1934–35–36.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

TENTH 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.

TENTH ANNUAL REPORT FOR YEAR ENDED 30TH JUNE, 1936.

I. INTRODUCTION.

1. *The Council.*—The financial year 1935–36 marks the completion of the first decade of the Council's activities. The first meeting of the Executive Committee took place on the 13th April, 1926, and its 338th meeting was held on the 4th June, 1936. The first session of the full Council was held in June, 1926, and its 19th session in April-May, 1936.

It is of interest to recall that initial steps for the creation of a national research organization in Australia were taken by the Commonwealth Government in March, 1916, when a temporary Advisory Council of Science and Industry was appointed by order of the Governor-General-in-Council. Although the Advisory Council was intended to be merely a temporary body for the purpose of preparing the ground for a permanent organization, it remained in existence until 1920 when it was superseded by the Institute of Science and Industry, established by an Act of Parliament passed in that year. The present Council came into existence in 1926 under the provisions of the Science and Industry Research Act passed in that year. The Council consists of the following members :—

(*a*) Three members nominated by the Minister and appointed by the Governor-General.
(*b*) The Chairman of each of the six State Committees.
(*c*) Such other members as the Council, with the consent of the Minister, co-opts by reason of their scientific knowledge.

A list of the members of the Council and of the six State Committees is given in an Appendix to this Report.

Ordinarily, the Council meets twice a year, one meeting being held sufficiently early to permit of the consideration of the draft Estimates of Expenditure for the following financial year. During the year 1935–36 two sessions of the Council were held, each extending over three days. The first meeting in August, 1935, was held in Adelaide. At that meeting, Dr. L. B. Bull, Chief of the Division of Animal Health, gave an account of his recent visit to Europe and the United States of America, and discussed the general position of the work of the Division and plans for its development. Mr. H. R. Marston, Acting Chief of the Division of Animal Nutrition, gave an account of the work of that Division and referred particularly to certain important developments in the investigations into coast disease and in the work concerning the efficacy of phosphatic supplements from the point of view of the Australian sheep industry. Professor J. A. Prescott, Chief of the Soils Division, furnished the Council with information regarding the position with respect to soil surveys in different parts of the Commonwealth and regarding developments in work on soil bacteriology and in analytical spectroscopy.

The second session of the Council in 1935–36 was held in Melbourne in April-May, 1936. A welcome was extended to Mr. T. E. Field who had recently been appointed Chairman of the South Australian State Committee of the Council in place of Sir Walter Young who had resigned, and also to Mr. W. E. Wainwright who attended as Acting Chairman of the Victorian State Committee in place of Mr. Russell Grimwade, who was absent in England. Appreciation was expressed of the valuable services rendered to the Council by Sir Walter Young. At this meeting, the Chairman (Sir George Julius) announced that arrangements had been made for Sir David Rivett, the Deputy-Chairman and Chief Executive Officer of the Council, to leave Australia on a six months' visit to Great Britain and the Continent of Europe in order to attend the British Commonwealth Scientific Conference to be held in London in September, 1936, and also to make certain inquiries for the Commonwealth Government abroad in regard particularly to (*a*) the production of oil from coal, and (*b*) wool research.* Addresses were given to the Council by Mr. F. N. Ratcliffe on his examination of the problem of soil drift in certain parts of South Australia ; by Dr. L. B. Bull on the arrangements for an intensive investigation into the problem of mastitis in dairy cattle and on the position regarding Sir Charles Martin's work on rabbit

* Sir David Rivett left Australia on the 26th May, 1936.

myxomatosis; by Mr. H. R. Marston on coast disease and the effect of phosphorus in licks; by Dr. Clunies Ross on his visit to China, Manchukuo and Japan to inquire into problems of the sheep industry and on recent developments in parasitological investigations at the McMaster Animal Health Laboratory; by Dr. A. W. Turner on the investigations into bovine pleuro-pneumonia; and by Dr. J. R. Vickery on developments in the work of the Section of Food Preservation and Transport and on plans for the concentration of the work of that Section at new laboratories and experimental cool chambers to be erected at Homebush, Sydney.

2. *Main Divisions and Sections of Council's Work.*—For the purpose of organizing the main activities of the Council, the policy has been adopted of establishing Divisions and of placing each Division under the control of a recognized authority in the sciences concerned. The Divisions of Animal Health and Nutrition have now been merged into one, so that at present there are five Divisions in existence :—

(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. (Chief).
(iii) The Division of Animal Health and Nutrition—Dr. L. B. Bull, D.V.Sc. (Chief). Dr. J. A. Gilruth, D.V.Sc. (Consultant).
(iv) The Division of Soils—Professor J. A. Prescott, D.Sc. (Chief).
(v) 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 investigations into viticultural problems are under the charge of Mr. A. V. Lyon, M.Sc., and its citicultural investigations are under Mr. E. S. West, B.Sc., M.S.

The investigations which are being conducted jointly by the Divisions of Plant Industry and Economic Entomology into the control and eradication of weed pests are under the control of Dr. G. A. Currie, B.Agr.Sc., D.Sc.

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

Many of the Council's investigations are carried out in co-operation with organizations such as the State Departments of Agriculture and the Universities, but the Council has found it necessary to conduct certain major groups of investigations under its own direct control, and for that purpose has established laboratories at various places. Thus at Canberra there are laboratories of the Divisions of Plant Industry and Economic Entomology; at Adelaide there are the Animal Nutrition and Soils laboratories; at Melbourne there is a temporary Forest Products Laboratory, and the erection of a permanent laboratory at that place is nearing completion. At Sydney there is the McMaster Animal Health Laboratory. Investigations into animal health problems affecting cattle in Northern Australia are centred at a laboratory near Townsville in Queensland; and work in connexion with chilled beef is carried out in a laboratory provided by the Queeensland Meat Industry Board at Brisbane. There is a Research Station at Merbein, Victoria, for the investigation of problems of the dried fruit industry; whilst those of the citrus industry are studied at a Research Station at Griffith, New South Wales.

In addition to the above, co-operative investigations are in progress in the laboratories of several of the State Departments, Universities, &c., while field experiments are carried out at various places in the Commonwealth.

3. *The Australian Council of Agriculture and the Standing Committee on Agriculture.*—In previous Annual Reports of the Council, attention has been drawn to the valuable work which was carried out by the Council's Standing Committee on Agriculture, which comprised amongst its members the permanent head of each of the State Departments of Agriculture, and also to the fact that the results of that Committee's work had been so satisfactory that steps had been taken by the Commonwealth Government to increase its status and to extend its sphere of usefulness.

As a result of a Conference of Commonwealth and State Ministers on agricultural and marketing matters, convened at Canberra in December, 1934, by the Commonwealth Government, an Australian Council of Agriculture was established. In order to enable that Council adequately to perform its duties a permanent Technical Committee was appointed to be known as the Standing Committee on Agriculture whose duties, in addition to acting as an advisory body to the Council of Agriculture, include the following :—

(i) To secure co-operation and co-ordination in agricultural research through the Commonwealth.
(ii) To advise the Commonwealth and State Governments, either directly or through the Council, on matters pertaining to the initiation and development of research on agricultural problems.

(iii) To secure co-operation between the Commonwealth and States, and between the States themselves, with respect to quarantine measures relating to pests and diseases of plants and animals, and to advise the Commonwealth and State Governments with respect thereto.

It was further decided that the personnel of the Standing Committee as reorganized should consist of (*a*) the permanent head of each State Department of Agriculture, (*b*) the three members of the Executive Committee of the Council for Scientific and Industrial Research, (*c*) the Secretary of the Department of Commerce, and (*d*) the Director-General of the Commonwealth Department of Health.

Meetings of the Standing Committee on Agriculture were held at Canberra on the 25th and 26th May, 1936, and were followed by meetings of the Australian Council of Agriculture on the next two days. At these meetings, reports by the Council for Scientific and Industrial Research were furnished on the following matters :—

(*a*) Research by the Council for Scientific and Industrial Research and State Departments of Agriculture on problems affecting the apple and pear industry.
(*b*) Codling moth pest.
(*c*) Survey of potato virus diseases.
(*d*) Defects in Australian export eggs.
(*e*) Recommendations by Royal Commission on Wheat regarding the allocation of funds for research.
(*f*) Tobacco investigations.
(*g*) Co-operation in research between the Council for Scientific and Industrial Research and the New Zealand Department of Scientific and Industrial Research.
(*h*) Imperial Institute of Entomology—Question of Australian contributions.
(*i*) Imperial Mycological Institute—Question of Australian contributions.
(*j*) Resolutions passed at the Imperial Botanical Conference, 1935, regarding the appointment of liaison officers to the Royal Botanic Gardens, Kew.
(*k*) Seed testing.
(*l*) Pasture plant breeding work.
(*m*) Weed pest investigations.
(*n*) Proposed expedition abroad to search for plants for arid and semi-arid regions.
(*o*) Grasshopper investigations.
(*p*) Soil drift.
(*q*) Standard form of certificate for plant imports.
(*r*) Spahlinger vaccine for tuberculosis in stock.
(*s*) Australian ampelography.
(*t*) Protection of birds of economic value.
(*u*) International Institute of Agriculture.
(*v*) Recognition of International organizations and Conferences concerning agriculture.
(*w*) International Institute of Agriculture—Cattle herd books.

On behalf of the Standards Association of Australia, for which body the Council for Scientific and Industrial Research acts as a liaison with the Commonwealth Government, reports were furnished on the following matters :—

(*a*) Standardization of wearing parts of agricultural machinery.
(*b*) Standardization of primary products.
(*c*) Standards for dusting sulphur.
(*d*) Standardization of wire netting and other galvanized products.

4. *Co-operation in Research with New Zealand.*—At the request of the Prime Minister of Australia, the Chairman of the Council (Sir George Julius) during a visit to New Zealand towards the end of the year 1935 discussed with the Prime Minister of New Zealand, the Minister in charge of the Department of Scientific and Industrial Research, and members of the Council of that Department the question of bringing about a more intimate association between the New Zealand Department and the Council for Scientific and Industrial Research. The Prime Minister of Australia informed the Prime Minister of New Zealand that there must be a great number of industrial primary problems which are common to the two Dominions, and that the work done in one of them could often be more or less directly applicable to the other. Whilst he had no doubt that the published results of each organization are utilized by the other, he felt that some further effort was required to ensure that each Dominion should obtain the maximum advantage from investigations carried out in the other.

As a result of the discussions, it was agreed that there were certain branches of work of common interest in which it is impracticable and also probably unnecessary for each country to establish a team of workers ; therefore, it was desirable that arrangements should be made for

each country respectively to attach members to teams of workers in certain investigations in the other. In that way, full information would be made available to each country and some measure of partnership would be established in the conduct of scientific industrial research.

It was accordingly agreed that the New Zealand Department of Scientific and Industrial Research should arrange for a worker to be attached to the Council for Scientific and Industrial Research in connexion with the latter's investigations into each of the following, viz., (*a*) mastitis, (*b*) sterility in sheep, (*c*) food preservation and transport problems; and that Australia in turn should attach an officer to work in New Zealand on dairy research which is being prosecuted actively in that country. The Council for Scientific and Industrial Research cordially welcomes these proposals for closer co-operation with the corresponding body in the sister Dominion, and steps are being taken to give effect to the arrangements made.

5. *Organization for Research into Problems Affecting Secondary Industries.*—The Prime Minister has announced that the Commonwealth Government has decided to extend the activities of the Council for Scientific and Industrial Research so as to embrace investigations into the problems of Australia's secondary industries. In making this announcement, he pointed out that the Council had hitherto devoted its attention almost exclusively to problems associated with primary industries, and that its achievements had won for it well-deserved confidence in its ability to carry out its functions efficiently and successfully. There was no reason to believe that in the work on secondary industries the Council would be any less successful. The Prime Minister also stated that the step taken was considered necessary not only in the interests of great new industries about to be started such as air craft and motor engine production, but also in relation to other new industries projected or possible, and to the greater efficiency of the manufacturing industry generally. He went on to say as follows:—

"The proposal marks an important step forward in the development of Australia, and although it will impose increased financial obligations upon the Government the money will be well spent if we secure more economical production and a widening of the field of employment. The contraction of world markets for primary products has forced us to recognize that the expansion of secondary industries is not only essential to the provision of an increased home market for primary products, but it is necessary to place Australia in a position to carry a progressively larger population".

With the approval of the Minister (Senator the Honorable A. J. McLachlan) and at the request of the Commonwealth Government the Council has accordingly appointed a Committee broadly representative of the various interests concerned (*see* Appendix) to prepare a report and recommendations on the whole matter. It is intended that the Committee will complete its work by December, 1936, on the following lines:—

(*a*) Define the field of work of the proposed organization in Australia and indicate the general lines of development of its activities.

(*b*) Prepare a definite programme of work and scheme of operations.

(*c*) Indicate the extent to which existing Institutions such as the Engineering and Physical Laboratories at the Universities, State Railways Departments, &c., could be utilized.

(*d*) Make recommendations as to the nature of the organization, staff, &c., which would be necessary to give effect to the proposals and furnish approximate estimates of cost.

