientific problems affecting our irrigation settlements; the control and eradication of animal diseases, and other problems so vitally affecting the agricultural and pastoral industries, all constitute groups of problems which exist not only in one State of the Commonwealth but in every State.

The main activities of the Council have accordingly been organized in the following Divisions:—

(i) The Division of Plant Industry—Dr. B. T. Dickson, B.A., B.Sc., Ph.D. (Chief).
(ii) The Division of Economic Entomology—Dr. A. J. Nicholson, D.Sc. (Acting Chief).
(iii) The Division of Animal Nutrition—Mr. H. R. Marston (Acting Chief).
(iv) The Division of Animal Health—Dr. J. A. Gilruth, D.V.Sc. (Chief).
(v) The Division of Soils—Professor J. A. Prescott, D.Sc. (Chief), with Mr. J. K. Taylor, M.Sc., M.Agr.Sc., B.A. (Acting Chief).
(vi) The Division of Forest Products—Mr. I. H. Boas, M.Sc. (Chief), with Mr. S. A. Clarke, B.E., A.M.I.E. (Aust.) (Deputy Chief).

In addition the Council has established a Section of Food Preservation and Transport, of which the Officer-in-Charge is Dr. J. R. Vickery, M.Sc., Ph.D.

The Council's Viticultural Research Station at Merbein is under the charge of Mr. A. V. Lyon, M.Sc., and its Citricultural Research Station at Griffith, in the Murrumbidgee Irrigation Areas, is under Mr. E. S. West, B.Sc., M.S.

A considerable number of other investigations not directly associated with these sections are either in progress or have already been completed.

2. *Financial Provision for Research.*—In the early years of the Council's existence progress was somewhat slow, owing mainly to two causes, firstly, the difficulty in securing the services of properly trained and experienced investigators, and, secondly, the need for the construction and equipment of laboratories and the provision of other experimental facilities. These difficulties were, however, steadily met, progress being facilitated by the provision made by the Commonwealth Government in these years not only for annual maintenance, but also for capital expenditure on the erection and equipment of laboratories.

Laboratories for the Divisions of Plant Industry and Economic Entomolgy have been established at Canberra. At Adelaide there are the laboratories for the Divisions of Animal Nutrition and of Soils. At Sydney there is the McMaster Animal Health Laboratory. At Melbourne there is a Forest Products Laboratory accommodated in temporary quarters. At Brisbane there is a Cold Storage and Food Preservation Laboratory, for which accommodation has been provided by the Queensland Meat Industry Board. Near Townsville there is a laboratory for the investigation of animal health problems affecting cattle in northern Australia, made available originally by the Queensland Government and since extended. At Merbein, in Victoria, there is a Research Station for the investigation of problems affecting dried vine fruits, and at Griffith, New South Wales, there is another Research Station for work on problems connected with the citrus industry.

In the Annual Report of the Council for 1932–33, attention was directed to the difficulties which had arisen owing to the curtailment of the Council's vote and to the uncertainty which prevailed as to its financial position, and it was pointed out that it was often impracticable to develop work on lines which were desirable, or to give effect to many requests received for the investigation of new and important problems.

In the planning and carrying out of scientific research, it is particularly important that there should be continuity of financial policy if efficiency and economy are to be attained. It was, therefore, strongly urged that financial provision should be made not merely for that continuity of effort which is imperative for the effective prosecution of the Council's work, but also for such reasonable expansion of its activities as is warranted from time to time. The Council realizes fully the urgent need for economy, but in view of the close relation of its work to the welfare of Australia's primary industries, of the economic value of the results already obtained from its researches and of the pressing demands made on it to undertake investigations of important and urgent problems, it is submitted that Australia cannot afford to lag behind other civilized countries in the national efforts which are being made to ensure the application of science to industry.

Apart altogether from the question of the provision of funds for the annual maintenance of work in progress and for its reasonable expansion, a further difficulty has recently arisen in the affairs of the Council. With the restricted annual votes by Parliament on which the Council is now largely dependent, it is quite impossible to provide for the further capital expenditure which is necessary. For example, the Division of Forest Products, which has gained the very strong support of timber-using industries throughout the Commonwealth, and which has already done much useful work for the development of these industries, is at present provided only with temporary laboratory accommodation and with facilities which are quite inadequate to meet its normal requirements. The laboratories of that Division are, in fact, accommodated in the old coach house, stables and outbuildings at the Head Office premises of the Council. Again, the laboratory buildings at the Viticultural Research Station at Merbein, which has also done work of great value to one of Australia's staple industries, viz., the production of dried vine fruits, are now quite inadequate for the purposes which they are intended to serve.*

It is only because the Council has been so successful in establishing confidence in its operations that it has been able to obtain funds from sources other than the Commonwealth Government, and thus to carry out researches into many important problems which otherwise could not have been touched. For example, the generous assistance rendered by the Queensland Government and by pastoralists and others in that State enabled the Council to establish and maintain the Animal Health Research Station at Townsville, where investigations are being conducted into the control of certain serious animal diseases which levy a large annual toll on the cattle industry of northern Australia. Again, the highly successful investigations on the preservation of chilled beef were made possible only by the action of the Queensland Meat Industry Board in making facilities available in the way of laboratories and experimental cold stores. Much of the work which the Council is conducting on animal health problems is the result of

* Since this report was drafted the Government has made £31,000 available for laboratories for the Division and for the Station.

assistance rendered in one direction or another. For example, the McMaster Animal Health Laboratory at Sydney was the generous gift of Sir Frederick McMaster, while the Australian Pastoral Research Trust has contributed substantial sums of money towards the cost of many of the Council's investigations in this sphere of work.

3. *Co-operation in Research.*—The Council has continued to work in close co-operation with State scientific and technical departments, universities and other scientific institutions. By far the greater number of the Council's investigations are, in fact, being conducted in co-operation with one or more of these bodies. This close co-operative relationship has been facilitated by the State Committees of the Council, of which Committees the main function is to furnish advice regarding the general work of the Council and regarding any particular matters of investigation of special interest to the respective States. These State Committees include among their members representatives of scientific and technical sections of State Departments and of different branches of science and industry.

One of the most effective bodies in facilitating co-operation with the State Departments of Agriculture and in preventing undesirable duplication of effort is the Council's Standing Committee on Agriculture, which comprises amongst its members the permanent head of each State Department of Agriculture. The last series of meetings of this Committee was held at Hobart in February, 1934. The results of the Committee's work have been so satisfactory that steps are being taken to increase its status and to extend its sphere of usefulness.

The Council has derived very valuable assistance from co-operation with sister organizations in other parts of the Empire, particularly the Department of Scientific and Industrial Research in England, the Natural Research Council in Canada, and the Department of Scientific and Industrial Research in New Zealand. The Food Investigation Board, the Fuel Investigation Board and many other organizations established by the Department of Scientific and Industrial Research in England have rendered most useful assistance to the Council in many directions.

During the year 1933–34 the Empire Marketing Board ceased to exist, and the Council desires to pay a tribute to the work which the Board conducted in linking together and co-ordinating scientific research work on agricultural problems throughout the Empire. This work was of outstanding importance and value, not so much by reason of the financial assistance which the Board gave to research institutions in different parts of the Empire (though that assistance was of outstanding benefit to Australia), but rather on account of the successful manner in which the Board brought such institutions into close touch with one another and enabled them to work together as members of a team. It is gratifying to be able to record that the Commonwealth Government has undertaken to shoulder the responsibility for the financial commitments of the Board in Australia as from the 1st July, 1934.

4. *The Council.*—Since the last Annual Report of the Council was made, two meetings of the full Council have been held, one at Melbourne on the 29th and 30th November, and the 1st December, 1933, and the other at Sydney on the 9th, 10th and 11th May, 1934. Unless special circumstances arise, two meetings of the Council are held each year, of which one is held sufficiently early to allow of consideration of the draft Estimates of Expenditure for the following financial year.

During the year 1933–34, Mr. B. Perry tendered his resignation as Chairman of the Western Australian State Committee and as a member of the Council, consequent on his departure from Western Australia. His resignation was accepted with regret, and the Council has placed on record its high appreciation of the valuable services rendered by him. Mr. E. H. B. Lefroy has been appointed in his place. The present constitution of the Council is given elsewhere in this report (*see* Appendix).

5. *Executive Committee.*—Under the Act constituting the Council, in between full meetings of the latter, all its powers and functions are vested in the Executive Committee. During the year 1933–34, 56 meetings of the Executive Committee were held : the 280th meeting was held on the 22nd June, 1934.

II. PLANT INVESTIGATIONS.

1. *General.*—The Division of Plant Industry has its laboratories and experimental plant houses at Black Mountain, Canberra, Federal Capital Territory. At the rear of the plant houses 10 acres of land have been laid out for the purpose of experimental plots, and a small experimental orchard has been established on a further area of about 1 acre. At Duntroon, 6 miles distant, 100 acres have been provided for field experiments. To the north of the Black Mountain plots is an area of approximately 17 acres, upon which it is planned eventually to develop an arboretum

and botanic garden. For the purpose of testing new plant introductions suitable for tropical areas, provision for experimental plots has been made in the grounds of the Council's Animal Health Research Station near Townsville, and at the State Agricultural College at Gatton, Queensland. Laboratory accommodation for investigations on certain fruit problems has been provided at Hobart by the University of Tasmania. The work of the Division has been materially assisted by the co-operation and help rendered in many directions by State Departments of Agriculture and other institutions.

During the year 1933–34 the environs of the laboratories at Canberra were improved by the laying down of lawns and the further planting of trees and shrubs. For this the Council expresses its appreciation to the Department of the Interior, particularly the Parks and Gardens Branch.

The experimental area at Duntroon has proved eminently satisfactory both for wheat and pasture plant investigations although black oats still cause trouble in the plots.

During the year Miss Phyllis H. Jarrett, resigned her position in the Division of Plant Industry in order to be married ; Mr. J. G. Bald, was given leave to go to Cambridge University to further his studies in virus diseases ; Mr. L. A. Thomas returned from the East Malling Research Station to take up work at Stanthorpe in stock and scion relations, &c., of fruit trees ; and Mr. S. G. Gray, was appointed in place of Mr. Harris to work under Mr. McMillan in genetics.

In connexion with the work at Stanthorpe the Council is co-operating with the Committee of Direction of Fruit Marketing and the Department of Agriculture and Stock for Queensland.

The Division of Plant Industry as a whole is much indebted to Miss F. E. Allan for her constructive criticism of working plans and analyses of results from the statistical point of view.

In connexion with yield investigations in wheat an experiment designed to provide data on the reaction of varieties to environment is being conducted at the Wagga Experiment Farm, New South Wales, the Waite Agricultural Research Institute, South Australia, the Merredin State Farm, Western Australia and the C.S.I.R. experiment area at Duntroon, Canberra. The co-operation of the New South Wales Department of Agriculture, the Waite Agricultural Research Institute, and the Department of Agriculture of Western Australia in providing land, accommodation, &c., is cordially appreciated. Mr. S. G. Gray, of the Genetics Section of the Division of Plant Industry, has been stationed at the Wagga Experiment Farm, New South Wales, and Mr. K. L. Hills at the Merredin State Farm, Western Australia, by arrangement with the respective Departments of Agriculture for the purpose of this investigation.

2. *Fruit Investigations.*—These cover work in Tasmania on non-parasitic diseases of the apple in co-operation with the Department of Agriculture, cool-stores and growers ; in Victoria and in South Australia on growth and bud development in co-operation with the State Departments of Agriculture ; at the Citricultural Research Station, Griffith, on alternate cropping of Valencias, and at the Viticultural Research Station, Merbein, on sultanas, in co-operation with officers of those Stations.

(i) *In Tasmania.*—The investigations in Tasmania, reported here up to the middle of the 1934 season, have for their scope the whole field of the non-parasitic diseases occurring in Tasmanian apples whether on the tree, in local storage, or on overseas markets. Experience has shown that the disorders are so interlinked that separately they cannot be studied satisfactorily. The investigations have three phases :—

(*a*) The identification and definition of the several disorders.
(*b*) The association of the disorders with the various orchard and storage factors.
(*c*) The association of liability or non-liability to the disorders with the factors of size, maturity, and physiological reactions.

The field work has been centred in a section of the Huon Valley, the most productive apple-growing area in Tasmania, where a soil survey has been carried out by Mr. C. G. Stephens, of the Soils Division.

The identifications of the disorders based upon symptoms and upon observations of occurrence in relation to variety and environmental factors is proceeding satisfactorily.

The second phase of the work has been attacked in several ways and in most cases the plans call for repetition over at least four seasons. Seasonal surveys in relation to climatic observations and soil types show very definite associations of certain troubles, notably water-core, crinkle,

internal cork, and low temperature breakdown, with these factors. Storage trials with the fruit of selected trees indicate definitely that soils differ in regard to the keeping capacity of the fruit they produce on the same variety. They also strongly indicate that the seasonal climate raises or lowers the general level of the keeping capacity of the fruit of the same trees in different seasons (e.g., 1934 has so far proved much superior to 1932 and 1933 in this respect). The size of crop on individual trees as indicated by the predominant size of the fruits has been found markedly to affect the liability of the fruit to orchard or storage disorders. Light and heavy winter-pruning and summer-pruning alone were found to affect the physiology of the fruits differently and to have very definite results on the incidence of cork spot and storage pit in Cleopatra. This test will be extended to include Sturmer next season.

In 1932 and 1933 it was found that certain varieties notably C.O.P., Jonathan, Scarlet, Sturmer and French Crab were very subject to low temperature breakdown, liability increasing with the size and maturity of the fruit. Following an abnormally dry and warm summer there is in 1934 a marked freedom from this disorder, at least in the earlier varieties. Deep scald was rare in 1933 (and so far in 1934) and was confined to storage temperatures below 36°F. Water-core and pit breakdowns have occurred in both seasons without obvious relation to storage temperature. Bitter pit has generally been more severe at the higher than at the lower temperature and least at room temperature.

As opportunity offered inspections were made on the wharves of the fruit being loaded for export, and predictions, since confirmed, made of its probable overseas condition. At the same time note was taken of the methods of refrigeration and stowage used on the boats for possible correlation with reports of bad out-turn overseas, if any.

For the third phase of the work the fruit on all trees selected for storage trials has been periodically sampled and submitted to determinations of ground colour, pressure test, iodine reaction, electrical conductivity of flesh, pH, total acidity, and refractive index of juice. For the last four tests the fruits were divided into four tissue zones tested separately. The results over two seasons show distinct differences between the better and poorer keeping varieties and between the better and poorer keeping lines of the same varieties. They have also demonstrated marked differences between tissues in the same lot of fruit. With the exception of electrical conductivity measurements, these tests will be continued. Results so far obtained suggest that it will be possible to recognize better and poorer keeping seasons, better and poorer keeping lines of fruit and also to recognize the physiological changes induced in fruit by changes in orchard practices.

The starch test and the ground colour are still the most satisfactory when used to determine different stages of maturity in fruit grown under the same or similar conditions.

We are indebted to the Department of Agriculture and particularly to the Horticultural Branch, to the Huonville Co-operative Cool Store and to the Moonah Cool Store for facilities and assistance ; also to many orchardists in the Huon Valley and elsewhere for assistance and fruit, particularly to Mr. T. A. Frankcomb for putting at our complete disposal a badly affected orchard.

(ii) *Growth and Bud Studies.*—The investigation of the process of fruit bud formation in selected varieties of apple, pear, plum, peach and apricot in the Goulburn Valley, Harcourt and Melbourne districts, has been completed for the third successive season. These studies, which have been carried out in co-operation with the Victorian Department of Agriculture, furnish information regarding the important growth phase of fruit bud differentiation and development in relation to seasonal conditions and vegetative growth.

A joint publication giving the results of the first year's work has been issued by the Council and the Victorian Department in the latter's Journal. The third season's records have substantiated and extended the results of the previous observations. These data will, it is hoped, furnish a guide in the conduct of manurial and pruning trials and will facilitate the application under Australian conditions of the results of experiments made in other countries. It has also been found that the behaviour of fruit trees as regards the setting of the fruit, blossom bud formation, and the response of shoot growth to environmental conditions is closely related to the growth conditions during the previous season. Stimulation of growth during autumn, for instance, accelerates the development of blossom buds but also depletes the food reserves upon which the first growth phase in the following season depends. Under unfavourable conditions a poor setting may then ensue. Moreover, subsequent growth phases, including fruit bud formation during the same season, are conditioned to a considerable degree by the

nature of the growth made during the first phase. In some varieties, especially of apple, the inter-relationships of the growth phases are such that the economically undesirable habit of bearing large crops only in alternate years arises under present cultural methods. Further progress in cultural practice is to be confidently expected from a study of the fundamental growth phases and their inter-relationships in deciduous fruit trees.

(iii) *Investigations in Irrigation Areas.*—The problem of alternate bearing in Valencia oranges in the Murrumbidgee Irrigation Area is similar to that of the biennial fluctuation in the apple crops. Heavy crops were produced in 1928, 1930 and 1932, whilst considerably lighter ones were borne in 1927, 1929, 1931 and 1933.

In the heavy crop years financial loss results for the fruit grower by reason of the preponderance of under-sized fruit, whilst in the light crop seasons the value of the small crop is diminished by the coarseness which accompanies over-large fruit. It has been found that thinning the fruit sufficiently early in the season will increase the amount of blossom formed for the following crop, though no effect of varied manurial treatment has yet been demonstrated. Observations have indicated that the tendency to bear heavy and light crops in alternate years varies with the strain of the variety.

At Merbein, Victoria, the "topping" experiments with vines have been continued in conjunction with studies in starch accumulation, growth, and bud development. The summer pruning experiment indicated that the present method of topping increased the number of fruit buds formed. Increased yield in the second season followed, though a slight reduction in the sugar content of the grapes was evident. In the third season, owing to a further reduction in the sugar content, the yield was only equal to or less than that of the untreated vines.

(iv) *Investigations in Queensland.*—A co-operative investigation was commenced in November, 1933, at Stanthorpe, Queensland, into the question of the low yield of marketable apples per unit area which is apparently determined by the dwarf stature of the trees due probably to the nature of the rootstocks employed, combined with the rather low fertility of the soil. The present average annual yield per tree in a commercial orchard is stated to be about 2 bushels. By comparison, records of 1,152 trees of ten to fifteen years of age, kept at Kybybolite, South Australia, from 1919 to 1923, show their average annual yield to be 4,291 bushels or nearly 4 bushels per tree. By arrangement the Department of Agriculture and Stock, Queensland, has made an area of land available for an experimental orchard and the Committee of Direction of Fruit Marketing has agreed to finance the work for a period of three years.

Mr. L. A. Thomas has been in the district since his return from East Malling in November, 1933, and has been co-operating closely with Mr. St. John Pratt of the Queensland Department of Agriculture and Stock, who has already commenced the nursery planting of certain East Malling stocks. Mr. Pratt has made available a nursery plot on his own area in which green manurial trials have been established, and stool beds have been laid down by Mr. Pratt for our use. East Malling stocks were received in early April from England and collections of rootstocks and scions are in progress.

A soil survey at Applethorpe has been commenced and a lime-deficiency experiment has been set up in the orchard of Mr. Newell at Cottonvale with respect to certain leaf symptoms on Jonathan trees.

3. *Wheat Investigations.*—Despite its present market position, wheat still constitutes the second most important export crop of Australia. Improvement in any factors which will tend to reduce the cost of production per unit area should make it more possible for the Australian producer to compete in the world's market. Consequently State Departments of Agriculture and other scientific institutions like the Waite Agricultural Research Institute and the Council are bending their energies to a solution of breeding, diseases and other problems. The programme of wheat investigations of the Division of Plant Industry includes such problems as flag smut, root-rots, yield and drought resistance.

(i) *Flag Smut.*—During the year work on flag smut of wheat was concentrated on investigating the factors which are necessary for as close an approach to 100 per cent. infection as is possible in order to facilitate breeding and genetical studies. In the course of the experiments it was found that infected seedlings were distorted and spotted, the distortion being evident within eight days of sowing the seed and the spotting after a few more days. The spotting was first reported by Dr. W. L. Waterhouse, of the University of Sydney, when trying the experiments carried out in Canberra. The discovery of these early signs of infection will be of value to

investigators of this and other smut diseases of cereals not only in this country but throughout the world. It was also demonstrated by the experiments that, provided conditions were suitable, practically every plant showed symptoms in the seedling stage irrespective of whether " resistant " or " susceptible " varieties were tried.

Mrs. A. J. Nicholson in reviewing her work for three years has reached the following conclusions :—From tests of 40 common varieties it appears that the number of tillers is increased in smutted plants but the number of grain-bearing heads is reduced with a consequent reduction in yield per plant. A further point is that the yield per plant from " apparently healthy " plants in rows treated with flag smut is significantly less than for similar plants in untreated rows ; in other words, flag smut may reduce the yield without manifesting itself in the plant.

Tests were made of fifteen reputedly resistant varieties from China and three from Cyprus for their susceptibility to the Australian flag smut, but only two from China and one from Cyprus showed resistance comparable with that of Nabawa.

(ii) *Root-rots.*—Following the lead given by the discovery of increased severity of seedling blight by the joint attack of the flag smut organism and a root-rotting organism (*Fusarium culmorum*), field experiments were made to ascertain the extent of damage under those conditions. The plots were laid out with a view to subsequent statistical analysis of yield, using varieties which were reputed to be, respectively, " resistant " and " susceptible " to flag smut and bunt. In the field experiments last season, the stand during the early stages of growth was equally good in the plots inoculated with *F. culmorum* and in the controls, but in those in which the grain was inoculated with both organisms, pre-emergence blight and seedling blight were severe.

On account of the widespread occurrence of *Wojnowicia graminis* in the wheat-growing districts, and its frequent isolation from foot-rotted plants, detailed experiments were made to settle its problematical importance as a cause of foot rotting. All the experiments failed to give evidence of any but weak pathogenicity, these findings being in agreement with those of other workers throughout the world.

Under greenhouse conditions the organism attacked fourteen graminaceous hosts of which barley grass *Hordeum murinum* was the most severely injured, being reduced in size by 30 per cent. and dying off a week earlier than the control plants. In the field the same fourteen hosts were more mildly attacked, but again barley grass suffered most. Its marked susceptibility may serve to explain in part the wide distribution of *W. graminis* in wheat fields.

(iii) *Yield.*—An arrangement has been entered into with the Departments of Agriculture of New South Wales and Western Australia, the Waite Agricultural Research Institute, and the Division of Plant Industry, whereby about 100 varieties of wheat are being tested for their reaction to different environments. The varieties have been sown in accordance with their relative period of maturity. Observations will be recorded throughout the coming season.

Work on the analysis of yield of wheat at Duntroon has been continued and two years' records show that within a given variety the number of ears is proportional to the number of tillers and that there is a high correlation between yields of grain and straw. Comparing varieties there is little correlation between ear number and tiller number, or yield of grain and straw, but there is an inverse relation between ear number and size. Exceptions occur, and Waratah, for example, stands out with a higher grain number and Canberra with a higher weight per grain than other varieties when related to ear number. Such differences are important in indicating varieties which might be crossed with a view to increasing yield.

(iv) *Drought Resistance.*—Capacity to withstand drought has largely been determined by the reaction of varieties in the field, but it is felt that for genetic investigations it should be possible to arrive at certain criteria which could be utilized as measures of this characteristic. A difficulty to be overcome is to make allowance for the inherent yielding capacity of a plant. With this in mind efforts are concentrated on attempting to arrive at some satisfactory measure of drought resistance.

Evidence shows that plants subjected to drought a short time before flowering have their grain number reduced but individual grain weight increased, whereas when subjected to drought shortly after flowering there is no significant loss in grain number but there is a considerable loss in grain weight.

Work is in progress on the relations between soil moisture, water content of leaves (bound and free) and dry matter content of expressed sap of Currawa, Federation and Major and some significant correlations have been obtained in this year's work.

(v) *Other Investigations.*—(*a*) "*Firing*".—During the course of examination of certain material it was observed that in some cases the first generation of offspring from particular crosses such as Cadia X Shepherd, Cleveland X Shepherd, &c., showed colour changes and death of tissues just about preheading stage to which the term "firing" has been given. It has been shown to be a heritable characteristic.

(*b*) *Vernalization.*—Russian workers have reported that by a method which involves treating seed with water, subjecting it to conditions favorable for germination for about 24 hours, then transferring it to low temperature conditions for some ten to fifteen days and finally sowing in the normal way an increased earliness in flowering and in maturity is obtained. This indicated the possibility of the application of such a method to the growing in short season districts of normally late varieties which will still reach maturity in the shorter season. Experiments were set up to try this with wheat and also with tomatoes, maize, soy bean, millet, sudan grass and field peas. Under the conditions obtaining here no significant differences were obtained between the controls and treated samples. .

4. *Plant Introduction.*—During the year some 323 additional plants, including 86 grasses and 114 legumes, were introduced from abroad for test, bringing the total introductions to 4,867 from 54 countries.

In replicated tests 70 promising introduced wheats were compared with Canberra, Waratah, Federation, Free Gallipoli, Yandilla King and Nabawa and it was found that for two years Schulz, Solid Straw Tuscan, Florence X Gluyas 17, Rooi Llama, Defiance, Onus, Green Fair, Major, Wheeler's 1925 Crossbred 10A, Rooi Unie, and others yielded better than some or most of the checks. In the case of oats, Algeria No. 61, Legacy, Kherson, Victory and Iowa No. 3 yielded better than the control, which was Mulga.

Additional plots of promising grasses were laid down during the year and work was continued on those subjected to periodic grazing and differential mowing. Examples of introduced grasses which have maintained good swards under the different treatments are *Agropyron cristatum, Agropyron intermedium, Oryzopsis miliacea, Phalaris stenoptera, Phalaris coerulescens, Bromus inermis, Dactylis glomerata* strain, *Festuca Mairei, Festuca elatior* and *Bromus unioloides.* All proved palatable to sheep, the *Phalaris* spp. being eaten last although coarser grasses such as *Festuca Mairei, F. elatior* and *Brachypodium phoenicoides* were readily eaten.

Trial plots of lucerne wherein some seven introduced varieties are being tested against a good strain of Hunter River, have been established at Duntroon. Results of one year's test indicate the superiority of both *Hairy Peruvian* and *Chinese* to the latter in yield of air-dry forage per acre in the Federal Capital Territory.

The trials at Gatton Agricultural College revealed a number of promising grasses including three Digitarias (woolly finger grasses from South Africa), four Brachiarias, three Panicums, two Eragrostis, &c., while among the leguminous plants were Lespedezas, Crotalarias, Alysicarpus, and three soy beans.

To date, 1,666 lots of seed and roots of introduced plants have been distributed for further test, the number for this year being 999, while 827 seed lots and roots have been sent abroad to 28 countries of which 623 samples represented seed of indigenous species.

Pyrethrum culture was continued during the year, the plants receiving only the natural rainfall at Canberra. Some 660 small samples of seed were sent out by request to 165 persons interested in pyrethrum culture in the various States, Papua and Norfolk Island.

5. *Agrostology.*—(i) *Detailed Study of Introduced Grasses.*—During the year special attention was paid to the following introduced grasses—*Brachypodium phoenicoides, Festuca Mairei, Festuca arenaria, Bromus macrostachys, Bromus brizaeformis, Eragrostis virescens, Ehrharta erecta, Oryzopsis miliacea, Phalaris coerulescens, Phalaris stenoptera, Agropyron cristatum* and *Agropyron intermedium.* These studies are being continued as conclusive results are not yet reached in all cases.

Brachypodium phoenicoides was found to be aggressive and well fitted to compete with weeds and the natural flora. It possesses good seeding habit and shows promise of being capable of providing excellent fodder during the greater part of any year. In general, this species should prove a valuable pasture plant under "Mediterranean region" conditions, in which region it should be distributed. *Festuca Mairei* is considered to be a very good pasture plant for the "Mediterranean region", though of rather less potential value than the former, and should be distributed in that region. *Festuca arenaria,* so-called, is believed to be identical with *F. rubra.* Though studies concerning the species are not very far advanced, there is reason to believe the

grass may prove very valuable under " Mediterranean region " conditions. *Bromus macrostachys* and *B. brizaeformis* are unlikely to prove of any great value in Australian pastures being annuals not of outstanding pasture value and not possessed of characters enabling them to compete successfully with other plants. *Eragrostis virescens* is unusually xerophytic for an annual. It is believed that this species might prove a plant of some value for re-vegetating denuded areas in dry country in arid regions but studies to date seem to point to the possibility of its becoming a pest in better rainfall country, including the " Mediterranean region ". *Ehrharta erecta* is most suited to an arid habitat, where it would be likely to prove a valuable fodder grass of fair nutritional value. It is unsuitable for the better rainfall country, such as the " Mediterranean region ". *Oryzopsis miliacea* is best suited to an arid habitat. Studies with *Phalaris coerulescens* and *P. stenoptera* do not seem to show that they can be recommended as plants of great potential value in such country as the " Mediterranean region ". It seems likely, however, that they would be of considerable value under more tropical conditions such as obtain in the Mitchell grass country—open grassland (northern). Though the studies with *Agropyron cristatum* and *A. intermedium* are as yet incomplete, it can be concluded that both are very xerophytic and, therefore, there is reason to believe that they may prove of great value in drier areas. They are believed to be of good nutritional value and they remain green throughout the year and produce abundance of seed at Canberra.

(ii) *Native Grasses.*—Detailed studies of Kangaroo Grass (*Themeda australis*) are being made and to date they go to show that in certain seasons it produces abundance of fertile fruits. Germination studies emphasize the importance, and possible necessity, of (1) an alteration of temperature, (2) high temperature for some period (about 35° C.), (3) from 50 to 60 per cent. soil saturation, and (4) shallow planting. Reproduction under natural conditions and general studies are being undertaken. The grass is slow in establishing itself, and it has a low mineral content. The above constitute some of the conclusions which are emerging from the study under review.

(iii) *Plot Studies.*—Sixteen grasses and other pasture plants were laid down in mixtures in large plots at Duntroon in September, 1931, and were subjected to depasturing by sheep and to mowing at intervals from October, 1932, to May, 1934. Ground cover estimations showed that Hawkes Bay Perennial Ryegrass (certified " Old Pasture "), Akaroa Cocksfoot, Lucerne and Sheep's Burnet did particularly well under the soil and climatic conditions obtaining in the Federal Capital Territory.

(iv) *Xerophytism in Grasses.*—A method of estimating the relative capacity for drought resistance of different grasses by measurement of the water balance of whole plants has been evolved and a number of species have been classified on the basis of their capacity for growth where there can be only a minimal absorption of water. Further studies are yielding information that gives promise of a better understanding of the phenomenon of xerophytism in grasses.

(v) *Pasture Map of Australia.*—Further data are being accumulated and incorporated in the descriptive matter which will eventually accompany the map. The map itself, giving the pasture zones in broad outline, is nearing the completion of the first proof.

(vi) *Standardization of Common Names.*—Grasses and other pasture plants may have several common names according to locality, and in publications or in dealing with seed problems, &c., some confusion may arise with respect to vernacular names. Consequently, lists of such names are being prepared and arranged with their corresponding botanical counterparts with a view to arriving at some agreed usage as to common names.

6. *Tomato Investigations.*—The main work during the year has been the study of the reaction to various chemical treatments of the viruses of tomato spotted wilt and ordinary tobacco mosaic, as present in the juice expressed from diseased plants. This work has been carried out by Mr. G. Samuel (now Mycologist at Rothamsted) and Mr. J. G. Bald, in co-operation with Mr. R. J. Best, Chemist, of the Waite Institute.

Quantitative methods of determining the activity of inocula have been studied in this investigation. The effects of the pH value of the medium and of oxidizing and reducing agents and other chemicals on the activity of the viruses *in vitro* have been studied.

With regard to the virus of tomato spotted wilt, it has been found (amongst other things) that the activity of an inoculum containing it is influenced to a marked degree by the pH value of the inoculum : that certain oxidizing agents even at low concentrations will rapidly inactivate the inoculum, whereas certain reducing agents will prolong its activity far beyond the normal life *in vitro* of a parallel untreated sample. Atmospheric oxygen can also bring about inactivation but only through the agency of an oxygen carrier present in the inoculum.