(*e*) Make a thorough survey of the work and organization of the more important engineering and physical research institutions abroad, and determine the extent to which information and advice can be obtained from other countries. In the latter connexion, Sir David Rivett has been asked to make certain inquiries in England.

It is anticipated that the new organization will undertake two main classes of work; the first is research in relation to scientific problems affecting the secondary industries. The need for this has long been apparent. Many problems associated with secondary production have been submitted by responsible individuals or organizations to the Council for Scientific and Industrial Research. In many cases a certain measure of help and advice has been given by reference to results of work conducted elsewhere. Frequently, however, the Council has been unable to furnish the desired information since it has no facilities at its disposal to carry out the necessary research. In many instances, men and equipment are available in the Commonwealth, but without adequate organization and supervision it was generally found to be impossible to make use of their services. Although private enterprise has undertaken an attack on many of these problems by its own staffs and laboratories, there are many problems which affect industry as a whole, or which should be carried out by a disinterested body.

The second branch of activity is that of testing methods and calibrating which is the basic requirement of precision manufacture and mass production. That this is so is clearly indicated by the activities of institutions in leading industrial countries such as the National Physical Laboratory in England and the Bureau of Standards in the United States of America.

II. PROGRESS AND DEVELOPMENT OF WORK.

1. *General.*—In this section of this Report brief information is given regarding developments of special interest in the Council's activities during the year 1935–36. Detailed information regarding the work of the various Divisions, &c., is given in later sections of this Report.

(i) *New Laboratories, &c.*—The erection of a new Forest Products Laboratory from a sum of £25,000 made available by the Commonwealth Government from the Unemployment Relief Funds is nearing completion, and the building should be ready for occupation in about October, 1936. The Victorian Government has made available at a nominal rent a valuable site in South Melbourne for this Laboratory, and additional plant and equipment are being purchased from the generous gift of £5,000 by Mr. Russell Grimwade, C.B.E., B.Sc., Chairman of the Victorian State Committee of this Council.

A new laboratory building at the Viticultural Research Station, Merbein, for which a sum of £6,000 was provided by the Commonwealth Government, also from the Unemployment Relief Funds, will be completed at an early date.

The Commonwealth Government has provided a sum of £20,000 for a laboratory to be used particularly for investigations into mastitis and other animal health problems affecting dairy cattle. It is, of course, essential that this laboratory should be erected in the vicinity of districts where the dairying industry is carried on, and that it should not be far distant from Berwick, near Melbourne, where a field station for mastitis investigations has been established. The Arrangements have accordingly been made with the University of Melbourne for the erection of the laboratory in the grounds of the Veterinary Research Institute, Parkville, Melbourne.

The work of the Council's Section of Food Preservation and Transport has up to the present been conducted at various places. For example, the work on chilled beef has been carried out at laboratories and experimental chambers made available at Brisbane by the Queensland Meat Industry Board. Investigations on the storage and transport of non-tropical fruits have been conducted at the Government Cool Stores, Melbourne, in co-operation with the Victorian Department of Agriculture ; while citrus preservation work has been in progress at three centres, viz., Newcastle and Griffith, New South Wales, and Melbourne. Arrangements have been made with the Sydney Metropolitan Meat Industry Commissioner for accommodation for the major part of the Section's work to be provided at the Homebush Abattoir, Sydney, where a building is to be provided wherein laboratories and experimental cold chambers will be constructed from funds provided partly by this Council and partly by the New South Wales Department of Agriculture and the Australian Meat Board. It is hoped that the new laboratory and cold chambers will be ready for occupation early in 1937.

An area of 800 acres of suitable land has been purchased near St. Mary's, about 30 miles from Sydney in the County of Cumberland, to be used mainly as a field station in connexion with investigations at the McMaster Animal Health Laboratory and for genetical work on sheep. The University of Sydney has approved of the purchase of an adjacent area of 400 acres to be used in connexion with the work of the Department of Veterinary Science, and it is anticipated that both the Council and the University will derive substantial benefits from the close contacts which will thus be established, and from the opportunities for collaboration which will be afforded.

(ii) *Fisheries Investigations.*—Preparation of plans and specifications for an exploratory fisheries vessel to be used particularly for the purpose of ascertaining the commercial possibilities of utilizing, in Australian waters, types of nets used in other countries for catching pelagic or surface swimming fish has involved a very considerable amount of work and inquiry abroad. Among the tenders for the construction of the vessel received, that submitted by the Melbourne Harbour Trust Commissioners has been accepted, and it is anticipated that the vessel will be ready for fishing operations in the early part of 1937.

In connexion with the concentration of the work of the Section of Food Preservation and Transport at Sydney, arrangements are being made for investigations to be conducted into methods of preservation of fish not only by quick freezing methods, but also by canning, smoking, curing, &c. Work will also be conducted on the utilization of non-edible fish for the manufacture of fish meal, &c., for use as a fertilizer.

Attention is also being given to marine biological investigations for the purpose of obtaining accurate information regarding the habits and life histories of the more important species of edible fish. With respect to the development of this branch of the work, Professor W. J. Dakin, Department of Zoology, University of Sydney, is obtaining information for the Council during a visit to the United States of America, Great Britain and the Continent of Europe.

(iii) *Ore-dressing Investigations.*—Considerable progress has been made in the co-operative ore-dressing investigations in which the Council is interested, and which were made possible as a result of the grant of £5,000 per annum for five years which the Commonwealth Government made for the financing of research work of value to the gold mining industry.

The actual testing work on any particular ore is carried out in one of the three laboratories which are co-operating in the scheme, namely, the Kalgoorlie School of Mines, the South Australian School of Mines and Industries, and the Metallurgy School of the University of Melbourne. Already about 90 ores have been examined and reports furnished thereon. They have been drawn from many parts of Australia, and include such localities as Bethanga and Granya (Victoria), Auburn Falls and Yeppoon (Queensland), Tennant's Creek (Northern Territory), Cobar (New South Wales), Norseman, Southern Cross, Yellowdine and Hampton Plains (Western Australia), and many others.

(iv) *Soil Drift.*—In consequence of a request made to the Council by the Minister (Senator the Honorable A. J. McLachlan) to consider whether any action could be taken to combat drift of soil in the arid and semi-arid parts of Australia, information and advice were obtained by the Council from a number of authorities in New South Wales, Victoria, Queensland, South Australia and Western Australia. A summary of information was brought before the Standing Committee on Agriculture last year for consideration. As a result, arrangements were made for an officer of the Council (Mr. F. N. Ratcliffe) to carry out a survey of the problem, particularly in the northern parts of South Australia. The results of Mr. Ratcliffe's observations have been published as one of the Council's Pamphlets and have attracted a great deal of attention. Arrangements were made for Mr. Ratcliffe to spend some time in Queensland particularly for the purposes of inquiring into the question of the regeneration of Mitchell grass after long periods of drought, and of visiting the south-western parts of the State, thus linking up his observations with those made in the north-east of South Australia.

(v) *Plants for Arid and Semi-Arid Regions.*—As a result of representations made to the Council by the Honorable F. W. Bulcock, Minister for Agriculture and Stock, Queensland, a statement regarding the question of sending one or more officers abroad to search for plants suitable for Australia's arid and semi-arid regions was brought up for discussion at the meetings of the Standing Committee on Agriculture and the Australian Council of Agriculture held in May, 1936. The following resolution (*a*) passed by the Standing Committee was adopted by the Council of Agriculture, which also passed resolution (*b*).

> "(*a*) In view of the importance to the pastoral industry of securing new plants suitable for the semi-arid regions of Australia, the Standing Committee endorses the principle of plant exploration and recommends that the matter be referred to the Council for Scientific and Industrial Research for further inquiry".
>
> "(*b*) That in order to facilitate the work of plant introduction now being performed by the Council for Scientific and Industrial Research, the Ministers present agree to recommend to their respective Governments that they make a contribution towards a central fund to be subsidized by the Commonwealth Government for the purpose of sending an officer or officers abroad in order to obtain, if possible, plants of economic value to Australia".

In accordance with the terms of the above resolutions, inquiries are being made by the Council as to the most appropriate place to which officers might be sent for the purposes in view and as to the arrangements which would have to be made for them effectively to carry out their work.

(vi) *Rabbit Myxomatosis.*—In the last Annual Report of the Council reference was made to investigations into a virus disease known as myxomatosis being conducted on behalf of the Council by Sir Charles Martin, C.M.G., F.R.S., &c. in the Laboratories of the Department of Pathology at the University of Cambridge. During the year 1935–36, Sir Charles Martin's investigations were completed and the results have been published in one of the Council's Bulletins. The experiments show that the fatality of the disease was 100 per cent. in wild (European) rabbits, and that the disease is so highly specific for the European wild rabbit (from which the Australian rabbit is descended) that so far no one has succeeded in producing the disease in other animals, although many attempts to do so have been made both in America and Great Britain. Nevertheless in his report, Sir Charles Martin draws attention to the desirability of further experiments being made in order to ascertain if some susceptible animal might be discovered.

Arrangements are being made by the Council to bring a supply of the virus to Australia in order to carry out further tests under strict quarantine conditions to see if any of our domestic animals, livestock, or Australian native fauna are susceptible to the disease. If the results of these experiments are negative, consideration will then be given to carrying out a field test, probably on some island, in order to determine the efficacy of the virus in exterminating rabbits under natural conditions. It may be well to give a warning at this stage against extravagant expectations. The present evidence clearly justifies further enquiry and experiment, but anticipations either of success or of failure in the practical application of the knowledge so gained are wholly unjustified. The problem is one demanding careful enquiry, not speculation.

2. *Division of Plant Industry.*—(i) *Tobacco Investigations.*—The work on the control of downy mildew (blue mould) of tobacco by benzol vapour in covered seedbeds has resulted in the possibility of prevention of a most destructive disease that had previously resisted all attempts at control. This is the first instance in which a vapour has been successfully used to protect growing plants from infection. When, in the autumn of 1935, extensive experiments on a practical scale in the tobacco district of North-east Victoria confirmed the results obtained in the laboratory and field at Canberra, the Departments of Agriculture in the various States decided to conduct trials during the seedbed season of that year. Hundreds of thousands of healthy seedlings were economically produced by the use of benzol under the different climatic conditions in five States. Substitutes were successful in some areas, but benzol was the only substance that proved effective under all conditions. The use of benzol for raising disease-free seedlings is an economical, practical, and effective means of removing what is reputed to be the greatest obstacle in the way of the development of the tobacco industry in Australia. Research into cultural problems, hitherto hindered by the disease, may now be expected to progress, and should result in an improved product. It seems reasonable to expect that, where soil and climate are suitable, stabilization of the industry should follow, and production of tobacco of good quality be assured.

Arrangements have been made through the courtesy of the Waite Agricultural Research Institute for Dr. A. H. K. Petrie to undertake a series of physiological studies, which it is hoped will lead to a better knowledge of the nutritional requirements of tobacco and so link up with the chemical work in giving guidance to the production of better quality leaf.

During July, 1935, a conference was held in Canberra, under the Chairmanship of the Chief of the Division of Plant Industry, at which officers working on tobacco problems in all States of the Commonwealth met to discuss their problems. There was a very useful interchange of experimental data and views on the problems facing the industry, and it was decided that twice a year all concerned would forward progress reports to the Division which would then act as a clearing house for the information received. Evidence is accumulating that as a result of the work of technical and advisory officers there is an improvement in the quality of leaf produced. It is anticipated that this will become more manifest as the areas most suited to tobacco culture are more certainly defined.

(ii) *Pasture Map of Australia.*—A large proportion of the total area of Australia is given over to pastoral pursuits, and it is, therefore, desirable in our own interests and in that of future generations to take stock of the size and type and state of pasture areas. About one-third of the continent (a little over one million square miles) receives less than ten inches of rain per annum, and a similar area receives between ten and twenty inches ; while the remaining area (less than one-third) which receives satisfactory rainfall also includes all the mountain country. This is therefore a rather dry continent, and the greatest care needs to be taken with our plant cover to maintain it in good state.

During the past several years information available in State Departments of Agriculture and of Lands has been collected, together with that supplied by many individuals, and utilized to form the basis for the pasture map recently issued by the Council. It is the first map of its kind ; and it is well recognized that, since actual surveys have not been possible, there are likely to be imperfections in boundaries of zones and so forth. Nevertheless it presents in broad outline the pasture zones as they are. As time goes on information newly acquired will cause boundaries to be modified in future editions ; but probably the greatest interest will attach to the increase in area of exotic pastures, and to the position obtaining in marginal areas bordering the low rainfall country.

(iii) *Plant Introduction.*—The preparation of the pasture map has strengthened the conviction that every effort on behalf of pastures is essential, and especially for marginal areas and summer rainfall areas. During the year the additional introductions of grasses and legumes brought their total over 1,800. Some from the Caucasus regions are quite promising, especially among the clovers, and others may serve as sand or soil-binders.

For the furtherance of the work an officer has been transferred to Gatton, and arrangements are in train for another to carry out trials at Fitzroy Vale, near Rockhampton.

(iv) *Pasture Plant Improvement.*—Introductions which have been established for a considerable time, such as lucerne, rye grass, paspalum, &c., may develop strains with certain outstanding characteristics. By combining desirable characteristics a more useful type may be produced. It may also be possible to breed new types by inter-specific crossing. Such work is now planned, and a beginning has been made in Queensland at Gatton College. An officer has been transferred there for the work, which is being organized in collaboration with the State Department of Agriculture.

(v) *Fruit.*—In the Murrumbidgee Irrigation Areas concern has been expressed at the incidence of what is known as citrus " decline " during the past few years. A survey was undertaken to determine the position, and it appears that while the acreage has decreased since

1931 the production rate has accelerated somewhat. The primary cause of tree death is attributed to waterlogging, due in part to overwatering, and in part to extraordinarily heavy rains during the winter of 1931 which gave rise to severe root injury. Since then neglect due to depressed economic conditions has played its part in many citrus groves.

The nutrition of citrus under irrigation is a problem of increasing importance; and a particular phase, viz., the role played by root fungi, is being investigated.

3. *Division of Economic Entomology.*—The glycerine-boric acid dressings for treating blowfly strike in sheep have now been used by a considerable number of graziers, and reports on their effectiveness under practical station conditions have generally been highly favourable. Work has also been undertaken to develop a suitable dressing for treating tailing wounds in lambs.

Considerable progress has been made in the investigation of the peach moth (*Cydia molesta*). Results obtained with nicotine-bentonite-sulphur sprays have been very favourable, and it would appear that considerable improvements in methods of control are in sight.

The Council's grasshopper investigations have been considerably expanded by the appointment of additional staff and the provision of means for carrying out field studies. Up to the present the work has been concentrated on the elucidation of life histories of the more important species, and the collection of records of outbreaks for correlation with seasonal climatic conditions.

Further investigation of the clover springtail (*Sminthurus viridis*) stongly indicates that the predatory mite, *Biscirus lapidarius*, is a valuable means of biological control in Western Australia. Arrangements have been made for further liberations of the mite in infested districts in other States.

Termites (white ants) in the northern part of Australia destroy large quantities of grass and seed, and they are also a serious concern to those responsible for the maintenance of aerodromes, by reason of the rapidity with which they build hard mounds to a dangerous height on runways. An investigation of both problems has been commenced and, while it is too early to say whether the grass-eating species significantly affect the carrying capacity of northern pastures, or whether they can be economically controlled in grazing country, there are definite indications that the cost of preventing regrowth of their mounds on aerodromes may be considerably reduced.

4. *Weeds Investigations.*—As a result of requests received from various States, the Council has during the last year increased its work on the control of weeds. In order to give greater unity to the enlarged programme, the two phases of the work—botanical and entomological—have been reorganized into a single Section under the joint control of the Chiefs of the two Divisions concerned. The principal recent developments in the weeds investigations are as follows :—

(i) *Work in the South of France.*—Two insects discovered in the south of France feeding on St. John's wort are of special interest for the possible control of this weed in Australia, as they are adapted to life in a climate in which a dry hot summer is a feature. It is hoped that tests with them will be completed, and that they will be introduced into Australia in the coming season.

(ii) *Lantana Bug.*—An entomologist was appointed to the Section in July last in the Division of Economic Entomology, his first duty being to visit Fiji to study the effect the Lantana bug, *Teleonemia lantanæ*, produced on its host plant and to make sure that it would be safe to introduce it into Australia.

Tests carried out in Fiji showed that the insects would not feed on economic crops and that their destructive effect on Lantana when present in large numbers was considerable. The bugs were introduced into quarantine insectaries in Canberra, where they have been bred successfully in captivity, and are now being further tested before being released in the Lantana areas.

(iii) *Noogoora Burr.*—The Prickly Pear Board has been able to devote the energies of some of its officers to the discovery of insects in America capable of destroying burrs. It is being arranged that the officer of the Council working in America should join forces with the prickly pear team in a close co-operative effort in the best interests of the work. A comprehensive survey in America has shown that more insects which attack burrs are to be found in Texas than in Kansas, so work will probably be concentrated there.

(iv) *Skeleton Weed.*—Work on skeleton weed carried out at Wagga in collaboration with officers of the New South Wales Department of Agriculture, and the Wagga State Farm, has given useful indications of the value of certain chemicals for the control of the weed and of plants which can compete against it. The co-operation of the Council with the bodies mentioned, and with the local Skeleton Weed Committee has led to a changed outlook in the Wagga district on this problem. Confidence in ultimate success in controlling this weed had largely replaced the formerly prevailing pessimism.

(v) *Galvanized Burr.*—This plant is a widespread pest of pastures in the higher rainfall areas of Queensland and New South Wales. It has been selected for special study to discover if any form of pasture management can lead to the regeneration of the valuable grasses, and the elimination of the weed in areas already heavily infested by it. The assumption behind the

experiments is that galvanized burrs and many other weeds of pastures are indicators of too great intensity of grazing, and that it may be possible to find a system of grazing applicable in practice which will not allow the pastures to become so open that weeds will encroach seriously. Studies are planned on broad ecological lines to discover the factors responsible for the spread and the density of weeds, so that rational control measures can be devised.

(vi) *Bulrush.*—The bulrush (*Typha latifolia*) has become a serious pest in the channels of the irrigation areas in New South Wales and Victoria. The Irrigation Commissioners have supplied the funds to appoint an officer to work in the Weeds Section of the Council on the problem.

(vii) *Chemical Control.*—Control of weeds by chemicals is a well recognized practice in other countries ; but in Australia, apart from its use in prickly pear destruction, it has been very sparingly used. There appear to be many instances where poisons could be effectively used in Australia ; so an officer has been detailed to study the effectiveness, cost, and mode of action of various herbicides when applied to some of the most important weeds.

5. *Division of Animal Health and Nutrition.*—(i) *Pleuro-pneumonia in Cattle.*—Great impetus was given to the pleuro-pneumonia investigations by the development of the insufflation method for the artificial dissemination of the disease, and of the complement-fixation test for its diagnosis. The reliability of the insufflation method of infection has been further tested, and fully proved, during the past year ; and its employment has considerably simplified the immunity experiments. As far as the practical application of the research is concerned, there has been a further increase in the use of the " culture virus " developed at the Townsville Laboratory ; while it is particularly gratifying to note that the complement-fixation test has been successfully employed in connexion with the control of natural outbreaks of pleuro-pneumonia in South Australia and Western Australia, and in the latter State has made possible the movement of cattle from hitherto prohibited northern districts

(ii) *Internal Parasites of Sheep.*—Again it is possible to record marked progress in the work being carried out at the McMaster Animal Health Laboratory. With the development and improvement of methods, both curative and prophylactic, for the treatment of *Haemonchus*, *Trichostrongylus*, and *Oesophagostomum* infections, the position of pastoralists regarding the control of these important parasites has been materially improved.

(iii) *Genetic Investigations.*—A study of the factors affecting the fertility of Merino sheep has been carried out during the past year. Stud breeders are particularly concerned with this problem ; and in the report of the investigation it is pointed out that since the inheritance of fertility apparently depends on a small number of Mendelian factors, genetic control of fertility in the relatively small flocks concerned should be a simpler matter than was previously suspected. The establishment of an experimental flock will enable this investigation to be developed on a practical basis.

(iv) *Animal Nutrition Investigations.*—Much of the research carried out at the Adelaide laboratory is designed to provide the fundamental information necessary before embarking on the study of more obviously practical problems. Satisfactory progress has been made in this basic work which has materially advanced the existing knowledge of the influence exerted by various nutrients on wool production. The remarkable flexibility of the so-called strong woolled Merino sheep as a wool producer has been demonstrated by an increase of nearly 150 per cent. in the amount of wool following the alteration of one dietary constituent. This increase was attended by a no less remarkable variation in the character of the wool produced.

Part of the research into the phosphorus metabolism of sheep has been concluded ; and the results of the finished and unfinished experiments indicate that sheep will do well while receiving much less phosphorus than is generally considered necessary, and that under natural grazing conditions they could assimilate phosphorus as well from the relatively inexpensive ground rock phosphate as from more costly dicalcic phosphate. To test thoroughly the value of phosphatic licks under natural grazing conditions, field experiments have been initiated in phosphorus-poor areas in New South Wales, South Australia, Queensland and Western Australia.

Recent work has established methods of determining the comparative nutritive value of various legumes and grasses employed extensively in sown pastures ; and it is hoped as a result that it will be possible to elucidate some of the problems connected with the husbandry of sheep grazing on such pastures.

The investigations into the nature of coast disease have received an impetus from the provision of facilities at the recently established field station near Robe, South Australia. Experiments already carried out there have confirmed the usefulness of cobalt as a curative agent under field conditions ; and work is now in progress to determine the preventive effect of periodic drenching with cobalt salts.

6. *Soils and Irrigation Investigations.*—(i) *Soils Division.*—In connexion with the soil survey of the settlements in the Murray River Valley progress was made during the year 1935–36 in the soil surveys of the irrigated horticultural areas of New South Wales. Surveys of such settled areas in New South Wales have now been completed.

In Tasmania work has been concentrated largely on the red basaltic loam soils of the north coast, particularly for the purpose of determining lime requirements.

The work on soil bacteriology has been developed, particularly with reference to the nitrogen-fixing organisms of leguminous plants, such as subterranean clover and lucerne, both of which are important pasture plants in southern Australia. The question of strain in these organisms has proved to be of considerable importance.

Investigations are also progressing in areas presenting problems of animal health apparently associated with soil deficiencies.

It is satisfactory to know that very considerable use is being made of the results of the soil surveys, particularly in the Murray River Valley settlements, not only by State irrigation authorities, but also by local committees and individual settlers. The surveys form the basis for elucidation of many problems associated with water-logging, fertilizer trials, the planning of drainage systems, the opening of further areas for settlement, &c.

(ii) *Viticultural Research Station, Merbein.*—The processing methods for dried fruits evolved at the Station have now been adopted practically throughout the industry; and the realization from sales in overseas markets compares favourably with that of other competitive countries.

The investigations into problems associated with the preservation of soil fertility have advanced to the extent that corrective measures are being applied by the State Departments concerned. Improved irrigation practices, in regard to method and frequency of irrigation, are in evidence in the majority of fruit-producing districts in the Murray Valley.

District drainage schemes, in course of construction in the Mildura, Red Cliffs, and Merbein settlements (Victoria), and Barmera (South Australia), are of particular interest. These schemes constitute the first comprehensive attempts in Australia for the reclamation and maintenance of the fertility of the irrigated lands by the removal of harmful sub-soil water on a large scale.

(iii) *Citricultural Research Station, Griffith.*—Valuable contributions have been made regarding the role of organic matter in plant nutrition. These explain, in part, the beneficial results obtained by green manure crops, of which details have been given in previous reports.

A technique has now been developed for the detailed study of the permeability relationships of soils and the design of suitable methods of irrigation. This has been used as an adjunct to soil surveys in determining the soil characteristics from an irrigation point of view of new areas in the Murrumbidgee scheme, so that information will be available to settlers and the irrigation authorities concerning suitable crops and irrigation systems to adopt.

7. *Forest Products Division.*—(i) *New Laboratories and Special Equipment.*—It is anticipated that building operations in connexion with the new laboratories in South Melbourne will be completed before the end of August, and that the Division should be installed in its new home by the end of October, though there will still remain much to be done before the work will be able to proceed smoothly.

Notable among the items of special equipment, the purchase of which has been made possible by Mr. Russell Grimwade's generous gift (referred to in the last Annual Report), is a 600,000 lb. Southwark Emery testing machine. This machine, which will allow the testing of large built-up structures, has now been delivered, and will shortly be erected. A further 20,000 lb. machine has been ordered, which will in the first case be used in a comprehensive series of tests on coach screws.

(ii) *Exhibition.*—The Division for the first time in its history had a small display, illustrating some of its activities, in the Ideal Homes Exhibition, which was held at the Exhibition Building, Melbourne, from the 21st of February to the 7th March, 1936. The exhibit attracted a great deal of attention, and led to many enquiries from interested visitors. So successful was this effort, that it is planned to extend this type of activity in the future.

(iii) *Plywood.*—During the year a full investigation was made of the veneer and plywood industry in Queensland, with special reference to gluing practice. This survey led to recommendations for improvements in the methods used; and a marked improvement in the quality of the products is already noticeable.

(iv) *The Use of Immature Trees.*—It will not be many years before the regrowth timbers, which are being grown on cut-over forest areas, will necessarily form an increasing volume of the timber available. In anticipation of this period, extensive studies of the properties and treatment of such timbers are being carried out by the different Sections of the Division. The results of this work will form the basis of much of the future timber practice.

(v) *Sawdust Utilization.*—A promising field of investigation, based on work begun at the Madison Laboratory in the United States, is an attempt to develop a plastic from sawdust. Some Australian timbers seem to offer particularly good possibilities in this direction.

(vi) *Wood Connecters.*—A great deal of interest has been created by the erection in Western Australia of the first wooden fire tower using wood connecters, and enquiries have been received for design of other towers. A comprehensive series of tests on built-up structures has been planned, and awaits the erection of the 600,000 lb. testing machine to be put into effect.

This form of construction is certain to develop greatly, and proper design must be based on actual tests.

(vii) *Bending.*—Very little work has hitherto been done on the bending qualities of Australian timbers. A machine has recently been installed, and a study of the optimum conditions for the bending of various species is being made.