Work along these lines is being continued by the Chemistry Department of the Waite Institute.

7. *Tobacco Investigations.*—(i) *Diseases.*—(*a*) *Blue Mould or Downy Mildew.*—In order to obtain an idea of the potential outbreak of blue mould for the coming season a wide, though not detailed, survey was made between 8th September and 3rd October, 1933, in southern New South Wales and Victoria. The districts visited included Tumut, Albury, Kiewa River Valley, Ovens River Valley (from Wangaratta to Eurobin), King River Valley (as far south as Whitfield), Corowa, Yarrawonga, Cobram, Tocumwal, Echuca, Deniliquin, Mathoura, Nathalia and Shepparton. Some fields had been ploughed, but hundreds of acres of growing as well as dormant plants from last season were observed. In the majority of fields examined overwintered diseased plants were found with conidiophores and conidia of the downy mildew fungus present in abundance on both old leaves and young sucker leaves. Seedbeds were frequently found within a few yards of overwintering diseased plants carrying a luxuriant crop of blue mould spores. This survey indicated a serious year for the industry if weather conditions were at all favorable to blue mould and unfortunately this was the case. The use of disease-free seed will not cure the trouble so long as overwintered plants are present to initiate infection in the new plants.

In North Queensland early seed beds were reasonably free, but from mid-December onwards the disease was epidemic and destructive. A number of sprays were tried in the seedbeds from December, 1933, to May, 1934, and all sprays checked the spread of the disease although the most effective were copper emulsion and colloidal copper as recommended by the Queensland Department of Agriculture.

(*b*) *Leaf Spot.*—(" Frog-eye " caused by *Cercospora nicotianae.*) The occurrence of this disease in epidemic form in North Queensland was noted in the previous Annual Report of the Council, and the results of preliminary, but intensive work, were issued as Pamphlet No. 3 of the Australian Tobacco Investigation in September, 1933. Laboratory and greenhouse studies were carried on at Canberra until December when further experimental work was continued at Mareeba, North Queensland. The investigations this year have served to confirm the results obtained last season and show that " frog-eye " can be checked by the application of control measures which are practical and effective.

The use of disease-free seedlings is the first essential, and in this connexion the provision of clean seed is of prime importance. Seedlings grown from seed collected on farms where the disease was prevalent during 1932–33 or 1933–34 developed the disease a short time after germination. Such plants constitute centres of infection from which the disease may spread throughout the seedbeds. Seed sterilization with 1–1,000 solution of silver nitrate has been found effective, but the selection of disease-free plants for seed purposes is strongly recommended.

The disease has been shown to persist over winter in leaves, so that seedbeds should be located at some distance from barns, and old plants should be destroyed. Sterilization of the seedbed is a wise precaution.

Spraying trials were conducted from December, 1933, to June, 1934, using Bordeaux mixture, copper emulsion and colloidal copper, and all were effective in controlling the disease in the seedbed.

Variations in methods of curing did not have any appreciable effect in reducing the incidence and amount of " frog-eye " barn spot. The development of barn spot depends on the extent of the infection in the field, and the prevention of this aspect of " frog-eye " lies in the adoption of methods of control for seedbed and field.

(ii) *Smoking Tests.*—During the winter, preliminary smoking tests were made of farmers' samples of the 1933 season. The results given can only be taken as presenting an indication of the quality position by States as the samples were not sufficient in number. Out of 123 samples from various sources in Queensland 4 per cent. were good cigarette and 60 per cent. good medium pipe tobacco. From Victoria 34 samples of the 1933 crop were obtained which, when tested, resulted in 50 per cent. good medium pipe, and from the Tasmanian crop 32 samples showed 20 per cent. good medium pipe tobacco. Of seven samples obtained from Western Australia one was good medium pipe tobacco.

(iii) *Curing Experiments.*—Curing procedure is more or less confined to a flue-curing process requiring a period of about six days for its completion. This is practised, as a rule, irrespective of the stage of maturity of the leaf when harvested. The view held by the Tobacco Investigation was that the duration of the curing should largely be determined by the stage of maturity of the leaf when first placed in the curing barn and for three years experiments have

been in progress dealing with the problem. Conclusions drawn from the results of the work of these three seasons indicate that where tobacco is uniformly ripe little difference in the resultant smoking quality is obtained by variation of the curing process from the usual method now practised and occupying about six days per cure. However, tobacco which has not reached full maturity in the field, when cured by a lengthened process of ten days or more, gives ultimately a better product than when cured for six days. Tobacco picked at a definitely immature stage, as is often the practice commercially, does not give a good product even at seventeen days of curing. One inference from the smoking tests is that there is a relation between poor smoking aroma, immaturity, and alkalinity of the smoke, whether the immaturity of leaf is due to premature ripening (resulting from dry, unfavorable soil and weather conditions) or to being harvested in a pre-ripe state.

(iv) *Chemical Investigations.*—With a view to determining what major factors were responsible for poor smoking aroma it was planned to carry out chemical analyses, and Mr. Kipps commenced an analysis of samples of leaf for nicotine and nitrogen content. Later the work was undertaken by Mr. N. F. B. Hall under the guidance of Professor J. C. Earl, of the Department of Organic Chemistry of the University of Sydney. Although but recently commenced, results to date indicate that the degree of alkalinity of the smoke decreases as quality is higher, the high grade smoke being faintly acid to litmus and the low grade distinctly alkaline. Low grade tobaccoes also give comparatively large amounts of tarry matter on burning, and the smoke from these low grade samples contains appreciable quantities of hydrogen sulphide while better samples give only very faint traces.

(v) *North Queensland Plot Work.*—" Date-of-planting " trials were conducted at Mareeba on two soil types, red and grey granite sandy soils, and on each the varieties Jamaica and Cash were planted early and late. Early plantings were completed in the last week of December and late plantings by the 15th of February. Early leaf from virgin red or grey soil was better than that from old soil and later planted leaf was generally better than that planted earlier. The leaf from a commercial point of view was bright in colour, rather light, of fine texture but somewhat lacking in elasticity. Some of it was " feather-tipped ", indicating that it had not developed fully as a result of adverse weather conditions or fertilizer shortage during a part of the growth period.

In the variety trials the early plots produced small, light, bright leaf with no outstanding differences between Hickory Pryor, Cash or Jamaica, but, in the late plantings, Jamaica was best with Cash, Hickory Pryor and Dunbur in that order.

The leaf produced on green manurial plots is similar to that from the variety plots but the texture is a little heavier and the colour duller. No smoking tests have yet been made to determine smoking quality differences if any.

Growers co-operated in date-of-planting trials at Alma Den, Petford, Dimbulah, Laura and Charters Towers.

8. *Pea Disease.*—During the year, a number of isolations of a species of *Aphanomyces* causing root rot of peas were made from diseased material from Tasmania. It has been observed that with some of them, oospores are not formed and the organism, consequently, dies after a few weeks. This finding has been applied in greenhouse tests with encouraging results and field trials will follow.

9. *Needle Fusion and other Diseases of Pines.*—Needle fusion is justly regarded by forestry officials as a very serious obstacle to the successful utilization of poor-class land for the growth of pines. Observations indicate that at least 20 per cent. of the pine trees now growing in New South Wales coastal plantations will have had their growth arrested and their commercial value more or less destroyed by the time the crop matures, whilst in some areas over 50 per cent. are already affected. In Queensland, infestations of 60 per cent. or more are reported. One species, *Pinus pinaster*, has never been found to show symptoms of needle fusion, but this species is very susceptible to attack by the insect *Chermes*, also a serious trouble.

During the year under review, field observations of the disease have been made in one Victorian and eight New South Wales plantations. The poorer the conditions under which the pines are growing, the greater appears to be the severity of attack, and vice versa. Whether the disease is infectious or not still remains to be determined although observational evidence points to the possibility of it being a virus disease. Eradication experiments, in which the New South Wales Forestry Department is co-operating, are being tried in two plantations with 17,000 trees.

10. *Fungal Discoloration of Paint.*—Fungal discoloration of painted surfaces is a source of expense to householders in certain coastal areas, being particularly troublesome in Queensland. Surfaces that under inland conditions require repainting only after the lapse of some years, become darkened so rapidly under conditions of high temperature and humidity that annual painting is sometimes necessary. During the year painted panels exposed in Brisbane indicated, by the extent of their discoloration, the lines along which future work should be done. Following this lead another series of painted panels was prepared, and they are being exposed in the same positions as were the previous series.

11. *Maize Breeding.*—Mr. J. R. A. McMillan, Senior Geneticist, has, by co-operative arrangement, continued his contact with work commenced in 1925–26 at the Queensland Agricultural High School and College. In the variety trial, the varieties "Improved Yellow Dent", "Fitzroy" and "Leaming" are outstanding for Lockyer Valley conditions (the College average annual rainfall over 34 years being 28.6 inches) giving average yields of about 50 bushels per acre as against approximately 40 bushels for the average of the trials including these varieties. The results of this work up to and including the season 1932–33 were published in the *Queensland Agricultural Journal* in February, 1934, jointly by Mr. McMillan and Mr. W. W. Bryan, Instructor in Plant Breeding at the Queensland Agricultural High School and College.

12. *Miscellaneous.*—A number of other matters, not included in the above-noted headings, received attention during the year.

Mr. Calvert investigated the effect of arsenical sheep dips on the germination of Noogoora Burr seeds and found that, with two sheep dips tested, the viability of the seeds was destroyed when subjected in the laboratory to a treatment comparable with that to which they would be subjected in the ordinary process of sheep dipping.

Mr. Kipps carried out analyses of some half dozen pasture grasses, and it was observed that the more drought resistant types among them appeared to have a higher pectin content than the lesser drought resistant. This work is being continued.

III. ENTOMOLOGICAL INVESTIGATIONS.

1. *General.*—The Division of Economic Entomology also has its central laboratories in Canberra. In addition to the laboratory building there are four large insectaries and one small one where investigations are carried out under quarantine conditions. Two of these insectaries are used chiefly for experiments in connexion with insects introduced from other countries for the control and eradication of noxious weeds. The others are fitted up for research work on insect pests of animals, particularly the sheep blowfly. Most of the problems which the Division is investigating are of a complex nature, and a great deal of fundamental work must necessarily be done before results of economic value can be expected. For example, many insect enemies of noxious weeds and of insect pests of animals have been introduced by the Division, but before they can be released from quarantine careful investigations have to be conducted in order to ascertain beyond doubt that they will not attack any plants or animals of economic value and to ensure that generations of them have been bred free from hyper-parasites. Again, in a problem such as that of the sheep blowfly pest, on which so large an amount of work has been done in the past by State Departments of Agriculture, it appears that further progress towards a solution of the problem is dependent on the acquisition of fundamental knowledge which can be obtained only as a result of careful and patient observations.

During the past year considerable progress has been made with most of the problems undertaken by the Division. This progress has been made mainly by increasing our knowledge of the details of the problems, and developing satisfactory methods for the investigation of practical difficulties. For example, a method has been developed for testing the susceptibility or resistance of materials to attack by white ants much more rapidly and accurately than was previously possible. Some results of immediate practical importance, however, have also been obtained, such as the discovery of a satisfactory substitute for pollen to be used by bees in times of shortage, and the development of improved methods of preventing the breeding of blowflies in carcases, and of destroying white ants in their nests. Moreover, there are clear indications that, as a result of the fundamental work carried out during the past few years, a number of other lines of investigation are nearing the point where practical results will be achieved.

2. *Entomological Control of Noxious Weeds.*—Many of the weeds of Australia are natives of the Mediterranean region. For this reason Mr. S. Garthside has made a quick survey of this region in order to find the most suitable localities in which research might be carried out. It is proposed that a research worker be sent soon to this region to amplify the work of the Council on noxious weeds.

(i) *St. John's Wort* (*Hypericum perforatum*).—Further consignments of various insect enemies of St. John's Wort were received during the year from the Farnham Royal Laboratory (Great Britain). During the past four years 26,000 *Chrysomela varians* and 28,000 *C. hyperici* have been liberated in Victoria and New South Wales in a number of districts in which all varieties of conditions under which St. John's Wort grows are represented. There has been little survival from these liberations and, as it is considered that these insects have now been given a fair trial, future work will be devoted to other enemies of St John's Wort. On the other hand, only 800 *C. brunsvicensis* have been liberated, owing to the difficulty of transporting insects of this species to Australia. Work on this species will, therefore, be continued. About 4,400 larvae of *Anaitis plagiata* and *A. efformata* were introduced during the season, and large numbers were bred in captivity. These species have been thoroughly tested in order to ensure that they will not attack plants of economic importance and will be liberated during the coming season. Tests of *Lathronympha hypericana* and *Aphis chloris* under Australian conditions have been continued, but are not yet completed.

(ii) *Noogoora Burr* (*Xanthium pungens*).—Burrs containing about 23,000 hibernating larvae of burr-seed flies (*Euaresta aequalis*), and 1,000 stem borers (*Cylindrocopterus adspersus*) were received from Mr. S. G. Kelly, the Council's officer in Kansas, United States of America. He also sent small trial consignments of the weevil *Baris callida*, the tests of which indicated that they are harmless to economic plants and he is continuing tests on the following insects :—*Ataxia hubbardi*, *Dectes spinosus*, *Hippopsis lemniscata* and *Epiblema strenuana*. A thorough test of *Cylindrocopterus adspersus* under Australian conditions on a large number of economic plants has shown this insect to be harmless to all except Jerusalem artichoke and sunflower. Permission to liberate will not be sought until more data have been obtained about the possible harmfulness of the insect. During the year 20,000 adult flies of *Euaresta aequalis* were liberated in suitable areas in various parts of Queensland

(iii) *Ragwort* (*Senecio jacobaea*).—As difficulty has been experienced in obtaining large consignments of *Tyria jacobaea* and *Pegohylemyia seneciella* from New Zealand, arrangements are now being made for supplies to come direct from England for liberation on ragwort in Victoria.

(iv) *Other Weeds.*—Mr. S. G. Kelly, in Kansas, United States of America, is investigating the insect enemies of the following weeds : ground cherry (*Physalis lanceolata*), bracken fern (*Pteris aquilina*), mint weed (*Salvia lanceifolia*), Mexican poppy (*Argemone mexicana*) and skeleton weed (*Chondrilla juncea*). He reports that in one place he found 90 per cent. of the seeds of the ground cherry destroyed by insects, and he is studying their life-history. Attempts to establish the moth *Papaipema pterisii* on an experimental plot of bracken at Manhattan, Kansas, are being continued.

3. *The Buffalo-fly Pest* (*Lyperosia exigua*).—To date 14,500 parasites of the buffalo-fly have been liberated in the northern parts of Australia, but it is considered improbable that the efficiency or otherwise of the parasites can be judged until at least two years after their liberation. In the meantime efforts are being made to have the buffalo-fly problem studied in India, so that if new kinds of parasites occur there they may be collected and introduced into Australia. Professor Patton has shown that *Lyperosia exigua* occurs in northern China, in places where the winters are much colder that in any parts of Australia. Hence it must be concluded that even the southernmost coastal regions of Australia may be endangered.

4. *The Sheep Blowfly Pest.*—(i) *Studies of the Flies.*—Field studies in Western Australia have shown that *Calliphora nociva* and *C. australis* are important sheep blowflies early in the season in the south-western parts of the State, but are replaced later in the season by *Lucilia cuprina*, which is the dominant fly from the beginning of the season in more northerly districts. The life-histories and breeding grounds of several Western Australian blowflies have been studied, and it has been shown that the western *Calliphora nociva* can be crossed with the eastern *C. augur*, so demonstrating the close relation of these species. The ecology of carrion insects in Western Australia was also investigated. In general features it was found to be similar to the ecology of carrion insects in New South Wales, but *Calliphora nociva* survived competition better, and was more abundant in the west, than *C. augur* in eastern Australia. An account of the investigations of the ecology of carrion insects carried out at Canberra during the past few years has been published by Miss M. E. Fuller (C.S.I.R. Bulletin, No. 82).

The fourth year's record of the seasonal prevalence of the more important species of blowflies at Canberra has now been completed. The curves obtained are fairly consistent for all years and work on the correlation of these curves with weather and other conditions is in progress.

The cultures of *Lucilia cuprina* and *L. sericata* have now been maintained for two and one-half and four years, respectively, without impairment of vigour. Flies from these cultures have been freely used in experiments. It was found difficult to maintain a culture of *Chrysomyia rufifacies* in the insectary, but a pure culture of this species has been maintained for over 50 generations in an artificially heated room.

In addition to the species previously recorded, *Muscina stabulans* and *Sarcophaga* sp. have been bred from live sheep at Canberra.

(ii) *The Problem of Susceptibility.*—Studies of strike in the field have been undertaken in Queensland, northern New South Wales, Canberra and Western Australia. All the work shows the value of Dr. H. R. Seddon's classification of sheep as an index of susceptibility to strike. In the experimental flock at Canberra, for example, 43 per cent. "A" class, 85 per cent. "B" class, and 100 per cent. "C" class sheep were struck, and a similar difference between the classes was recorded in the experimental flocks at Cranmore Park, Western Australia, and at Therribri, New South Wales. Field and insectary experiments with ten Polwarth ewes, supplied by the Polwarth Sheepbreeders' Association, indicate that these sheep are less susceptible to crutch strike than pure merino ewes, but definite conclusions will not be drawn until the work has been extended further next season. The exceptionally high incidence of strike at Canberra during the past season has provided a mass of data which are being studied carefully in relation to weather and other conditions, and it is hoped that useful information bearing on the general problem of susceptibility will thus be obtained. A considerable amount of information about the factors influencing susceptibility to body strike has also been collected in Queensland.

Satisfactory methods for the chemical analysis of the raw fleece have been developed. It has been found that the relative proportions of the components, suint, wax, dirt, and fibre, differ not only in samples from different sheep, but in samples from different parts of the same sheep, and even from different sections along the length of an individual staple. The suint fraction has been analysed in some detail. From 10 to 20 per cent. of the dried weight of suint consists of fatty acids, the potassium content is high, the chloride content is lower than in human sweat, and no protein was detected. It was found that the suint fraction is not a nutritive medium for maggots, but slow growth of maggots occurred in the dirt fraction, which contained a considerable quantity of insoluble protein.

The study of the bacteriology of the fleece has been continued, special attention being paid to those organisms which are capable of hydrolysing keratin, as there is good reason to suspect that these are responsible for providing a suitable nutritive medium for maggots in fleece. A study of the incidence of keratin hydrolysers on different parts of the sheep when subject to different weather conditions is in progress, and the origin and mode of transmission of the more important fleece bacteria are being investigated.

(iii) *Carcass Disposal.*—Previous work has shown that burial favours blowflies, particularly the primary ones, and burning of carcasses is rarely done efficiently in practice. Poisoning appears to be the most promising method of carcass disposal, so attention has been concentrated mainly upon the search for a suitable powder which is cheap, can be carried easily, and can be applied efficiently with a minimum of handling of the carcass. Numerous experiments have been carried out, and so far sodium fluoride, diluted with two to four parts of inert dust, is the most efficient substance tested. It is almost completely effective when applied to a shorn carcass, but it is somewhat less efficient when applied to sheep in wool.

(iv) *Trapping.*—Two large-scale experiments are in progress at Therribri, New South Wales, and at Cranmore Park, Western Australia, respectively. In each experiment two fairly similar areas have been chosen in the same neighborhood, one of them being heavily trapped, the other left untrapped. The experiments have been in progress for two seasons at Therribri and for one season at Cranmore Park. The average result is that the sheep have been struck approximately twice as frequently in the untrapped areas as in the trapped ones. It should be noted, however, that far more traps were used than would be practicable under normal conditions on a station, and that insufficient data have yet been collected to make the results conclusive. In the Cranmore Park experiment the opportunity was taken of testing the treatment of baits with sodium sulphide under field conditions. This treatment was found to increase considerably the attractiveness of the baits and to maintain them in an attractive condition for an unusually long period.

With the ultimate object of improving traps and baits, further work has been carried out on the development of satisfactory apparatus and technique for the study and comparison of traps and baits. The importance of the influence of wind on the catching power of compared traps has been amply demonstrated. Two satisfactory types of experimental trap have been developed. When set up in a standard way and exposed on a rotating table, these traps give results which are sufficiently consistent for present purposes.

(v) *Jetting.*—Observations made in Queensland and Western Australia show that jetting as practised by pastoralists is not effective for more than about three weeks. An experiment carried out under insectary conditions showed that sheep jetted with arsenicals were poisonous to adult flies for two or three days after jetting, but the jetting did not appreciably affect the attractiveness of the sheep for adult flies, nor did it affect oviposition. Jetting with arsenicals killed the maggots in existing strikes. Sodium arsenite (0.7 per cent.) and Paris green (1.0 per cent.) protected sheep from blowfly strike for two to three weeks. Calcium arsenite (1.0 per cent.) gave marked protection for over four weeks, those strikes that did develop being limited in extent and not requiring dressing.

5. *Orchard and Fruit Pests—Thrips.*—As indicated in the previous annual report, investigations on the apple-blossom thrips (*Thrips imaginis* Bagnall) are being carried out in co-operation with various bodies, and are under the immediate direction of Dr. Davidson of the Waite Agricultural Research Institute, and, during the past year, have been centred on two main lines, viz.:—(*a*) a study of the causes underlying the occurrence of this species in epidemic numbers in certain years, and (*b*) the use of suitable insecticides as dusts or sprays in order to protect fruit blossom from thrips during the critical periods before the fruit has set. In addition, a concise account has been prepared of twelve of the more important economic species of thrips in Australia.

Daily counts have been made of the numbers of *Thrips imaginis* in flowers throughout the year in certain centres in South Australia and Victoria; the close correlation between fluctuations in the numbers of thrips and meteorological events has been demonstrated. The numbers are low during mid-summer; there is an increase in numbers in the autumn; the numbers are low to absent in the mid-winter months; there is an increase in early spring (first spring rise) followed by a further increase in numbers about October (second spring rise). The second spring rise is the critical period for the apple crop; if the number of thrips is large and coincides with the flowering of the apple, many of the "thrips infested" blossoms may fail to set fruit.

The potential numbers of thrips which will develop in the second spring rise depend upon the numbers present in the autumn rise, and the weather (particularly rainfall and temperature) during the subsequent months. From analysis of the daily records of thrips and meteorological data, it was possible in the early spring of 1933 to predict that a plague of thrips would not occur. The prediction proved to be correct.

The aim of investigations on insecticides is to advise a dust or spray which, when applied to the blossoms, will retain a repellent or toxic action against thrips, for at least two days; this will safeguard the apple blossom during the critical period before the fruit has set. Preliminary experiments with derris and pyrethrum have given encouraging results; owing to the small numbers of thrips in the field, adequate field trials were not possible last spring; the experiments are being continued.

6. *Bee Research.*—Investigations aimed at the discovery of satisfactory substitutes for pollen have been continued by Mr. G. A. Currie. The object of this work is to provide bees with a satisfactory food at times when there is a good honey flow but an absence of suitable pollen, and when the bees suffer from what is known to apiarists as the "disappearing trick." Many substances have been tried, and those which most successfully supported brood rearing were white of egg, casein, dried milk, yeast, and fresh milk. Mr. Morris Morgan, President of the Victorian Apiarists' Association, has tested under field conditions the substances supplied to him during a period in late autumn when no natural pollen was available, and when brood rearing had ceased. The immediate result of providing pollen substitutes was that brood rearing was re-commenced, and the young larvae in the first and second days after hatching were fed copiously with "brood food," a glandular secretion of the adult bees. This brood rearing was maintained up to the end of June, while hives given honey or sugar syrup only had entirely ceased to rear brood, as also had hives which were left unfed as controls. In these experiments the pollen substitutes were fed to the bees inside the hives, but other experiments are being carried out using dry substances in boxes outside the hives. Larger field experiments during periods of pollen shortage need to be carried out before it can be claimed with certainty that the problem has been solved.

7. *Field Crop and Pasture Pests.*—(i) *Clover Springtail.*—During July and August a survey was made of the area in Western Australia in which the predaceous mite *Biscirus lapidarius* occurs. This mite attacks the lucerne flea, or clover springtail (*Sminthurus viridis*), and shows strong indications of being a satisfactory controlling factor of the lucerne flea. As its power of spreading without aid is very poor, large numbers, 13,600 in all, were collected and sent to various parts of Western Australia, South Australia, Victoria, and Tasmania. Reports have recently been received that mites have been found in Victoria and in South Australia at places where liberations were made last season, but it is as yet too early to judge whether they have any important influence on the lucerne flea in the new areas where they are now established.

(ii) *Underground Grass Grub (Oncopera).*—A survey of the damage caused by the underground grass grub in Tasmania was made in October and November, 1933. It was observed that native pastures were less severely attacked than sown ones, and that certain pasture plants appear to be preferred by *Oncopera* larvae, although these larvae will attack any kind of plant when the preferred plants are not available. Much evidence was accumulated showing that a thick growth of grass in late summer or autumn, by providing cover for the moths and young larvae, favours infestation by *Oncopera*. It is recommended that such cover should be removed about the time of the flight of the moths either by heavy grazing or by burning. In low lying areas pastures may be freed of larvae by flooding between July and October. The principal natural enemies of *Oncopera* were found to be starlings and bandicoots, which should be encouraged as far as possible. Some larvae were found to be attacked by native flies (Tachinidae) but, as these parasites primarily attack other kinds of insects, it is considered improbable that they can ever have much influence on the control of *Oncopera*.

Further consignments of the parasitic fly *Hexamera (Protohystricia)* were received from New Zealand. Most of these were liberated at Moe, Victoria, but a few were retained at Canberra for experimental purposes. The particular difficulty in establishing these parasites is that the flies emerge sometime before the main Tasmanian species of underground grass grub (*O. intricata*) has reached a suitable stage to be attacked. Liberations of the parasites have so far been confined to Victoria because several related species of underground grass grubs, which pass through their life cycles earlier than *O. intricata*, occur in that State. It has now been found that two additional species of *Oncopera* occur in Tasmania, and that fact greatly increases the chances of establishing the parasites there.

8. *Termite (White Ant) Problem.* (i) *Studies on the Direct Control of Termites.*—With the object of destroying white ants in their mounds, experiments have been made with nineteen different materials in a large number of mounds of *Eutermes exitiosus*. Many substances commonly recommended for the control of mound colonies have been found quite unsatisfactory. Arsenicals as a group have given the best results, and of these substances white arsenic (trioxide) has proved to be the best and most economical. Colonies with a population of about 500,000 have been totally destroyed by the application of $\frac{1}{8}$th ounce of white arsenic. The cost of materials per mound is 1/20th of a penny.

Preliminary observations on the use of zinc chloride for soil treatment have shown that termites working in the earthen floor of a grain shed, and attacking wheat stored there, were repelled by the application of zinc chloride solution to the soil.

(ii) *Field Tests.*—Field tests of the resistance of the following materials are still in progress:—(*a*) untreated Australian commercial timbers; (*b*) impregnated timber of *Pinus ponderosa* (part of international termite exposure test); (*c*) samples impregnated and brush treated with crude oil; (*d*) "Xylamon" treated timbers; (*e*) impregnated "Tentest"; (*f*) fluarized karri crossarms; (*g*) untreated Canadian timbers; (*h*) "Wolman" treated samples; (*i*) telephone cable casing; and (*j*) "Bruce" preservatives. The spacing tests already reported are still in progress, and a new series of tests has been set up to determine the best method of exposing samples in the field in order to find their resistance or susceptibility to termite attack.

(iii) *The Attack of Lead Telephone Cables by Termites.*—Reports have been received that considerable loss and inconvenience is caused by faults due to termites attacking the lead sheathing of telephone cables. Observations made in laboratory colonies have shown that termites will eat through the lead of a piece of sealed telephone cable. An effort will be made to discover the cause of this.

(iv) *The Development of Standard Laboratory Colonies.*—The ordinary method of testing timber samples by exposing them to the attack of termites in the field is open to the objection that each sample is subjected to somewhat different conditions, owing to the great variations in the natural environment. Moreover, several years must elapse before results can be obtained. It is for this reason that much attention has been given to the development of standard laboratory colonies in which the samples can be exposed under identical controlled conditions, and it has been found that reliable results can be obtained in a few months by the use of such colonies. A series of experiments was carried out during the year to determine the most satisfactory moisture content and the optimum population density for laboratory colonies. The method as at present developed has been thoroughly tested by carrying out a number of independent experiments in each of which carefully selected similar wood samples were used. The results obtained were so closely similar that the method is shown to be satisfactory and dependable. Experiments in which a resistant wood, a susceptible wood, and an intermediate one were used

were also carried out. These gave clear results, the susceptibility or otherwise of the wood being shown both by the amount of wood eaten and by the time of survival of the laboratory colony. Routine testing of timbers and of treated samples by this method can now be begun.

(v) *The Physical Ecology of Termites.*—Field experiments have been set up to study the influence of the distribution and distance of food from mounds on the manner in which exposed timber samples are attacked. The ultimate object of this work is to discover why such variation in results is often obtained when similar timber samples are exposed in the field.

Records of the temperatures in two selected mounds have been kept for over a year. These show that the temperature inside a mound varies with the seasons but is definitely influenced by the presence of living termites. It is dependent upon the size of the population present, and can be affected by the presence of particular castes, notably nymphs and winged individuals, which cause the temperature to be unusually high. A satisfactory apparatus has been developed for the study in the laboratory of the preferred temperatures of termites. The results so far obtained suggest that the preferred temperature is related to the moisture content of the mound material, and that it varies with the season.

9. *Pine Chermes.*—Pine plantations in the Federal Capital Territory have shown a decided increase in Chermes infestation during the past year. Inspections of plantations in New South Wales and Tasmania were made, and it was noted that native natural enemies were scarce and appeared to be of little importance. Experiments carried out during the spring showed that freshly hatched Chermes are carried by wind, and that infestation is unquestionably spread in this way. A further consignment of *Leucopis* was received from England, and, as has always happened with this species, it was in bad condition. Owing to the extreme difficulty of transporting this insect from England it has been decided to concentrate attention upon other natural enemies of Chermes for the time being. About 1,300 *Exochomus quadripustulatus* (in three consignments) and 40 *Anatis ocellata* were received during the year. These lady-bird beetles (Coccinellidae) arrived in excellent condition and appeared to flourish in the insectary but, with the exception of a few *E. quadripustulatus* in the last consignment, they did not lay any eggs. Attempts are being made to find the cause of infertility, and further consignments of the beetles will be introduced. One hundred eggs of the lace-wing fly *Hemerobius stigma* have been received from England and a number of larvae have hatched from them. These will be liberated as soon as climatic conditions improve. Laboratory and field experiments have been made with a considerable number of materials for winter and spring spraying. Kerosene emulsion sprays, which are reported to give good control of Chermes in other countries, were found of little value. Lime-sulphur spray gave the best results, and further experiments are planned to test its efficiency in freeing seedlings of infection before transplanting.

10. *Blood Parasites of Cattle.*—Because of the special facilities available at Canberra, arrangements were made for this Division to undertake investigations for the Division of Animal Health upon the following organisms :—

(i) *Anaplasma marginale.*—The object of these experiments was to find whether biting flies could carry the disease anaplasmosis from one animal to another. Eight experiments were carried out with the stable-fly (*Stomoxys calcitrans*). In each of these a large number of freshly bred stable-flies were allowed to suck the blood of an infected calf and were then caused to bite an uninfected calf. In the various experiments different intervals were allowed to elapse between the time when the flies fed on the infected calf and the time they fed on the uninfected calf. Daily microscopical examinations of the blood of the experimental animals were made over a long period, but none of the animals developed anaplasmosis folowing the bites of *Stomoxys calcitrans*. The experiments were carried out with such thoroughness, and the conditions were made so favorable for the transmission of the disease, that the negative result of the experiments shows that the transmission of anaplasmosis by stable-flies under natural conditions is extremely unlikely. A single similar experiment with the March-fly *Tabanus circumdatus* has so far also given a negative result, but the experiment is not yet complete. These experiments were carefully controlled in every possible way. For example, after ample time had elapsed for the disease to develop in the infected animals and there was still no sign of it, infected blood was injected into the calves. In due course they developed the disease, so showing that failure to develop the disease was not due to a special resistance of the animals.