(viii) *Handle Timbers.*—An investigation has shown that the timber of *Eucalyptus astringens* ("mallet") and *Acacia penninervis* should prove suitable for handle making. The former in particular gives every indication of proving suitable for anything but the highest grade handles. This is of importance in view of the fact that large areas of *Eucalyptus astringens* are being planted in Western Australia to supply bark for the tanning industry.

8. *Food Preservation Section.*—(i) *Chilled Beef.*—Very few data have hitherto been available concerning the rate of growth of the bacteria and asporogenous yeasts responsible for the microbial spoilage and loss of bloom in Queensland beef stored at a temperature of 30° F. (approximately). Experiments have now defined, for each of the genera tested, the critical water contents (below which growth is impossible), and also the rates of growth at various water contents above these critical levels. These results have an important bearing on the procedure adopted in the cooling and storage of beef in the meatworks, and in its transport on shipboard. In the meatworks the water contents of the surface tissues can readily be maintained at a sufficiently low level to restrict the proliferation of the most important organisms. On shipboard, however, the results of these investigations cannot be applied so confidently owing to complications due to the presence of carbon dioxide in the atmosphere.

(ii) *The Storage of Peaches and Plums.*—Investigations on the storage of peaches and plums, carried out in conjunction with the Victorian Department of Agriculture, have been in progress for three years; and promising results from the point of view of export to Great Britain are now being obtained. In the case of plums, some of these results have already been applied to commercial practice.

The optimum maturity at picking, a very important factor in the subsequent storage life and palatability, has now been defined for both types of fruit, and the most suitable temperatures for ripening after cold storage have also been determined.

Of the varieties of peaches tested, only one, the Crawford, appears to possess a sufficiently extended storage life to enable successful export to Great Britain to take place when the usual methods of storage in air at the low temperature of 32° F. are employed. Trials of the method of "gas" storage, however, showed that, by maintaining a concentration of 8 per cent. carbon dioxide in the storage atmosphere, four varieties of peaches could be kept in good condition at 32° F. for periods in excess of the normal storage life of certain varieties of plums now being successfully exported to Great Britain. Before this method of preservation can be applied successfully in commercial practice, however, it will be necessary to discover means of controlling attack by brown rot, which has its origin in the orchards.

The results of the experiments on the storage of plums have indicated that none of the Japanese varieties tested have a sufficiently long "life" at 32° F. to ensure safety in export to Great Britain. On the other hand, several European varieties have been proved to be suitable for these purposes. Unlike peaches, the storage life of most varieties of plums is definitely reduced by the inclusion in the storage atmosphere of concentrations of carbon dioxide in excess of 2 or 3 per cent.

The export of commercial consignments of plums has been proceeding for some years past, and greater freedom from wastage in such exports should accompany the application of the increased knowledge concerning the most suitable varieties and the best procedures to be adopted in their picking, handling, and transport.

9. *Other Investigations.*—(i) *Commonwealth Prickly Pear Board.*—Again it is possible to record an appreciable advance in the control and eradication of prickly pear by *Cactoblastis cactorum*. In Queensland the dense primary growth of the major pest pears is a thing of the past; and the vigorous secondary growth which followed the collapse of the primary pear is under effective control. Throughout the former dense pear country the improvement of the land for agricultural and pastoral purposes is proceeding steadily. Although the *Cactoblastis* population has suffered a great reduction with the disappearance of its food-plant, it is gratifying to note that the insect is well established wherever regrowth or seedling pear is found.

The importation of insects for the control of the lesser pest pears has proceeded, and in addition attention is being devoted to insect enemies of *Bassia* and related plants, and by the overseas collectors to the study of *Xanthium* (Noogoora and Bathurst burr) insects.

(ii) *Radio Research Board.*—During the past year the work of the Board has progressed very satisfactorily. The ionospheric and fading work, centred at Sydney University, has helped to throw light on the nature and conditions of the gases present in the region between 50 and 250 kilometres above the earth. At the University of Melbourne, a test has been initiated to determine the possible value of atmospheric direction-finders for weather forecasting.

(iii) *Mineragraphic Investigations.*—The object of these investigations, which are centred at the Department of Geology of the University of Melbourne, is to assist in the rehabilitation of the mining industry by the development of efficient methods for the extraction of valuable minerals from complex ores in which the mineral associations can only be determined by the microscopical examination of polished surfaces in reflected light. During the past year nineteen separate examinations of ores and mill products have been carried out. Twelve of these have been utilized in the Council's ore dressing investigations and the remainder by different mining companies and individuals. In addition, a comprehensive study of the iron ores of the Middleback Ranges of South Australia has been made, with special reference to the nature and distribution of manganese-bearing ore.

(iv) *Fuel Problems.*—The Commonwealth Government has invited applications for taking over the Newnes-Capertee shale field, after considering reports by the Newnes Investigation Committee and by two experts who investigated the project on behalf of the Anglo-Iranian Oil Company.

Since the completion of the Newnes Committee's enquiry, Mr. L. J. Rogers, who has been engaged in advising the Government on problems of fuel technology, has submitted a report on the preparation of alcohol from surplus wheat, and has witnessed a series of road tests of a motor vehicle using alcohol as fuel.

III. PLANT INVESTIGATIONS.

1. *General.*—It is a pleasure again to acknowledge the help given in many ways by State Departments of Agriculture, private organizations and individuals in the different investigations undertaken by the Division of Plant Industry. These investigations cover a wide field, but are of necessity limited in number. Because of their great economic importance, the major part of the Division's work is concentrated on pasture plants, wheat, apples, tobacco, and weeds.

In the case of pasture plants the various countries of the world are being canvassed with a view to collecting seed of such grasses, legumes, and herbage plants as may be of use in one or other of the pasture zones of Australia. Naturally such work requires time because testing must be thorough; but already out of the many being tested some quite promising types are becoming evident. A recent development is the initiation of actual breeding in pasture plants, whereby it is hoped to develop strains for particular purposes. Allied with the pasture plant investigations is the preparation of a first pasture map of Australia. This has been recently issued.

Wheat investigations include research into diseases such as flag smut and root rots, yield and environment, and drought resistance.

Apple problems are mainly confined to those ills which affect the storage and carriage of fruit. These are known as physiological disorders in contrast with such diseases as blackspot, canker, &c., caused by fungal and other agencies. Attention has been paid to bitter pit, water core, internal cork, &c.; and undoubtedly the work has resulted in a better appreciation of the problems of the orchardist, and in many instances in improved carriage of fruit. Recently work has been done in Tasmania which tends to corroborate the New Zealand results in the reduction of internal cork by the application of boron.

The major problems facing the tobacco industry are really two, viz., the control of downy mildew (blue mould) so that growers may have seedlings to plant at the proper time, and improvement in smoking quality of much of the leaf produced. The former is now in sight, and there is evidence of an improvement in quality which it is hoped will increase.

Weeds, like diseases and droughts, may materially affect the welfare of a district. Skeleton weed, galvanized burr, nutgrass and Noogoora burr are examples of such weeds upon which work is in progress and which form the subject of a separate report. (*See* Section V.).

During the year Mr. W. M. Carne, F.L.S., was loaned to the Department of Commerce for service in London in connexion with the fruit inspection work; and Mr. H. K. C. Mair resigned to join the Department of the Interior as Inspector for Agriculture for the Northern Territory.

2. *Plant Introduction.*—(i) *General.*—In order to carry out tests of introductions which may be more suited to summer rainfall conditions, an officer was transferred from Canberra to Gatton, Queensland, to take charge of extended trial plots; and arrangements have been made for establishing a testing area at Fitzroy Vale near Rockhampton, through the courtesy of the Central Queensland Meat Export Company.

During the year seeds of 339 additional plants were obtained from overseas, thus making a total of 5,561 from 63 different countries. Of this total 2,765 are wheats and 1,864 are grasses and legumes. There are also 165 barleys from which some good malting types may be derived, and a number of tea, rubber, oil, and fibre plants, as well as species possessing insecticidal properties. While the wheat collection is a large one, our main concern is with the grass and legume collections, especially those which may give plants suitable either for semi-arid districts or for

summer rainfall areas of the north. In applying to other countries for material it is to be expected that they will look for exchanges, and 1,040 lots of seed or roots have been sent abroad to 33 countries and dependencies. Of this 639 samples were of native species, the others (401) being seed of species and varieties already introduced.

(ii) *Cereals.*—Among the ten best wheats from the point of view of yield (36–43 bushels per acre) are Solid Straw Tuscan from New Zealand, Rooi Llama from South Africa, Italian 13, an unnamed wheat from Mexico, and a hybrid of two Australian wheats (Florence x Gluyas) from South Africa. None has proved better than Waratah or Canberra. Club Mariout among the barleys has given evidence of good malting quality and it is a good yielder.

(iii) *Grasses.*—In the plots at Duntroon, Federal Capital Territory, good results were again obtained with *Agropyron cristatum, A. intermedium, Brachypodium phoenicoides,* strains of *Bromus inermis,* Uruguayan strain of *B. unioloides,* Oregon strain of *Festuca elatior,* strain of *Dactylis glomerata* from southern France, *Phalaris stenoptera,* &c., and among the more recently introduced are *Agropyron sibiricum, A. desertorum,* a vigorous Russian strain of *A. cristatum, A. elongatum, Panicum obtusum* (a good soil-binder from Arizona), *Calamagrostis epigeios* and *Elymus giganteus* (also soil or sand-binders).

At Gatton College (Lawes, Queensland), grasses which are under special observation include such as *Ischaelmum laxum, Brachiaria brizantha, Pennisetum ciliare, Panicum virgatum, Digitaria pentzii.*

(iv) *Legumes.*—Of the large number of leguminous plants that are being tested and which are worth study, only a few can be mentioned at present. The Hairy Peruvian, Cape, and Chinese varieties of lucerne continue at least to equal the Hunter River variety in yield. A lucerne from Turkey and a lucerne-like legume from Bolivia are very vigorous. *Medicago coerulea,* a drought-resisting lucerne from the semi-desert regions of Transcaucasia, and a *Medicago falcata* from the Volga region, are also promising. A number of clovers which are showing valuable characteristics come from the Caucasus or neighbouring regions, and include *Trifolium repens v. giganteum, T. tricho-cephalum, T. tumens, T. canescens, T. ambiguum,* &c. A legume from Arizona known as *Phaseolus Metcalfei* may be suited to semi-arid country, and *Medicago getula* from Algeria shows some promise of being suitable for rather dry conditions. *Lespedeza striata* (Japan clover) and *L. stipulacea* (Korean Japan clover) continue to re-establish themselves each season by self-seeding in Canberra.

At Gatton College trials of *Crotalarias, Lespedezas,* cowpeas, various fodder beans, &c., are in progress; and particular interest attaches to *Stylosanthes guyannensis* and *Alysicarpus longifolius* because of their possible worth in northern areas.

(v) *Plot and Sward Studies.*—The productivity of certain species of introduced pasture plants has been tested by using sixteen mixtures at Duntroon. Mixtures which carried lucerne were the more productive, even though the seeding rate for lucerne was low.

The grasses recently reported on for persistency under grazing (*vide* Pamphlet 59) are being examined for productivity, and other introductions are under study for persistency.

(vi) *Detailed Studies of Grasses.*—As preliminary work demonstrates the possible value of any grass or legume, that plant is subjected, as soon as time will allow, to special closer study. Five grasses have been so treated and the results published recently as Pamphlet No. 63. The grasses are *Agropyron intermedium, Agropyron cristatum,* native to the steppe region of U.S.S.R., *Brachypodium phoenicoides* from the Mediterranean, *Ehrharta erecta* from South Africa, and *Festuca Mairei,* a native of Morocco. *Ehrharta erecta* is more suited to warm-winter areas, while the others should be suited to the pastoral region having from 15 to 35 inches of rain and known as the "Mediterranean Zone."

(vii) *Pasture Map of Australia.*—This map, which is to be regarded as a base map, is now issued with the description of the fourteen major pasture zones as Bulletin No. 99. From page 18 to page 56 the description is technical and detailed, but the general reader will find the same zones discussed less technically on pages 10 to 18. It is hoped that the work will stimulate interest in pasture zones and types and that more information will be available against the time when a revised printing is required.

3. *Pasture Plant Improvement.*—The necessity of having the best types of pasture plants in Australia is well recognized, and during the year consideration was given to the desirability of the Council entering the field of pasture plant breeding. In the first place information was obtained from the State Departments of Agriculture on the work which they were doing in order to avoid unnecessary duplication. Subsequently an arrangement for co-operative work was made between the Council and the Departments of Agriculture and Stock and Public Instruction of Queensland to undertake pasture plant breeding. The investigations are being done at the Queensland Agricultural College, which is providing land, laboratory, and office accommodation. An officer of the Division was recently transferred from Canberra for this work.

4. *Fruit Investigations.*—These cover work in Tasmania on non-parasitic diseases of apples; on sultana vines at the Viticultural Research Station, Merbein, Victoria; on citrus problems at the Citricultural Research Station, Griffith, New South Wales; and at Stanthorpe, Queensland, mainly on stock and scion relations for apples.

(i) *In Tasmania.*—The investigation of physiological diseases of fruit in the field and disorders following storage has been continued.

(*a*) *Storage Tests.*—These have been conducted with the same varieties as in 1935, and further data have been obtained for correlating storage capacity and the occurrence of disorders in the fruit with field conditions such as climate, soil type, crop size, and maturity, as well as delay in storage and storage temperature. Pre-storage treatment with carbon dioxide as a means of preventing low temperature breakdown was extended to cover two pickings of five varieties.

(*b*) *Chemical and Physiological Tests.*—Results similar to those reported for 1935 were obtained. These tests are being used to investigate differences between varieties and different sized crops of the same variety, as well as rates of ripening in respect to the relative lateness or earliness of the season.

(*c*) *Storage Disorders.*—Storage pit was again practically confined to Cox's Orange Pippin and was serious with light crops. Climatic conditions being favorable to good keeping quality, there was less liability to low temperature breakdown. In view of the widely held belief that liming decreased liability to breakdown, a trial was made with a limed plot but without positive results. The disorder did not occur or was negligible in Jonathan, Democrat, French Crab, Sturmer Pippin, and Scarlet Pearmain, which varieties were susceptible in 1933, for example. Water core breakdown may develop in late-picked Cox's Orange Pippin, Jonathan, and French Crab. The practice of allowing Jonathans to hang late for colouring is likely to give rise to wastage in years of high temperatures.

(*d*) *Disorders in Fruit on Trees.*—Tree Pit was worse in 1936 than in 1935. Cleopatra on shallow and inferior soils suffered severely; while Sturmer Pippin suffered to a lesser extent where fruit was dwarfed by drought; but the disorder was more widespread where fruit attained a normal size. The relation of pruning methods to the incidence of this disease in Cleopatra was again investigated.

Internal Cork was more serious than in 1935, areas free in that year being affected in 1936. A series of experiments to test the hypothesis that this disease is a result of boron deficiency were laid out in eleven orchards, and four different methods of applying the boron were used. It was found that applications of boric acid markedly reduced the incidence of the disease in Sturmer Pippin and Granny Smith varieties, but had no appreciable effect in Cleopatra. In the case of pears the treatment was not successful.

Water Core.—This disorder was very prevalent in large-fruited and light-crop French Crabs, but of moderate intensity in Cox's Orange Pippin and Jonathan. On the whole this disease was worse than in 1935.

Superficial Drought Spot appeared in Scarlet Pearmain from trees on shallow soil.

(ii) *Growth and Bud Studies.*—Studies of the fundamental phases of shoot growth and development and the relation of cyclic growth periods to environmental conditions in the sultana vine have been continued along the lines previously reported.

(iii) *Investigations in the Irrigation Areas.*—At Merbein, Victoria, experiments on the sultana vine dealing with the relations between shoot growth, the accumulation of starch and nitrogenous compounds, the current season's crop, fruit bud formation and yield in the following season have been continued. It has been found that the mean weight of prunings may be taken as a useful index for defining the vegetative vigour and also the yield potentialities of a block of vines. On the other hand, except in the case of vines of low vigour, there is little correlation between the amount of shoot growth and the yield of the following season in individual vines of the same vineyard. The quality of the shoot growth is more closely associated with the amount of fruit produced. Uninterrupted and sustained shoot growth during the period September to February is conductive to the accumulation of reserve starch, the proper maturation of the shoots, and the formation of fruit buds. These findings are not in agreement with a current conception that the vines require a mid-summer rest in order to obtain the best results. One of the most important of the factors which depress shoot growth, and which retard the accumulation of reserve starch and the formation of fruit buds, is the presence of the current season's crop. The heavier the crop the more necessary it becomes to maintain continuous shoot growth during the September–February period in order to ensure the proper development of fruit buds for the following season. The question of the renewal of shoot elongation growth subsequent to February (i.e., during period March–April), is being investigated.

Experiments dealing with the practice of summer pruning or tipping have been concluded; and results confirm the conclusions previously reported. It has also been found that the practice of cincturing sultana vines is not to be recommended; while disbudding or the removal of barren shoots also has a detrimental effect upon total growth and production.

In the Murrumbidgee Irrigation Areas a survey has been made of the "decline" of citrus trees, which has been manifest during the past few years. The acreage under citrus has decreased since 1931, while production following a drop in that year has since increased at an accelerating rate. The primary cause of the high death rate of the trees since 1930 has been attributed to extensive soil waterlogging caused in the first place by over-irrigation, but accentuated by extraordinarily heavy rains during the winter of 1931. Severe root injury incurred about this time has resulted in the gradual decline and death of many trees. These conditions have been aggravated by a certain amount of neglect of orchard cultivation on the part of growers. Neglect has been due in a large measure to the depressed economic conditions during the period 1930–1934.

The nutrition of citrus trees is a problem which is becoming increasingly important in the irrigation areas; and as part of a comprehensive investigation in this regard, studies have been initiated to determine the role of mycorrhiza in citrus root absorption. The progress of investigation in respect to the alternate cropping of Valencia oranges is recorded under the Citricultural Research Station, Griffith (page 49).

(iv) *Investigations in Queensland.*—The propagation of root-stocks for apples, pears, and plums has been continued in the nursery area on the Government reserve at Stanthorpe. These stocks include East Malling Nos. I. II., VII., IX., XII. and XVI., Northern Spy, Ben Davis, Emp. Alexander, Duchess of Oldenburg, Transparent de Croncels, Winter Majetin, Zuccamaglio, Niedwetzkyana, Lady Carrington, Kirks, Allsopp's Early, Reinette Seedling Pomme de Niege, four Merton and some ten unnamed local stocks for apples; Myrobolan B, Pershore, Brompton and Common Mussel for plums; and East Malling Nos. C2, C6, C7, D4 and D3 for pears. Of these the following, viz., Malling Nos. XVI., XII and I., Northern Spy, Seedling Pomme de Niege and two of the selected local stocks have been budded to Granny Smith and Jonathan, and sufficient trees obtained for planting out in a permanent field trial next season. The remainder are subject to experiment and observation in the nursery to determine the best means of propagation for each variety, compatibility with the principal scion varieties of the district, rooting characteristics, relative vigour, &c. In preliminary nursery experiments on the propagation of varieties on their own roots, of apples only two, Marjorie Hay and Mona Hay, rooted satisfactorily from cuttings of one-year-old wood. Layer beds of some 30 varieties were established during the past season to extend this aspect of the investigations. A number of vigorous East Malling stocks have been planted in the field alongside trees on Spy stock and marched (grafted) into their trunks, in order to determine whether additional vegetative vigour may be imparted by these means.

A beginning has also been made in the investigation of nutrition problems associated with fruit culture in the Stanthorpe area. A certain type of leaf blotch, which is prevalent among apple trees in the district has been shown to be caused by a deficiency of lime in the soil. Preliminary trials to test the effect of injecting certain salts into the trunks and main limbs of trees have been initiated.

5. *Wheat Investigations.*—(i) *Flag Smut.*—As experiment has shown that all varieties of wheat are equally susceptible to infection by the flag smut organism over the range of soil temperature normally prevailing at the time of germination, the environmental factors involved in the relative field resistance of different varieties are under investigation. The resistance of certain varieties to manifestation of the usual symptoms is greatly influenced by variation of soil and air temperature after germination. Different varieties do not appear to react to these factors in the same general way.

Further tests are being made to ascertain whether the selection of individual plants for reaction to the disease in generations later than the F2 is of any value, it having been shown to be of no use selecting in the F2 generation.

The data from an experiment, noted in last year's report, planned to determine whether or not there is an association between yielding ability and reaction to flag smut, have yet to be analysed.

(ii) *Root rot.*—Work on the influence of three of the organisms concerned in the complicated problem of root rot was continued in the greenhouse and field during the year. Experiments on the joint action of certain smuts, and on the influence of deficiency or excess of soil moisture,

of toxic compounds, and of different methods of inoculation, gave inconclusive results under greenhouse conditions. In the field there was no detectable difference between control plants and others inoculated with a moderately large amount of the three principal root rot organisms.

A paper on *Wojnowicia graminis*, an organism commonly found on wheat, is now ready for publication. Until about ten years ago this organism was thought to be important economically. It is now concluded, after thorough study, that it does not reduce the yield of wheat, and consequently may be eliminated as a factor in root rot of wheat.

(iii) *Yield.*—The variety experiments were continued at Canberra, Wagga, Adelaide and Merredin, and with improved technique quite good crops and useful data were obtained.

The experiment to determine whether a highly fertile soil would be more useful in differentiating varieties with respect to yield showed that there was no significant difference between the results from a highly fertile and a poor soil. There did appear to be significant differences at different spacings; but in the 1935 experiment this could be attributed solely to difference in maturity. This trial is being repeated.

The work on inheritance of yield and methods of selection for yielding ability has been continued.

An experiment has been commenced to determine the loss in yield in wheat varieties, both resistant and susceptible to stem rust, when they are subjected to a rust epidemic.

(iv) *Drought Resistance.*—The work on drought resistance of wheat has been continued with the object of determining physiological characters associated with drought resistance and, if possible, to discover a reliable method for indicating the relative drought resistance of small samples. Examinations of the bound and free water of expressed sap have been made and the results related to soil moisture content. A further experiment on exosmosis of injured roots was conducted, but the results of the previous experiment were not confirmed.

A determination was made of the rate of absorption of water by germinating grains of different varieties of wheat. Significant differences in rates were obtained but it is doubtful whether these are associated with drought resistance.

(v) *Grass Clumps.*—As a result of study over several years the inheritance of grass clumps in common wheats can be accounted for on the basis of a 4-factor hypothesis. About 100 varieties have been classified into groups the results of the intercrossing of which have been determined. This information should be useful to the plant breeder in planning crosses, because he will be able to forecast the occurrence of grass clumps.

6. *Tobacco Investigations.*—(i) *Diseases.*—During the year effort was largely concentrated on the control of downy mildew by benzol, but attention was given to other phases of the downy mildew problem and to other diseases.

(*a*) *Downy Mildew or Blue Mould.*—Field experiments on the prevention of downy mildew by benzol and other hydrocarbons were made during last spring, officers of the Division superintending the work at three stations—Eurobin, Victoria, Ashford, New South Wales, and Canberra, Federal Capital Territory. Thirty-six covered seed beds were used for the purpose at Eurobin, two at Ashford, and three at Canberra. Blue mould did not occur in any of the beds protected by benzol, whereas those that were untreated were either thoroughly diseased or altogether destroyed. At Eurobin, toluol was used in two beds; and after the seedlings were inoculated with a heavy suspension of conidia in water, a few diseased plants were observed. No disease occurred in the toluol bed at Ashford. Six to ten thousand plants were obtained from each treated seedbed. Costs in connexion with the use of vapours can be considerably reduced. Experiments are now in progress on this phase of the work. The objective in the experiment on the use of vapours during the last seedbed season was to prevent the disease under conditions that were otherwise optimal for its occurrence and spread. Up to the present, benzol is the only hydrocarbon that has given completely satisfactory results; but varying degrees of control have been obtained with others. All seedlings grown in covered beds, whether hydrocarbons were used or not, were noticeably free from attack by insect pests.

The results obtained with benzol vapours at Canberra and elsewhere have now been confirmed under a wide variety of weather conditions by the State Departments of Agriculture of Queensland, New South Wales, Victoria, South Australia, and Western Australia.

During the past season tobacco seedlings at three field stations were sprayed with copper emulsion, colloidal copper, or Bordeaux mixture, for the control of downy mildew. The sprays did not prevent the occurrence and spread of the disease, but in some instances delayed its appearance for a few weeks, during which time healthy transplants were occasionally obtained. Copper emulsion and colloidal copper were almost equally effective and both were much superior to Bordeaux mixture. Sprayed seedlings failed to transplant satisfactorily in nearly all cases.

The use of heated seedbeds of the Bathurst type at Ashford and Wangaratta, and the Marks' seedbed at the latter place, did not prevent the occurrence and spread of downy mildew.

The results of the experiments with heated seedbeds support the view, expressed by other investigators, that satisfactory control of the disease is not likely to be obtained by their use.

(*b*) *Dwarfing.*—The repeated occurrence of this condition in tobacco fields in Victoria and New South Wales, and a particularly severe outbreak at Pomonal, Victoria, last season, have emphasized the necessity for determining the cause and developing methods of control. In some fields at Pomonal, practically all plants were dwarfed, and all crops were more or less seriously affected. Experimental work is proceeding at Canberra, and will be continued in the coming season in the greenhouse and field.

(*c*) *Virus Diseases.*—The increasing importance of virus diseases has necessitated attention to the problem. A preliminary survey of their occurrence in Tasmania and Victoria was made and a plan of work on spotted wilt, the most serious disease observed in Tasmania, was drawn up. This will be undertaken by the tobacco expert of that State. Mosaic was commonly found in both States, but was of comparatively little importance. Spotted wilt was observed for the first time at Shepparton and Eurobin, Victoria.

(*d*) *Fermentation Studies.*—The organisms associated with or likely to affect the fermentation of flue-cured tobacco and their influence, if any, on smoking quality are being investigated.