In the hope that some light might be thrown upon the failure of biting flies to transmit *A. marginale*, three needle experiments were carried out. In the first an uninfected calf was stabbed in the back twenty times with a needle, each stab alternating with a stab in the back of an infected calf. The interval between withdrawing the needle from the infected calf and plunging it into the clean calf was from one to two seconds, and the needle pierced rather deeply, often drawing blood. The recipient calf developed anaplasmosis after an incubation period of

31 days. The second experiment was similar, except that the needle was held in the air for ten seconds between the stabs. The third experiment was also similar to the first, except that the needle was guarded so that it could penetrade only 2 mm. into the skin, which is the maximum depth to which the probosces of the biting flies can penetrate. After 60 days the animals used in the second and third experiments showed no sign of anaplasmosis. Although these experiments are not conclusive, they suggest that the failure of the flies to transmit *A. marginale* was partly due to the interval between bites (the minimum being nine seconds), and partly to the shallow penetration of the probosces.

(ii) *Anaplasma centrale.*—This organism is similar to *A. marginale* but has little, if any, effect on the health of cattle, and it was considered possible that it might be used to immunize cattle against *A. marginale.* Dr. J. A. Gilruth accordingly arranged for two calves infected with *A. centrale* to be sent to Canberra from South Africa. To make sure of the purity of the strain, these calves were kept under close observation for 56 days, but showed no sign of any infectious disease. Blood from these calves was injected into two cows, which subsequently showed a good infection of *A. centrale.* Later, blood containing *A. marginale* was injected into them, but subsequently no sign of this organism could be detected in their blood. Other cross-immunity experiments were carried out, including some in which the spleen was removed from the experimental animals. The results of these experiments show that (*a*) a decided cross-immunity between *A. marginale* and *A. centrale* develops in normal cattle, (*b*) the immunity (premunition) is stronger for *A. centrale* against subsequent *A. marginale* than the reverse, and (*c*) the removal of the spleen interferes seriously with the mechanism responsible for the development of cross-immunity.

(iii) *Piroplasma bigeminum.*—As attempt was made to transmit *P. bigeminum* by the bites of *Stomoxys calcitrans.* Fifty-three stable-flies bit a clean calf after having fed on an infected calf. The recipient calf did not develop red-water, and was subsequently shown by splenectomy and cross-inoculation not to have been infected by the flies.

(iv) *Theileria mutans.*—Infected blood received from Townsville was injected into calves, both of which later showed well-developed infection. Blood from one of these calves was then injected subcutaneously into two sheep. Fifty-nine days later, inoculations of two fresh calves with blood from these sheep was commenced. Both these calves developed a mild infection of *T. mutans.* The conditions of the experiments were such that there can be no doubt that this organism was transmitted through the sheep to the calves.

11. *Greenhouse White-fly (Trialeurodes vaporariorum).*—So far six wardian cases containing tomato plants infested with white-flies parasitized by *Encarsia formosa* have been sent to Tasmania from England. None of these consignments was successful. Fortunately *E. formosa* has recently been established in New Zealand, and attempts will be made to introduce parasites from this source into Tasmania next spring.

12. *Oak Scale (Asterolecanium variolosum).*—Examination of the localities where the parasite *Habrolepis dalmani* has been released during the previous spring were made, but no trace of parasites could be found. A fresh consignment of several thousand parasitized scales was received from New Zealand and released at Launceston, where it is considered the parasites will have a good chance of establishing themselves.

13. *Chocolate Factory Pests.*—An inspection of a chocolate factory in Melbourne was made to study the insect-pest situation there, and a number of recommendations were made. A programme of research has been drawn up for the study of the life-histories and behaviour of the insects under local conditions and the development of satisfactory methods of control. Cultures of *Plodia* and *Ephestia* have been established, and several experiments on the reactions to light and the food preferences of these insects are in progress.

14. *Mound Ant (Iridomyrmex detectus).*—As the generally recommended methods of destroying this troublesome pest were found to be by no means fully satisfactory, a series of experiments was carried out using Paris green, sodium fluoride, calcium arsenate and white arsenic as dusts, " Cyanogas " as a fumigant, and creosote, crude oil, residual oil, and crank-case oil as liquid treatments. A single treatment with any one of these substances was generally effective in destroying small colonies, but it was found difficult to destroy all the individuals in medium and large sized colonies. So far Paris green has given the best results, but further work needs to be carried out in order to find a thoroughly satisfactory method of exterminating these ants.

15. *Garden Snails.*—Sodium fluoride used as a dust was found to be the most effective contact poison, but it is extremely destructive to foliage. It should be a most satisfactory substance to use to clear snails from waste land. Preliminary experiments showed that the dusting

of foliage with calcium arsenate was a promising method of control, so some gardens were treated with calcium arsenate dust, while others were treated with poison bran baits, the usually recommended method of control. Under favorable weather conditions in spring over 98 per cent. of the snails were killed in a dusted garden, while only 64 per cent. were killed in a garden treated with poison baits. Under unfavorable conditions in summer from 69 per cent. to 97 per cent. of the snails were killed in dusted gardens, but only 16 per cent. were killed in a garden in which poison baits had been scattered. These experiments will be continued, as it is considered that the methods have not yet been given a sufficiently extensive trial.

16. *Natural Enemies sent Overseas.*—(i) *New Zealand.*—Two consignments consisting of about 300 fully grown larvae of *Stathmopoda* have been forwarded to New Zealand. The forest entomologist in Nelson reports that the moths have emerged in good numbers, and that there is a good prospect of this predator becoming established on the *Eriococcus* scale. Several large supplies of *Paropsis* larvae and eggs, many of which appeared to be parasitized, have also been forwarded to New Zealand. So far a number of tachinid flies have emerged from this material.

(ii) *South Africa.*—A consignment of 5,000 egg-clusters of *Gonipterus* was sent to South Africa in November. Some parasites were bred from this consignment, but a request for more material has been received. The eucalyptus weevil (*Gonipterus*) is a particularly serious pest in South Africa.

17. *Systematic Entomology.*—About 4,000 specimens, mostly provided by members of the staff of this Division, have been added to the museum during the past year. Mr. A. L. Tonnoir has completed a paper on the Australian species of *Phlebotomus*, a genus of bloodsucking flies known to be of medical importance in other countries. He has also studied the taxonomy of the gall-making flies of the genus *Fergusonia*. Mr. T. G. Campbell has begun a study of Australian Tachinidae, one of the most important families of parasitic insects. Mr. G. F. Hill has made a special study of the genus *Eutermes*, which is the largest and one of the most important genera of termites. Miss M. E. Fuller has worked out the life history of *Actina incisuralis*, a Stratiomyiid fly which inhabits carrion at a late stage of decomposition. Numerous identifications of specimens have been made for entomologists and institutions in all parts of the world.

18. *Advisory Work.*—From time to time advice has been given on many entomological problems, for example, the treatment of termite infested buildings, the control of carpet beetles, "silverfish", booklice, cockroaches, ants in houses, and mound ants and snails in gardens. In most cases it has been possible to follow up the recommendations with observations, and the treatments recommended have been found to be successful.

IV. ANIMAL HEALTH INVESTIGATIONS.

1. *General.*—The main work of the Division of Animal Health is concentrated at the F. D. McMaster Animal Health Laboratory in the grounds of the University of Sydney, and the Animal Health Research Station near Townsville, but in addition researches are being conducted at the Veterinary Research Institute of the University of Melbourne, the Government Laboratory of Bacteriology and Pathology of the Adelaide Hospital, the Veterinary Laboratory of the State Department of Agriculture at Perth and the Veterinary Laboratory of the State Department of Agriculture at Launceston, while field stations in several of the States enable special investigations to be widened in scope. The valuable financial assistance rendered under the co-operative scheme with the Australian Pastoral Research Trust for the investigation of certain animal (sheep) problems has been continued.

During the year the Chief of the Division (Dr. J. A. Gilruth) furnished the Council with an exhaustive report on the beef cattle industry of northern Australia. This formed the basis of a full report by a Special Committee established by the Council. He also furnished a report on northern Australia and its possibilities, for the special guidance of the Council in its consideration of problems which might come under its purview. Unfortunately, portions of this confidential report, separated from their contexts, became public in some unauthorized manner, and led to some misunderstanding.

At the request of the Government of the State of Victoria, Dr. Gilruth was commissioned to inquire into the occurrence of beef measles (*Cysticercus bovis*) in the herd of cattle on the Werribee Sewage Farm belonging to the Melbourne and Metropolitan Board of Works, and to make suggestions regarding control. The thanks of the State Government, together with an expression of its appreciation, were duly received.

Recently, at the request of the Government of Tasmania, Dr. Gilruth in association with the Public Service Commissioner of the State was deputed to inquire into the organization of the Department of Agriculture. This task was duly accomplished, and an expression of the Government's appreciation of the action of the Council and of Dr. Gilruth's services has been received.

The Council at all times welcomes opportunities of assisting and co-operating with State Departments in any problem of mutual interest and has derived much assistance from the close contacts which have been established.

Dr. Lionel B. Bull, formerly Director of the Pathological Laboratory of the Adelaide Hospital, who has rendered signal service to the research work of the Council in connexion with certain animal health problems, was at the beginning of the year appointed Deputy Chief of the Division. He was commissioned to visit Europe and America in order to familiarize himself with the work and methods of investigators there and, after a survey of the activities of the various workers in the Division, left Australia in February last. On his return next year it is certain that the experience he gains and the observations he may make will prove of great value in the prosecution of the various investigations associated with the live-stock industry in Australia.

2. *Research Station at Townsville.*—(i) *Pleuro-pneumonia in Cattle.*—Work on the diagnosis of this disease in the living animal by means of the complement fixation test has been greatly extended; to date over 10,000 individual tests have been carried out by Mr. A. D. Campbell and the technique standardized and simplified. Nevertheless, it still remains a laboratory test that can be satisfactorily carried out only by highly skilled workers.

With the 107 experimental animals on the Station that have been subjected to weekly blood testing, a total of 3,271 tests have been performed. As a result it may be stated briefly that every uninoculated animal that has given a positive test has shown evidence of the disease on post mortem examination, and every animal that has failed to give a positive test has been proved on such examination to be free.

Blood samples from 935 animals slaughtered at the neighbouring meatworks have been tested. In these cases, blood collection had to be made from the heart after slaughter. Although this is a relatively unsatisfactory method, 82 out of 92 positive reactors, i.e., 89 per cent. were confirmed by post-mortem examination and/or by the demonstration of the causal organism in the body, and no positive reactions of animals that were submitted both to post-mortem and cultural examination were unconfirmed. 833 out of 843 of the negative reactors (98.8 per cent.) had been regarded by the meat inspectors as uninfected. The 1.2 per cent. of apparent discrepancies could not under the circumstances be submitted to cultural confirmation. There were accordingly no cases absolutely demonstrated to be " false negatives."

Preparatory to the peg-leg investigations at Helenslee, the 250 experimental animals placed on the property from other stations were submitted to the complement fixation test. Three positive reactors were found and slaughtered. Of these, one was shown to be an acute case, another a chronic case, and the third probably a recently recovered case. The value of the test was thus once more confirmed.

The test, when carried out by officers of the Townsville Laboratory, has thus shown itself to be of a very high degree of accuracy and a very valuable method of diagnosis and control. Similar satisfactory results are reported to have been secured in New South Wales and in Victoria. Nevertheless, the less satisfactory results experienced by Dr. Bennetts in Western Australia necessitated further tests on a large scale, and these are in progress.

The investigations on immunization by means of culture-vaccines have been pursued with interesting results. It is well known that the supply of " natural " virus is very limited and its effects very erratic. A very rich culture virus that will maintain its immunizing properties when kept on ice for at least nine weeks can now be produced quickly; and excellent immunity evidently can be conferred by culture-vaccines that cause little or no readily observable tail reaction, though as with natural virus certain animals appear more liable to severe reaction than others, a susceptibility not yet explained.

The culture vaccine prepared at the laboratory is being tested out extensively under field conditions by the Chief Veterinary Officer of the Northern Territory. To date, over 19,000 doses have been forwarded and full reports are awaited. So far the preliminary reports received are most favorable.

In connexion with the use of " natural " virus-vaccine, although a great deal of technical difficulty has been encountered in the drying of the " virus " or exudate as a means of preserving it for use for long periods, this work has been persevered with owing to its extreme practical

value. It has been found possible to prepare a dry virus, but the results to date have been too inconsistent to make its use practicable. The most recent experiments, however, have made the workers hopeful that they may yet succeed.

Other work includes a study of the morphology and the biology of the causal organism ; the microscopical study of the disease processes in the animal body ; and the susceptibility of small non-bovine laboratory animals such as rats, mice, guinea pigs, rabbits, sheep and goats.

(ii) *Peg-leg Disease.*—Evidence has accumulated that the principal cause of this disease is a deficiency of phosphate in the soil, and consequently in the pastures of the affected districts. This deficiency becomes aggravated by the long dry season during which the cattle are forced to subsist on ripened dry herbage, which is notoriously deficient in this element. That the protein deficiency is not very serious is indicated firstly by the favorable nutritive ratios found in dried rumen contents of the grazing cattle, and secondly, by the fact that, whereas control untreated animals did very poorly, similar animals grazing with them on the same pastures but given a supplement of phosphate by the mouth, did very well.

As recorded in the last Annual Report, a field trial to test out the above hypothesis was instituted at Helenslee with the valued co-operation and active assistance of Mr. Archie Black.

At the close of the field trial last year it was found that those animals which received a supplement of phosphate had a relatively high amount of phosphate in their blood and had increased greatly in weight, whereas the controls had a relatively low blood phosphate index and had increased in weight comparatively little. All groups commenced to make rapid weight gains soon after the onset of the seasonal rains in November, but the controls even then lagged far behind those groups which received phosphatic supplements.

At the end of the dry season the average weight of the controls had increased only 8 per cent., that of the disodium phosphate (soluble phosphate) group 18 per cent., and that of the dicalcic phosphate group (dosed by mouth) 23 per cent. ; on the termination of the experiment, owing to wet conditions, the average weight of the controls had increased 19 per cent. ; of the disodium phosphate group 37 per cent. ; and of the dicalcic phosphate group 50 per cent.

In order to permit the confirmation of these results, and their extension on a larger and more satisfactory scale and under conditions more closely approaching grazing conditions, Mr. Archie Black very generously transferred to the Council at the beginning of this year the property of Helenslee for such period as might be necessary, and without charge for the improvements thereon, the Council undertaking to pay rental and taxes while in occupation.

The Commonwealth Government has assumed the whole responsibility for matching contributions for the upkeep of the Townsville Station formerly granted by the Empire Marketing Board, and has provided a sum of £450 to enable the work at Helenslee to proceed. Two hundred and fifty cattle have been supplied to the Council on loan by interested pastoralists for experimental purposes at Helenslee, and this assistance in the work is much appreciated.

Four large paddocks have been fenced off and four main groups of cattle, very carefully selected, have been established. One group will be used to determine the minimum necessary dose of dicalcic phosphate ; and another will be used to afford information on the palatability of various phosphatic licks and on the practical use of them under grazing conditions. Each of the other two groups comprises 48 head, each animal being matched so far as possible against one in the other group, and these are being depastured on two adjoining similar paddocks that have normally no natural water : watering is carried out by troughing, and a system has been installed that permits the water in one paddock being medicated with soluble disodium phosphate. Rotation of depasturing will be practised regularly. It is hoped that a conclusive demonstration of the possible value of soluble phosphatic supplement in the drinking water may thus be obtained.

These experiments will continue until the end of the wet season in 1936 (about April), when the final results will be available. In the present experiment, the groups include about 20 per cent. of steers ; with them the influence of pregnancy is avoided and information on the economics of giving phosphatic supplements to steers will be obtained.

Finally a selected group of about 25 clinical cases of peg-leg in varying degrees of intensity is maintained at Helenslee both for demonstration to interested pastoralists and as a source of material for laboratory study.

The work is controlled by blood phosphate analyses, at two monthly, or if possible, monthly intervals. Field analyses of the blood of cattle on various peg-leg properties are being conducted.

(iii) *Tick-fever and Dipping.*—A considerable amount of information has been obtained concerning the incidence of babesiellosis. *Babesiella* sp. is a very potent cause of outbreaks of tick-fever in certain districts. The work on babesiellosis by Dr. J. Legg has now progressed sufficiently to warrant the preparation of a statement which will be published shortly as one of the Council's Bulletins or Pamphlets.

Experiments indicate that cattle which have recovered from babesiellosis are not immune from ordinary redwater (piroplasmosis), but are just as susceptible to it as clean cattle, though on the other hand cattle which have recovered from ordinary redwater are resistant to babesiellosis.

Experiments are being carried out with *Anaplasma centrale* to determine whether, as claimed elsewhere, it can act as a suitable vaccine against *Anaplasma marginale.* If it is found that inoculation with *A. centrale* of African origin will protect cattle against *A. marginale* of Australian origin, then the production of a suitable vaccine to deal with all forms of tick-fever in this country may be deemed to be in sight. The provision of *A. centrale* has been due to Dr. du Toit, Director of the Onderstepoort Experiment Station, South Africa, and to the Union Government which kindly supplied the carrier heifers. These animals were quarantined in special insect-proof quarters at Canberra, and there tested exhaustively for the possible presence of other disease producing agents. The results confirmed the assurances of Dr. du Toit. The work at Canberra was conducted by Dr. I. M. Mackerras and staff. It has also included some interesting experiments in connexion with suspected vectors of anaplasmosis and on cross immunity, of which particulars will be published in due course.

Some experiments with piroblue in the treatment of piroplasmosis (*P. bigeminum*) have been carried out and the drug has proved exceedingly effective in the early stages of the disease.

Experiments to determine the safe period which may be allowed to elapse between treatment of cattle by dipping and their removal from tick-infested country, indicate that cattle become capable of reinfestation with larval ticks within 36 hours of dipping and that these ticks may ultimately reach maturity and produce fertile eggs. This information is important in connexion with tick eradication and control measures.

The major problems under study at Townsville above referred to have occupied fully the time of the staff. Consequently, other matters of less importance have had to be in the main postponed, save in the direction of collecting information and specimens for future examination.

3. *Zebu Importations.*—Early in September, 1933, the males (inclusive of the hybrid, kindly granted to the Council by Messrs. Kleberg) and the females were liberated from quarantine and distributed in Queensland amongst the properties of the various owners who agreed to conduct the matings and cullings of progeny under the supervision of the Council's geneticist, Mr. R. B. Kelley. A weighbridge has been installed on one of the properties—Waverley—where different breeds of British female cattle are being experimented with, so that comparative data concerning weights may be obtained. Already a few cross-bred calves have been born and are doing well. All the animals have maintained their health and vigour in the new environment. A progress report will be issued in the near future, although naturally no results of value can be expected for a number of years.

4. *McMaster Laboratory.*—The field station at Hinchinbrook has proved very valuable in furthering studies connected with sheep parasites, and particularly in the supply of suitable parasite-free experimental animals as required. Through the courtesy of Sir Frederick McMaster a satisfactory extension of the Council's lease of portion of the property has been secured. Accordingly some much needed improvements, including the erection of a telephone line, are under way. Work on the Meteor Downs (Queensland) and Gundowringa (New South Wales) field stations has been discontinued, and the Council again desires to express its gratitude to Major D. Donkin, of Meteor Downs, and to Mr. C. E. Prell, of Gundowringa, for their generous co-operation in the past.

Experiments at Frodsley, Tasmania, the property of Mr. K. Brodribb, are being continued mainly with the view to determining exactly the effect, both nutritional and medicinal, of anthelmintic and preventive measures on wool growth and character, the experimental lambs having been carefully selected by Mr. H. Haile, of the Wool-sorting Department, Melbourne Technical College, both from the standpoint of body-weight and of fleece.

(i) *Footrot.*—Footrot in sheep has been the subject of further research, a special bacillus having been isolated. Experiments are being made by Mr. D. Murnane at the Veterinary Research Institute, Melbourne University, with a vaccine which so far has given some suggestive and hopeful results. The possibility of the germ being transmitted by the larvae of certain common internal parasites (*Strongyloides*) which gain entrance to the system through the skin, is being investigated, and there is reason to believe they may frequently provide the means of

transmission. A special article on the subject by Mr. W. I. B. Beveridge, of the McMaster Laboratory, appeared in the April issue of the *Australian Veterinary Journal*. Further experiments are being conducted.

(ii) *Survey of Distribution of Internal Parasites.*—The survey of the distribution of the important internal parasites of sheep is being continued, and it is now possible to determine that distribution with some degree of accuracy. The seasonal incidence of various species has also been determined. Such information when completed will, it is confidently hoped, prove of value in devising adequate measures of control.

(iii) *Drenches.*—Experiments have been continued concerning the immediate destination of drenches administered to sheep. Whereas in the great majority of cases the usual drenches enter the rumen, in most cases solutions of copper sulphate will pass directly to the abomasum or fourth stomach. This indicates that solutions of copper sulphate, which are themselves of value in eliminating the large stomach worm (*H. contortus*), may serve as a medium for conveying other anthelmintics directly past the rumen and so increase their efficacy.

Evidence has been obtained that the 24 hours' preliminary starvation generally recommended prior to drenching with carbon tetrachloride or with solutions of copper sulphate is not warranted. Consequently, much inconvenience to the animals and considerable trouble for the owner now obtaining may be avoided.

(iv) *Tick Paralysis in Dogs.*—Considerable progress has been made by Dr. Clunies Ross in the investigation of this problem, the main results being (1) the determination that the aetiological factor is present in the salivary glands of the engorging adult female tick, *Ixodes holocyclus*, (2) the determination of the minimum lethal dose of salivary gland emulsion for small experimental animals, (3) the demonstration of the value of the serum of hyper-immune dogs in neutralizing such toxin, (4) the value of the hyper-immune serum as a protective and curative agent in the dog, and (5) the possibility of actively immunizing dogs to tick paralysis. The minimum lethal dose of salivary emulsion for white mice and the anti-toxin titre of the serum of two hyper-immune dogs have been determined, 1 cc. of such serum being capable of neutralizing 20–24 mouse m.l.d. The serum of one of these dogs has been found capable of protecting puppies, on which ticks are allowed to engorge after a dose of the serum has been administered. It has also been used for curative purposes in naturally occurring cases of tick paralysis and has given 75 per cent. recoveries in badly affected animals, which, in the opinion of practising veterinarians, is very satisfactory. More carefully controlled experiments will be conducted in the near future. Certain dogs have also been actively immunized by allowing ticks to engorge upon them for short periods, gradually building up an immunity which has made them capable of resisting the effects of large numbers of fully engorged ticks. Whether this method of immunization can be applied with safety to all dogs will be investigated after the cold weather when the supply of ticks can be assured.

5. *Caseous Lymphadenitis.*—Experiments and observations on caseous lymphadenitis (cheesy glands) of sheep continue to be made both in New South Wales and in South Australia. Tests of the vaccine prepared by Dr. L. B. Bull and Mr. C. G. Dickinson, having been encouraging, a proportion (nearly 3,000—approximately one-third) of the wether lambs dropped last season on a large southern Queensland property have been vaccinated. In due course they will be slaughtered and careful examinations made post-mortem.

On another property (in South Australia) all the sheep are palpated three times a year and vaccinated each autumn, careful records being kept. Soils from sheep camps and faeces from certain selected sheep, some infected, some non-infected, and from cows grazing therewith, are the subject of frequent examination for the causal organism. Certain sheep camps have been heavily top-dressed with sulphur, thus rendering the soil more acid and less favorable for the bacillus; these are being kept under observation and frequent examination made of the soils.

The results of an extensive experiment which has been continued for three years, and which point definitely to the wounding of animals which occurs at marking and shearing providing main opportunity for the entrance of infection to the system, will be published in an early issue of the Council's Journal. Notwithstanding these experiments, other observations, particularly in drafts of young sheep forwarded periodically from the above-mentioned New South Wales station, indicate that under certain conditions infection may be spread otherwise, probably, as shown by Dr. Bull and Mr. Dickinson, through infected sheep camps and accidental injuries to the skin. The large amount of caseous lymphadenitis vaccine required for use in the field experiments is prepared at the Pathological Laboratory of the Adelaide Hospital, where extensive bacteriological and microscopical examinations are also made.

6. *Redwater* (*Haematuria vesicalis*).—Experiments with a view to testing the hypothesis that this disease is causally associated in some manner with the fact that the urine of cows depastured on farms on which it is prevalent show a lower sulphur content than those on healthy areas, are being conducted both in the Mt. Gambier District in South Australia and in a Gippsland (Victoria) district wherein the disease is prevalent. Certain areas have been topdressed with gypsum in order to add to the sulphur content of the soils, and on these some cows are being kept exclusively, along with their progeny in some instances, adequate controls being maintained on untreated pastures. In these experiments the owners of the land and stock are willingly co-operating with the Division. One small badly affected farm in Gippsland has been placed at the disposal of C.S.I.R. by the State Closer Settlement Board, while the necessary dozen heifers have been contributed by the Melbourne and Metropolitan Board of Works. As the lesions characteristic of this form of *Haematuria* develop slowly, probably several years will elapse before the results of the experiment can be available.

Press reports to the effect that a similar disease characterized by bladder lesions and blood in the urine has been determined in Bengal to be due to a coccidium, are not supported by the evidence obtained in different parts of Australia, so far as the local condition is concerned.

The work in Adelaide continues to be carried on since Dr. Bull's departure by Mr. Dickinson at the Pathological Laboratory of the Adelaide Hospital.

7. *Joint Ill in Foals.*—Representations having been made to the Council by the Clydesdale Horse Society of South Australia that this disease is prevalent and serious in certain districts, arrangements were made whereby the incidence and cause might be studied with the co-operation of breeders, the work to be undertaken in South Australia by Mr. C. G. Dickinson, and in Victoria, where the trouble appears in certain parts, by Mr. D. Murnane. This will be commenced in spring.

8. *Arthritis or Joint Disease in Lambs.*—This condition, which is somewhat serious in certain districts, has been further studied by Mr. D. Murnane, the causal organism isolated and a vaccine produced which is at present under experiment.

9. *Coast Disease.*—An extensive survey of the incidence of the conditions generally known as " Coast Disease " in South Australia (the subject of exhaustive investigations in Adelaide and on Kangaroo Island by the Division of Animal Nutrition) has been recently conducted by Mr. D. Murnane in co-operation with the Department of Agriculture of that State. This survey necessitated a careful examination of practically all the coastal area from within the Victorian border to the head of the Great Australian Bight, as well as certain inland districts and islands off the coast. Valuable data have been secured. It is known now that some 2,000 square miles of coastal and settled country is affected more or less with the disease termed " Coast Disease," and that an affection of lambs similar to, if not absolutely identical with, the Gingin disease of Western Australia termed Enzootic Ataxia is very prevalent in certain areas.

10. *Black Disease of Sheep.*—Black disease work has been directed towards the preservation of toxicity of bacterial strains over long periods and of the efficacy of vaccines under modifications of the Turner technique.

11. *Contagious Mammitis.*—Beyond a preparation of a précis of the numerous publications (nearly 2,000 in all) embodying the work done in various countries, which is so necessary for the conduct of future experiments and which will be available for investigators here and elsewhere, in the absence of adequate facilities no research work has been done.

It is hoped, however, that in co-operation with the Australian Dairy Cattle Research Association, and with the provision of certain funds from the Commonwealth and State Governments, certain dairying organizations and the Commonwealth Bank, a suitable property will be secured very shortly, and that an extensive investigation in association with the Melbourne University Veterinary Research Institute and the Victorian Department of Agriculture will be undertaken forthwith.

12. *Investigations in Western Australia.*—(i) *Entero-toxaemia* (Braxy-like disease of Western Australia and pulpy kidney of lambs) is still the subject of field observations and certain experimental work. The vaccine devised by Dr. H. W. Bennetts is used on many properties as a regular preventive procedure in Western Australia. On a few properties where pulpy kidney has been prevalent the vaccine has also been used on young lambs with success. In one instance where a heavy mortality in the stud lambs of a New South Wales property was being experienced last year, the vaccination was attended with what appeared to be dramatic success, the death rate dropping immediately to zero. Evidence accumulates that " pulpy kidney " so called is assuming more serious proportions in the eastern States. Last year in part of one flock a mortality of 25 per cent. occurred. Vaccination of the remainder was followed by a cessation of the outbreak. As, however, the appearance of the disease in lambs is associated with condition and age to a very great extent, other factors may have contributed greatly if not entirely to the

cessation of the mortality in such instances. Furthermore, as proper measures connected with the management of the flock can usually be relied upon to prevent the appearance of the lamb disease, vaccination of lambs is not recommended as a general rule, at all events at present, save in valuable studs where the incidence is liable to be high.

Dr. H. W. Bennetts, who has been seconded to the Council by the Western Australian Department of Agriculture for special research on braxy-like disease (now known to be an entero-toxaemia) has been re-transferred to his Department. The work on entero-toxaemia had attained for all practical purposes satisfactory results, the cause and preventive measures having been elucidated, although further studies in connexion with the duration of the artificially produced immunity and the acquisition of natural immunity are being prosecuted.

Arrangements have now been entered into whereby Dr. Bennetts's services in the interests of the Council's veterinary researches are retained through the provision of a payment to the Western Australian Department equal to half of his salary. His special work for the Council is the study of botulism (due to *B. parabotulinus*) in stock, and of poison plants. An article has appeared in the Council's Journal (Vol. 7, No. 3) on the former, which is directly associated with a form of depraved appetite termed " Sarcophagia " due to lack of an adequate percentage of protein in the diet. Preliminary work on the latter, in co-operation with Dr. Underwood of the Western Australian Department of Agriculture is now in progress at the Avondale Agricultural Experiment Farm, Western Australia.

(ii) *Gingin Disease.*—Work in connexion with enzootic ataxia (Gingin disease) in lambs is being continued. Although early spectographic analyses of milk seemed to indicate an association with lead salts in milk as a possible cause, further investigation has not supported the hypothesis. Nevertheless, the provision of a lick containing ammonium chloride to ewes, the progeny of which would ordinarily be expected to develop the disease, seems to have been attended with favorable results. Consequently, further experiments will be conducted on such lines although the etiology of the disease still remains obscure. As previously noted a disease of lambs apparently identical has been determined to be fairly common in certain districts of South Australia.

13. *Investigations in Tasmania.*—The Council is assisting in defraying the salary of a competent veterinary pathologist and bacteriologist in the Tasmanian Department of Agriculture in the person of Mr. W. E. Chamberlin, M.V.Sc. Arrangements have been made for research work to be undertaken in that State on problems associated with those on which the Division of Animal Health is conducting investigations in other States.

14. *Mouse Plague.*—An investigation into the recent mouse plague in Victoria, which includes a series of experiments, was conducted by Mr. Murnane and the results published in the Council's Journal (Vol. 7, No. 1).

15. *Miscellaneous.*—Other investigations were concerned with rabbit septicaemia, the effects of carbon tetrachloride, the feeding of young sheep on protein deficient diet, &c., the results of which were duly published in the Journal.

V. ANIMAL NUTRITION INVESTIGATIONS.

1. *General.*—The Division of Animal Nutrition was founded in 1927 for the study of the nutrition of domestic animals. It was decided that in the first instance the Division should concentrate its attention upon problems affecting sheep for the reason that the raising of sheep for wool and meat was the principal industry of Australia, and also because knowledge of the nutritional physiology of the sheep was less advanced than that of the dairy cow and pig which had been studied with great energy of recent years in Europe and America.

The Division's laboratories are situated in the grounds of the University of Adelaide, and experience has shown that the contacts established with, and the facilities afforded by, the University, have in no small measure contributed towards the satisfactory progress which has been made in the work of the Division. Field experiments are in progress at Wambanumba, near Young, New South Wales, and on Kangaroo Island, South Australia.