(ii) *Smoking Tests.*—The several State Departments of Agriculture submitted farmers' samples of leaf from the different tobacco-growing districts. In some cases it was apparent that not enough samples were collected to give a true indication of the general quality. However, on the whole there has been an increase in the production of the bright and better types of leaf during recent years. The results of tests of the 1935 samples are given in the accompanying table.

State.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.	Tasmania.
Samples received	9	37	232	7	7	7
Per cent. good smoking quality	66	45	90	43	71	57

It is to be recalled that the proportion of good useable leaf is based on the samples submitted only.

Referee samples of 48 tobaccos from the United States of America have been distributed to State and Commonwealth officers for report on quality.

(iii) Further curing experiments were conducted at Wangaratta with leaf grown on rich river flat soils in the Markwood and Myrtleford districts. Smoking tests on the product have not yet been made, but with leaf similarly cured in 1934–5, and aged one year, they indicated an improvement on smoking quality where the curing period had been prolonged beyond the usual six days.

(iv) *Maturing and Processing.*—Preliminary tests of district leaf which has been matured (aged) show that the bright leaf from Western Australia improves considerably in burning and in general smoking quality after one year's maturing; while the free-burning tobacco from some Queensland districts, which irritates the mucous membrane if smoked too soon after curing, is mellowed down when kept in suitable condition for a year or more.

Experiments on the processing of heavier types of tobacco indicate that the addition of carbohydrates improves the smoking quality of such leaf.

(v) *Chemical Investigations.*—Chemical analyses were undertaken with a view to determining the chief products of combustion which give the characteristic smoking qualities of the various types of tobacco. From these it may eventually be possible to suggest such modifications in field culture, of curing processes, or of ageing and manufacturing methods, as will raise the quality of the finished product.

Further work on the resins and waxes of tobacco has demonstrated that these constituents, while playing their part in moulding the general aroma, do not appear to be of as great importance in this respect as was at first believed. An attempt was made to estimate sugars in leaf samples, and to determine the effect of topping, suckering and shading on the chemical composition of the leaves. Following the resignation of Mr. N. F. B. Hall this work has been temporarily suspended.

(vi) *Physiological Studies.*—Arrangements have been made whereby Dr. A. H. K. Petrie of the Waite Agricultural Research Institute is undertaking investigations of nutritional problems. As smoking tests and fertilizer trials have indicated the importance of nitrogen and phosphorus, attention is being given to the total nitrogen content of leaves and their protein-nitrogen content as governed by the phosphorus supply and by topping. Estimation of organic acids, phosphate and total nitrogen in leaf samples, and the statistical work and preparation of data of the first experiment will occupy the attention of Dr. Petrie's two assistants for the next twelve months.

(vii) *Disease Resistance.*—The disease resistance work has been aimed at downy mildew. Before any actual breeding can be commenced it is necessary to obtain, as a basis, types possessing some degree of resistance. As no known commercial variety is resistant, a search is being made to obtain a large collection of samples of seed from as many sources as possible. To date 277 samples have been obtained from 14 different sources. Many of these have been tested for reaction to the disease but they have proved susceptible. Others remain to be tested.

If no resistant *Nicotiana tabacum* is obtained there remains the possibility of resistance in other species. This is being investigated in the same manner, although East, an American investigator, who has worked with *Nicotiana* crosses for many years, maintains that it is very unlikely that anything of commercial value can be obtained from inter-specific crosses.

No samples of seed from disease-free plants in heavily infected fields have been received for testing.

(viii) *Tobacco Conference.*—In July, 1935, technical officers from all States and the Commonwealth held a very successful conference at Canberra, at which a free interchange of views and discussion of work took place. As a result closer co-operation is now being maintained between all officers concerned with tobacco, especially in connexion with disease investigations and smoking tests ; and the exchange of information by means of half-yearly progress reports has been arranged.

7. *Virus Diseases of Potatoes.*—Over a century ago potato growers in the south of England found that their stock began to develop curly leaf symptoms and yields went down ; and to counter this degeneration they imported potatoes from Scotland. It is now known that this running out or degeneration is due to virus diseases, of which there are a number. Some occur in every potato-growing country ; and all the common varieties of potatoes are subject to infection by one or more viruses. The losses vary from slight to heavy, and even in a crop which exhibits little evidence of high infection, yields may be reduced by something like 20 per cent. Paddocks have been inspected in which the crop was so heavily diseased that it was not worth digging.

The virus diseases of potatoes have been described from the symptoms occurring in the varieties commonly grown in the major producing countries, so that a knowledge of varieties is essential to a correct interpretation of virus symptoms in Australian, English, and American potatoes. Arrangements have been made with several Departments of Agriculture to obtain stock material in order to make a survey of virus content and symptoms for Australian types. In addition the investigation will concentrate on the possibility of obtaining absolutely virus-free stock of the important varieties.

8. *Pea Disease.*—The study of root rot of peas was continued in the greenhouse and experimental plots during the year. Attention was directed mainly to the role of nitrogenous fertilizers. Under the conditions of the experiments it was found that they controlled the disease, increasing yields to such an extent as to justify the expectation that it will be economically practicable to use them under field conditions. Arrangements have been made for field experiments over a number of years to be carried out in a small experimental area in Tasmania.

9. *Needle-fusion of Pines.*—This disease appears to be of importance only where pines are growing under adverse conditions. Diseased trees replanted in good soil apparently recover, but become diseased again on replanting in poor soil. Affected trees were treated with compounds of about 30 mineral elements, to determine whether the disease is due to a lack of any of these elements. Insufficient time has elapsed since the treatments were made for any conclusions to be drawn. Since annual observations were begun, the rate of spread has varied considerably in different species of pine. A progress report has been prepared for publication.

10. *Fungal Discolouration of Paint.*—On account of the fact that painted panels have to be exposed to outdoor conditions in Brisbane for at least a year before any differences between treatments are apparent, progress with this problem is relatively slow. No great differences due to variation in the linseed oil vehicle were discerned after exposure for twelve months ; but, under the same conditions, there were slight differences in favour of certain combinations of pigments. In this connexion it is of interest to note that certain vapours used in attempts to control blue mould of tobacco had a definite influence in controlling fungal discolouration of the seed bed covers.

11. *Herbarium.*—In November, 1935, the control of the herbarium was entrusted to the Weeds Investigations Section. Loose specimens which have been permanently mounted since that time total 1,200. The herbarium has been transferred into new quarters ; all specimens were poisoned during transfer (5,083 specimens) and classified. The distribution of four major families represented is :—*Graminae* 462 ; *Leguminosae* 719 ; *Myrtaceae* 939 ; *Compositae* 503. A general collection of 646 specimens from Papua has been added during the year. The material in the herbarium is at present being checked and catalogued.

12. *Maize Breeding.*—The maize breeding programme at Gatton has been continued. Some of the " single " and " double " crosses of inbred strains have maintained their early promise, and have greatly outyielded the parent varieties from which they were derived. Further tests are being conducted.

IV. ENTOMOLOGICAL INVESTIGATIONS.

1. *General.*—While most of the work of the Division of Economic Entomology is centred at Canberra, a considerable amount of field work is also undertaken, and investigations have been made in every State and Territory of the Commonwealth. Moreover, as the introduction

of beneficial insects from abroad forms an important part of the Division's work, officers are stationed in other countries for the purpose of studying natural enemies of weeds and insect pests. These studies are at present centred in England, the south of France, and the United States, while similar work in Fiji has been arranged. In the course of its work the Division has received valuable co-operation and assistance from other Divisions of the Council, from State Departments and research institutions, from growers' organizations, and from many individuals n Australia, as well as from institutions and individuals abroad. This co-operation and assistance is cordially appreciated.

The scope of the Division's work is wide, and includes investigations into pests of stock, pastures, crops, forests and timber, stored foodstuffs, and the garden and household, as well as studies of beneficial insects which may control noxious weeds, and research into disease of hive bees. Some of these problems are of greater economic significance or are more complex than others, and therefore require more elaborate and intensive investigation. Consequently, noxious weeds research, blowfly research, white-ant research, and pasture pests research form the main sections of the Division's activity, the other problems being distributed among these sections as subsidiary investigations.

2. *Noxious Weeds Research.*—As this research is now jointly administered by the Divisions of Economic Entomology and Plant Industry, the report of the work undertaken is included on page 29 in a separate section in which all phases of the work, both on the entomological and botanical sides, are reviewed.

3. *The Sheep Blowfly Pest.*—(i) *Organization.*—The Divisions of Economic Entomology and Animal Health and Nutrition have been brought into closer association by the appointment of an Inter-Divisional Blowfly Committee comprising Drs. J. A. Gilruth, L. B. Bull, A. J. Nicholson, and I. M. Mackerras. Dr. L. B. Bull has been co-opted as a member of the Joint Blowfly Committee, which co-ordinates the work of the Council and the New South Wales Department of Agriculture, and Mr. W. L. Hindmarsh was appointed to that Committee in place of Professor H. R. Seddon. It is appropriate here to place on record the Council's appreciation of the work done by Professor Seddon in the field of blowfly research, and as a member of the Committee.

(ii) *Studies of the Flies.*—Maggots have now been identified from more than a thousand cases of strike in different parts of Australia. Analysis of the records shows that *Lucilia cuprina* is present in 80 per cent. of strikes, that in the remaining 20 per cent. *Calliphora augur* (including *C. nociva*) is the most frequent primary fly, with *C. stygia* (including *C. australis*) next in importance, and that *Lucilia sericata* is rare as a primary sheep-striking fly in this country. It has found that temperature influences the maturation of the eggs of *Lucilia cuprina*, that lowered temperatures at night cause a considerable increase in the time required for maturation, and a reduction in the number of eggs produced, and that these findings can be associated with the occurrence of experimental strikes in the insectary. Field observations have shown that *L. cuprina* is particularly well adapted to live in arid country, and the mechanism of this adaptation is being studied. It has been found so far that increasing the rate of desiccation by passing a current of dried air over carrion causes a retardation of growth rate of the maggots living in the carrion, with the production of under-sized prepupae, but does not affect survival.

The study of substances which attract or repel blowflies has been continued. Much of the work has been designed to check results previously obtained and reported last year ; but further progress has also been made in various directions, notably (*a*) in the fractionation of the egg-yolk sulphide bait, which has been reduced to a relatively simple attractive residue after distillation of the attractive filtrate obtained from a lecithin-sulphide preparation ; and (*b*) in the discovery that certain volatile compounds, such as acetic acid, restore the attractiveness of old baits, when exposed so that they do not mix with the bait but their odours mingle with the emanations from the bait. The usual tests of supposed repellents have not been reliable in the past, and a simple method has been developed for mixing the odour from a substance to be tested with that from an attractive bait without affecting the composition of the bait. Using this method, many substances which have generally been regarded as repellent have been shown to possess no true repellent properties. In fact, the only substances which have so far been proved to be truly repellent are the halogens, iodine and chlorine.

(iii) *Studies of the Sheep.*—(*a*) *Field Studies.*—It is now well known that the conformation of the breech influences predisposition to breech strike, but little has been written about the relative importance of different parts of the breech. An attempt was therefore made to assess this by defining the different sections of the breech and recording the number of natural field strikes that occurred on each section in a flock of ewes kept under continuous observation. It was found that nearly 90 per cent. of all breech strikes involved the inner breech folds, about 50 per cent. being restricted to these folds. 6 per cent. of strikes started on the tail, and the remainder were divided between the perineum, the true crutch, and the outer breech area.

(*b*) *Experimental Studies.*—The clinical course and pathology have been studied in controlled artificial strikes, as well as in strikes occurring under natural conditions. It has been found that the maggots can produce perceptible injury to the skin in four to six hours after hatching, and that by the third day the skin and subjacent tissues are extensively inflamed, the epithelium is denuded over extensive areas, the wool follicles and glands are disorganized, the body temperature has risen to 104–105° F., and the animal is sick and wretched. The temperature rises further on the fourth day, and at this stage a break may develop in the general body fleece. The maggots begin to leave on the fifth day, after which the temperature gradually falls to normal, and healing takes place by simple resolution without scarring and without effect on the subsequent growth of a new fleece. The chief complications of strike are ; extension (by development of additonal maggots from eggs deposited on the highly attractive struck area), break in the fleece (which may be restricted to the struck area, when it is due to the inflammatory disorganization of the wool follicles and occasionally to bacterial decomposition of the fibres, or widespread, when it is an expression of the general constitutional disturbance), sepsis in the strike wounds, death (due to exhaustion and toxic absorption, or possibly to invasion by highly virulent bacteria).

Artificial and experimental strikes have now been produced under a considerable variety of conditions. During the past year these have been extended by producing artificial strikes on scoured, shorn areas protected by a cellophane covered pad, and by producing in the field experimental body strikes by continuously wetting the fleece along the back of merino sheep. These results, taken in conjunction with earlier experimental studies and with field observations, show clearly : (*a*) that the one condition essential for all forms of strike is that the fleece should be palpably wet right through to the skin, and remain wet for periods varying from a few hours for artificial strikes up to several days for natural or experimental field strikes ; (*b*) that inflammatory changes in the skin and bacterial activity in the fleece are important accessory conditions influencing the occurrence of strike, especially under field conditions ; and (*c*) that the various conditions which are known to predispose a sheep to be struck act by favouring the deposition and retention of moisture in the fleece, or by rendering the area more quickly attractive to the flies and the skin more easily invaded by the maggots, thereby decreasing the time for which the area must remain wet, or by supplying the newly-hatched maggots with readily assimilable food.