The field investigations carried out by the Division during the years 1930 to 1933 made it clear that the production of wool-fleece by merino sheep may be limited by the seasonal protein shortage which occurs in the pastures of many important grazing areas in Australia, and that when this deficiency is acute a good economic return may be expected to follow the provision of relatively small quantities of certain protein concentrates. Subsequent work strongly suggested that each protein bears a different supplementary relationship to the pastures and, so far as our knowledge of the cystine content of proteins has gone, it would seem that the wool-producing capacity of individual proteins, when the intake of them is low, is determined by their cystine content. The analysis of plant materials for this sulphur-containing amino-acid is fraught with many pitfalls owing to the ephemeral nature of cystine under the conditions of preliminary

chemical treatment to which proteins are subjected prior to the estimation of their constituent amino-acids. Recently, however, our knowledge has been clarified by the application of more satisfactory chemical procedures which render available better estimates of the cystine content of fodder species and these substantiate the hypothesis that the cystine necessary for fleece production must be ingested in the fodder. The series of studies in the laboratory of the Division have proved that the rate of growth of wool by the sheep subsisting on protein-poor rations could be materially augumented by an additional supply of cystine but not by increasing the ingestion of the other naturally-occurring sulphur-containing amino-acid, methionine. They have also provided much evidence as to the principle which should determine the practice of supplementary feeding for wool production. In consequence of this, a laboratory study of the individual wool-producing capacity of commercially feasible protein concentrates is projected.

The study of the energy consumption of the fasting sheep has been extended and much information has been gained which is fundamental to the adoption of a standard and logical procedure of drought feeding. To further this knowledge the energy metabolism of sheep consuming rations of varying quantities and with different amounts of proteins, is being investigated.

It has long been established that the soils of extensive tracts of the Australian continent are poor in phosphate, and this fact, together with the experience of graziers with cattle on similar territory in other countries, has led to the current idea that more often than not the low phosphorus content of the herbage growing on such country limits the growth and protection of the sheep which are depastured on it. The facts that the amount of phosphorus in plants is closely correlated with their protein content and that the concentration of both of these constituents diminishes as the plant matures are not so generally realized. As a rule the sheep grazing on phosphorus-poor areas exhibit the untoward effects of protein shortage before any serious aphosphorosis is evident. In order to throw some further light on the problem as it exists in Australia, the estimation of the concentration of phosphate in the blood of sheep and its use as a quantitative diagnostic measure of aphosphorosis are being subjected to exhaustive critical test by the Division, and methods for the estimation have been adapted for use in the field to which the investigations must be extended. In order to combat the assumed aphosphorosis, the use of phosphatic licks is now fairly general in Australia, and the price of concentrates used for compounding these supplements varies from £5 to £20 per ton. While the solubility of phosphates in the alkaline medium of the intestine of the sheep is very much reduced by high concentrations of calcium and magnesium, pen-feeding experiments in progress indicate that sheep subjected to the radiation of Australian sunshine may overcome this disability and absorb sufficient phosphate for their normal needs from diets which contain excessively high concentrations of these alkaline metals. These experiments indicate that the sheep may assimilate as much phosphorus from the relatively insoluble mineral rock phosphates as from the very much more expensive dicalcic and monocalcic phosphates. It is proposed to put this contention to a critical test in the ensuing year, when the extent of utilization of phosphorus from mono-, di- and tricalcic phosphate will be studied.

The general use of mineral phosphates as supplements for grazing animals has been objected to on the ground that such supplements contain sufficient fluorine to induce toxic effects in the stock consuming them. While this may be true in the case of the continental rock phosphates of relatively great geological age which contain up to 4 per cent. of fluorine, it has been hitherto overlooked by veterinarians that the insular deposits of more recent origin contain so little fluorine that it is unlikely that untoward effects will be suffered by sheep ingesting sufficient of this material to fulfil their phosphorus requirements. The extensive deposits of high grade mineral phosphate in Curacao Island and Christmas Island contain 0.7 and 1.3 per cent. of fluorine, respectively. Pen-feeding experiments indicate that rock phosphate from either of these sources may be employed for the compounding of mineral licks with a feeling of confidence that the consumption of them by sheep will not be followed by the effects of chronic fluorosis.

The results from the field operations at Wambanumba, New South Wales, indicate that the small quantity of available sulphur in highly leached soils may limit the growth of pasture and that manurial dressings with phosphate should be accompanied by sulphur when the concentration of the latter element is low. The quality and carrying capacity of pastures at Wambanumba that were topdressed with a mixture of sulphur and rock phosphate were very much increased above those of pastures which were dressed with rock phosphate without any accompanying sulphur; and the response to the mixture suggests that good economic returns might be expected to follow such treatment of soils which are poor both in phosphorus and in sulphur.

Investigations into the nature of "coast disease" have been extended and an epidemiological survey of its incidence along the southern coast of Australia has been carried out by Mr. D. Murnane, B.V.Sc., a veterinary officer seconded from the Division of Animal Health. It is hoped that the experimental work now in progress will clarify some of the existing hypotheses relating to its aetiology.

The members of the Division are indebted to their colleagues at the Waite Institute and in other departments of the University for their stimulating help and collaboration during the year.

2. *Individual Investigations at the Laboratories of the Division.*—(i) ***Sulphur Metabolism in Sheep and the Production of Wool.***—(*a*) *Estimation of Cystine in Fodder Species.*—The work on the estimation of cystine in fodder species has been continued and recent analyses support the hypothesis that the small quantity of this amino-acid which is available to sheep subsisting on fodder of low-protein content, might be expected to provide a first limiting factor for wool production. The independent investigations of Professor A. C. Chibnall (London) have lent much support to this contention.

A critical investigation into the source of errors encountered when cystine is estimated in the presence of other substances is being carried out and, during the course of these studies, the use by other workers of "labile sulphur" as an indication of the cystine content of plant tissues has been proved to be seriously misleading.

(*b*) *Balance Experiments and Investigations on the Influence of Food Constituents on Growth of Wool.*—These investigations, which were referred to in a previous report, have been extended and the results strongly suggest that the naturally occurring amino-acid, methionine which, like cystine, contains sulphur, has little, if any, direct influence on the process of keratinization and consequent wool growth. The further addition of this amino-acid to the dietary when the intake of it is low, may spare some of the cystine which, under such conditions, is utilized for intermediate metabolic processes. Two papers on this aspect of the work have been submitted for publication in the *Journal of Agricultural Science* (Cambridge).

(*c*) *Biological Assay of the Amount of Cystine in Fodders.*—The technique of biological assay which is at present in general use has been subjected to further critical test. In the course of these studies it has been shown that the growth-promoting capacity of diets usually employed for estimation of cystine is not primarily limited by their cystine content, but by the low amount of the sulphur-containing amino-acids in them, and that while rats subsisting on such rations grow better if cystine is added, a similar response may be brought about by the addition of methionine, which (as suggested above) spares some of the cystine that is taken for intermediary metabolic processes and thus renders it available for the processes of growth and for the production of hair or wool.

(*d*) *The Multipartite Nature of Vitamin B.*—It was explained in the last report that considerable difficulty is encountered in the study of cystine deficiency by biological means owing to the fact that the B accessory food factors are difficult to separate from cystine.

The observations, which indicated that the growth of rats receiving the rations usually employed for the study of B avitaminosis will respond to the addition of cystine to the ration, have been repeated and it has been found that a supplement of cystine will considerably augment the growth rate when the consumption of the diet is low.

A diet which contains an adequate supply of vitamins and essential amino-acids other than cystine is being sought, as such a ration would provide a useful means for the study of the metabolism of the amino-acid which is so essential for the production of wool fleece. A series of papers on this aspect of the work is in the course of preparation.

(ii) ***Phosphorus Metabolism in Sheep.***—(*a*) *The Concentration and Distribution of Phosphorus in the Blood of Sheep.*—As animals suffering from deficiency of phosphorus show a marked diminution in the concentration of this element circulating in the blood, the determination of the blood phosphate might be expected to provide a reliable quantitative means for the diagnosis of aphosphorosis in grazing sheep. The delicate chemical procedure has been adapted to field conditions and during the last year investigations were initiated to determine the correlation between the composition of pastures and the amount of the various forms of phosphate in the blood of the sheep grazing thereon. Five groups of ewe lambs of practically identical age, grazing at Wambanumba on the areas which have received different manurial treatments, are being studied. The pastures are analysed bi-monthly for protein and for phosphorus and other inorganic constituents, and the phosphorus content and partition in the blood of groups, each of fifteen ewes, depastured on these are determined every three months. Over 700 analyses have already been completed.

Recent investigations in the laboratory have demonstrated that the inorganic phosphate shows marked diurnal variation in the blood of sheep which are subject to a constant and rigid routine of feeding, and that its concentration is influenced by rumination, for which process considerable quantities of phosphate are poured out into the upper digestive tract by the parotid salivary glands.

These investigations have demonstrated some of the hitherto unrecognized pitfalls in the use of blood phosphate analyses for diagnostic work, but from our experience it is evident that if discretion as to the time of bleeding is exercised and a sufficient number of estimations are carried out and the results treated statistically, the method affords a very valuable and rapid means for the detection of phosphorus deficiency in grazing sheep.

(*b*) *The Influence of High Concentrations of Calcium and Magnesium on the Assimilation of Phosphate by Growing Sheep.*—The solubility of phosphates and other elements of nutritive value in the alkaline medium of the intestinal contents is very much reduced by high concentrations of calcium or magnesium ions, and for this reason the assimilation of such elements by the sheep might be expected to be adversely influenced by the ingestion of abnormally high concentrations of salts of the bivalent alkaline metals. The study of growth and development of lambs which were pen fed on rations containing 30 gm. of calcium and 15 gm. of magnesium per day indicates that after the lapse of a few weeks the sheep may overcome this disability and absorb sufficient phosphates for its requirements. Such animals grow as rapidly as others receiving similar rations free from added alkalis.

Apart from an initial depression, no significant difference in the concentration of phosphate in the blood accompanied the ingestion of the diet containing excessive amounts of calcium and magnesium.

These experiments are being continued as the results will have considerable bearing on the problems associated with the choice of phosphatic supplements for use as sheep licks.

(iii) *The Energy and Protein Metabolism of the Merino Sheep.*—(*a*) *Standard Metabolism.*—The studies on the basal energy consumption of the merino sheep have been extended and the effects of previous nutritional history and seasonal influence on the fasting metabolism have been determined. Seasonal variation in the competition of the pasture was found to influence the standard metabolism of grazing sheep. The mean consumption of energy by a sheep which has been taken off rich spring pastures and fasted 48 hours was 1,350 calories per square metre of body surface per day, while the much lower mean figure of 1,080 calories was noted in the same sheep after they had subsisted on dry summer fodder for some months previous to the estimations.

Very young suckling lambs consumed about 1,900 calories per square metre of body surface per day. After they had developed sufficiently to consume enough pasture for their main requirements but were still receiving some milk from the ewes they consumed about 1,310 calories under fasting conditions.

No difference in basal energy exchange followed shearing. The energy consumed by standing sheep was some 8 per cent. above that of those reclining in the normal resting position.

(*b*) *The Composition and Amount of Milk Supplied by Merino Ewes.*—A knowledge of the yield and composition of the milk of merino ewes is fundamental to the study of the early growth of sheep. Investigations showed that the average production of milk of six merino ewes was 1,205 gm. per day during the third week of lactation and 650 gm. per day during the ninth week. The gross energy of the milks was 1.13 and 1.22 cals. per gm., respectively. The casein percentage increased towards the end of lactation from 3.43 to 4.38 per cent. and the fat from 7.41 to 7.90 per cent. The lactose percentage remained more or less constant throughout the lactation. The details of these analyses have been published in the Australian Journal of Experimental Biology and Medical Science, Vol. XII. (1934).

(*c*) *The Utilization of Protein and its Relation to Energy Consumption.*—Previous reports stressed the fact that if supplementary feeding for wool production is to be a commercial success the value of the concentrate must not be assessed merely upon the amount but also on the quality of protein it contains. As already stated, the determination of the relative merits of economically feasible protein concentrates is projected, but prior to any extensive investigations along these lines it is necessary first to determine the most economic quantity of protein to feed to the sheep. For this reason the utilization of protein and the energy expenditure which follows the consumption of different quantities of protein in the dietary are being investigated at the laboratory of the Division. While it is as yet too soon to make a final pronouncement, the investigations indicate that the standard figures in the literature for the maintenance requirements of protein for the sheep are much too high. Wool production is lowest when the energy requirements and the minimal protein requirements are just fulfilled and from this level the addition of protein of good quality has a very favorable influence on the growth of fleece, which

bears a direct relationship to the amount of protein fed while the intake is still reasonably low. At higher levels the sheep becomes very uneconomical both in the utilization of protein and in its energy consumption, and the animal is unable to maintain energy balance when consuming fodders containing very high amounts of protein. The grazing of very rich, young sown pastures should thus be avoided until the plants have developed sufficiently to dilute the very high protein concentration that is invariably present in the young shoots.

(*d*) *The Energy Metabolism in the Fed Sheep.*—The total energy transactions of the metabolism of normally fed sheep are being studied. It has been found that mature merino ewes weighing about 45 kg. and maintaining weight on 1 kg. of dry matter per day, consume approximately 3,900 calories. Of this 1,950 calories are undigested and pass in the faeces, approximately 100 calories are voided as end products in the urine, and about 200 calories are expelled in the form of the inflammable gas, methane, which is one of the products of the bacterial cleavage of cellulose. The energy expenditure is greatly influenced by the amount of food consumed and especially by the protein concentration of the dietary. As complete knowledge of the heat consumption by animals receiving sub-maintenance diets is fundamental to the compounding of drought rations this aspect is receiving special attention.

(iv) *Secondary Anaemia in Sheep.*—The progressive anaemia suffered by sheep which are heavily infested with blood-sucking intestinal parasites has recently been attributed to loss of blood and it has been suggested that a moderately heavy infestation of *Haemonchus contortus* would account for about 30 cc. of blood per day. Hæmorrhage into the lumen of the bowel from the multitude of punctiform wounds which are left by the worms when they detach themselves would undoubtedly increase this figure still further.

During the last twelve months the effect of secondary hæmorrhage in sheep has been studied by the Division, and it has been shown that mature merino ewes may continue to lose up to 60 cc. of blood each day for at least a year without showing any pathological change in the number of erythrocytes, volume of cells, or the percentage of haemoglobin in their blood. Such animals maintain their weight, but those donating the larger volumes expend very much more energy than normal animals. This increased expenditure is compensated by a greatly increased consumption of food.

As the anaemia which follows a heavy parasitic infestation in sheep seems to originate from causes other than simple blood loss it is not likely that the untoward effects of acute nematodiasis may be alleviated by supplementing the diet of grazing sheep on good pasture with licks containing materials necessary for blood regeneration.

(v) *The Effects which Supervene on the Continual Ingestion of Fluorine by Sheep.*—Experiments with pen-fed sheep indicate that the ingestion of 500 mg. of fluorine per day as Florida rock phosphate plus calcium fluoride is well tolerated by mature animals for several months. After the lapse of about nine months acute anorexia develops and this is accompanied by a rapid decline in weight which culminates in death. The skeletons of such animals are characterized by chalky exostoses on the bones, these outgrowths being most prevalent on the maxillae. Young pen-fed sheep receiving 115 to 150 mg. of fluorine per day have maintained their growth rate for a year, but are now showing some untoward symptoms. The permanent teeth of these animals are erupted with mottled enamel. Those animals which constitute the group receiving 80 mg. of fluorine per day for over a year have not suffered in any way ; they have continued to consume as much fodder and have grown as well as their normal controls. It may reasonably be concluded that the continual ingestion of from 2 to 3 mg. of fluorine per kilo body-weight is well tolerated by the sheep and that the ingestion of up to 80 mg. of fluorine per day in the form of rock phosphate will not be followed by any symptom of chronic fluorine poisoning.

3. *Field Stations.* (i) *Wambanumba, Young, New South Wales.*—It was pointed out in previous reports that the response of the natural pastures at Wambanumba to manurial treatment with phosphate applied as 100 per cent. super. was not commensurate with that which followed dressing immediately adjacent country with a corresponding amount of phosphorus in the form of ground Nauru phosphate mixed with finely-powdered sulphur. The former area was not benefited by the further addition of nitrogen.

In order to throw some light on the factors involved, these studies have been extended [illegible] dressing the natural pasture (i) with rock phosphate without sulphur, and [illegible] phosphate plus sulphur, are being investigated. Bi-monthly pasture clips from [illegible] sed at random showed that the area treated with phosphate and sulphur was [illegible] he most productive, while dressing with phosphate or sulphur alone had little [illegible] le effect on the production of fodder. The August–September clip indicated [illegible] ea produced at least 300 per cent. increase in the bulk of fodder above [illegible] reas. The nitrogen content of the pastures which had been dressed with

sulphur, either alone or admixed with phosphate, was continually higher than that of the pasture produced on the control unmanured area or on that which was treated with phosphate alone, while the phosphate content of the pasture grown on both areas upon which phosphate was applied was continually about 80 per cent. above that on the control and sulphur dressed areas.

It becomes evident that the lack of response to the application of pure phosphate is not due to the inability of the pasture species to assimilate phosphorus from the dressing of relatively insoluble ground Nauru rock and, furthermore, the results strongly suggest that not only has nitrification of the soil been increased by the sulphur dressing but also that the assimilation and utilization of nitrogen by the plant has been materially augmented by increasing the amount of available sulphur.

The control (unmanured) area and that which received a dressing of sulphur, each carried 1.2 sheep per acre, the area which was dressed with rock phosphate carried 1.4 sheep per acre, while that which was dressed with the rock phosphate-plus-sulphur mixture carried 3.2 sheep per acre throughout the year and, in spite of the heavier stocking, the growth of lambs on the last area was definitely superior to that of the experimental groups grazing on the other areas.

The ewe lambs, 50 of which constitute each experimental group, will be shorn in November and the response in wool growth studied.

The area which received the original phosphate and sulphur dressing in 1929 and has not since been treated further, produced by far the greatest growth of pasture and, after five years, continues to carry over three sheep to the acre and still provides sufficient fodder to grow better lambs than any of the most recently dressed areas. This lasting response renders top-dressing natural pastures with this mixture a sound economic proposition when, in districts of assured rainfall, it is applied to soils which are low in both sulphur and phosphate.

(ii) "*Coast Disease*" *Investigations, Kangaroo Island.*—Previous reports drew attention to the fact that sheep which are continually depastured on the highly calcareous coastal littorals of Southern Australia are subject to the wasting and fatal malady known to the pastoralist as "coast disease". Sheep which become affected after grazing on this type of country rapidly recover if moved to the adjacent though much poorer ironstone heath, and the relatively unsuccessful grazing of some thousands of square miles of country of high rainfall and temperate climate is at present rendered possible only by alternating the flocks between the "healthy" and "coasty" areas.

While the skeletons of animals which expire from "coast disease" are, as a rule, poorly mineralized—a condition which suggests phosphorus deficiency—the concentration of phosphate in the blood of those animals exhibiting the lethargic behaviour of the advanced stages of the malady proved to be as high as, or even higher than, that normally encountered in perfectly healthy sheep. Continual dosing with dicalcic phosphate did not alleviate the symptoms of "coast", although licks composed of bone-meal seemed to benefit the growth of lambs on affected country. Neither dosing with iron in the form of soluble salts nor feeding it in organic combination had any effect on the progress of the disease.

Notwithstanding very favorable climatic conditions both virgin "coasty" and the ironstone heath regions are but poorly covered with herbage. Study of the disease was thus at times complicated by a shortage of fodder in the relatively small areas on which the experimental heep were grazed.

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bears a direct relationship to the amount of protein fed while the intake is still reasonably low. At higher levels the sheep becomes very uneconomical both in the utilization of protein and in its energy consumption, and the animal is unable to maintain energy balance when consuming fodders containing very high amounts of protein. The grazing of very rich, young sown pastures should thus be avoided until the plants have developed sufficiently to dilute the very high protein concentration that is invariably present in the young shoots.

(*d*) *The Energy Metabolism in the Fed Sheep.*—The total energy transactions of the metabolism of normally fed sheep are being studied. It has been found that mature merino ewes weighing about 45 kg. and maintaining weight on 1 kg. of dry matter per day, consume approximately 3,900 calories. Of this 1,950 calories are undigested and pass in the faeces, approximately 100 calories are voided as end products in the urine, and about 200 calories are expelled in the form of the inflammable gas, methane, which is one of the products of the bacterial cleavage of cellulose. The energy expenditure is greatly influenced by the amount of food consumed and especially by the protein concentration of the dietary. As complete knowledge of the heat consumption by animals receiving sub-maintenance diets is fundamental to the compounding of drought rations this aspect is receiving special attention.

(iv) *Secondary Anaemia in Sheep.*—The progressive anaemia suffered by sheep which are heavily infested with blood-sucking intestinal parasites has recently been attributed to loss of blood and it has been suggested that a moderately heavy infestation of *Haemonchus contortus* would account for about 30 cc. of blood per day. Hæmorrhage into the lumen of the bowel from the multitude of punctiform wounds which are left by the worms when they detach themselves would undoubtedly increase this figure still further.

During the last twelve months the effect of secondary hæmorrhage in sheep has been studied by the Division, and it has been shown that mature merino ewes may continue to lose up to 60 cc. of blood each day for at least a year without showing any pathological change in the number of erythrocytes, volume of cells, or the percentage of haemoglobin in their blood. Such animals maintain their weight, but those donating the larger volumes expend very much more energy than normal animals. This increased expenditure is compensated by a greatly increased consumption of food.

As the anaemia which follows a heavy parasitic infestation in sheep seems to originate from causes other than simple blood loss it is not likely that the untoward effects of acute nematodiasis may be alleviated by supplementing the diet of grazing sheep on good pasture with licks containing materials necessary for blood regeneration.

(v) *The Effects which Supervene on the Continual Ingestion of Fluorine by Sheep.*—Experiments with pen-fed sheep indicate that the ingestion of 500 mg. of fluorine per day as Florida rock phosphate plus calcium fluoride is well tolerated by mature animals for several months. After the lapse of about nine months acute anorexia develops and this is accompanied by a rapid decline in weight which culminates in death. The skeletons of such animals are characterized by chalky exostoses on the bones, these outgrowths being most prevalent on the maxillae. Young pen-fed sheep receiving 115 to 150 mg. of fluorine per day have maintained their growth rate for a year, but are now showing some untoward symptoms. The permanent teeth of these animals are erupted with mottled enamel. Those animals which constitute the group receiving 80 mg. of fluorine per day for over a year have not suffered in any way ; they have continued to consume as much fodder and have grown as well as their normal controls. It may reasonably be concluded that the continual ingestion of from 2 to 3 mg. of fluorine per kilo body-weight is well tolerated by the sheep and that the ingestion of up to 80 mg. of fluorine per day in the form of rock phosphate will not be followed by any symptom of chronic fluorine poisoning.

2. *Field Stations.* (i) *Wambanumba, Young, New South Wales.*—It was pointed out in previous reports that the response of the natural pastures at Wambanumba to manurial treatment with phosphate applied as 100 per cent. super. was not commensurate with that which occurred on dressing immediately adjacent country with a corresponding amount of phosphorus in the form of ground Nauru phosphate mixed with finely-powdered sulphur. The former treatment was not benefited by the further addition of nitrogen.

In order to throw some light on the factors involved, these studies have been extended and the responses to dressing the natural pasture (i) with rock phosphate without sulphur, and (ii) with rock phosphate plus sulphur, are being investigated. Bi-monthly pasture clips from quadrats dispersed at random showed that the area treated with phosphate and sulphur was outstandingly the most productive, while dressing with phosphate or sulphur alone had little or no measurable effect on the production of fodder. The August–September clip indicated that the former area produced at least 300 per cent. increase in the bulk of fodder above that of the other areas. The nitrogen content of the pastures which had been dressed with

sulphur, either alone or admixed with phosphate, was continually higher than that of the pasture produced on the control unmanured area or on that which was treated with phosphate alone, while the phosphate content of the pasture grown on both areas upon which phosphate was applied was continually about 80 per cent. above that on the control and sulphur dressed areas.

It becomes evident that the lack of response to the application of pure phosphate is not due to the inability of the pasture species to assimilate phosphorus from the dressing of relatively insoluble ground Nauru rock and, furthermore, the results strongly suggest that not only has nitrification of the soil been increased by the sulphur dressing but also that the assimilation and utilization of nitrogen by the plant has been materially augmented by increasing the amount of available sulphur.

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Attempts have been made to establish sown pastures of subterranean clover on both types of country so that it would be assured that the bulk of fodder would be ample for the experimental sheep. Satisfactory establishment was obtained on the "coasty" areas, but an attempt on the ironstone heath was not successful although individual plants were quite well developed.

These facts demonstrated clearly that the affected country might be improved and that the grazing of these areas would no doubt provide good returns if it were possible continuously to depasture sheep on them.

A condition known locally as "rickets" accounts, in some seasons, for many lambs in the "coasty" areas, but while this complaint has, in the past, been confused with the progressive lethargic wasting of true "coast disease", we have been led to believe that it has no intimate connexion with the latter, for it occurs spasmodically on both the highly calcareous littorals

and on the " healthy " areas. The in-coordination of gait and final loss of control of the hind limbs, which are the main symptoms of the " rickets " (ataxia) are accompanied by a degeneration of the spinal cord, a condition which may arise from several causes. The incidence of the disease is seasonal and does not seem to be increasing as the similar malady, Renguera, appears to be on the Peruvian Andes.

During the last twelve months, a survey of the incidence of "coast disease" and of ataxia in lambs was carried out in South Australia by a veterinary officer of the Division of Animal Health, the expenses being met by the South Australian Government. The results of the survey indicate that the areas which are seriously affected with " coast disease " are of much greater extent than anticipated.

Attempts to study the ataxia by depasturing ewes in lamb on an area on Kangaroo Island, where a high incidence of this malady was noted in the previous year, were abortive as all of the lambs from the ewes developed free from any signs of disordered gait. These ewes have again been mated and the incidence of the disease will be studied after they have grazed for two years on the affected area. The paddocks on which they are run are subject to agrostological surveys from time to time in order to determine whether the ataxia is the result of the consumption of poison or fungus-infected plants.

The effects which follow the consumption of licks composed of finely-ground ironstone concretions, which are an important constituent of the soils of the " healthy " areas, are being studied in two groups of sheep grazing on the calcareous soils at Antechamber Bay, Kangaroo Island. This material is readily consumed by the sheep and seems to be having some beneficial effects. The percentage of hæmoglobin in the blood of those animals partaking of the lick is increased and their general well-being is improved above that of the control flock in the same paddock.

The most striking difference between the soils of " healthy " and " coasty " country is the limy nature of the latter, in which calcium carbonate sometimes exceeds 60 per cent. Such a condition naturally favours calcium-loving plants, and the shores of lagoons support a strong growth of the semi-succulent species which are eagerly consumed by sheep. Those animals confined to areas where they, perforce, ingest nothing but *Selliera* rapidly develop " coast disease ". Analysis of the ash of this plant indicates that the animals would consume from 20-30 grammes of calcium oxide and from 25 to 30 grammes of magnesium oxide per day while living exclusively on it. This abnormally high consumption of uncompensated alkali in the plant tissues by the sheep is no doubt materially augumented by the ingestion of the calcareous soil itself, for the sheep is a close feeder.

Consumption of such quantities of basic compounds might be expected to complicate the absorption of other elements of nutritional value and the disease may be one of excess rather than one of deficiency of an essential element of the pasture. Experiments are being carried out to test this hypothesis and the behaviour of a group of 20 ewes and their lambs grazing on " coasty " country and provided with a good quality protein supplement plus a galaxy of added elements is being contrasted with that of a similar group running on the same area at " Hawk's Nest ", Kangaroo Island.

Conversely, the effects supervening on the intake of large quantities of magnesium and calcium are being investigated with pen-fed sheep. These latter animals have not shown any definite symptoms of true " coast disease " as it is observed in the field, although the percentage of hæmoglobin in their blood is significantly reduced after six months, a symptom which they share with sheep running on the highly calcareous coastal areas.

So far as can be seen at present these investigations will considerably clarify the current hypotheses relating to the causal factors of the malady.

4. *Mineral Content of Pastures.*—The five-year programme carried out as a co-operative investigation by the Empire Marketing Board, the Council for Scientific and Industrial Research, and the University of Adelaide, was completed in July, 1932. A report of this work, together with a list of papers prepared, was published in the Journal of the Council (Vol. 5, No. 3, August, 1932).

The work was extended for a further period of twelve months, after which support from the Empire Marketing Board ceased owing to the abolition of the Board. The Carnegie Trust, however, recently undertook to provide for the current year the full financial support previously supplied by the Empire Marketing Board, and for the ensuing year one half of this amount, provided that the investigational work be continued after the expiry of the grant in June, 1935. This assurance has been given to the Carnegie Trust by the University of Adelaide.

The preliminary phases of the work, which included the investigation of the composition of pastures in mineral deficient areas, the factors affecting the protein and mineral content, the water requirements of pasture plants, and the determination of economic methods of alleviating mineral deficiencies, have been completed. Twenty-five papers dealing with various phases of the work have been published.

The more fundamental aspects of mineral content in regard to pasture species and strains have been investigated in the pot culture house and in the laboratory. A study has been made of the drift with age of the potassium and calcium content of grasses, and of the physiological basis of the drift. Work has also been continued on the relation of the nitrogen supply to growth, and the interaction of nitrogen and phosphorus on the growth rate. The fixation and assimilation of nitrogen in pure legume and grass-legume associations, the relations of nitrogen and phosphorus to the grass-clover balance, and phosphorus and nitrogen assimilation in a grass-clover mixture are being investigated.

The field investigations carried out at a number of centres in the winter rainfall region have shown the importance of rye-grass, *Phalaris tuberosa*, and subterranean clover as a basis for pasture improvement in areas of moderate rainfall. Strain has proved to be a most important consideration in each of these species, and the isolation and breeding of drought-resistant types is proving an important phase of the work. Suitable grass-legume mixtures have been obtained which have proved satisfactory for considerable areas of country on which seeded perennial pastures had not previously been grown.

Problems of establishment, seeds rates, strain, compounding of seeds mixtures, and of the intra-competition factor in mixed pastures are under investigation. Fertilizer problems have centred round phosphorus and nitrogen in relation to the management of a grass-legume association.

VI. SOIL INVESTIGATIONS.

1. *General.*—The Division of Soils has its head-quarters at the Waite Agricultural Research Institute about four miles from Adelaide, and is housed there in the Darling Laboratory and part of the Melrose Laboratory. A considerable part of the Division's work is, of course, conducted in the field. As the production of wealth in Australia's pastoral, agricultural and horticultural industries is dependent ultimately on the soil, the investigations of the Division of Soils, aiming at accurate knowledge which will permit of intelligent and economic methods of soil management, treatment and improvement, are obviously matters which, in the interests of those great industries, cannot be neglected without serious consequences.

The main objects of the Council's soils investigations are, therefore, two-fold, viz. :—

(*a*) To provide a centre for the systematic investigation of Australian soils and soil problems in order to provide a fundamental basis for the advisory work of the State Departments of Agriculture and for the developmental and executive work of the Departments of Lands, Irrigation and Forestry.

(*b*) To make soil surveys of virgin areas for future settlement and development, and of such recently settled areas as present problems of immediate importance and which may provide a groundwork of information for further settlements of a similar character.

While losses in certain land settlement schemes may be due to a variety of factors, in many instances, as in the irrigation areas, a major contributing factor has been the lack of information regarding soils or a lack of appreciation of the nature of the soil problems involved. The work of the Division in the irrigation areas, correlated with that of the Research Stations at Griffith and Merbein, indicates not only that much loss of money and of individual effort could have been avoided had the necessary soil investigations been made, but also that future developments can be undertaken with a reasonable degree of confidence due to our enhanced knowledge of the soil conditions essential for successful production. One prominent instance lies in the appropriate selection after survey, of sites for irrigation experiments and the ready application of results to similar soils mapped on the settlement.

In addition to benefiting the settler by furnishing him with authoritative advice as to methods necessary to increase production, the Division has already been able to afford valuable assistance with respect to new settlement projects.

2. *Soil Surveys and Chemical Investigations of Soils.*—The Division has been concerned with work in four States carried out by its own or State officers and in the main connected with closer settled horticultural areas. It is satisfactory to record that a co-operative agreement has been reached with the New South Wales Department of Agriculture, whereby the analysis of samples collected by the field staff during the survey of the Murrumbidgee Irrigation Area is being undertaken by one of the Departmental chemists.

During the past year field surveys have proceeded in the following localities :—

	Acres.
Irrigation Areas of Cobdogla, &c., South Australia	8,000
Murrumbidgee Irrigation Area, New South Wales	17,000
Soils of apple-growing districts of Tasmania	..
St. Kilda Marsh, Adelaide, South Australia	2,500

Work was continued by Messrs. Marshall and Hooper on the survey of the Cobdogla, Moorook, Kingston and Lyrup settlements bringing the total area surveyed in that district to 21,800 acres. The soil maps have been completed and seven new soil types and one new sub-type described, all of them being peculiar to the locality. The main concern of the Murray River settlements is the control of applied irrigation water and as this is plainly related closely to the character of the soil, the crop requirements and the movement of added water can be satisfactorily studied only after a full examination of the soil types has been made. It is hoped that these surveys will show their practical value in the near future as a means of interpreting and applying results of irrigation experiments at present being carried out under the direction of the Merbein Research Station on the Berri and Cobdogla areas.

A soil survey was begun at Griffith (Murrumbidgee Irrigation Areas, New South Wales) in September, 1933, and a total of 15,000 acres was covered at that centre, together with 2,000 acres at Leeton in the Merungle Hill section. Mr. Parbery, of the Chemist's Branch, New South Wales Department of Agriculture, is associated with the analytical work and the New South Wales Water Conservation and Irrigation Commission kindly set free Mr. H. N. England for part of the time in the field. The survey has not yet been completed.

In Tasmania, a notable advance has been made by the preparation by Mr. C. G. Stephens of a soil map of that State and recent publication in the *Journal of the Council for Scientific and Industrial Research.* This represents a considerable improvement in detail on previous tentative maps. Mr. Stephens has proceeded during the past year with a systematic examination of soils in recognized apple-growing centres in Tasmania. Soil samples have been taken from eleven settlements and full data obtained on the important Huonville area, which has been mapped. The chemical work is being carried out by the same officer in a laboratory of the University of Tasmania. Acknowledgment is made of the valuable co-operation afforded by the Horticultural Section of the Department of Agriculture. It is hoped that such questions as the relation of tree growth to soil, the suitability of certain apple varieties to definite soil types, and the possibility of relating physiological disturbances in apples to soil conditions will be cleared up. In regard to the last point analyses have been made of representative soil samples from the experimental plots established by Mr. W. M. Carne (Division of Plant Industry).

At the request of the South Australian Parliamentary Public Works Committee a survey was made of a tidal marsh of 2,500 acres near Adelaide, proposed for reclamation. As a result of Messrs. Marshall and Walkley's survey it was possible to give a definite report on the basis of which the proposal was rejected. This is a further example of the usefulness of soil survey methods in assessing the practicability of reclamation schemes and in preventing the wasteful expenditure of large sums of money on such schemes.

The survey of the Gingin (Western Australia) district, begun last year by Messrs. Hosking (Council for Scientific and Industrial Research) and Greaves (Western Australian Department of Agriculture), has been completed in the field by the latter and in the analysis of the samples by the former. It is hoped to publish the results later in the year. Soil investigations connected with a " wasting disease " of stock at Denmark (Western Australia) have been undertaken jointly by the State Department and the Division of Soils, the latter being responsible for the analytical work which will be continued into 1935. Mr. Hosking has also completed a useful fundamental study of the black soils of Queensland and New South Wales and compared them with the " black cotton soils " of India, samples of which had been obtained through the Indian Department of Agriculture.

Dr. Walkley has directed his attention to the further chemical study of the soils of the Murray River horticultural areas, South Australia, with particular reference to their replaceable base status. The work is still proceeding.

Professor Prescott made an extensive tour of the country in North Queensland between Townsville and the Gulf of Carpentaria in 1933. He has compiled a report on the relation of the soils to peg-leg disease in cattle and was able to define at first hand the field characteristics of the major soil types and vegetation associations occurring in the districts in which the disease is prevalent. He has also published a paper on " The Composition of Some Ironstone Gravels from Australian Soils " from various sources in Western Australia and South Australia.

Miss P. M. Rountree, whose studentship terminated last April, continued her work on sulphur oxidizing bacteria. A field trial at Berri, South Australia, on treated plots, showed an increase in acidity from pH 8.3 to pH 5.6 after eight months with 1 ton, and to pH 6.4 with ½ ton dressing of sulphur to the acre. There was a marked improvement in the physical condition of the surface soil. She has also reported preliminary investigations on the problem of the disappearance of nitrate nitrogen from fallow soils and on the bacterial examination of soils from Macquarie Island. There is a wide field open for investigation in the bacteriological problems of Australian soils.

For the forthcoming year a full programme of field and laboratory work has been outlined, including further surveys in the Murrumbidgee Irrigation Area, New South Wales, at Mildura, Victoria, and the completion of the study of apple soils in Tasmania. In the spring of 1934 an attack is to be made, at the request of the State Department of Agriculture, on the problems associated with the basaltic soils of the north-west coast of Tasmania. In connexion with the Mildura project an excellent series of aerial photographic mosaics has been prepared for the Division by the Photographic Section of the Royal Australian Air Force.

VII.—IRRIGATION SETTLEMENT INVESTIGATIONS.

A.—Viticultural Research Station (Murray Irrigation Areas) Merbein, Victoria.

1. *General.*—The principal work in progress at the Research Station and on selected sites in viticultural areas, comprises investigations into (*a*) irrigation problems, (*b*) cultural methods, (*c*) methods of processing and transporting the produce, and (*d*) the control of vineyard and dried fruit pests. Administrative work in organizing and improving the routine practices of dried fruit producers and exporters has also been undertaken at the request of, and with funds supplied by, the industry. This work is carried out in co-operation with the officers concerned in the various States and with primary producers' organizations. Extension work of this nature occupies portion of the time of the Officer-in-Charge, while the remaining members of the staff of the Station are exclusively engaged on research.

Short-dated investigations, calling for immediate inquiry into urgent problems affecting the production and sale of the produce, are now becoming relatively rare, the major activities of the Station being systematic investigations designed to extend over a number of years.

2. *Irrigation Problems.*—Irrigation investigations include an examination of appropriate methods for distributing water in relation to soil type as defined by the Division of Soils; the frequency of irrigation, determined by a study of "loss of water" curves; and the preservation of soil fertility in relation to "free soil water" and agricultural drainage.

(i) *Method of Irrigation.*—The inquiry into methods of application is of primary importance, since it has been established that there is an intimate relation between the continued productivity of the land and the quantity of irrigation water applied. It has been found that there is a general tendency to apply irrigation water too copiously, with the result that portions of the irrigated settlements are becoming wholly or partially unproductive. By a study of "penetration" profiles, it is practicable to determine the minimum efficient quantity of irrigation water; and the investigations have now reached the stage at which service trials are in progress on selected sites representing major soil types. These service trials are located in the Mildura and Nyah-Woorinen districts of Victoria, and Barmera and Waikerie districts of South Australia.

(ii) *Periodicity of Irrigation.*—The study of soil moisture changes during the inter-irrigation period is being continued and extended so as to include the determination of the effective penetration of soil moisture, seasonal "loss of moisture" curves, and the quantities of, and the periods for, irrigation water necessary to maintain satisfactory conditions for plant growth. The field work has been completed and laboratory examinations are in progress. The maximum and minimum soil moisture percentages for the inter-irrigation periods are being defined for various soil types in terms of "moisture equivalent", "sticky point", and "wilting point".

(iii) *Salt Investigations.*—The investigation on a potentially salted area planted with vines is being continued with a view to determining the changes in the distribution of soil salts resultant on irrigation. The land has now been irrigated for three complete seasons, and the results show that a decrease of injurious salts in the soil horizons in which roots are established can be secured either by effective control of the distribution of irrigation water, or by agricultural drainage. The incidence of salt, as affected by agricultural drainage and by the method of irrigation, and the quantity of water applied, are also being measured intensively, and the growth of vines noted under these various conditions.

(iv) *Agricultural Drainage.*—The investigation of this problem is in the preliminary stages, being limited chiefly to a survey of existing conditions. An examination of the sub-soil on selected sites in the Mildura district (Victoria) and the Berri, Barmera and Waikerie districts

(South Australia) has shown that free water in excessive quantities exists over wide tracts. The work at present consists of an examination of drainage methods for the removal of free soil water, of the extent to which relief may be secured by a modification of irrigation practices, and of the occurrence and removal of free soil water in relation to the location of agricultural drains.

3. *Viticultural Investigations.*—Field plot experiments are in progress to determine the effects of pruning methods, growth control, and spring and summer work in dis-budding and tipping growing shoots. A close examination of present practices, considered in relation to the results of the investigations, shows the desirability of a closer balance between the quantity of fruiting wood and the varying soil vine groups in different environments. The investigations are being continued and extended to include the reactions of yield to designed variations in the quantity of annual vegetative growth and to shoot-removal and topping. The nutrition and development of the bunch in relation to contiguous shoots, are also being studied. An important advance has been made in the establishment of a correlation between the growth and the yield of each unit of annual wood preserved at pruning. The investigations embrace methods of re-constituting old vines which have been adversely affected by the cumulative effects of pruning, bad seasons, cincturing, &c.

4. *Fruit Processing.*—Investigations into methods of processing dried fruits have been undertaken in the endeavour to obtain a product more generally suitable to the oversea market. During the past three years, the investigations have been extended to test the application of the Station's methods to other districts where soil, climate and general environment differ materially. In semi-commercial trials of this nature, the work is carried out with the co-operation of State officers concerned, and under the direction of the Council's Fruit Processing Committee. The stage has now been reached where standardized practices are adopted.

In January, 1934, the Council accepted a generous offer made by four packing companies in the Mildura district to contribute £1,000 per annum for three years for an investigation into the fundamental principles of dipping, drying and packing grapes for the dried fruits trade. Mr. E. C. Orton, B.Sc., a graduate of the University of Western Australia, was selected for the work, and commenced duties in March. The companies are:—

The Irymple Packing Co. Pty. Ltd.
The Mildura Co-operative Fruit Co. Ltd.
The Red Cliffs Co-operative Fruit Co. Ltd.
The Aurora Packing Proprietary Ltd.

The work to date has consisted of a survey of existing field processing methods; the application of an electrical method for determining moisture in dried fruits on a commercial scale; a study of relative merits of fumigants for the destruction of insect pests; and a trial shipment for further investigation of colour changes resultant on transport to the United Kingdom.

Mr. D. C. Winterbottom, Manager of the Mildura Co-operative Fruit Co., who was on a visit to England, travelled with the trial consignment and made observations of the temperature and humidity conditions in the hold and the condition of the fruit on arrival.

The prevalence of dried fruit pests in the 1934 season has rendered fumigation very necessary, and an important section of Mr. Orton's work has been the introduction of recently applied fumigants which are already in use elsewhere on a commercial scale. The indications are that better results will be obtained with certain of these than have been possible in earlier practice.

5. *Control of Dried Fruit Pests.*—Acting in conjunction with the Department of Commerce, steps have been taken to ensure, by regulations devised to prevent infection and by regular inspections of packing houses, &c., that the infestation of dried fruits by insect pests is kept at a minimum. The results have been satisfactory, the present position being that the pests are kept in check to such an extent that practically the whole export pack is successfully marketed. Further refinements, namely, the development of insect-proof containers to give absolute protection and an improved design for dried fruit boxes, have been investigated in co-operation with the Division of Forest Products. The work also includes a study of pest control by fumigation and paraffin application.

6. *Co-operation with State Departments and Primary Producers' Organizations.*—(i) *Processing of Dried Fruits.*—The Interstate Fruit Processing Committee has extended its operations to include the processing of prunes, in addition to other stone fruits and grapes. This Committee continues to arrange co-ordinated investigations at existing Commonwealth and State institutions of urgent problems connected with the processing and export of dried fruits. The Merbein Station participates in this work. An important feature of the work of the Committee is the standardization of recommendations to primary producers on a common State basis. Considerable improvements in the quality, and consequently the ready sale of export parcels, have been secured.

(ii) *Investigations in the Nyah-Woorinen District.*—The staff of the Merbein Station co-operates with a local Committee in investigations of special problems affecting this district. A report of two years' work has already been submitted and provision made for continuation. The investigations are carried out conjointly by Mr. F. Penman, Department of Agriculture, Victoria, and the staff of the Merbein Station.

(iii) *The Non-irrigated Vine Areas in South Australia.*—The first half of the two years' work originally planned has been completed and provision made for continuation. The Merbein Station co-operates in this work with the Dried Fruits Board of South Australia, the Department of Agriculture, and local Committees formed in each of the three principal districts. The expense of working the plots is being borne by the Dried Fruits Board.

(iv) *Irrigation Problems in South Australia.*—At the request of the Lands Department of South Australia, irrigation investigations have been extended to include a study of methods of irrigation for additional soil types in the Berri and Barmera areas, and a survey of free water associated with salt development in certain areas. Assistance in initiating improvements in community irrigation as suggested in the Council's Pamphlet No. 26 has also been rendered, in co-operation with administrative officers of the Department of Lands.

7. *Application of the Results of the Work.*—The economic value of the work of the Station has been recently reviewed (Journal of the Council, Vol. 6, No. 2). The results of investigations dealing with the production and processing of grapes have been published from time to time, and the present position is that processing methods devised at the Station are in general use in the industry. In reference to production, the rate of improvement in yield may be considered satisfactory, with further advance probable.

A pleasing feature of the past few years has been an increased interest throughout irrigation settlements in the problems associated with soil wastage. The recommendations of the Council in reference to irrigation practices (Pamphlet No. 26) are being taken up by the irrigation authorities and settlers concerned, and remedial measures are being put into operation. The preservation and productivity of the irrigated lands on which grapes are grown constitute at present the major problem on which the staff of the Station is engaged. The extreme importance of this question and the necessity for immediate adoption of remedial measures when indicated by the results of research, are recognized by all concerned.

It may now be said that the transition stage has been reached when settlers are changing from the wasteful and damaging methods associated with the over-use of water to a nearer approach to the minimum efficient quantities; and are also recognizing the necessity of agricultural drains, which are being installed relatively rapidly, partly under area schemes on a community basis.

8. *Financial Assistance.*—Various bodies directly connected with the dried fruit industry have indicated their appreciation of the work of the Merbein Station, by granting financial assistance. The total annual contributions from all sources now exceed £3,000. The contributing bodies include the Dried Fruits Export Control Board, the four chief packing companies of Mildura, and the Nyah-Woorinen district growers. The State Dried Fruits Board of South Australia, the State Rivers and Water Supply Commission of Victoria, and the Lands Department of South Australia also contribute by constructional work and the supply of water, to the upkeep of the various experimental plots.

B.—Citricultural Research Station (Murrumbidgee Irrigation Areas) Griffith, New South Wales.

1. *General.*—Investigations of irrigation and related problems being carried out at the Council's Research Station at Griffith on the Murrumbidgee Irrigation Areas have made satisfactory progress. The work is financed partly by the Water Conservation and Irrigation Commission of New South Wales, and in addition to the general liaison with that body, the Station co-operates with various other branches of the Council in attacking certain problems.

In recent years the citrus industry has, coincident with an increase in production, suffered severely from low prices. This position has emphasized the value of research in decreasing costs, improving quality, and facilitating export and cold storage. During the year the Commonwealth Citrus Investigation Committee was appointed to review these and other matters associated with the industry. Mr. E. S. West, Officer-in-Charge of the Station, was among the Council's representatives on the Committee, which is considering detailed reports on citrus research from various Commonwealth and State bodies.

As indicated in previous reports, the work of the Station includes a comprehensive study of green manuring, fertilizer applications, soil moisture conditions and various cultural practices on an irrigated area of about 28 acres of oranges. Certain features of this work are extended

to other farms on the area, where studies under varying soil and tree conditions are of value. More recently, greater attention has been paid to fundamental problems, such as climatic influence on plant growth, methods of irrigation, and cool storage of fruit, and much of this work will be valuable in its application to the horticultural industry generally.

2. *Green Manuring.*—It has been found that by the growth of a winter legume as a green manure, yields of citrus are increased by 33 per cent. In addition the structure of the soil is maintained, thus facilitating tillage operations and the application of irrigation water. The nitrate relationships of the green manure plots are being studied extensively. It has been shown that during the growth of the legume, soil nitrates are depressed, but on ploughing-in the legume there is an immediate increase of nitrates near the surface. In the lower layers the nitrate content of the clean culture plots is greater than that in the green manure plots. Green manures have a big effect on the growth of both trees and cereals, and this appears to be greater than can be explained by the increase in soil nitrates. Interesting effects of green manuring on the ripening of the oranges have been noted.

3. *Fertilizer Experiments.*—It has been found that mature citrus trees respond to nitrogenous fertilizers, but young trees do not, as the nitrification in the cultivated soil is sufficient. Citrus trees do not respond to superphosphate; but superphosphate is indirectly necessary in the growth of green manure.

4. *Alternate Cropping of Valencia Oranges.*—Progress has been made in the investigations into the causes of and remedies for the objectionable cropping habit of Valencia Late oranges in the irrigated areas. This habit seriously affects the quality of the fruit and leads to marketing difficulties. The investigations, which are being conducted in co-operation with the Division of Plant Industry, have shown that the blossoming and setting of the fruit depends on the size of the previous crop. Thinning the fruit of a heavy crop appears not only to improve the quality of the fruit of that crop, but to prevent an excessively light crop the following year. The investigations are still proceeding.

5. *Cool Storage of Citrus Fruits.*—Extensive cold storage experiments with oranges are being carried out by the Station on behalf of the Citrus Preservation Committee, the activities of which are described in another part of this report. In this work very useful assistance is being received from the Griffith Producers Co-operative Co. Ltd., which has made available cold storage facilities. This work will not only assist in the export of citrus fruit, but will permit a more orderly supply to the Australian market.

6. *Methods of Irrigation.*—Water-logging and soil salt troubles which result in large losses in irrigation areas can usually be traced to faulty methods of applying irrigation water. The Research Station is paying particular attention to this problem. Investigations of furrow methods of irrigation were continued. In this work varying flows are used on typical soils and slopes, the soakage being measured at intervals along the furrow. The data being obtained in this way will serve as a basis for a more systematic control of irrigation water.

7. *Spray Irrigation.*—The hydraulic principles of a method of spray irrigation have been investigated. The results will shortly be published in a Pamphlet which will also include a discussion of the design of systems and costs. Spray irrigation is a useful method on certain soil types where surface methods are either difficult or impracticable. Some of these soils are among those most suitable for irrigated horticulture.

VIII.—FOREST PRODUCTS INVESTIGATIONS.

1. *General.*—The Division of Forest Products was established in 1929 to undertake research into utilization of products of the forest, of which timber is obviously the most abundant and important. Its functions are distinct from those of the State Forest Services whose activities are confined for the most part to the care of the forests and the growth of the trees up to the stage at which they are converted into timber for use. There is, however, the closest co-operation between these State Services and the Division.

The Commonwealth Bureau of Forestry has the field of sylvicultural research under its care, and the line of demarcation between its work and that of the Division has been more or less arbitrarily fixed at the felled tree. From that point through every stage into its conversion into timber and articles of use there is enormous waste, and one of the most important functions of the Division is the study of methods to prevent or reduce this waste. No permanent laboratories have yet been erected for the Division; temporary accommodation has been provided at 314 Albert-street, East Melbourne.

The work is divided into two main sections—

A. The collection and dissemination of all known facts about Australian timbers, their uses, and methods of treatment. This is attempted by means of—

(*a*) Trade circulars issued free to all sections of timber users.
(*b*) A Monthly News Letter issued to and published by a large number of newspapers and trade journals all over Australia.
(*c*) Lectures to timber organizations ; wood-working classes at Technical Schools, &c.
(*d*) Classes in seasoning held at the laboratories and elsewhere.
(*e*) Replies to inquiries by mail.
(*f*) Visits to plants to advise on best practices.

The greater part of the energies of the Division, in its first few years, is being devoted to the above work, because it is recognized that there is an enormous amount of information in existence, which, if properly applied, can be of the greatest value to all forms of timber industries. This practical application of existing knowledge, it is held, should take precedence over the accumulation of new information.

B. The collection of new information by research in some of the most important of the numerous fields of work as yet neglected or only partly explored. Although, as stated above, greater prominence has so far been given by the Division to the application of existing knowledge, the development of research is being steadily pursued, and will form an increasing branch of the Division's activities as time goes on.

The main sections being studied at present are : (i) Preservation, (ii) Seasoning, (iii) Utilization, (iv) Wood Structure, (v) Timber Mechanics, (vi) Wood Chemistry, and (vii) Timber Physics.

An important feature of the work during the year 1933–34 was the increased recognition given to the Division by a widespread section of the timber trade as the centre of timber knowledge in Australia. This was shown, not only by the large demand for its publications and its advice, but also by the considerable increase in the number of those actively engaged in the industry who send their representatives to the Division's laboratories for training, and by the frequent visits to the laboratories of members of the timber trade.

Series of classes, both for lectures and practical work, on the identification of timbers and on timber seasoning were held by the Division at different centres and were attended by a large number of students and others, a number greatly in excess of that anticipated.

During the year a spacious wooden building was erected adjacent to the Division's laboratories for the accommodation of the collection of timbers and of the Division's publications. Room was also provided for the Head Office library and publications and for a spare office. The building has a number of special features such as the use of reject flooring to illustrate the wastefulness of the usual grades ; the reduction of dimensions below those ordinarily in use to illustrate the possibility of saving timber by making fuller use of the strength of our hardwoods ; and a system of connexions to various parts of the building to facilitate " blinker " moisture tests from time to time and to supply information as to moisture changes in buildings throughout the year. While this building gave some much needed relief for general storage, the accommodation provided for the Division is still extremely cramped ; it is barely sufficient to house the existing equipment and permit the necessary activities associated with the experimental work. The arrangement is neither economical nor efficient, and must be regarded as a makeshift. Steps should be taken as soon as possible to house the Division in properly designed and equipped laboratories.

2. *Wood Preservation.*—Many projects are at present under way in this Section of the Division's work. In this Report reference is made only to some of the investigations on which work has recently been initiated and to some of the valuable results which have been obtained from the Section's work.

(i) *Telegraph Poles and Railway Sleepers.*—Karri is being tested out—both powellized and fluorized—as cross arms, and fluorized as sleepers. In the former tests which have been in progress for three and a half years, sufficient data have been accumulated to cause karri to be re-included by the Postmaster-General's Department in the schedule of timbers for cross arms. In the case of fluorized sleepers, inspection after four years' service shows 99.1 per cent. of these to be in good condition, whereas of the untreated controls only 62 per cent. are sound.

On account of the large number of inquiries regarding pole preservation and related pole problems, it was decided to prepare a publication on the statistics, properties, distribution and supply of pole timbers, the effect of defects on durability, and methods of treatment, together with a key for identification. It appears that there are about 3,000,000 wooden poles in use in Australia for electrical, telephone and telegraph purposes. It is estimated that in the near

future the cost of pole renewals (cost of poles only), will be of the order of £300,000 per year. An increase in life due to preservative treatment will, therefore, mean a considerable annual saving in capital and maintenance charges. The reasons for the renewal of wooden poles are approximately, decay 80 per cent., termites 14 per cent., other causes 6 per cent.

The poles installed at Mount Jamberoo in New South Wales to test the arsenic collar method of preservation have proved the method to be unsuccessful. The arsenic has not penetrated the wood longitudinally to any extent and the poles have been attacked.

A comprehensive pole test using *E. obliqua* has been started in Victoria on two sites, one of which is in a bad decay area and one in a bad termite area.

Plans for a similar test with 500 poles in New South Wales are now in hand and arrangements are under discussion for the co-operation of the principal users of poles in that State.

Tests of the oxyacetylene scouring and charring process for the treatment of partly decayed poles were carried out and the treated areas of twelve poles were submitted to detailed pathological examination. The degree of sterilization varied considerably, but some poles were rendered completely sterile in the treated region. The creosote spray treatment appears to be essential, but the method at present in use can undoubtedly be improved and more consistent and better results could be obtained. Arrangements have been made for further work along these lines.

(ii) *Fence Posts.*—A further inspection of the fence posts in Western Australia, after three and a half years' exposure, showed that whereas all the untreated controls were badly attacked, those treated with creosote plus oil and zinc chloride plus arsenic are all sound. None of the posts subjected to treatments containing arsenic in solution have been attacked by termites. In the sodium fluoride plus arsenic treated posts, the extent of decay increases with increase in rainfall. Also, in the wetter localities particularly, decay is commencing in the arsenic solution treated and arsenic collar treated posts.

(iii) *Marine Piling.*—Pile sections of *E. pilularis*, *E. saligna* and *Tristania conferta* were treated with creosote in 1932 and forwarded to Queensland for service tests. After two years, the creosoted specimens at one station have been attacked by *Nausitoria* in surface patches, while two of the creosoted specimens at the other station are sound, and one has very light attack by *Sphaeroma*. The untreated controls in all cases have been either destroyed or severely attacked.

(iv) *Creosote Oil.*—In co-operation with the Standards Association of Australia, the Senior Preservation Officer has acted as Honorary Secretary of the Technical Committee on Creosote. This Committee has issued a draft specification for creosote oil for wood preserving purposes, the specification being intended to include both horizontal and vertical retort creosote oils. During the past few years, the demand for creosote oil as a wood preservative has increased very markedly.

(v) *Investigation of Lyctus (powder post beetle).*—The investigation of this problem has been continued, using *E. obliqua*, *E. regnans* and *Schizomeria ovata*, the sapwood of all these being susceptible to attack. Work on the effect of the presence of starch on Lyctus infestation has been recently published in England by S. E. Wilson, and analyses of the results obtained in the past year and examinations of Lyctus infested samples bear out the main conclusions of this work. A paper is now in course of preparation on the relationship of vessel size and starch content to Lyctus attack.

3. *Timber Seasoning.*—The whole of the work done in this Section during the year 1933–34 either involved contact with the trade or was of such a nature as to have direct bearing on trade practice. The former class of work consisted, mainly, of visits to plants, either to discuss seasoning problems or to help in the initial runs of new kilns. Interest in kiln-drying continued to develop in the trade, a number of new kilns having been built during the year. At the end of June, 1934, there were 87 establishments in Australia in which kilns had been erected, the total number of the kilns being 224.

In addition to work under projects, the programme of educational work was continued through the medium of Trade Circulars, lectures and demonstrations and correspondence courses.

Trade inquiries received either by correspondence or by personal calls at the laboratory continued to occupy a considerable amount of time. As a result of such inquiries, sets of kiln plans were forwarded to 46 concerns. It is interesting to note that several inquiries about kiln design and seasoning practice were received from New Zealand and other countries.

(i) *Collapse in Timber.*—Work on the comparison between laboratory and commercial treatments was continued from the previous year and completed, but the results have not yet been completely analysed.

Investigations were also made regarding the effect of boiling green timber on subsequent collapse, the moisture pick-up and rate of heating during reconditioning, and the occurrence of checks in reconditioned stock.

(ii) *Kiln-drying Schedules.*—Work under this project formed the main part of the laboratory work for the year, the three laboratory kilns being in constant operation. Material for more than 50 kiln runs was still on hand at the end of the year, and information regarding schedules for several other species has been sought by the trade.

(iii) *Kiln Design and Construction.*—Tests were made on four kilns designed by the Division for commercial plants. One of these is an overhead longitudinal shaft internal-fan type, and the others are of the overhead cross shaft internal-fan type. Tests were also made on a modified type of Grant kiln. The Division is continuing to advocate the cross shaft internal-fan type of kiln for general purposes. The co-operation of a number of kiln operators was obtained in collecting information relevant to depreciation of kiln buildings and equipment.

(iv) *Moisture Equilibrium Survey.*—The major preliminary survey covering the capital cities of the Commonwealth was completed during the year. The work has been reported in outline in an article in the *Journal of the Council for Scientific and Industrial Research*, and a detailed report has been prepared for limited circulation.

(v) *Kiln Aerodynamics.*—A special kiln for this work was designed and is almost ready for use. A working plan has been prepared and work will commence early in the coming year.

4. *Utilization*—(i) *Standardization and Grading Rules.*—Definite progress has been made during the year with the development of standard specifications, and in this work the Division has been closely associated with the Standards Association of Australia. The Timber Sectional Committee of that Association, with its State Sub-committees, has drawn up Australian Standard Grading Rules for milled flooring, lining and weatherboard and these have been issued. Considerable simplification of flooring profiles has also been brought about and recommended profiles have been included in the grading rules. Grading rules for plywood are being prepared, and work is proceeding on the standardization of joinery items.

For the general purposes of timber standardization work it is essential that accurate data should be obtained regarding the occurrence and extent of defects in timber as milled.

A commencement has already been made in collection of information of this type, in the extensive grading investigation carried out in Western Australia in co-operation with the Forests Department of that State. The extent to which the grading rules thus formulated have been accepted and put into practice is a recognition of the soundness of this method of attack.

The need for extending this work to cover the timbers of all States has been indicated rather forcibly by the publication by the Imperial Institute of a set of grading rules and standard sizes for Empire hardwoods, prepared by the Advisory Committee on Timbers of the Institute and recommended for use in shipments of these timbers to the United Kingdom. Australian timbers were included, and while it was felt that the specifications proposed were not altogether satisfactory from the Australian point of view, lack of fundamental information made it impossible to recommend alternative proposals. That this difficulty is a general one is indicated by the following suggestion of the Director of the Imperial Institute: "The Governments concerned should institute inquiries, including mill studies, with a view to ascertaining the percentages of material, conforming to the different grades, which are capable of being produced from average logs of the various species of timber exported from their respective countries."

The need for comprehensive grading studies is, therefore, a very pressing one. It is gratifying to record that a sum of money has been placed on the Estimates for the coming year which will enable this greatly neglected field of work to be attacked with some approach to the vigour which its importance warrants.

(ii) *Young Eucalypts.*—A general problem throughout Australia is the utilization of young eucalypts. As a result of regeneration activities, dense stands of young trees are a common sylvicultural feature, and the thinning of these is becoming an increasingly pressing need. If profitable outlets can be found for the thinnings, considerable advantage to the forests must accrue.

Accordingly, arrangements were made with the Victorian Forests Commission for the supply of sufficient young mountain ash for laboratory tests. Eighty-two logs from 40 young mountain ash trees of varying sizes and ages were selected by officers of the Forests Commission. The logs were converted at the laboratories of the Division, the occurrence of defects being noted, and the material was distributed amongst the various sections. When the laboratory tests are complete, it is proposed to convert a larger quantity of material for grading studies and commercial seasoning and utilization tests.

(iii) *General.*—During the year, a wide range of inquiries was received for timbers for special purposes, and for new uses for special timbers. In connexion with these inquiries, a large number of manufacturing plants was visited.

5. *Wood Structure.*—(i) *Wood Anatomy.*—The general work of this Section has been concentrated on a study of the wood anatomy and properties of commercial Australian timbers. Previously, tentative keys for the identification of approximately 80 of the more important timbers belonging to the genus *Eucalyptus* were developed, those dealing with the pale coloured timbers being published during the past year. Work on other timbers belonging to this genus was discontinued in order to enable more attention to be devoted to the numerous commercial timbers of other genera. Sufficient progress has been made to justify the statement that within the next six months it will be possible to publish information on, and methods for the identification of, some 100 commercial non-eucalypt timbers.

A start in the collection of all available information regarding the properties of Australian timbers has been made and the first publication, dealing with the properties of eight timbers (the " ash " group) of the genus *Eucalyptus* has been issued. This work is being continued and a publication on the pole timbers of Australia is in course of preparation. Several interesting studies have been carried out including (*a*) structural variations throughout the tree, and (*b*) the anatomy and properties of immature eucalypts.

(ii) *Basic Density.*—Some preliminary experiments were undertaken to determine the effect of various treatments on the subsequent soaked volume of the small specimens used in basic density determinations. The main points of interest resulting from these experiments are that it is possible (i) to obtain reliable basic density results with a sample which has been dried to obtain oven dry weight prior to soaking or boiling in water to obtain the saturated volume, and (ii) to speed up the determinations by boiling in water, instead of soaking for long periods in cold water. Both these points are of interest since it is often necessary in cases of identification to obtain results in a short time.

During the year an extensive series of basic density determinations was completed in connexion with the investigation of variation throughout a tree, and throughout a species (using both immature and mature trees). The question of variation of basic density is of great importance in connexion with methods for identification in which basic density has been used as a means of separation.