In view of the importance of free moisture, studies of the " wettability " of the fleece have been initiated, and have been associated with an examination of its form, characteristics, and chemical composition.

(iv) *The Prevention of Strike.*—(*a*) *Carcass Disposal.*—The chief difficulty remaining to be overcome in the treatment of carcasses with a powdered poison was to discover a substance which would be as effective on the body of a sheep in full wool as on a shorn or skinned animal. Borax, diluted with one or two parts of inert dust, has been found to be superior to sodium fluoride for the treatment of a shorn carcass, and just as effective on the long-woolled as on the shorn animal. Moreover, it is less poisonous than sodium fluoride to dogs or other animals that might eat the carcass.

(*b*) *Trapping.*—The final experiment at " Cranmore Park " has been completed, and the results of the " Cranmore Park " and " Therribri " experiments have been analyzed. These experiments have demonstrated conclusively that intensive trapping decidedly reduces the incidence of strike in sheep. They were not designed to show whether trapping is an economical measure to adopt in station practice, and further work is required to elucidate this point. Work on the chemical treatment of baits has been continued, and suggests that calcium sulphide may prove superior to sodium sulphide for this purpose. The studies of the compounds responsible for attracting primary flies hold out the hope that useful artificial baits may perhaps be discovered.

(*c*) *The Mules Operation.*—The large-scale field experiment in Queensland has so far given inconclusive results ; but some aged ewes treated at Canberra have shown a decided improvement in breech formation, which has been maintained for twelve months, and a decided reduction in strike incidence, both as compared with their previous history, and with other sheep in their original conformation class. Work is being undertaken to determine how far the improvement in conformation is maintained in sheep treated at various ages.

(*d*) *Swabbing.*—Experiments with the glycerine-boric acid preparations suggested that they might have some preventive value as swabbings, and subsequent field experience of graziers strongly suggests that they are useful applications for the prevention of head strikes in rams. These preparations, made from pure glycerine with strong heating, were, however, thought to be too expensive for routine application to the breech of flock ewes. A field experiment was therefore set up, in which a cheap and relatively simple preparation made with crude glycerine was swabbed on the breeches of ewes, but it gave no protection.

Tailing wounds in lambs present a special and difficult problem. In these there is a raw bleeding surface on which dressings will not remain. The only effective preparation would be a repellent, which would keep flies off when merely smeared on the fleece around the wound;

and a search is being made for an effective repellent. As mentioned above, iodine and chlorine (used as a bleaching powder) have been shown to possess some repellent action. Artificial "lambs' tails" were then made, an attractive bait representing the wound and a wrapping of wool representing the fleece-covered stump. These "tails" were treated with bleaching powder, care being taken that none of the powder came in contact with the bait. They were exposed, together with similar but untreated control "tails" in the field. Flies laid eggs on all, but much more heavily on the controls than on the treated "tails". This work will be continued next year, when dressings containing chlorine will also be tested on actual tailing wounds.

(v) *The Treatment of Strike.*—The glycerine-boric acid dressings have been tested further under insectary conditions, with good results. It was found that dilution of the di-boric preparation with 25 per cent. of ethyl alcohol improved the consistency, shortened the time required to rid the strike of maggots, and slightly cheapened the preparation. Commercial methylated spirit did not prove satisfactory for dilution, but alcohol denatured with up to 5 per cent. of methanol was suitable. It was also found that ordinary soap-crude glycerine was unsuitable for the preparation of the dressing. Commercial manufacture is now being undertaken by various firms, and generally very favorable reports have been received from graziers who have used the alcohol-diluted diboric preparation. It is suitable for treating all forms of strike, and as a preventive swabbing on the heads of rams; but it is not satisfactory as a preventive application on fresh tailing wounds in lambs.

4. *The Buffalo-fly Pest* (*Lyperosia exigua*).—Four years ago, various races of *Spalangia orientalis* and *S. sundaica* were liberated at Burnside Station, North Australia. During the past autumn the abundance of buffalo-flies, the extent of the injuries they produce in stock, and the incidence of parasites have been re-examined at Burnside, Marrakai, and the Daly River. This survey has shown that the parasites have not produced any detectable effect on the abundance of buffalo-flies, or on the damage they cause. It will consequently be necessary to search for other natural enemies or competitors that may possibly be effective.

5. *Blood Parasites of Cattle.*—This investigation has been undertaken at the request of the Division of Animal Health and Nutrition. Work at Canberra in the past year has been restricted to the maintenance of pure strains of *Anaplasma marginale*, *A. centrale*, *Piroplasma bigeminum*, *Babesia argentinum*, and *Theileria mutans*. These are maintained by sub-inoculation at suitable intervals, and are available for the use of workers who find difficulty in maintaining pure infections in tick-infested districts.

6. *Orchard and Fruit Pests.*—(i) *Peach Moth* (*Cydia molesta*).—During recent years the loss of fruit due to moth infestation has steadily increased, culminating in the serious outbreak in the season 1933–34. The loss in the 1934–35 season was 20-25 per cent. but in 1935–36 was estimated at 50-52 per cent., which was almost as serious as the outbreak of 1933–34. These facts suggest that heavy infestation has become normal and that outbreaks are unlikely to be merely sporadic. These losses are so great that they threaten the existence of the canned peach industry.

Although peaches are the chief fruit attacked by the moth, almond fruit and twigs, apricot fruit, plum twigs, pears and quinces may also be attacked. The larvae of the first and second broods cause extensive damage to young succulent tips, a single larvae attacking three tips in the course of its feeding period. The larvae of the third and fourth broods attack the fruit. Injury to quinces and late season's growth on young peaches and almonds is caused by the fifth brood larvae.

The special difficulty of control by spraying is due to the habits of the larvae and the vigorous growth of the peach. New tissues are rapidly produced throughout the season, so that cover sprays cannot long remain effective. This rapid production of new growth, and the variation in the time of brood emergencies in different orchards throughout the district, makes it necessary to time very accurately the application of sprays, so that each spray is applied at a time when the vulnerable stages of the insect are present. The time for spray application may be determined by the use of lures in the orchard, 10 per cent. "Golden Syrup" in water being the best of those tested. There are two vulnerable stages against which control can be directed—the egg, and the newly-emerged wandering larva; any tozic spray material directed against these stages must act both as an ovicide and as a larvicide. Only nicotine sulphate has been found to be effective in both these capacities. Field experiments with this substance have shown it to be a satisfactory toxic agent. Its chief disadvantage is that its effective period of toxicity is too short.

During 1935–36 a substance named Kolofog, which is a bentonitic clay fused with sulphur, was imported from America in an attempt to "fix" the nicotine sulphate and so lengthen its toxic period. Previously it had been found in America that this substance increased the toxic period of nicotine up to 32 days. Tests of a mixture of this substance and nicotine sulphate on foliage sprayed in the field showed that under Australian conditions toxicity was maintained

up to 29 days, and that it acts as a deterrent to oviposition, as an ovicide, and as a larvicide. Dry-mixed lime and sulphur together with nicotine sulphate was found to be the next best spray; but the toxic period of the nicotine was not increased. All the accumulated evidence shows that nicotine does exert a controlling influence on the moth.

Additional methods of control, which are under investigation, and which have given indications of being decidedly helpful, are bandaging the trunks of trees, deep cultivation, and general orchard sanitation.

Two parasites, *Macrocentrus ancylivorus* and *Glypta rufiscutellaris*, have been successfully introduced from America and small numbers have been liberated in a heavily infested area. Further introductions from America will be made; and it is proposed to breed large numbers in the Goulburn Valley prior to liberating them. In America it has been found that *M. ancylivorus* is quite successful in many States; but there are, however, areas where it has failed to establish itself and effect a control of the oriental peach moth. It is very sensitive to low humidities and high temperatures; and, while it is probable that this parasite may be able to establish itself in the Goulburn Valley, no guarantee to this effect can be given. In America *Glypta rufiscutellaris* requires an alternative host, which lives in a weed to carry it over part of its life-cycle. As the alternative host is not present in Australia, it is unlikely that this parasite will establish itself, unless it can find some native alternative host to replace the American one.

(ii) *Codling Moth* (*Cydia pomonella*).—As a result of recommendations made by the Committee appointed last year, investigations by the various organizations are being extended, and a chemist is being appointed to study special problems in connexion with the use of insecticides.

(iii) *Thrips Investigations.*—Experimental work on various aspects of the biology of the apple thrips (*Thrips imaginis* Bagnall) has now been completed, and the results published in a series of eight articles which have appeared in the Council's Journal between August, 1933, and February, 1936. During the past year, exact information has been established relating to the effect of temperature and food upon the rate of laying and number of eggs laid by this species; also on the duration of life of the adults. The influence of temperature on the development of the immature stages of this species, and the associated species *Haplothrips victoriensis* (Bagnall), has also been studied. The number of thrips present in apple blossom during the spring of 1935 was insufficient to allow of adequate control experiments being carried out in orchards. The information which has been established by the experimental work referred to in previous annual reports will be of great value in connexion with future control field trials. Future work will be concerned with control tests in orchards, with selected insecticides, when thrips occur in suitable numbers.

7. *Field Crop and Pasture Pests.*—(i) *Grasshopper Investigation.*—The senior officer in charge of these investigations spent some months in Egypt and Europe studying the methods adopted in those regions for the investigation and control of the plague locust. The assistant research officer appointed to work on the grasshopper problem in Australia travelled out via the east coast of Africa and South Africa, making further studies on the grasshoppers in that country. He had previously worked on plague locusts in South Africa and at the Imperial Institute of Entomology, London.

During the past few years this Division has carried out studies on the life histories and systematics of grasshoppers and the work is now being intensified with the main object of discovering the causes of outbreaks of grasshoppers in plague form. In this connexion extensive field studies must be made, and for this a motor van has been specially equipped as a travelling laboratory. During the past season the course of a number of small outbreaks of grasshoppers was followed to the adult stage, after which they dispersed. Grasshoppers of various species have been kept under observation in the laboratory and in field cages. The eggs of many important species have been studied and it is now possible to distinguish these species by their egg characters. It will therefore now be possible to recognize a species from examination of the egg-beds after the swarm has disappeared.

In future particular stress will be laid on studies of plague grasshoppers in the field; but this will be supplemented by observation, experiment, and taxonomic studies in the laboratory. Particular attention will be paid to *Chortoicetes terminifera* in the central west regions of New South Wales, where most plague swarms in eastern Australia appear to originate. Although *C. terminifera* is the principal species of plague grasshopper, other species occur which sometimes become serious pests, and these must be included in the investigation.

Co-operation with the various State Departments of Agriculture has been arranged and these Departments have kindly promised to make available to us the information collected from past outbreaks. These records will be carefully examined to see if any relationship can be found between past outbreaks and weather conditions. Co-operation has also been arranged with the Waite Institute which is carrying out a somewhat similar investigation in South Australia.

(ii) *Underground Grass Grub* (*Oncopera*).—Further attempts have been made to introduce the Tachinid parasite, *Hexamera*, from New Zealand; but owing to bad weather there a very small supply was obtained. These flies have not yet been recovered from the localities in Victoria where they were liberated in previous years. *Oncopera rufobrunnea* is now spreading in various parts of the Federal Capital Territory. Further attempts to establish *Hexamera* will therefore be made in Canberra.

The common European toad, *Bufo bufo*, has been introduced from England and kept under quarantine conditions in the insectaries. Tests show that toads feed readily on *Oncopera* larvae, pupae, and adults; and further tests will be carried out in quarantine under field conditions before applying for permission to liberate the animals.

(iii) *Clover Spring Tail* (*Sminthurus viridis*).—An extensive field survey of this pest, commonly known as the lucerne flea, was made in Western Australia and Tasmania last spring. Abundant evidence was obtained to show that there has been a marked reduction in its abundance during the last five or six years. The invasion of the predatory mite, *Biscirus lapidarius*, was carefully watched in several localities; and the information gathered strongly indicated that the reduction of the lucerne flea was due to its activities, thus giving considerable support to the opinion expressed in previous Annual Reports, that the mite was likely to be a valuable means of biological control. Arrangements have been made for further liberations of the mite in Victoria and also for liberation in New South Wlaes.

(iv) *Shelter Bag Moth* (*Ochrogaster contraria*).—This insect causes considerable damage to the borree or myall tree in parts of south-western New South Wales. This tree is a valuable sheep-fodder, and a preliminary investigation indicated that the problem is not so much entomological as a matter of station practice, as no regeneration of the boree can occur where sheep are numerous. The possibilities of controlling the moth by means of natural enemies are, however, being investigated.

8. *Termite* (*White Ant*) *Research.*—(i) *The Direct Control of Termites.*—During the year, white arsenic, which had previously been used successfully for the control of mound colonies of *Eutermes exitiosus*, and against various species attacking timber, has been used against *Coptotermes lacteus*, a mound-building, wood-eating species. The treatment was fairly successful, but larger doses of arsenic were required than for *Eutermes exitiosus*. The same and other methods of applying white arsenic have been used to control mound colonies of various grass-eating species in North Australia.