(iii) *Identification of Non-eucalypts.*—An investigation is being conducted on the anatomical features of non-eucalypt timbers and the development of keys for identification, the aim being to include 100 of the most important commercial timbers of these species.

The work has been carried out according to family classification. Information is recorded regarding the habits and distribution of the species and the general properties of the timbers in addition to macroscopic and microscopic features. Three hundred and twenty-four samples from 100 species and 45 genera have been examined and reports prepared on the Myrtaceae, Proteaceae, Cunoniaceae, Meliaceae, Rutaceae, Lauraceae and Leguminosae.

(iv) *Heart.*—One of the most important factors contributing to low recovery from the log in the milling of Australian hardwoods is the presence of " heart ". This is the name given to the central portion of the log which is very brittle and which is sometimes visibly affected by decay. This unsound material is excluded in milling, but because heart is often wrongly confused with the rapid grown low density material from the centre of the tree, sound timber is not infrequently rejected. Associated with heart, are often to be found compression failures, but although at one time it was thought that these were a diagnostic feature of heart, it is now known that sometimes they extend beyond the limits of the heart timber.

It will be obvious that a knowledge of the nature and extent of heart will permit more effective utilization, while a sound theory as to its formation might prove of value in the sylviculture of second growth eucalypt forests.

In the preliminary investigation of the difference in structure between brittle heart of certain eucalypts and the tougher truewood of the same tree, two interesting points were observed :—

(*a*) The wood fibres isolated by maceration from the brittle heart were nearly all broken at right angles to the fibre axis, i.e., they themselves were brittle, in comparison with the whole fibres isolated in the same manner from normal tough wood.

(*b*) The presence of marked initial compression failures in the brittle wood as revealed by microscopic examination of radial sections under polarized light.

The results showed definitely that the limit of heart as determined by brittle failure under impact coincided with the limits of broken fibres observed in macerated material from the same block. Also, just as there is often a gradual decrease in brittleness from pith to sap until tough wood is reached, so it was found that the percentage of broken fibres gradually decreased as the toughness of the wood increased. Where, however, there was an abrupt change from brittle to tough wood there was also a sudden change from broken fibres to whole fibres. Examination of the sections taken from the brittle wood revealed the presence of minute compression failures. While it was impossible to determine the exact limits of these, it is significant that they are common in heart and not in truewood. It would seem fairly conclusive, therefore, that such initial compression failures are the forerunners of both broken fibres and brittle wood. The cause of these minute compression failures is, however, not so easy to explain.

In order to explore some of the possible causes of heart, tests were carried out in which samples of karri (*E. diversicolor*) were subjected to end compression. It was found in all cases that the toughness was not reduced except at, or very near to, the induced compression failure. Broken fibres were found in the macerated material from near the compression failures, but not in material slightly removed from these gross failures. These experiments indicated that brittle wood could not be induced by compression in this species at least.

To investigate further the cause of heart, sections were prepared from the numerous samples of brittle wood and truewood used in the experiments previously described, so that examination could be made for the presence of fungi (heart rots). This work has been carried out by the Preservation Section, and preliminary results indicate that fungus is present in all the brittle samples. These studies on heart are being continued in the hope of establishing some explanation of the observed facts.

6. *Timber Mechanics.*—During the year, a considerable volume of testing work was carried out, approximately 6,000 individual tests (exclusive of moisture content determinations) having been made. The increased work necessitated the addition of further staff. The Universal testing machine can now be operated continuously while toughness tests are being carried on at a steady rate.

(i) *Holding Power of Nails.*—The publication of the results on holding power of nails aroused considerable interest. From the tests it appeared that the Australian cement-coated nails were no better than plain nails.

The New Zealand Forest Service and the Canadian Forest Products Laboratories each forwarded samples of cement-coated nails used in those countries, with the request that tests should be carried out on them along similar lines. These showed that the efficiency of the overseas cement-coated nails as measured by combined static and impact composite figures, was little higher than that of the Australian cement-coated nail and showed no improvement over the Australian plain nail.

(ii) *Toughness and Bending Tests.*—Toughness and bending tests of brown mallet (*E. astringens*) showed that this timber has a very high impact strength resembling medium quality hickory. To confirm or disprove these results, fifteen logs are now being tested. If results are confirmed, it will greatly increase the value of the large areas in Western Australia which are being planted with this species. Other timbers tested were wirewood (*Acradenia franklinii*), white handlewood (*Pseudomoris brunoniana*) and grey handlewood (*Aphananthe philippineusis*), spotted gum (*E. maculata*), yellowwood (*Flindersia oxleyana*), willow, horizontal (*Anodopetalum biglandulosum*) and insignis pine (*Pinus radiata*).

(iii) *Standard Mechanical Tests on Australain Timbers.*—Although very comprehensive tests on karri (*E. diversicolor*) had been carried out by Sir George Julius in 1905, the need for further tests for the purpose of studying the variation in properties throughout the tree and between trees became evident. This was particularly true in the case of timber for cross-arms and tool handles, both of which require wood of high static and impact strength. The proper selection of material entails a knowledge of the manner and, if possible, the causes of variation. Consequently, as mentioned in last year's report, a comprehensive series of tests was planned in co-operation with the Western Australian Forests Department for the purpose of studying the variation in mechanical properties with a view to improving the utilization of the species for high quality articles. Advantage was taken of the opportunity to carry out, as far as possible, complete standard tests according to B.S.I. and A.S.T.M. standards, so as to enable the strength of the clear wood of karri to be compared directly with that of overseas woods with which it is likely to come into competition.

The tests on the green specimens have been completed, and the results are now being analysed. They show that karri is a very hard, strong and stiff timber of moderate impact strength, and that it is much superior to such well known structural timbers as Douglas

fir and English oak in practically all strength properties. One interesting feature is the comparative uniformity of karri in comparison with overseas woods. A preliminary statistical analysis of the results of the tests on the green specimens has shown that the correlation between the various strength properties and specific gravity is only fair. In most cases the mechanical properties vary as an unusually high power of the specific gravity.

In addition to the standard tests, special tests have been carried out on the strength of karri in compression perpendicular to the grain, a property in which karri appears to be somewhat unusual, in that the bearing strength when the load is applied to the tangential surface is 33 per cent. greater than when the load is applied to the radial surface. Tests on the effect of the width of the plate on the bearing strength checked the results obtained by the United States Forest Products Laboratory and showed that with narrow plates the resisting force caused by the bending of the wood fibres at the edges of the loading plate is of considerable importance. A series of tests is in progress to determine the effect on the bearing strength of applying the load at varying angles to the grain.

(iv) *Boxes.*—The Division's work on various wooden containers is approaching a stage when it may become effective in altering existing practice.

(*a*) *Apple Cases.*—The work on apple cases, which has been reported and published in Council for Scientific and Industrial Research Pamphlet No. 45, has been followed by a shipment of 540 cases, half of which were in the modified dump case of seasoned hardwood and half in Canadian softwood standards. Preliminary reports are to hand and on receipt of a detailed report from the Cambridge Low Temperature Research Station, which undertook the examination of the shipment, the results will be published.

(*b*) *Butter Boxes.*—Work on spraying butter boxes of hoop pine with a casein formalin mixture has been reported previously. As the result of overseas shipments the Department of Commerce has decided to enforce this method by regulations, and these come into force in November, 1934. From time to time, objections have been raised in Queensland, but there is now a fairly general acceptance of the necessity for spraying and there is no doubt that once it is adopted, the absence of taint will soon follow and everyone will be pleased at the results and forget the old opposition.

(*c*) *Dried Fruit Boxes.*—Eleven shipments of dried fruits were sent during the year to test out the improved nailing schedule, developed as a result of laboratory tests during the previous year. Half the cases were nailed the old way and half according to the new schedule. Reports have been received on these and indicate clearly an advantage in the new nailing.

(*d*) *Banana Cases.*—Work was also carried out during the year on banana boxes. Following on the inspection of banana boxes at Albury and Melbourne, a working plan for laboratory tests of the box was drawn up. The tests were confined to an investigation of the influence of the various construction details on the strength of the cases. The factors studied were—(i) the species of timber, five different species being tested, (ii) the thickness of the timber, (iii) the nailing schedule, (iv) wiring, and (v) the extent of the bulge.

The results showed that use of badly milled shooks and lack of care in construction are mainly responsible for inferior cases. With the soft brush timbers such as blush cudjerie (*Euroschinus falcatus*) particular care is necessary to eliminate unduly thin shooks, as other things being equal, boxes made of these timbers are not as strong as those made of eucalypts. If care is taken, satisfactory boxes can be made from all the species of timber. Up to 1½ inches, the amount of bulge did not seriously affect the strength of the case, but with greater bulges than this, there was a pronounced falling off in strength. It was found that in practice failure is usually due to a combination of high bulges and thin tops.

7. *Wood Chemistry.*—The work of this Section included a continuation of the studies on identification of wood by chemical means and on the lignin determination. In both, definite progress has been made, but analysis of the results had not yet reached a stage to allow of publication during the year. It is quite clear that the method of lignin determination as recently modified, as a result of work at the Forest Products Laboratory at Madison, United States of America, is still unsuitable for many Australian woods, especially those in which kinos occur which are more or less difficultly soluble in hot water. Extensive work has not resulted in a complete solution of this problem, but it is hoped to show in a technical paper, to be shortly issued, that the method developed in this Division gives generally the closest approximation to correct results.

In a study of the chemical reactions of aqueous, alcoholic and alkaline extracts of 37 coloured eucalypts, two tests were found to be of use in identification. The alkalinity of the ash still proves to be one of the most useful guides. Over 560 samples were examined and results will be published shortly.

Work done by Dr. Herty and his associates in the Georgia Paper Experimental Station indicates that the technical difficulties in the way of making white papers from resinous pines have been overcome, provided that only sapwood is used. It becomes of importance, therefore, to know at what age heart begins to form in *P. radiata* (*insignis*) which is so largely grown in Australia and New Zealand, and which it is hoped to pulp. A survey of the occurrence of heart and of the differences in amount and nature of the resins in the sap and heart of this pine was, therefore, begun.

In connexion with the study of wood preservatives, it was found necessary to estimate the arsenic content of treated timbers. Though several methods had been published, considerable difficulty was found in obtaining accurate determinations when the quantities were larger than usual. Finally a method published by the Society of Public Analysts in *The Analyst* (1930) was suitably modified. The results will be published shortly.

8. *Timber Physics.*—During the year 1933–34 a start was made with a Section of Timber Physics. This was only possible by robbing another section of the services of one of its officers; but the importance of the physical studies makes this sacrifice worth while, and as the researches bristle with difficulties and will only slowly yield results of value, it was considered wise to make a modest beginning as soon as possible. The Section is at present making a study of the fundamental shrinkage of timber and is developing a technique in a field of work at present very little understood. As the Section consists of only one officer and a cadet, and the former still has to give some time to the Seasoning Section, progress must necessarily be slow. The work is, however, of interest as the beginning of a type of work which must become of increasing importance with the growth of the Division, and which must be developed as rapidly as funds can be provided. Definite progress has been made in investigations on the fundamental shrinkage of wood, which is a problem of the greatest importance.

The object of the studies on shrinkage is to develop a method of determining for any species representative shrinkage figures which are unaffected by drying stresses or collapse and also to investigate the more fundamental aspects of shrinkage. Different methods of preparing and measuring shrinkage samples have been investigated and the outline of a possible method of determining fundamental shrinkages has been suggested. The effect, on their subsequent shrinkage, of heating green samples, of soaking green samples in water and of keeping them in a saturated atmosphere, has been studied. A working plan for a further systematic study of the factors which affect the shrinkage has been prepared.

The Section is also conducting work in connexion with correction figures for the blinker electrical moisture meter. A total of 85 species has been tested at 15 per cent. and nineteen over the full range. These figures are published from time to time for the guidance of the trade. Over 80 of these instruments are now in use in Australia. An attachment by which veneers can be tested with the blinker has been built to the design of the Division.

IX. COLD STORAGE INVESTIGATIONS.

1. *General.*—During the year 1933–34, no new investigations were commenced by the Section of Food Preservation and Transport. More detailed studies were, however, carried out on each problem on which active work was in progress in the previous year.

In addition to an extensive range of experiments in the laboratory, in certain fields considerable attention has been given to investigations of commercial procedure and to the application in industry of the results of scientific investigation. While such work naturally restricts the progress of more fundamental investigation, it is, nevertheless, to be regarded as an essential part of the Section's activities, not only in ensuring the more speedy application in industry of the results of scientific work, but also in affording the investigators a more thorough knowledge of the details and scope of industrial problems.

Co-operation with other scientific institutions, both in the collection of data and in the joint attack on problems of the storage and transport of fruit and meat, has been established. The help of the Food Investigation Board of the British Department of Scientific and Industrial Research has been enlisted in the examination in London of small experimental consignments of oranges and pears and of several shipments of chilled beef. Such investigations have already yielded valuable data, and with the continuation of such work in conjunction with experiments in the laboratory, it is hoped that it will be possible to indicate the optimum conditions to be adhered to during preparation and transport of the various perishable foodstuffs in order virtually to eliminate all forms of wastage and deterioration. An agreement has been entered into whereby the Council will co-operate with the Plant Pathology Branch of the Queensland Department of Agriculture in investigations designed to discover preventive measures for the several diseases of bananas, such as "squirter" and "black-end", which become apparent during transport and ripening of the fruit. At the request of the Sydney Metropolitan Meat

Industry Commissioner, a report has been furnished by the Officer-in-Charge of the Section indicating the most useful methods by which the scientific staff of the Sydney Abattoir could co-operate with the investigations on chilled beef being carried out in Brisbane. This report indicated that a detailed survey of the micro-flora found on beef prepared at the Sydney Abattoir, and studies of the low-temperature type organisms so isolated would probably prove to be the most valuable fields of investigation, particularly by affording comparisons with similar work in Brisbane. The Commissioner has recently agreed to such investigations being undertaken and has made arrangements for the bulk of the scientific work to be carried out by Mr. C. Wright, Lecturer in Bacteriology in the University of Sydney, and the necessary facilities, such as large constant temperature incubators, are being erected in Mr. Wright's laboratory. The Section of Food Preservation and Transport will co-operate with the investigator by seconding an officer to aid in the initiation of the experiments and by affording advice as desired.

The Queensland Meat Industry Board has continued its generous financial support of the investigations into the preparation and storage of chilled beef. The investigations into the handling, transport and ripening of bananas have again been financed by grants from the funds at the disposal of the Commonwealth Banana Committee and of the Banana Industry Protection Board of the Queensland Department of Agriculture and Stock, and have been aided by the provision of free passes to the investigator by the Railways Departments of New South Wales and Queensland. Especial thanks are due to various officers of the New South Wales Government Railways, the Queensland Committee of Direction of Fruit Marketing and the New South Wales Banana Growers' Federation; the investigations of the transport of bananas, concerned as they were with almost every phase of the banana industry, would not have been possible but for the co-operation afforded by these officers and by many banana growers.

The recent appointment of Mr. N. E. Holmes, formerly the Section's Engineer, as liaison officer in England, has materially facilitated the planning and execution of several experiments on the handling and overseas transport of fruit and meat carried out in conjunction with the British Food Investigation Board. The liaison officer has also paved the way for closer co-ordination of the investigations in which each body is mutually interested and, through regular detailed reports, is keeping the Section's officers fully informed of the progress of important food preservation and transport investigations in Great Britain. It will, of course, be realized that this liaison work could not have been attempted without the full consent and generous co-operation of the Food Investigation Board, and it is pleasing to record that the Director and officers of the Board have done everything within their power to facilitate Mr. Holmes' work. Further changes and additions to the Section's staff have been the appointment of Mr. W. J. Scott to the position of Assistant Bacteriologist in the Brisbane Food Preservation Research Laboratory, and the resignation, in December last, of Miss S. Hoette, who was the temporary mycologist working on the diseases of "squirter" and "black-end" in bananas. Miss Hoette is, however, continuing in Melbourne part-time work on "black-end".

Associate-Professor W. J. Young, the Council's adviser in matters of food preservation, has continued to supervise the investigations of non-tropical fruits in Melbourne and has devoted considerable time to the problems of the storage of oranges, a more comprehensive attack on which has now become urgent in view of the policy of the growers in exporting more fruit to distant overseas markets.

The recent death of Sir William Hardy, F.R.S., Director of the Food Investigation Board of the British Department of Scientific and Industrial Research, has been keenly felt by all workers in the field of biological science, and has meant a personal loss to those officers of the Section who had the privilege of receiving part of their scientific training under his guidance. At all times, his wise counsel was available to those directing food preservation research work in Australia, and, insofar as it was possible, his far-sighted policy for the development of the science of food preservation, pursued so successfully in the several laboratories of the Board, has been followed in the prosecution of similar work in Australia.

2. *The Preparation and Storage of Chilled Beef.*—(i) *General.*—In the last Annual Report attention was directed to the economic importance to the Australian meat industry of the development of a trade in chilled beef with Great Britain. No changes have since occurred in the condition of the British markets to alter the opinions then expressed. The initiation of an expert of chilled beef has followed closely on the development of the method of using relatively low concentrations of carbon dioxide in the storage atmosphere, a technique so fully investigated by Dr. T. Moran and his colleagues at the Cambridge Low Temperature Research Station. While it is unlikely that, for some years to come, there will be an increase in the total exports of beef from Australia, a considerable proportion now exported in the frozen condition

will be replaced by chilled beef. Since the details of the most desirable technique of preparation, pre-cooling, handling and transport of the beef have by no means been fully outlined, the need for intensive scientific work has become even more pressing.

Dr. Moran and his colleagues at the Cambridge Low Temperature Research Station having carried out extensive investigations of most aspects of the transport of chilled beef, and the results of experiments in Brisbane, outlined in the Annual Report of the Council for the year 1932–33, having indicated the extreme importance to safe storage of the various phases of treatment of the beef in the meat-works, the efforts of the Brisbane workers have been directed very largely to further studies of the microbial contamination acquired by the beef in the meat-works, of the precautions to be adopted greatly to reduce such contamination, and of the most desirable conditions to be adhered to during chilling (pre-cooling) and handling. Nevertheless, a considerable amount of time has been devoted to storage experiments, with the following objects: testing on a semi-commercial scale the results of laboratory studies in Cambridge and determining in what respects local conditions may modify the conclusions drawn from such laboratory work; with a fixed set of physical conditions during storage, to correlate the types and extent of the initial microbial contamination of the beef with the length of its storage life before the onset of appreciable deterioration due to attack by micro-organisms; to determine the effects during storage of variations in the normal procedure of treatment in the meat-works; to determine the effects of variations in the physical conditions of storage upon the bloom and the extent of microbial proliferation.

Full data of each phase of treatment obtaining in several commercial shipments of chilled beef, including detailed reports of the conditions on arrival in England, have been obtained, and it is hoped thereby to determine whether the results of laboratory investigations can be substantiated in commercial practice and also to determine the most desirable conditions to be maintained during transport, particularly in regard to the aspects on which it is difficult to obtain useful data by means of small scale storage experiments on land.

Surveys of types and numbers and sources of the microbial contamination of beef have been carried out in five beef exporting works in Queensland, one in New South Wales and one in Western Australia. Extensive, though not complete, physical data concerning the handling and chilling (pre-cooling) in each works have also been collected. On the basis of these data, reports have been furnished to the companies concerned indicating desirable structural alterations to the works, or changes and modifications in procedure in order to ensure a more satisfactory out-turn of chilled beef exported to Great Britain. These surveys have been carried out at the request of the management of the works who have frequently borne the whole or part of the cost of the work, and it is pleasing to record an unusual degree of confidence on the part of the managements in the value of scientific investigation; almost without exception, the alterations recommended have been installed.

During the past year, a large number of inquiries on various phases of the preparation, storage and transport of meat and meat products have been received from representatives of the beef exporting works. These, and almost daily personal interviews at the laboratory, particularly with marine engineers from overseas ships, indicate the growing interest in the work being carried out by the Section.

(ii) *Micro-biological Investigations.*—Further studies of the nature of the microbial contamination capable of comparatively rapid growth at low temperatures of the order of −1 degree C. (30.2 degrees F.) have indicated that various strains of *Achromobacter* usually exceed the sum of all other types of organisms. Depending on the season and the nature and location of the meat-works, certain species of bacteria such as *Pseudomonas* and *Micrococcus*, of wild yeasts, and of moulds such as *Penicillium* and *Sporotrichum* may be fairly prevalent on the beef immediately after slaughter.

During the winter months, the percentage of low-temperature type *Achromobacter* and moulds tends to attain a maximum and, in addition, during this period there is a higher proportion of the strains of *Achromobacter* having rapid growth rates at −1 degree C. (30.2 degrees F.). With the approach of the summer months, the percentage and activity of *Achromobacter* and moulds tends to decrease, and low-temperature type yeasts make their appearance, until at the height of summer, the numbers of such yeasts per unit area usually equal, and often exceed, the numbers of *Achromobacter*. Thereafter, a gradual reversion to winter conditions takes place, with a virtual disappearance of low-temperature type yeasts.

The majority of the organisms found on the beef have their origin in the soil and, from month to month, it has been found that there is a reasonably good correlation between the nature and relative percentages of the organisms infecting the beef and the nature and relative percentages of the organisms in the soil surrounding the meatworks.

A still closer correlation in these respects exists between the organisms in the hides and hoofs of the animals and those found on the beef. The hides and hoofs form the main medium of transport of organisms from the soil to the meat.

Since, during the height of summer, temperatures of the order of 55°C. (131°F.) are often reached in the surface layers of undisturbed soil freely exposed to solar radiation, it appears probable that such high summer temperatures cause a mortality among certain active strains. It is possible, too, that heat resistant variants of particular strains may be the only survivors of such conditions. The decreased numbers and activity of organisms found to proliferate on beef stored in the summer months are, therefore, probably a result of high temperatures in the soil, and, again, the increased numbers and activity during the winter months are probably related to the fact that soil temperatures more closely approximate the optimum temperature for the growth of these organisms.

Investigations, in many meatworks, on the immediate origin of the initial microbial contamination of the beef have indicated that by far the most abundant sources are the hides and hoofs of the animals. Unless appropriate precautions are adopted, large numbers of micro-organisms are transferred from such sources to the carcasses by direct contact during dressing or by way of the slaughtermen's hands, arms, knives and clothes. The importance of subsidiary sources varies greatly from works to works, but the water, washing brushes, wiping cloths and the air of the slaughter floor are the more usual. Contamination acquired subsequent to dressing of the beef may arise from the sawdust and brine often used in the chilling chambers and from the knives and saws used in the cutting of the sides into hindquarters and crops.

Having located the main sources of infection, it was possible to suggest alterations and additions to equipment and procedure in the works in order to secure reduced microbial contamination of the beef. In one works, the old and the modified techniques were studied over a period of several weeks, and the average value of large numbers of counts of organisms both from the exposed muscle (lean) and from the fat showed that the use of the new methods (including the use of additional equipment) resulted in the reduction of the contamination to approximately one-seventh of its former average. The added margin of safety for the storage of chilled beef is, therefore, considerable.

(iii) *Chilling* (*Pre-cooling*).—This phase of treatment in the meatworks, wherein the temperature of the beef is reduced to approximately that obtaining during transport, has been found to have an important bearing on the duration of storage possible without the onset of deterioration due to microbial attack. If the rate of cooling is such that the average surface temperature of a standard side of beef weighing 350 lb., measured at four standard points $\frac{1}{4}$ inch below the surface, falls to 10° C. (50° F.) in less than 11 hours from slaughter, and if a relatively dry surface on the meat is produced, then no appreciable increase in the numbers of low-temperature type micro-organisms occurs during the normal duration of chilling (72 hours); in fact, there is usually a slight decrease in beef prepared during the summer months. Extremely rapid chilling during the early stages is, therefore, essential to subsequent safe storage. If these stringent conditions are not adhered to, and if strict cleanliness is not maintained in the rooms, the maximum period of storage of the beef, without deterioration, may be reduced by as much as ten to fourteen days.

(iv) *Storage.*—In the last Annual Report, it was stated that even when the extent of the initial infection by micro-organisms was extremely low, the use of the method of "air conditioning" alone in the storage of chilled beef did not permit of a sufficient margin of safety for its export from Queensland, the chief beef-producing State, unless the extent of superficial desiccation exceeded the safe limit for the preservation of the bloom of the meat. It was indicated, too, that the use of 10 per cent. of carbon dioxide in the storage atmosphere appeared to secure the necessary margin of safety. Investigations have since shown (*see* Council's quarterly *Journal*, Vol. 6, No. 4, pages 233 to 243), that the extent to which small concentrations of carbon dioxide, of the order of 10 per cent. in the storage environment restrict the rate of growth of *Achromobacter* determined the length of storage possible without appreciable deterioration occurring in the beef, and this period was approximately 40 per cent. greater than that possible under similar conditions of storage in air. The degree of retardation of the growth of different moulds has not been accurately determined, but it is probable that the rate of growth of *Sporotrichum carnis* in 10 per cent. carbon dioxide is 70 per cent. (approximately) of that in air, while those of *Penicillium* spp. and *Mucor mucedo* are 50 per cent. (approximately). Except for a small number of minute colonies of *Sporotrichum*, fungal attack on chilled beef stored in the experimental rooms was never apparent until deterioration from other causes, such as the presence of bacterial slime, had become well advanced. The results indicate too that beef in the chilled condition obtained from meatworks in which *Achromobacter* constitutes the main type

of initial infection, may safely be held, at a temperature of —1.3 degrees C. (29.7 degrees F.) in 10 per cent. carbon dioxide, for a period of 53 to 57 days (calculated from the time of slaughter) provided that strict hygienic conditions are maintained during slaughter, dressing and chilling, in order to ensure an extremely low bacterial infection. The maximum permissible numbers of slime-producing bacteria and yeasts per square centimetre, found immediately after slaughter, cannot yet be stated accurately since the value may be permitted to vary from season to season according to the activity of the organisms.

For beef closely stowed, as is the case in ships' holds, the use of forced air circulation in conjunction with the use of carbon dioxide during storage, for the period stated above, would seem to be essential in order to prevent the onset of microbial deterioration. Insufficient evidence from experiments is, as yet, available to indicate precisely the desirable amounts of air circulation for different relative humidities obtaining during storage.

A considerable amount of work, too, has been carried out to compare the effects on the beef of different concentrations of carbon dioxide, maintained continuously. Apart from the fact that concentrations of the order of 6 per cent. are not so effective as are concentrations of 10 to 12 per cent. in suppressing microbial growth, insufficient work has been carried out to enable detailed conclusions to be presented.

(v) *Experimental Shipments.*—Six shipments of chilled beef from three works, in which alterations were made to conform with the recommendations of the investigators, have been studied in detail, the most complete data being obtained in the case of the shipment per M.V. *Idomeneus* on which the Section's engineer travelled in order to collect complete data regarding the physical conditions obtaining in the chamber containing the consignment of 45 tons of beef. On three consignments, of which details of the out-turn in England are available, the initial microbial contamination was considerably lower than the probable maximum permissible and, after arrival in England, no visible microbial growth could be detected. There is some evidence from these shipments that the limit on the duration of the transport from Australia to England may be set by the tendency to loss of bloom rather than by the onset of deterioration due to microbial attack. In other words, the maximum period of holding in the chilled condition before the onset of appreciable loss of bloom may be somewhat lower than the period elapsing before the onset of microbial deterioration in beef having an initial microbial infection equal to, or lower than, that probably permissible. A more detailed study of the factors causing loss of bloom in commercial shipments is, therefore, being made.

3. *Handling, Transport and Ripening of Bananas*—(i) *Ripening.*—(*a*) *Time of removal of fruit from the ripening rooms.*—Systematic tests have been carried out throughout the year, in which samples have been moved at various stages of ripeness to different weather conditions, artificially created when necessary.

The results reported in Council for Scientific and Industrial Research Bulletin, No. 64, have been confirmed, but it is evident that in spring and autumn and in mild summer and winter weather, fruit may generally be safely removed earlier than recommended in Bulletin No. 64.

Previous work indicated that our winter-grown fruit is more affected by high temperatures and less affected by low temperatures than our summer-grown fruit. This has been well demonstrated in the present series of tests.

(*b*) *Finger Dropping.*—Considerable difficulty has sometimes been experienced in the commercial handling of bananas on the bunch, because of the tendency of the individual fruits, or fingers, to fall from the bunch when they are fully ripe, tearing the peel of the fruit. Tests have been carried out with the object of discovering means of overcoming this trouble, and the following conclusions have been reached:—

The tendency to finger dropping is much less in bunches removed from the ripening rooms at the stage of the colour show or slightly later, than it is in bunches allowed to remain in the rooms at 75 to 80 per cent. humidity until they are fully coloured. It is probable that bunches could generally be handled quite satisfactorily using the standard ripening conditions set out in Bulletin No. 64, if they were always removed from the rooms not later than the half colour stage.

Storage of the bunches, before ripening, for periods up to four days at 55–60 degrees F., with a good air circulation over them, decreases the tendency to finger dropping very greatly, and the effect increases with increasing time of storage and, to a lesser extent, with decreasing temperature. Storage at temperatures above 60 degrees F. is of some value, but for commercial applications it is recommended that a temperature of 60 degrees F. be employed, when preliminary storage is found necessary.

The tendency to finger dropping was increased by removing some hands from the bunches, but this effect appeared to be due to the reduced mechanical support to the bananas.

No difficulties were encountered in ripening loose hands of bananas under standard conditions.

(c) *Chilling.*—Further observations have confirmed the view that the dull colour of winter fruit is due to plantation conditions, and not to transport conditions, as has been commonly supposed.

(ii) *Transport.*—During the summer of 1933–34, the investigations of the effects on the bananas of the prevailing conditions of handling and railway transport have been continued. Three methods of attack have been employed, viz. :—

(a) Studies of the methods of handling and temperature attained by the fruit on the plantation and during transport to the railhead.

(b) Determinations of the rates and directions of air ow and of temperature conditions in louvred trucks filled with cases of bananas.

(c) Examination of marked cases of bananas in Queensland or New South Wales and again in Melbourne in order to determine whether fruit delivered in good condition to the railways always arrives in good condition in Melbourne.

Comparisons of the physical conditions obtaining in open and closed stacks of fruit in the trucks have also been made.

These investigations have been completed and the data obtained are being prepared for publication.

The air circulation through the loads of cases on a moving train was found, in general, to be adequate in the great majority of the vans employed. The speeds are generally of the order of one to four feet per second, and occasionally lower speeds in small pockets, but the existence of such spaces is unimportant since only small portions of each case around them are affected. The general movement in the body of the load is downwards, with a fast stream of air out of the sides of the van at the bottom.

Many series of measurements of the temperatures of the air and the fruit throughout the vans showed that the temperatures of the fruit generally fell gradually throughout the journey to Melbourne, but in one or two well-defined regions of the stack the fruit temperatures tend to follow the external air temperatures more closely than the bulk of the load, but no evidence of damage therefrom to the fruit, when examined at Albury, has been found. These observations on the temperature conditions confirm those reported by Holloway and Barr (Council for Scientific and Industrial Research Bulletin No. 64).

In one type of van used to transport a small percentage of the fruit, the air circulation was less satisfactory than in the main type of van usually employed. During the early part of the journey, too, the rate of cooling of the fruit was slower. It is understood that, in view of these data, such vans may not in future be employed in their present form during the summer months.

When the cases were stacked seven high in the trucks, the air circulation was appreciably reduced, and it is understood that, as the result of such observations, the cases will, in future, be stacked only six high during the summer months.

Observations on open and closed stacks of cases in the trucks have indicated that there are no appreciable advantages to be gained in the way of better air circulation and faster reduction of temperature of the fruit by using the open method. There is also a greater risk of damage to the cases and fruit by using this type of stacking. As the result of these tests, the use of the open stack from Clapham (Queensland) was abandoned during the past summer.

Examinations of the fruit at loading and discharge stations have shown that, during the summer months, a large percentage of the wastage due to either normal or abnormal ripening during transport was caused by the fruit being loaded in a ripening condition, but, nevertheless, a considerable proportion of the fruit arriving in bad condition was not obviously ripening when loaded. Of the latter fruit, some was allowed to become unduly hot before loading, and some was soft-natured fruit which had become very mature, but which had been well treated between the times of cutting and loading. Some soft-natured fruit not obviously beginning to ripen often arrived in mixed-ripe condition in Melbourne. High atmospheric temperatures at the loading station are much more likely to be the cause of wastage than high temperatures during the period of railway transport.

Since most of the wastage occurring may be caused by faulty treatment prior to delivery to the railway, notes have been prepared for publication in growers' trade journals indicating the precautions to be adopted during the handling of fruit in the summer months.

(iii) "*Squirter*".—The spores of the pathogen causing squirter are present on the fruit in the plantations and infection of the cut stalks no doubt occurs in the packing sheds or in the early stages of transport.

Better conditions close to the packing shed, obtained by cleaning up dump, &c., seem on the average to reduce the incidence of squirter; but nevertheless, in some cases, after very adequate measures had been adopted to ensure cleanliness in the vicinity of the shed, bad squirter was reported in bananas from such sheds, indicating that in these instances the pathogen was brought in from the plantation on the bananas.

Further evidence was obtained to confirm the view that low temperatures favour the development of squirter. It is uncertain whether the low temperature is a factor operating on the fungus increasing its sporing capacity and so increasing squirter by increasing the chance of infection, or whether it is a factor affecting the fruit itself, rendering the fruit more prone to attack. From inoculation experiments with spores, it seems that some change is brought about actually in the banana itself by the lower temperature. An attempt was made at the end of the summer to gain some data relevant to this point. No definite conclusions can be drawn from the number of observations which were possible in the time at disposal, but results indicated that spores of the fungus were still present and viable during February, 1934, in the Tweed area. Spores were obtained in the plantation generally and also from individual banana leaves.

A similar experiment at Nerang and Landsborough gave negative results—no viable spores appeared on exposed plates in these districts during the same period. Both experiments were conducted under comparable climatic conditions.

If fruit is packed in hands or half-hands, the incidence of squirter in susceptible fruit is very greatly reduced. The length of stem left on the bananas appears to have an effect on the incidence of squirter, the disease being more likely to develop if the stems are very short than if they are long.

As squirter is due to infection with a definite organism, its control may be practicable by the use of a suitable fungicide. The value of various fungicides, and especially of formalin, for this purpose, is being investigated by Mr. J. Simmonds of the Queensland Department of Agriculture and Stock.

(iv) *Black-end.*—This condition causes much wastage in ripe bananas, in Melbourne and Sydney. While the mould *Gloeosporium musarum* is the more usual causal organism, *Nigrospora musae* and the causal organism of squirter and several species of *Fusarium* appear also to be pathogens during the winter months. The temperature relations of these organisms have been studied, and it would seem probable that, in the winter, when the temperatures during transport and after ripening are low, most of the black-end of bananas is caused by *Nigrospora musae* and *Fusarium*; in the summer months, when the temperature before ripening (during the long journey to Melbourne) and after ripening is high, in the vicinity of that for maximum growth of *Gloeosporium musarum*, the majority of the wastage is caused by this fungus, and some of it by the organism provisionally called *Fusarium A*. Inoculation experiments have proved the pathogenicity of these organisms. It is almost certain that the infection takes place in the field, the spores being carried in the fruit.

Further studies of black-end and its causal organisms are now being made in Melbourne and studies of preventive measures are being carried out in Queensland.

(v) *Packing.*—Tests have been carried out to determine the effects of different sizes of bulge in banana cases on the damage to the fruit during handling and transport. The experimental methods were similar to those employed in apple case work by Carne and Turnbull (Council of Scientific and Industrial Research Pamphlet No. 45). While the data obtained are rather incomplete, it would seem that the use of bulges greater than $1\frac{1}{2}$ inches is likely to lead to increased bruising. The variations in bruising due to differences in the size of the bulge, within the range $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches, are small.

4. *Storage and Transport of Non-tropical Fruits.*—These investigations have been continued at the laboratories shared by the Council and the Victorian Department of Agriculture at the Victorian Government Cool Stores, and also at the Biochemistry Department, University of Melbourne. Some experiments on Valencia Late oranges have been undertaken directly by the Council's Citrus Preservation Committee, but part of its programme was again deputed to be carried out under the direction of the Advisory Committee on Fruit Cool Storage Investigations. A brine circulation system with overhead coils has been substituted for the direct expansion system in the experimental storage rooms, and has proved a much more efficient method for temperature control.

(i) *Storage and Ripening of Williams' Pears.*—The influence of size and maturity at time of picking, locality and temperature on the subsequent storage life of Williams' pears has been studied. For this purpose fruit of three sizes, viz., $2\frac{1}{4}$ inches, $2\frac{1}{2}$ inches, $2\frac{3}{4}$ inches, was selected from Doncaster and Shepparton at three different picking times, and stored at 30

degrees, 32 degrees, 34 degrees and 36 degrees F. Samples were removed at weekly intervals from these temperatures to 65 degrees F., the optimum ripening temperature to this variety of fruit. The resistance of the fruit to penetration during storage and during ripening was recorded and the colour changes, which invariably take place during storage and ripening, were noted. The daily output of carbon dioxide and the sugar, acid and starch content of the fruit were also determined, and physical changes associated with ripening were noted. The results of the investigations are being prepared for publication.

As a result of last year's work it was felt that, whilst several factors still required close observation, the information which had been obtained would be of interest and value to growers and shippers of pears. A paper was published in the *Journal of the Department of Agriculture of Victoria*, just prior to the export season, setting out briefly the factors to be observed in the picking, handling, transport and ripening of pears, chiefly the Williams' variety, in order to ensure successful overseas transport of this variety of fruit. Close co-operation between the investigators, officers of the Department of Agriculture, and those intimately connected with overseas transport of pears, resulted in the arrival of Williams' pears in England in excellent condition.

(ii) *Experimental Consignments of Pears Overseas.*—Through the courtesy of the shipping companies, two experimental consignments of fruit were despatched to London and examined on arrival by investigators of the Low Temperature Research Station, Cambridge. The report is not yet to hand. The lengths of storage life at 32 degrees F. of several other varieties of pears are also being determined.

(iii) *Experiments with Jonathan Apples.*—(*a*) *Sampling Methods.*—Following on last year's experiments, when an attempt was made to determine a true sample of a tree's crop which would form the basis for all future apple storage experiments, a more comprehensive study was made this year, using 200 cases of apples from Doncaster, one case of similar size and maturity from each of 200 comparable trees. The time to reach a certain percentage of breakdown was recorded, and the results were examined statistically by Mr. A. G. Strickland of the Victorian Department of Agriculture. The results have enabled an estimate to be made of the inherent variability in keeping quality to be expected among a number of presumably identical cases of fruit picked from different trees. On the basis of the variability found, a technique of cool storage experimentation, that will enable statistical evaluation of results, is being evolved.

(*b*) *Effect of Spray Treatments.*—The effect of spray treatments with lead arsenate and oil during the course of the growing period of the fruit in the orchard, on its subsequent cool storage life, is being determined.

(*c*) *Effect of Maturity, Size and Locality on Storage Life.*—Apples of three maturities and three sizes were selected from trees used in previous experiments at Harcourt, Geelong, Somerville and Red Hill. The time to reach a certain percentage of breakdown was recorded, but as the results seem to be bound up intimately with seasonal conditions, replication over several seasons is highly desirable before any general conclusions can be drawn.

(*d*) *Jonathan Scald.*—Past observations have indicated that Jonathan scald, very prevalent in some seasons, is associated with the physiological condition of the fruit, maturity and some other inherent factor, temperature, humidity and ventilation. Experiments have been designed embracing all these factors, and the results have indicated that the physiological condition of the fruit and temperature are controlling factors.

(iv) *Storage of Passion Fruit.*—Respiration and storage experiments were carried out at 36 degrees, 43 degrees and 50 degrees F. with fruit from Gosford, New South Wales. The results confirm the previous findings of the investigators, in that the life of the fruit is relatively short, viz., four to five weeks, and that low temperatures are detrimental to the fruit. Low temperature breakdown, in the form of a blood-red discolouration of the skin quickly followed by mould attack, occurred at temperatures below 50 degrees F. Such a high storage temperature as 50 degrees F. cannot be regarded as cool storage.

(v) *Storage of Peaches and Plums.*—Experiments were designed to study the influence of maturity at time of picking on the subsequent storage life of the fruit at 32 degrees F. Both plums and peaches are usually allowed to ripen on the tree, but this year's experiments have proved that the fruit can be picked when hard and firm, and ripened at 65 degrees with excellent flavour. There is, however, a critical stage at which the fruit must be picked, for fruit picked too early will ripen at 65 degrees with full juice, but is rendered inedible by laxative properties characteristic of immature fruit. At present there is no physical or chemical means of determining maturity, but pickings at daily intervals will be made next year in the hope of determining the correct picking time.

Considerable progress has been made in the storage of plums. Excellent flavour has been developed in the Grand Duke and President, usually worthless as dessert varieties, by picking the fruit slightly immature and ripening at 65 degrees F. The maximum length of time for which these varieties could be stored at 32 degrees F. and then ripened normally on removal to 65 degrees F. was approximately eight weeks.

The investigators realize that there is a ready market for plums and peaches in London, and are concentrating on the storage and transport of these soft fruits.

(vi) *Experiments on Oranges*—(*a*) *Maturity at Time of Picking.*—Experiments on the effects of maturity at time of picking and locality on storage life have been carried out for the Citrus Preservation Committee. The daily carbon dioxide output at 40 degrees F. was measured during the whole time of storage. Two districts were chosen in Victoria, Merbein and Lockington, which differ very widely in the time at which the fruit is usually picked, this picking being made when the juice reaches the standard acidity as measured by titration. The normal picking time at Merbein is considered to be the beginning of July, whilst that at Lockington is two months later, for although the fruit in the two districts colours at the time, the fruit at Lockington is allowed to remain on the tree until it conforms to the maturity standard.

Three pickings of fruit were made from each district, the first a month before, the second at the normal time of picking, and the third a month later. The fruit was stored at 40 degrees F. and examined at weekly intervals. The daily output of carbon dioxide at 40 degrees F. was measured over the whole period of storage. In addition, determinations were made of the acid and sugar of the juice and peel, and examinations for mould and flavour were also made.

The chemical constituents, acid, sugar, &c., are of little or no value in the interpretation of the results, and the only clue lies in the records of the daily carbon dioxide output. After fruit is picked, it continues to take in oxygen and liberate carbon dioxide until it attains a maximum termed the climacteric. The rate of daily carbon dioxide output then decreases until the fruit ceases to liberate carbon dioxide and dies. After the climacteric, therefore, the fruit begins to enter its senescent stage, and gradually drifts towards the end of its storage life. The measurement of carbon dioxide gives a true measure of the fruit's activity and of its maturity.

It was observed that the first picking of Merbein fruit took 60 days to reach its climacteric, the second 30 days, and the third had just reached its climacteric at the time of picking. The time to reach 10 per cent. mould in each pick was approximately 70 days after the climacteric.

With the Lockington oranges, on the other hand, the climacteric had been reached at the first picking, so that this fruit was exactly in the same stage as the third lot of Merbein fruit picked approximately at the same time, and its storage life as measured by the mould wastage was substantially the same. In the late Lockington picks the fruit was past its climacteric and nearer to extinction and the storage life correspondingly shorter.

Other results of considerable interest and value were obtained from the experiments which are being continued over another season. It is at present premature to draw final conclusions from them. References to experiments conducted on similar lines by the Citricultural Research Station, Griffith, New South Wales, have already been made in the part of this Report relating to the work of that Station.

(*b*) *Ripening.*—Some experiments have been done on the ripening of early Navel oranges by holding them at various temperatures. Oranges of the first pick from Merbein, which were sour and green, developed a fairly good orange colour and sweet flavour if kept for three or four days at 65 degrees to 70 degrees F. This ripening treatment was best given after storage, since the oranges show a tendency to revert in cold storage. Temperatures above 75 degrees F. could only be used for short times, as flavour deteriorates at this temperature.

(*c*) *Valencias.*—An experiment was carried out by the Citrus Preservation Committee on the effect of spraying with paraffin. This confirmed the conclusion previously reached, namely, that oranges so treated develop much less skin-browning in cold storage.

(*d*) *Export of Oranges.*—The Citrus Preservation Committee was called into consultation over the export of oranges to the United Kingdom during 1933, and gave advice as to temperature of carriage, &c. Reports from the Food Investigation Board of Great Britain as to the condition of the fruit on arrival in England were obtained.

(vii) "*Gas Storage*" *of Peaches, Plums and Grapes.*—Experiments on peaches and plums were conducted in small refrigerated chambers in the Biochemical Department, University of Melbourne. Unfortunately a period of very high atmospheric temperatures made it impossible to keep these chambers lower than an average of 38 degrees F.

The peaches were Smith's Seedlings, and samples were kept in air, and in 5, 10 and 15 per cent. concentrations of carbon dioxide, these atmospheres being obtained by controlled ventilation in small metal containers. Peaches kept in air and in a 5 per cent. concentration of carbon dioxide ripened in three weeks. Those in a 10 per cent. atmosphere, however, failed to ripen in the same period, but rotted rapidly after removal from this atmosphere to ordinary temperatures. At 15 per cent. of carbon dioxide an unpleasant taste was developed.

The varieties of plums were Grand Duke and President, and they were stored in similar atmospheres and temperatures to the peaches. After five weeks, samples were removed to the laboratory, but none ripened satisfactorily. Those which had been stored in 10 and 15 per cent. of carbon dioxide ripened much more slowly.

The grapes had been stored for about a month in air at 30 degrees F. before the gas-storage experiment was started. During this period a considerable amount of mould had developed, but the mouldy grapes were removed as far as possible. Seven varieties were used, and the grapes were stored at the Government Cool Stores at 32 degrees F. in similar atmospheres to the peaches and plums.

After seven weeks in gas-storage, the flavour of all samples was unimpaired, but considerable mould wastage had developed. The average wastage developed for all varieties was, in air, 61 per cent.; in 5, 10 and 15 per cent. of carbon dioxide it was, 56, 50 and 41 per cent. respectively.

X. OTHER INVESTIGATIONS.

1. *Commonwealth Prickly Pear Board.*—A mild winter and spring, followed by an abnormally mild summer, provided ideal climatic conditions for *Cactoblastis cactorum*. In both generations, mortality in the pupal stage was considerably below normal. Hence, in most districts the rate of increase was unusually high.

The great increase in the *Cactoblastis* population is reflected in the altered conditions in many areas where regrowth of prickly pear had flourished with little check for two or three years. Much of this persistent secondary growth has been destroyed, and although regrowth occurs in greater or less degree in all districts, the infestation of *Cactoblastis* larvae is at present most satisfactory. The renewed attack on areas of vigorous regrowth in south-west Queensland and north-west New South Wales has been extended to relatively heavy infestations of seedling pear which had sprung up on improved pastoral lands. In fact, the capacity of the insect to attack scattered prickly pear on open country has been a pleasing feature of the year's progress.

The destruction has continued of the remaining areas of primary pear in Queensland, where the original infestation of *O. inermis* and *O. stricta* has been reduced to comparatively small patches of partially-injured resistant types of plants, or has been replaced by secondary growth, except at higher elevations in the Toowoomba district where yellow pear persists on the harder ridges. In north-west New South Wales, similar conditions prevail. There is, however, a rather extensive tract of resistant pear on the timbered hills of the Bingara-Inverell district; in this region *Cactoblastis* has caused good destruction at intervals, and its population has increased very definitely in the past year.

In the Hunter River district of New South Wales, *Cactoblastis* has continued to make steady progress toward the control of this large belt of resistant yellow pear.

Distribution of further supplies of *Cactoblastis* has been limited to small numbers released in special areas.

The reclamation, for pastoral and agricultural purposes, of former dense prickly pear land, made available by biological methods of destruction, has been further advanced in Queensland. The developmental work necessary to bring these lands into production can be observed in most districts. During the year, large areas were thrown open for settlement in the Wandoan-Taroom district; probably the largest and most compact tract of dense prickly pear reclaimed by the insect's activities.

The cochineal, *Dactylopius confusus*, introduced from the Argentine in 1933 for establishment on the tiger-pear, *O. aurantiaca*, has been liberated and is well-established at various points. Another cochineal, a strain of *Dactylopius indicus*, has recently been introduced from the Argentine for tiger-pear control.

Investigations in North America have been devoted to the insect enemies of tree-pear types, such as *O. tomentosa* and *O. streptacantha*, in Mexico. In South America, the Board's officers have continued to study cochineal and lepidopterous insects of potential importance in the control of *O. aurantiaca*.

The Board's staff in Australia has been engaged mainly on the work of breeding certain prickly pear insects and on the study of the progress of *Cactoblastis* in the field and of the many phases connected with its welfare.

2. *Radio Research Board.*—The work of this Board has been continued with the co-operation of the Postmaster-General's Department and of the Universities of Melbourne and of Sydney.

The work on fading and on reflection of radio waves from the ionosphere is centred in Sydney, much of the receiving equipment being located at Liverpool some 20 miles away from the experimental transmitter in the Electrical Engineering Department of the University of Sydney.

The technique of examining the lateral deviation, polarisation, and angles of incidence of downcoming waves has been improved. A marked degree of lateral deviation has been found at Liverpool, and the point of reflection at the Kennelly–Heaviside layer has been observed to sweep through distances of as much as 50 kilometers in a few seconds. The results of the experiments made between Sydney and Melbourne using the frequency change method of path measurement have now been analysed. It has been found that several waves are normally received in transmission between these cities. From the measurements, it has been possible to determine the average ionization density in the E. layer each night. A close correlation has been found between this quantity and the barometric pressure at ground level. This correlation has also been confirmed by the analysis of fading records taken at Seymour on the transmitter 3AR Melbourne. This result suggests a closer connexion between troposphere and the ionosphere than has previously been thought possible.

As part of the Board's general study of the ionosphere, some attention has been given to the new form of interference due to the high-powered transmitters such as the one in Luxembourg. With the assistance of Associate-Professor V. A. Bailey, it has been shown that the interference can be explained by the effect of the emitter on the collision frequency of the electrons in the ionosphere. The assistance of Professor Bailey has also been obtained in the problem of determining the dispersion and absorption curves for radio propagation in the ionosphere and of the influence of the earth's magnetic field. This work and other studies of a similar nature have been simplified by the method of conformal representation.

The Board's work on atmospherics is centred in Melbourne, but during the year, the two investigators concerned spent a considerable proportion of their time at a small station established at Toowoomba, Queensland. Observations were thus possible on a longer base line (Toowoomba–Canberra) than the former one (Laverton–Canberra). The results of the work are now being analysed, but up to date they have confirmed some previous conclusions with regard to the variation in the peak intensity of atmospherics, the belief that all atmospherics are due to lightning flashes, the seasonal, diurnal and geographical distribution of occurrences of atmospherics, the duration and composition of atmospherics, the degree of interference with broadcast reception, and the higher average activity of sources in the north as compared with those in the south.

During the year, an atmospherics recorder designed in the Natural Philosophy Department of the University of Melbourne has been under construction in Melbourne and is now nearing completion. This recorder will be installed at some convenient site chosen so as to give the best possible triangulation with the recorders already in operation.

3. *Mineragraphic Investigations.*—Of recent years the Australian gold and base metal mining industry has experienced a serious decline largely as a result of the exhaustion of many of the richer deposits of ore. The rehabilitation of the industry will involve, *inter alia*, the development of the lower grade but extensive deposits which are known to exist in various parts of the continent. This in its turn, will involve the utmost efficiency in treatment methods. In the past, a difficulty that has always hampered the development of the best method of ore treatment has been the lack of information regarding the precise mineral content of the deposits. Ordinary assays of a complex ore are not enough. What is of greater importance is a knowledge of the precise minerals in the ore, the size of their individual crystals, their association with each other, &c., because milling and ore dressing procedure are based primarily on the characteristics of the ore treated. A knowledge of the relation of the individual minerals to each other is also quite frequently of vital importance to the mining geologist, giving him information as to the genesis of the deposit, and thus leading to suggestions for the better development of the mine.

In the past, it has been practically impossible to obtain full information regarding mineral associations in a complex ore because many valuable minerals occur in particles of microscopic size which are opaque to light, and which cannot be identified by the ordinary and well known petrographic methods. The difficulty has now been largely overcome by the examination of polished surfaces with a reflecting microscope together with special methods of identification. These methods are used by the Council's investigator, Dr. F. L. Stillwell.

During the year Dr. Stillwell has completed the examination of the zinc lead ores of Rosebery, Tasmania, in which small quantities of gold are, for the most part, associated with disseminated particles of fahl ore.

The examination of an auriferous slate from Amherst, Victoria, disclosed that the gold occurs in minute flakes along the cleavage planes and that it is secondary and probably derived from the primary gold in small limonitic veins lying along the bedding planes of the slate.

The main source of the silver in the Silver King Lode, near Omeo, has been traced to the presence of the silver mineral, pyrargyrite.

An examination of a slime fraction of the flotation residues at Wiluna indicated, by comparison with the auriferous ore, that the gold content of the residues may be due in part to minute particles of gold which are embedded in the quartz gangue. The bulk of the gold passes into the flotation concentrates because it is embedded in arsenopyrite, but as small particles of arsenopyrite are to be found in the slime fraction, part of the gold losses may be associated with the unfloated arsenopyrite.

A microscopical examination has been made of samples of mine dust from Broken Hill. Attention has been directed to the mineralogical composition of mine dust by the view developed by recent work on silicotic lungs, that sericite and other fibrous minerals are more potent in inducing silicosis than silica. The Broken Hill mine dust has been found to contain some fibres of sericite and sillimanite, while rhodonite, which is an abundant gangue mineral in the Broken Hill lode, is capable of splitting into needle shaped particles when shattered by blasting.

Petrological examinations have also been made of the andesitic rocks at the bottom level of the Mount Coolon mine, and in the bore cores obtained in the search for an extension of the Mount Coolon ore body.

The investigations carried out by Dr. Stillwell have been facilitated by a contribution by a number of mining corporations through the Australasian Institute of Mining and Metallurgy. The University of Melbourne has also assisted by granting the investigator laboratory accommodation at the Geology School.

4. *Standards Association of Australia.*—The Standards Association of Australia, for which the Council is the means of liaison with the Commonwealth Government, received renewed and slightly increased support from the Commonwealth Government during the year 1933–34, and was thereby enabled to maintain current activities and to renew some of the work which had remained in abeyance during the period in which funds were more limited. Though the full extent of its operations has not yet been resumed and many new projects have necessarily been deferred, the work has been carried on so effectively that the number of specifications and codes published during 1933–34 exceeds that for the two preceding years combined. The system of collaboration between the standardization bodies of the Empire has also been developed to such an extent that there is continuously a considerable number of draft British specifications under review in Australia and vice versa. The appeals to the Association from industry for new work to be undertaken are greatly extending the scope of activities and are an indication of confidence in the effectiveness of the Association's work.

5. *Fuel Problems.*—During the year Mr. L. J. Rogers, the Commonwealth Fuel Adviser, who is attached to the staff of the Council, was occupied upon a number of fuel problems with which the Government was confronted. His services were made available to the Newnes Investigation Committee, which was conducting an investigation into the economics of shale oil production in the Newnes–Capertee area of New South Wales. One of the important matters associated with that investigation was the question as to whether the crude oil produced from Newnes shale could be cracked into motor spirit of a marketable quality. Inquiries were made of manufacturers of cracking plant for guarantees regarding the operation of their plants, but it was found that, in the absence of specific tests, such guarantees could not be furnished. Therefore, it was decided that Mr. Rogers should visit Great Britain, the Continent of Europe, and the United States of America, with a view to investigating cracking processes, arranging for cracking tests to be undertaken, and obtaining information generally on fuel production in these countries. He arranged for detailed tests to be undertaken in the United States and obtained a guarantee from a company in that country.

At the instance of the Commonwealth and New South Wales Governments, Mr. Rogers made a further visit to the United States of America, where he at present is, for the purpose of carrying out tests in order to ascertain the precise cost of refining crude oil from the New South Wales shale deposits. In addition, he will arrange to bring back 50 gallons of the refined product for road tests in Australia.

Mr. Rogers also carried out investigations into various retorting systems, and was a member of a Committee which investigated the economics of shale oil production in the Railton-Latrobe area of Tasmania; he also investigated the cannel coal deposits at Preolenna in Tasmania.

6. *Biometrical Work.*—The necessity for exact methods of planning in biological experiments so as to enable the results to be analysed with precision has become increasingly apparent during recent years. Previously one main line of differentiation between the biological and the physical sciences was that definite quantitative measurements could not be made in the former; the development of statistical methods has, however, now enabled biological experiments to be properly planned and the results to be analysed and classified mathematically.

Even with the most meticulous care and with every precaution against errors, it would hardly be possible to conduct two parallel biological experiments and to obtain exactly identical results. The degree of uniformity that could be expected would vary according to the type of the investigation and the conditions under which the experiments were conducted. There must be some knowledge of the expected variability before any critical comparison can be made between the results of a series of experiments.

In order, therefore, to provide for the proper planning and statistical analysis of its experimental work, the Council appointed Miss F. E. Allan, M.A., in 1930, as Biometrician. She is attached to the staff of the Division of Plant Industry, but carries out work for several Divisions of the Council concerned with biological investigations. During the year 1933–34, visits were made by her to the Laboratories of the Divisions of Animal Nutrition, Animal Health and Forest Products, and the Waite Agricultural Research Institute. Advice was given to a number of officers of these Divisions on the methods of planning experiments and of handling the statistical analyses of the results. Addresses were given to officers on statistical methods of experimentation.

At the Waite Agricultural Research Institute, assistance was rendered in a variety of problems including the counting of lesions due to virus diseases in tobacco and tomato plants, the analysis of data obtained from field experiments and methods of planning permanent fertilizer trials. For the Division of Forest Products, an analysis was made of data from experiments on the strength of different types of packing cases and on the absorption of various solutions by different woods. Counts made at the Division of Animal Nutrition of the number of fibres of different diameters in the wool of particular sheep give skew frequency curves of the same general shape. An examination has been made of these curves in order to determine what changes in wool fibre are brought about by different methods of treating the sheep. An analysis of the results of the experiments on the feeding of sulphur to sheep has also been conducted.

In the Division of Plant Industry a number of officers are engaged on experiments which present statistical and mathematical problems, and Miss Allan has devoted a considerable amount of her time to these problems. Assistance has also been rendered by her in connexion with problems which are being investigated by the Division of Economic Entomology, and by research workers in various parts of the Commonwealth who have applied for assistance.

XI.—MISCELLANEOUS.

1. *Publications of the Council.*—The following publications were issued by the Council during the year:—

(i) *Bulletins*—

No. 75.—*Nigrospora Musae* n. sp. and its Connexion with "Squirter" Disease in Bananas; by Associate-Professor E. I. McLennan, D.Sc., and Shirley Hoette, M.Sc.

No. 76.—A Soil Survey of the Hundreds of Laffer and Willalooka, South Australia. Report of the Division of Soils; edited by J. K. Taylor, B.A., M.Sc.

No. 77.—Studies on the Phosphorus Requirements of Sheep 1. The Effect on Young Merino Sheep of a Diet Deficient in Phosphorus but Containing Digestible Proteins and Vitamins; by Sir Charles J. Martin, M.D., D.Sc., F.R.S., and A. W. Peirce, B.Sc.

No. 78.—Methods for the Identification of the Light-coloured Woods of the Genus *Eucalyptus*; H. E. Dadswell, M.Sc., Maisie Burnell, B.Sc., and Audrey M. Eckersley, M.Sc.

No. 79.—The "Lucerne Flea" *Smynthurus viridis L.* (Collembola) in Australia; by J. Davidson, D.Sc.

No. 80.—The Establishment, Persistency and Productivity of Selected Pasture Species on an Irrigated Reclaimed Swamp; by H. C. Trumble, M.Agr.Sc., and J. Griffiths Davies, B.Sc., Ph.D.

(ii) *Pamphlets*—

No. 41.—The Grading of Western Australian Timbers. Report on, and Suggested Specifications for, the Grading of Jarrah and Karri based on Investigations in 1932 ; by F. Gregson, B.E., and R. F. Turnbull, B.E.

No. 42.—Meteorological Data for Certain Australian Localities. Prepared in Collaboration with the Commonwealth Meteorological Bureau.

No. 43.—Investigations on the Buffalo Fly *Lyperosia exigua* de Meij.

I. The Host Preference of *L. exigua* (*resume*) ; by Dr. B. J. Krijgsman and G. L. Windred, B.Sc.Ag.

II. The Relation between the Adult *L. exigua* and Mammalian Faeces ; by Dr. B. J. Krijgsman and G. L. Windred, B.Sc.Ag.

III.—Some Food Reactions of the Larvae of *L. exigua* ; by G. L. L. Windred, B.Sc.Ag.

IV.—The Influence of Moisture on the Larvae of *L. exigua* ; by G. L. Windred, B.Sc.Ag.

No. 44.—The Chemistry of Australian Timbers. Part 3—The Chemical Composition of Four Pale-coloured Woods of the Genus *Eucalyptus* : *E. gigantea*, *E. obliqua*, *E. regnans*, *E. sieberiana* ; by W. E. Cohen, B.Sc., A. G. Charles and A. B. Jamieson, M.Sc.

No. 45.—Australian Export Apple Cases ; by W. M. Carne and R. F. Turnbull, B.E.

No. 46.—The Holding Power of Special Nails ; by Ian Langlands, B.E.E.

No. 47.—Properties of Australian Timbers. Part 1—Eight Timbers of the Genus *Eucalyptus* (Ash Group) ; collated and edited by H. E. Dadswell, M.Sc.

(iii) *Quarterly Journal*—

Vol. 6, No. 3, August, 1933.
Vol. 6, No. 4, November, 1933.
Vol. 7, No. 1, February, 1934.
Vol. 7, No. 2, May, 1934.

(iv) *Annual Report for the year ending* 30*th June*, 1933.

The confidential Monthly Summary is being issued as previously to members of the Council and of its State Committees as well as to members of the staff and students who are working in isolated positions or who have been sent overseas. The summary is also issued to certain research organizations in other parts of the Empire. In this last-mentioned direction it thus serves as one means of keeping these organizations acquainted with the various investigations, and to that extent plays its part in the general movement for the closer co-ordination of research work throughout the Empire as a whole.

2. *Catalogue of Scientific Periodicals.*—The 1928–1934 Supplement was published in April. Though every effort was made at the time of the publication of the original Catalogue to make it complete, it was impossible in a pioneer work of this nature to achieve this aim. The lack of cataloguing facilities in various libraries caused, as was anticipated, the omission of many entries which should have been included. The Catalogue, however, not only served its main purpose by indicating where periodicals were to be found, but acted as a checking list of the holdings of those libraries which had omitted, either through the cause mentioned, or through an uncertainty as to the exact scope of the work, an undue proportion of their entries, and these entries have been made available for inclusion in the Supplement. It cannot, therefore, be assumed that the 6,962 new entries in the Supplement have been added during the intervening period. But the Supplement and original Catalogue, when used together, can be taken as giving a fairly complete account of the holdings of the libraries which are included in them. Unfortunately, several libraries were not able to co-operate in the revision of their entries, but is encouraging to be able to report that six new libraries have been added since the publication of the original volume. The editorial work of the Supplement was under the direction of Mr. E. R. Pitt, Chief Librarian of the Melbourne Public Library, and was successfully carried through by Mr. C. A. McCullum, B.A., Senior Assistant of that Library, and Mr. D. W. I. Cannam, also from the same staff.

3. *Library.*—The additions to the shelves of the Council's head office library during the year 1933–34 amounted to 244, of which 97 consisted of bound volumes of periodicals. The number of bulletins, pamphlets, &c. coming to hand is again slightly lower than last year, averaging

573 per month. The number of periodicals to which the Council subscribes has not been decreased and the decrease in total number of publications is again due to a smaller number of bulletins and pamphlets being received as exchanges. Improved storage facilities which were provided during the year have been appreciated, and have made it possible to catalogue and put in the correct files an amount of material which had previously been inaccessible. The libraries of the several Divisions are steadily increasing in size and usefulness.

The Library continues to be used extensively not merely by members of the Council's staff, but also by many other workers in the field of applied science and technology as a source of information regarding scientific and technical matters.

4. *Bureau of Information.*—As in previous years, inquiries for information on a diversity of subjects have been received by the Bureau of Information. Numbers of these inquiries concern problems which are actually under investigation by the Council's various Divisions and Sections. In such cases full information can readily be given. Many of the inquiries, however, are not directly covered by the Council's investigations and these have been dealt with either personally or by letter, as fully as possible, using the resources of all the Council's libraries, and, where necessary, obtaining the required information from outside sources. The more important subjects under this category and concerning which answers have been furnished during the year under review are as follow :—

(i) *Agricultural and Horticultural.*—Stock foods—peanuts and coco-nuts, dairy bacteriology, weeds—chemical control, botulism, taro root, *Fasciola hepatica* in cattle, narcissus culture, cotton cultivation, red scale on citrus, tung oil—New Zealand experiments, medicinal plants and herbs, pyrethrum, mint weed, wattle bark, arrowroot, rabbits, bananas, maize by-products, superphosphate and the Australian wheat crop, seaweed as fertilizer, soya bean, esparto, blackberry control.

(ii) *Food Preservation.*—Gas storage of fruit, canning problems, wines, concentrated fruit juice, lemon oil, crystallized fruit, canned apples, turtle meat, industrial refrigerating plant.

(iii) *Industrial Minerals, Chemicals, &c.*—Emulsification of paraffin wax, synthetic resin, brown coal, sulphonated oils, dicalcic phosphates, ethyl formate as insecticide, lime sulphur sprays, hydrogenation of brown coal, alunite, anhydrous ammonia, manganese arsenate as insecticide, fluorspar, sulphate of ammonia, pectin, dextrin, pepsin, magnesite, gluten, rotenone, glucose, salt.

(iv) *Manufactures.*—Ivory soap, soap drying, adhesives, sheep dip, margarine, potato starch, lemon oil, block condensed milk, glue and gelatin, bakelite, plasticine, pottery glazes, pins, sulphur, artificial marble, potato flour, sand blasting, citrus by-products, plaster of Paris, dyeing and bleaching of woollen goods, separation of oil from water, rubber solvents, power alcohol, wire-netting, colouring of benzine, water-proofing, cellophane, bitumen pipes, oilskin coats, fly spray.

(v) *Miscellaneous.*—Semolina—definition, shellac as binder in abrasives, eye protection in welding, Woods metal, eradication of household pests, soot, producer gas vehicles, wind power, mussels, fuels—calorific power, sponges, basement drainage, eucalyptus oil, butter fat, preservation of cinematograph films, toxicity of zinc, pipes, sericulture, liquid smoke, kelp ash, cement manufacture, gas jets, rat poisoning.

XII. FINANCIAL MATTERS AND STAFF.

1. *Finance.*—The statement of expenditure from 1st July, 1933, to 30th June, 1934, is as follows :—

	£	£	£
1. Salaries and contingencies	..	..	*13,557
2. Remuneration of Chairman and Members of Council	..	.	†1,980
3. Investigations—			
(i) Animal Problems—			
(a) Black disease, walkabout disease, foot-rot, entero-toxaemia, and preputial disease	1,496		
Less contributions from the Australian Pastoral Research Trust and the Empire Marketing Board, England	588		
		908	

* The main items of expenditure under this heading are salaries of the Administrative Staff at the Council's Head Office; staff and upkeep of State Committees; part salary of representative at Australia House; travelling expenses of head office staff, members of the Council, &c., and printing and general office expenditure.

† Provided from Consolidated Revenue Fund.

	£	£	£
(*b*) Parasitology	4,366		
Less contributions from the Australian Pastoral Research Trust and the Empire Marketing Board	1,181		
		3,185	
(*c*) Caseous lymphadenitis (New South Wales)	1,396		
Less contributions from the Australian Pastoral Research Trust and the Empire Marketing Board, England	119		
		1,277	
(*d*) Bovine haematuria and caseous lymphadenitis (South Australia) ..	..	712	
(*e*) Tick and tick fevers, pleuro-pneumonia, &c.	6,959		
Less contributions from Queensland Government, Council of Agriculture, Brisbane, and the Empire Marketing Board, England..	6,959		
		..	
(*f*) Entero-toxaemia (Braxy-like disease), Moora (Gingin) disease, &c. (Western Australia)	..	278	
(*g*) Parasitology and caseous lymphadenitis (at Noondoo, Queensland) ..	48		
Less contributions from the Australian Pastoral Company ..	48		
		..	
(*h*) Peg leg disease (Queensland) ..	683		
Less contributions from Empire Marketing Board and certain graziers of Charters Towers District	415		
		268	
(*i*) Zebu cattle project	2,254		
Less contributions from Messrs. Winter-Irving and Alison, Queensland Stations Ltd., Messrs. Meredith Menzies & Co. Pty. Ltd. and C. W. Wright, Esq.	1,614		
		640	
(*j*) Central office salaries, &c.	..	1,982	
		9,250	
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..	..	1,500	
			7,750
(ii) Plant Problems—Division of Plant Industry—			
(*a*) Central Laboratory—			
Annual	4,360		
Capital	134		
		4,494	
(*b*) Experimental plots	..	474	
(*c*) Plant pathology	2,199		
Less contributions from Empire Marketing Board, England ..	400		
		1,799	

	£	£	£
(*d*) Plant genetics	3,208		
Less contributions from Empire Marketing Board, England ..	915		
		2,293	
(*e*) Plant Introduction	..	1,298	
(*f*) Agrostology	1,038		
Less contributions from Empire Marketing Board, England ..	753		
		285	
(*g*) Plant physiology	567		
Less contributions from Empire Marketing Board, England ..	419		
		148	
(*h*) Noxious plants	..	386	
(*i*) Fruit problems	1,169		
Less contributions from Empire Marketing Board, England ..	377		
		792	
(*j*) Experimental Farm, Duntroon ..	..	684	
(*k*) Tomato wilt	..	309	
(*l*) Plant Introduction Garden, Gatton, Queensland	..	53	
(*m*) General botany	..	459	
(*n*) Apple root stocks, Stanthorpe, Queensland	268		
Less contributions from Committee of Direction of Fruit Marketing, Brisbane, Queensland	214		
		54	
(*o*) Tobacco Investigations	617		
Less contributions from Tobacco Trust Fund	617		
		..	
			13,528
(iii) Entomological Problems — Division of Economic Entomology—			
(*a*) Central laboratory	..	4,876	
(*b*) Noxious weeds	..	1,887	
(*c*) Blow-fly and buffalo-fly	..	3,519	
(*d*) Orchard and fruit pests	..	289	
(*e*) Forest insects	..	1,719	
		12,290	
Less contributions from Empire Marketing Board, England, Australian Pastoral Research Trust and Sir MacPherson Robertson	..	2,510	
			9,780
(iv) Animal Nutrition—Division of Animal Nutrition—			
(*a*) Central laboratory	5,080		
(*b*) Waite Institute	1,510		
(*c*) Field Station, Young, New South Wales	178		
	6,768		
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	3,000		
		3,768	

	£	£	£
(*d*) Field Station, Springsure, Queensland	40		
Less contributions from the Australian Pastoral Research Trust and the Empire Marketing Board, England..	40	..	
(*e*) Field Station, Kangaroo Island, South Australia	428		
Less contributions from the Australian Pastoral Research Trust and the Empire Marketing Board, England	428		
(*f*) Drought feeding experiments at Waite Agricultural Research Institute, Glen Osmond, South Australia	1,029	..	
Less contributions from the Australian Pastoral Research Trust, the Empire Marketing Board, and the Commonwealth Bank (Rural Credits Development Fund)	1,029	..	
(*g*) Agrostological Investigations at Waite Agricultural Research Institute, Glen Osmond, South Australia	445		
Less contribution from the Empire Marketing Board, England	334		
		111	
(*h*) Survey of Coast Disease	156		
Less contribution from Department of Agriculture, South Australia	151		
		5	
At Waite Institute in co-operation with Empire Marketing Board and Adelaide University—Mineral deficiencies in pastures	..	686	
			4,570
(*v*) Horticultural Problems of the Irrigation Settlements—			
Citricultural—			
(*a*) Research Station, Griffith—			
Salaries and incidentals ..	3,310		
Capital	151		
	3,461		
Less funds provided from Station Revenue ..	481		
	2,980		
Less contributions by New South Wales Water Conservation and Irrigation Commission	1,200		
		1,780	

	£	£	£
Viticultural—			
(*b*) Research Station, Merbein—			
Salaries and incidentals ..	4,257		
Capital	673		
	4,930		
Less contributions by Dried Fruits Control Board and Woorinen Dried Fruits Inquiry Committee	1,775		
		3,155*	
(*c*) Ripening, Processing, &c., of vine fruits, Mildura District ..	231		
Less contributions by Irymple Packing Pty. Ltd., Mildura Co-op. Fruit Co., Red Cliffs Coop. Fruit Co. Ltd. and Aurora Packing Pty. Ltd.	228		
		3	
			4,938
(vi) Soil Problems—			
(*a*) Investigations at Waite Institute and Irrigation Areas—			
Salaries, &c.	5,156		
Capital	66		
		5,222	
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..		2,500	
			2,722
(vii) Food Preservation and Transport—			
(*a*) Meat and fish investigations (Brisbane Abattoir)	1,859		
Less contributions by Queensland Meat Industry Board, Australian Meat Industry Employees' Union, and Wyndham Meat Works ..	219		
		1,640	
(*b*) Banana investigations (Queensland University)	702		
Less contribution by Commonwealth Banana Committee	702		
		..	
(*c*) Non-tropical fruits (Melbourne) ..	..	1,167	
(*d*) Citrus preservation	..	92	
(*e*) Engineering problems	..	444	
(*f*) Adviser on Food Preservation ..	..	316	
		3,659	
Less contributions from Commonwealth (Rural Credits Development Fund) ..	..	2,000	
			1,659
(viii) Prickly Pear—			
(*a*) Grant for investigations	..	4,500	
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..	..	4,500	
			..

* £762 was received from sale of produce and credited to Trust Fund receipts.

	£	£	£
(ix) Forest Products—			
(*a*) Central Laboratory—			
Annual	10,534		
Capital	1,280		
		11,814	
Less contributions—			
Commonwealth Bank (Rural Credits Development Fund	1,500		
Commonwealth Banana Committee	45		
Ballarat Water Commission	5		
Lands Administration Board, Brisbane, Queensland ..	2		
Messrs. Allen-Liversidge (Aust.) Ltd.	50		
Messrs. Avery & Anderson, Melbourne	3		
		1,605	
			10,209
(x) Mining and Metallurgy—			
(*a*) Mineragraphic Investigations		737	
Less contribution by Australasian Institute of Mining and Metallurgy		336	
			401
(xi) Radio Research—			
(*a*) Melbourne University	1,832		
(*b*) Sydney University	2,760		
(*c*) Advisers on Radio Research ..	115		
		4,707	
Less contributions by Postmaster-General's Department		3,500	
			1,207
(xii) Library		..	828
(xiii) Contributions to Imperial Agricultural Bureaux Imperial Institute of Entomology, Farnham House, Imperial College of Science and Technology, Slough, and Low Temperature Research Station, Cambridge ..		..	7,664
(xiv) Miscellaneous—			
(*a*) Wood taint in butter investigations ..	13		
Less contributions by Australian Dairy Council	13		
(*b*) Bee Investigations..	173	..	
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..	173		
(*c*) Thrips investigations	1,179	..	
Less contributions from the Thrips Investigations League ..	1,179		
		..	
(*d*) Supplement to Catalogue of Scientific and Technical Periodicals in the Libraries of Australia	391		
Less contributions from various sources	267		
		124	
(*e*) Various		205	
			329
		..	
Total of Item 3—Investigations ..			65,585
		..	

2. *Contributions.*—The following statement shows the receipts and disbursements during the year 1933–34 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled " The Specific Purposes Trust Account " :—

	Receipts including balances brought forward from 1932–33.		Expenditure 1933–34.
	£		£
Commonwealth Bank (Animal Health, Horticultural, Food Preservation and Transport, Prickly Pear and Forest Products Investigations)	15,000	..	15,000
Commonwealth Bank (Erection of Drought Feeding Building)	17	..	12
Commonwealth Bank (Bee Investigations)	177	..	173
Empire Marketing Board, England (Entomological Investigations)	2,438	..	2,422
Empire Marketing Board, England (Plant Industry Investigations)	3,198	..	3,198
Empire Marketing Board, England (Animal Health and Animal Nutrition Investigations—Sheep Research)	1,494	..	1,494
Empire Marketing Board, England (Animal Health Investigations—Cattle Research)	3,748	..	3,748
Postmaster-General's Department (Radio Research) ..	3,506	..	3,500
Australian Pastoral Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,284	..	1,964
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	1,200	..	1,200
Queensland Government (Animal Health Investigations—Cattle Research)	3,406	..	3,328
Council of Agriculture, Brisbane (Animal Health Investigations—Cattle Research)	300	..	225
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	420	..	*420
Dried Fruits Control Board (Dried Fruits Investigations) Woorinen Dried Fruits Enquiry Committee (Dried Fruits Investigations)	1,881	.	1,776
Australian Dairy Council (Wood Taint in Butter Investigations)	42	..	13
Australian Meat Industry Employees' Union (Food Preservation Investigations)	50	..	50
Queensland Meat Industry Board (Food Preservation Investigation)	105	..	94
Contributions received through Graziers' Association of Central and North Queensland (Peg Leg Disease Investigations)	73	..	73
Various Contributions (Printing of Supplement to Catalogue of Scientific and Technical Periodicals in Libraries of Australia)	267	..	267
Sir MacPherson Robertson (Entomological Investigations)	186	..	4
Thrips Investigation League (Thrips Investigations) ..	1,408	..	*1,387
Messrs. Winter Irving and Alison (Zebu Cattle Project)	419	..	419
Queensland Stations Ltd. (Zebu Cattle Project) ..	388		388
Meredith Menzies & Co. Pty. Ltd. (Zebu Cattle Project)	419	..	419
C. W. Wright, Esq. (Zebu Cattle Project)	388	..	388
Commonwealth Banana Committee (Banana Investigations)	1,469	..	748
Revenue Fund—Griffith Research Station (Citricultural Investigations)	1,265	..	481
Carried forward ..	45,548	..	43,191

* Includes £84 on account of 1932–33 expenditure.

	Receipts including balances brought forward from 1932–33.		Expenditure 1933–34.
	£		£
Brought forward ..	45,548	..	43,191
Messrs. Allen-Liversidge (Aust.) Ltd. (Forest Products Investigations)	50	..	50
Lands Administration Board, Queensland (Special Forest Products Investigations)	250	..	2
Ballarat Water Commission (Forest Products Investigations)	5	..	5
Avery & Anderson (Forest Products Investigations) ..	3	..	3
Committee of Direction of Fruit Marketing (Apple Root Stocks Investigations)	214	..	214
Tobacco Trust Fund—Prime Minister's Department (Tobacco Investigations)	6,568	..	618
Mildura Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	57	..	57
Irymple Packing Co. (Dried Vine Fruits Investigations, Merbein)	57	..	57
Red Cliffs Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	57	..	57
Aurora Packing Co. (Dried Vine Fruits Investigations, Merbein)	57	..	57
Wyndham Meat Works (Food Preservation Investigations)	75	..	75
Australian Dairy Cattle Research Association (Printing of Mastitis Report)	50	..	..
Australian Pastoral Co. (Animal Health Investigations, Noondoo)	62	..	48
Office of Minister of Agriculture, South Australia (Survey of Incidence of Coast Disease)	151	..	151
Carnegie Institute (Mineral Deficiencies in Pastures Investigations)	1,750	..	..
	54,954	..	44,585

3. *Staff.*—The following is a list of the staff of the Council as at the 30th June, 1934. The list does not include typists, laboratory assistants and labourers, &c.

1. Head Office Staff.

Chief Executive Officer—A. C. D. Rivett, M.A., D.Sc., F.A.C.I.
Secretary—G. Lightfoot, M.A.
Assistant Secretary—G. A. Cook, M.Sc., B.M.E., A.A.C.I.
Chief Clerk and Accountant—H. P. Breen, L.I.C.A.

Library—

Librarian and Scientific Assistant—Miss E. Archer, M.Sc.
Assistant Librarian—Miss A. L. Kent.

Accounts, Staff, Stores—

M. G. Grace, L.I.C.A.
D. J. Bryant.
R. Viney.
V. Leonard.

Orders—

R. W. Constable.

Records—

P. Domec Carre.
H. T. Chadwick.
W. Gillespie.

Head Typiste—
Miss M. Polwarth.

Clerical Assistant to Chief Executive Officer—Miss A. Slattery, B.A.
Clerical Assistant to Chairman—Mrs. N. Roberts.
Clerical Assistant, Waite Institute—Miss J. L. Thomas.
Local Secretary, Canberra—R. F. Williams.
Clerk, Canberra—H. H. Wilson.

2. Secretaries of State Committees.

New South Wales—
Mrs. N. Roberts, 906 Culwulla Chambers, Castlereagh-street, Sydney.
Victoria—
G. A. Cook, M.Sc., B.M.E., A.A.C.I., 314 Albert-street, East Melbourne.
Queensland—
Miss H. F. Todd, corner Ann and Edward streets, Brisbane.
South Australia—
J. Ward Walters, Division of Animal Nutrition, University of Adelaide.
Western Australia—
L. W. Phillips, M.Sc., A.A.C.I., Box K766, General Post Office, Perth.
Tasmania—
F. J. Carter, Box 631B, General Post Office, Hobart.

3. Australia House, London.

Representative in Britain—F. L. McDougall, C.M.G. (part-time).

4. Division of Plant Pathology.

At Canberra—
Chief—B. T. Dickson, B.A., Ph.D.
Senior Plant Pathologist—H. R. Angell, B.Sc.Agr., M.S., Ph.D.
Senior Plant Geneticist—J. R. A. McMillan, B.Sc.Agr., M.S.
Senior Plant Introduction Officer—A. McTaggart, M.S.A., Ph.D.
Assistant Botanist—C. Barnard, M.Sc.
Assistant Plant Pathologist—W. L. Geach, B.Sc.
Assistant Plant Pathologist—W. V. Ludbrook, B.Agr.Sc., Ph.D.
Assistant Plant Introduction Officer—W. Hartley, B.A., Dip. Agr.
Assistant Plant Geneticist—H. F. Smith, B.Sc. (Agr.), M.S.A.
Assistant Plant Geneticist—C. S. Christian, B.Sc.Agr., M.Sc.
Technical Assistant (Genetics)—S. G. Gray, B.Sc.Agr.
Technical Assistant (Genetics)—K. Loftus Hills, B.Agr.Sc.
Assistant Botanist (Agrostological Investigations)—H. K. C. Mair, B.Sc.
Assistant Physiologist—J. Calvert, M.Sc., F.L.S.
Assistant Plant Physiologist—C. G. Greenham, M.Sc.
Biometrician—Miss F. E. Allan, M.A., Dip. Ed.
Assistant Botanist (Agrostological Investigations)—T. B. Paltridge, B.Sc.
Chemist—E. H. Kipps, B.Sc.
Librarian (part-time)—Miss A. Taylor, B.Sc.
Assistant Plant Pathologist—J. M. Allan, B.Agr.Sc.
Assistant Research Officer (Tobacco)—A. V. Hill, B.Sc.Agr.
Technical Officer (Tobacco)—G. H. Marks.

At University of Sydney—
Adviser on Chemical Problems of Tobacco Investigation—Professor J. C. Earl, D.Sc., Ph.D., F.I.C.
Research Officer (Tobacco)—G. E. Marks.
Chemist (Tobacco)—N. F. B. Hall, M.Sc.

At Stanthorpe, Queensland—
Assistant Research Officer (Investigations on root stock problems with special reference to deciduous fruit trees)—L. A. Thomas, M.Sc.

At University of Tasmania, Hobart—
Senior Plant Pathologist—W. M. Carne, F.L.S.
Assistant Plant Pathologist—D. Martin, B.Sc.

5. Division of Soils.

At Waite Agricultural Research Institute—

Chief—Professor J. A. Prescott, D.Sc., A.A.C.I. (part-time).
Soil Survey Officer—J. K. Taylor, M.Sc., B.A.
Assistant Field Officer—T. J. Marshall, M.Agr.Sc.
Assistant Chemist—J. S. Hosking, M.Sc.
Assistant Field Officer—P. D. Hooper.
Chemist—A. Walkley, B.Sc., B.A., Ph.D.

At Commonwealth Research Station, Griffith—

Assistant Soil Chemist—H. N. England, B.Sc., A.A.C.I. (seconded to New South Wales Water Conservation and Irrigation Commission).
Chemist—A. Howard, M.Sc.

At University of Tasmania—

Assistant Soil Chemist—C. G. Stephens, M.Sc.

6. Irrigation Settlement Problems.

Commonwealth Research Station, Griffith—

Liaison Officer—F. K. Watson, M.A., B.Sc., A.M.Inst.C.E. (part-time).
Officer-in-Charge—E. S. West, B.Sc., M.S.
Accountant (part-time)—D. Chalmers.
Orchard Superintendent—B. H. Martin, H.D.A.
Field Assistant—R. R. Pennefather, B.Agr.Sc.
Clerical Assistant—Miss E. Beck.

Commonwealth Research Station, Merbein—

Officer-in-Charge—A. V. Lyon, M.Agr.Sc.
Agricultural Officer—J. E. Thomas, B.Sc., B.Agr.Sc., B.V.Sc.
Technical Assistant—D. V. Walters, B.Agr.Sc.
Technical Assistant—A. L. Tisdall, B.Agr.Sc.
General Assistant—J. E. Giles.
Research Officer (part-time)—A. C. Ingerson.
Research Officer—E. C. Orton, B.Sc., A.A.C.I.

7. Division of Animal Health.

At Head Office, Melbourne—

Chief—J. A. Gilruth, D.V.Sc., M.R.C.V.S.
Deputy Chief—L. B. Bull, D.V.Sc. (abroad).

At Melbourne University Veterinary Research Institute—

Veterinary Officer—D. Murnane, B.V.Sc.
Technical Assistant—Miss C. Eales, B.Sc.

At Adelaide Hospital Pathological Laboratory—

Veterinary Officer—C. G. Dickinson, B.V.Sc.

Townsville (North Queensland) Cattle Research Station—

Officer-in-Charge—A. W. Turner, D.Sc., D.V.Sc.
Veterinary Officer—J. Legg, B.Sc., D.V.Sc., M.R.C.V.S. (seconded from the Queensland Department of Agriculture and Stock).
Veterinary Field Officer—R. B. Kelley, B.V.Sc.
Assistant Bacteriologist—A. D. Campbell, B.V.Sc.
Chemist—A. T. Dann, M.Sc.
Assistant Bacteriologist—A. T. Dick, B.Sc.
Administrative Officer—J. Derum.

At Department of Agriculture, Western Australia—

Veterinary Officer—H. W. Bennetts, D.V.Sc. (seconded from Department of Agriculture, Western Australia).

F. D. McMaster Animal Health Laboratory, University of Sydney—

Officer-in-Charge—I. Clunies Ross, D.V.Sc.
Assistant Parasitologist—H. McL. Gordon, B.V.Sc.
Bacteriological Technician—E. Parrish.

Field Officer—N. P. Graham, B.V.Sc. (seconded to Australian Pastoral Research Trust as from 1st October, 1932).
Assistant Parasitologist—G. Kauzal, D.V.Sc.
Assistant Veterinary Officer—W. I. B. Beveridge, B.V.Sc.
Assistant Bacteriologist—E. Munch-Petersen, M.Sc. (temporary).
Secretary and Statistician—Miss H. A. N. Turner, B.Arch.

At the University of Adelaide—
Acting Chief—H. R. Marston.
Chief Assistant—J. Ward Walters.
Field Officer—E. W. Lines, B.Sc.
Chemist—R. G. Thomas, B.Sc.
Assistant—J. D. O. Wilson.
Assistant Chemist—J. W. H. Lugg, M.Sc., A.I.C., A.A.C.I.
Statistical Recorder—G. W. Bussell.
Chemical Assistant—F. C. Farr.
Assistant Technician (Drought Feeding)—H. Munz.

At Waite Agricultural Research Institute—
Assistant Field Officer—A. W. Peirce, B.Sc.
Agrostologist—A. B. Cashmore, B.Sc. (Agric.).

At "Wambanumba" Field Station, Young, New South Wales—
Field Assistant—R. Tout.

9. Mineral Deficiency of Pastures Investigation.

At the Waite Agricultural Research Institute—
Analytical Chemist—R. E. Shapter, A.A.C.I.

10. Division of Economic Entomology.

At Canberra—
Acting Chief—A. J. Nicholson, D.Sc.
Senior Entomologist—G. F. Hill.
Senior Systematic Entomologist—A. L. Tonnoir.
Senior Entomologist—I. M. Mackerras, B.Sc., M.B., Ch.M.
Senior Entomologist—G. A. Currie, B.Sc., B.Agr.Sc.
Entomologist (Thrips Investigations)—J. W. Evans, M.A. (at Waite Institute).
Entomologist (Termite Investigations)—F. G. Holdaway, M.Sc., Ph.D.
Assistant Entomologist—Miss M. Fuller, B.Sc.
Assistant Entomologist (Blowfly Investigations)—Mrs. M. J. Mackerras, M.Sc., M.B.
Junior Research Officer—F. J. Gay, B.Sc.
Assistant Entomologist—T. G. Campbell.
Field Assistant—T. Greaves.
Veterinary Officer (Sheep Blowfly Investigations)—C. R. Mulhearn, B.V.Sc.
Librarian (part-time)—Miss A. Taylor, B.Sc.

At Farnham House Laboratory, England—
Entomologist—S. Garthside, B.Sc.Agr., M.Sc.
Junior Research Officer—F. Wilson.

At State College, Manhattan, Kansas, United States of America—
Assistant Entomologist—S. G. Kelly, M.S. (Agr.).

11. Division of Forest Products.

At Head Office, Melbourne (temporarily)—
Chief—I. H. Boas, M.Sc., A.A.C.I.
Deputy Chief—S. A. Clarke, B.E., A.M.I.E. (Aust.).
Senior Chemist—W. E. Cohen, B.Sc., A.A.C.I.
Senior Seasoning Officer—C. S. Elliot, B.Sc.
Senior Preservation Officer—J. E. Cummins, B.Sc., M.S., A.A.C.I.
Senior Wood Anatomist—H. E. Dadswell, M.Sc., A.A.C.I.
Timber Testing Officer—I. Langlands, B.E.E.
Seasoning Officer—W. L. Greenhill, B.E., Dip. Sc.
Utilization Officer—R. F. Turnbull, B.E.
Assistant Chemist—A. G. Charles.

Assistant Chemist—Miss I. H. Robertson, M.Sc., Dip. An. Chem.
Assistant Seasoning Officer—A. J. Thomas, Dip. For
Assistant Wood Anatomist—Miss A. M. Eckersley, M.Sc.
Technical Assistant (part-time)—Miss J. Galbraith.
Librarian and Records Clerk—Miss I. Hulme.
General Assistant—S. G. McNeil.
Draughtsman and Computer—B. Whitington.

12. Cold Storage Investigations.

At Brisbane Abattoir—
Officer-in-Charge—J. R. Vickery, M.Sc., Ph.D.
Assistant Biochemist—W. A. Empey, B.V.Sc.
Assistant Biochemist—W. J. Scott, B.Agr.Sc.

At University of Melbourne—
Adviser and Investigator—Associate-Professor W. J. Young, D.Sc. (part-time).
Assistant Biochemist—S. A. Trout, M.Sc., Ph.D.
Assistant Biochemist—F. E. Huelin, B.Sc., Ph.D.

At University of Queensland—
Assistant Biochemist—E. W. Hicks, B.Sc.

At Australia House, London—
Assistant Research Officer—N. E. Holmes, B.E.E.

13. Radio Research.

At University of Melbourne—
Research Physicist—G. H. Munro, M.Sc.
Research Physicist—H. C. Webster, M.Sc., Ph.D.

At University of Sydney—
Research Physicist—A. L. Green, M.Sc., Ph.D.
Research Physicist—D. F. Martyn, A.R.C.Sc., Ph.D.
Research Physicist—G. Builder, M.Sc., Ph.D.

14. Other Investigations.

Minergraphic Investigations—
Investigator—F. L. Stillwell, D.Sc.

Thrips Investigation—
Entomologist—J. W. Evans, M.A. (at Waite Institute).
Assistant Entomologist—H. G. Andrewartha, M.Agr.Sc. (at University of Melbourne).
Assistant Entomologist—Miss H. V. Steele, M.Sc. (at University of Melbourne).

XIII. ACKNOWLEDGMENTS.

The Council desires to acknowledge the very valuable assistance so freely afforded by many organizations and individuals. It is also desired to make special reference to the various State Departments, particularly those of Agriculture, and to the Universities. The help these bodies have given in affording laboratory accommodation and the use of their other facilities has been invaluable. Other organizations, including Commonwealth Departments and independent bodies, have also been particularly helpful. In addition to those who have been specified in the main part of this report, mention must also be made to many other private individuals who have taken a keen interest in the work of the Council and afforded it much help, both financial and otherwise.

(Sgd.) G. A. JULIUS, Chairman
A. C. D. RIVETT, Deputy Chairman and Chief Executive Officer
A. E. V. RICHARDSON
} Executive Committee.

G. LIGHTFOOT, Secretary,
November, 1934.

APPENDIX.

A.—Personnel of the Council and of its Various Committees.

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A. C. D. Rivett, M.A., D.Sc. (*Deputy Chairman and Chief Executive Officer*).
Professor A. E. V. Richardson, M.A., D.Sc.

Chairmen of State Committees.

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Russell Grimwade, B.Sc. (Victoria).
Professor H. C. Richards, D.Sc. (Queensland).
Sir Walter J. Young, K.B.E. (South Australia).
E. H. B. Lefroy (Western Australia).
P. E. Keam (Tasmania).

Co-opted Members.

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Professor E. J. Goddard, B.A., D.Sc.
Professor H. A. Woodruff, M.R.C.V.S., &c.

STATE COMMITTEES (AS AT 30TH JUNE, 1934).

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Professor R. D. Watt, M.A., B.Sc. (*Chairman*).
E. C. Andrews, B.A., F.G.S.
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C. H. Hoskins.
The Hon. Sir Norman W. Kater, Kt., M.L.C., M.B., Ch.M.
F. Leverrier, K.C., B.A., B.Sc.
J. Nangle, O.B.E, F.R.A.S.
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Professor T. G. B. Osborn, D.Sc.
Professor J. D. Stewart, M.R.C.V.S., B.V.Sc.
G. D. Ross.

Victoria.

Russell Grimwade, B.Sc. (*Chairman*).
B. Perry.
Professor W. E. Agar, M.A., D.Sc., F.R.S.
W. Baragwanath.
Sir Herbert W. Gepp, Kt., M.Aust.I.M.M., M.Am.I.M.M.
G. D. Kelly, LL.B.
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Emeritus-Professor Sir David Orme Masson, K.B.E., M.A., D.Sc., LL.D., F.R.S.
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F. J. Rae, B.Agr.Sc., B.Sc.
W. E. Wainwright, A.S.A.S.M., M.Aust.I.M.M., M.Am.I.M.M.
L. J. Weatherly, M.A.
Associate-Professor W. J. Young, D.Sc.

South Australia.

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E. H. Bakewell.
L. B. Bull, D.V.Sc.
Professor Kerr Grant, M.Sc., F.Inst.P.
W. A. Hargreaves, M.A., B.C.E., D.Sc., F.I.C.
W. J. Hill.
Professor T. H. Johnston, M.A., D.Sc.
Professor A. J. Perkins.
F. T. Perry.
Professor J. A. Prescott, D.Sc.
L. K. Ward, B.A., B.E., D.Sc.

QUEENSLAND.

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E. Graham.
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G. D. Ross, Under-Secretary, Department of Agriculture, New South Wales.
G. L. Sutton, Director, Department of Agriculture, Western Australia.
F. E. Ward, Director, Department of Agriculture, Tasmania.

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Adelaide.

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