(ii) *Field Testing.*—Improvements in the methods of field testing, by spacing the samples to be tested fairly close to the centre of the mounds, by removing existing food for a distance of 50 feet around the mound, and by breaking up existing galleries leading from the mound, have been further examined during the year. An attempt has also been made to use colonies of *Coptotermes lacteus*, as well as those of *Eutermes exitiosus*, but the results so far have been inconclusive. Field tests of various treated and untreated timbers mentioned in previous Annual Reports have been continued, and others have been commenced. The total field tests, and experiments in connexion with field testing, at present involve 112 mounds and 2,207 samples.

(iii) *Standard Laboratory Colonies.*—Further improvements in technique have resulted in an increase in the survival rate of the termites and in the amount of susceptible wood consumed in the laboratory colonies. Standards for survival and for wood consumption have also been set up for a susceptible, a moderately resistant, and a resistant timber; and these standards are now used for comparison in tests of timbers of unknown resistance.

A number of tests of susceptibility have been undertaken with the laboratory colonies including:—(*a*) Tests which showed that the true wood of *Eucalyptus regnans* is a slightly better food for *Eutermes exitosus* than the sapwood, and that both are distinctly better than pure cellulose. It was demonstrated, however, that pure cellulose was a satisfactory material for the study of the anti-termitic properties of extractives; (*b*) Tests which indicated that considerable differences in resistance to termites may occur in samples from different trees of the same species; (*c*) Tests of the relative resistance of different materials to attack by termites. These form part of the series in which various timbers and other materials are being graded according to their susceptibility to attack; (*d*) Tests of the anti-termitic properties of timber extractives and related chemicals. These tests are being undertaken in collaboration with Dr. V. Trikojus, of the University of Sydney, who has prepared extracts from *Callitris glauca*, and synthetic compounds related to callitrol. Pure cellulose is used as a carrier; and tests so far made show considerable differences in the anti-termitic properties of the various compounds, one of which appears to be extremely effective.

(iv) *Termites in Pastures.*—In the northern parts of Australia pasture-eating species are exceedingly numerous, and in certain types of country they destroy large quantities of grass and seed. An investigation has been commenced to determine whether the amount of grass destroyed

significantly affects the carrying capacity of the country for stock and whether the termites could be controlled efficiently and economically. The results so far indicate that the mounds of some important species can be treated effectively by methods previously used at Canberra, and that others can be dealt with by different and often simpler methods. Sufficient time has not yet elapsed to determine whether destruction of the termites will affect the quantity and quality of the pastures.

(v) *Termites in Aerodromes.*—On aerodromes in the northern part of Australia the growth of termite mounds is a source of danger, and their destruction a considerable item of maintenance. Methods of destroying the colonies and prevention of mound building are being investigated. Already there are indications that maintenance costs may be considerably reduced by efficient treatment, especially if treatment can be undertaken before the aerodrome area is cleared and the runway prepared.

9. *Pine Chermes* (*Pineus pinea*).—A large consignemnt of puparia of the parasitic fly, *Leucopis obscura*, was received, and 2,000 flies which emerged from these were released in a pine plantation near Mt. Stromlo, Federal Capital Territory. Large numbers of adults of the ladybird beetle, *Exochomus quadripustulatus*, were also received and kept under quarantine conditions in the insectary. This species has not yet been recovered in a plantation where a number were liberated last year. It has been noticed that the native ladybird, *Scymnus pumilio*, a predator on chermes, is becoming more abundant in pine plantations in the Federal Capital Territory. Three lace-wing insects, *Hemerobius stigma*, *H. nitidulus*, and *Wesmaelius concinnus*, were introduced in the egg stage from England and a small number of adults has been bred out in the laboratory.

10. *Oak Scale* (*Asterolecanium variolosum*).—*Habrolepis dalmani*, the parasite of this scale, which was reported last year as established at Launceston, has made much headway. It was found that 50 per cent. of the scales on a sample of infested twigs examined last summer were attacked by this parasite.

11. *Greenhouse White-fly* (*Trialeurodes vaporariorum*).—The parasite, *Encarsia formosa*, which was introduced last year, has been liberated in glasshouses in New South Wales, Victoria, and Tasmania ; and a culture is being maintained in the insectaries at Canberra to supply material for further liberation. It was reported that this parasite practically cleared glasshouses of white fly at Launceston ; and reports from Victoria and New South Wales show that the parasite is well established in glasshouses and in the open, and is increasing rapidly. It has already been found at a place 200 miles distant from the nearest point of liberation in Victoria.

12. *Bee Research.*—From time to time serious pollen shortages occur even when there is an abundant honey flow, and this causes heavy mortality amongst hive bees. Several substances have been found which under laboratory and experimental field conditions have proved to be satisfactory substitutes for pollen. Commercial bee keepers have been recommended to test these various substitutes in the field when required, but so far no serious pollen shortage has occurred and so it has been impossible to determine which substance is the most satisfactory for commercial use.

13. *Mound Ants* (*Iridomyrmex detectus*).—Further efforts have been made to find a satisfactory means of controlling this pest. The work has been concentrated mainly on finding the most efficient way in which to apply carbon bisulphide, and on the influence of weather conditions on the effectiveness of this substance.

14. *Silverfish* (*Ctenolepisma longicaudata*).—This pest is causing serious damage in houses, offices, and libraries throughout Australia. It is generally recommended that silverfish can be controlled by using, as baits, cards covered with a mixture of arsenic and flour or starch paste ; but recent tests have shown that arsenic is repellant. A mixture of flour paste and sugar was shown to be more attractive than unsweetened paste ; and a satisfactory poison bait was made by adding barium fluosilicate to this. Pieces of cardboard covered with this poisoned paste were exposed in many infested houses and were readily fed upon by silverfish. An extensive series of experiments is in progress in which many different toxic materials are being tested for baits, dusts, fumigants, and sprays.

The effectiveness of pyrethrum-kerosene sprays in directly reducing a gross infestation of silverfish has been demonstrated.

15. *Garden Snails* (*Helix aspersa*).—200 young larvae of the English "glowworm," *Lampyris noctiluca*, have been introduced and bred under quarantine conditions. These larvae feed exclusively on young snails and appear to breed readily under Australian conditions. The second generation, which is at present hibernating, will be treated in a circumscribed area in the field next year.

16. *Systematic and General Entomology.*—A well arranged reference collection of insects is as necessary to the Division as a library or any other service. The work of building up a satisfactory collection has been slow, because it is not the exclusive duty of any member of the staff, but has depended almost entirely on the spare time efforts of officers who are primarily engaged on other investigations. About 3,000 specimens, including a number of types of new species, have been added to the collection during the year, and progress has been made with the arrangement of the collection and in cataloguing types. In addition, specimens of insects have been identified for various individual workers and institutions in Australia and abroad.

As opportunities offer, work is undertaken on the life-histories, habits, and ecology of Australian insects, more particularly of species belonging to groups of economic importance. During the year the life histories of several additional species of *Tabanidae* (march flies) have been discovered, including some belonging to the primitive genus *Pelecorhynchus*, of which nothing was known previously.

17. *Natural Enemies Sent Overseas.*—It is part of the Division's work not only to receive beneficial insects from abroad, but to send useful Australian species to other countries that require them. A native coccinellid beetle, *Scymnus pumilio*, which has been observed to attack pine chermes in the Federal Capital Territory, has been sent to New Zealand where it is hoped that it may be more effective in the absence of its native natural enemies.

18. *Advisory Work.*—Requests for assistance have been received from private individuals, business houses, and Government Departments in Canberra and elsewhere. These have mostly concerned household and office pests, ants, and termites. In some instances advice was given, and in others treatment was carried out as part of the experimental work of the Division.

V. NOXIOUS WEEDS INVESTIGATIONS.

1. *General.*—During recent years Australia, in common with other parts of the civilized world, has become more acutely aware than before of the great losses in primary products due to weeds. Following many requests from landholders, and a resolution by the Council of Agriculture, research work on the control of weeds has been intensified. To give unity to the weed control work, the different phases of which had previously been carried out by the Divisions of Plant Industry and Economic Entomology, a section of Weeds Investigations was established in 1935 under the general control of the Chiefs of the two Divisions concerned, with Dr. G. A. Currie as officer-in-charge.

The attack on noxious weeds problems has been organized along the following lines :—(*a*) control by insects ; (*b*) control by herbicides ; (*c*) control, in the case of pasture weeds, by controlled grazing and other forms of pasture management ; (*d*) control by the use of aggressive competing plants ; and (*e*) control by cultural methods.

Four research workers have been added to this Section since the expansion of work began, three in the Division of Plant Industry, and one in the Division of Economic Entomology.

Co-operation with State officers of Departments of Agriculture and of Lands is essential for efficient work, and in New South Wales this is secured by a special weeds co-ordination committee consisting of representatives from the State Department of Agriculture and from this Council. Co-operation with other States is assured by direct approach to officers interested.

The skeleton weed problem may be cited as an example of such co-operative work. So acute had the problem become in 1935, in the wheat growing areas of the Riverina, that a mass meeting of landholders met in Wagga to see what steps could be taken to combat it. A local Skeleton Weed Committee was formed and has functioned as a stimulus to the people of the district and to the officers of the State Department of Agriculture and of the Council working on this problem. The State Department has planned numerous demonstration plots, helped and advised growers ; while officers of the Council have planned extensive experiments with chemicals, smothering plants, and cultural control methods, and, in close collaboration with State officers, have carried them through. No cheap and easy means of eradicating skeleton weed has yet been found ; but means are being found of smothering it with more useful plants, using it in its young stages only as fodder for sheep, killing it with chemicals where economic considerations warrant it, and also of modifying the agricultural practices of the district so as to adjust them to its presence.

Work on St. John's wort carried out at Hyéres in the South of France has already vindicated the action of the Council in placing an officer there. Two insects have been studied at Hyéres, both of which possess qualities that appear to make them more suitable for survival in the Australian environment than insects obtained in England.

2. *Entomological Control.*—(i) *St. John's Wort* (*Hypericum perforatum*).—The three species of beetles of the genus *Chrysomela*, *C. varians*, *C. brunsvicensis*, *C. hyperici*, which have been liberated in large numbers in Victoria, have failed to become established, so some study of the

biological and climatic environment in which they have been placed is in progress to attempt to explain their disappearance. A fourth species of *Chrysomela, C. geminata,* is at present undergoing tests in the south of France. This species aestivates during the dry hot period, so it may survive in Australia better than the others already introduced.

Lathronympha hypericana.—Of 1,500 over-wintering larvae sent from England 700 arrived alive. Thirty adult moths were reared, but in spite of every effort to induce them to oviposit they died without doing so.

Anaitis plagiata.—12,000 over-wintering larvae were sent from England in cool store. Of these 8,000 arrived alive and many reached maturity. From the following generation reared in the insectary 16,000 larvae, 500 adults, and over 1,000 eggs were liberated during the year near Bright, Victoria. Observation showed that predatory enemies, notably ants, attacked them heavily; but some time must elapse before it can be said whether they will survive or be killed out.

Agrilus hyperici.—Study of this insect in southern France demonstrated that considerable damage is done to St. John's wort by the larvae burrowing in stems and roots. Starvation tests to determine whether it will attack economic plants are in progress.

Zeuxidiplosis giardiana.—Gall midges of this species have been bred and studied in England and France. Their probable value in controlling the plant has not yet been assessed.

A number of other insects including moths, aphids, and Tenthredinids are under study.

(ii) *Noogoora Burr* (*Xanthium pungens*).—Investigation of the insect enemies of burrs has continued in Kansas, U.S.A. Arrangements are being made for the Council's investigator to be transferred to Uvalde, or some other suitable centre where he can work directly with the team from the Prickly Pear Board's organization which is now concentrating on burr work.

Euaresta aequalis.—35,000 adult flies were bred in Canberra from burrs sent from Kansas. The flies were forwarded to Queensland where they were liberated in suitable areas by officers of the Prickly Pear Board.

Baris Callida.—Starvation tests with this insect were completed; no liberations are yet being made.

Cylindrocopterus adspersus.—It was found that this insect could feed on sunflower and on artichoke, so it has been decided that permission to liberate in Australia should not be sought unless it is impossible to find less potentially dangerous insects.

During the year the Council's investigator toured much of the southern United States in company with an officer of the Prickly Pear Board. As a result, much information about the distribution of insects attacking the burrs was gained.

(iii) *Lantana* (*Lantana camara*).—An entomologist visited Fiji during the year to study the lantana bug, *Teleonemia lantanae.* He discovered that the bugs were attacked by a fungus disease which destroyed large numbers of them in the very wet periods. Tests showed that the bugs did not attack any economic plant and, as the destruction caused by the bugs when present on Lantana in great numbers was very considerable, consignments were sent to Australia. In the insectaries at Canberra bugs were successfully bred in captivity; and there the fungus disease has not been seen. Tests have now been completed and it is expected that liberations will be made during the 1936–37 season.

(iv) *Nut Grass* (*Cyperus rotundus*).—Two insects *Bactra truculenta,* a moth, and *Athesapeuta cyperi,* a weevil, were introduced into Hawaii from the Philippines some years ago for the control of nut grass. Only partial success resulted. Small consignments of both these insects have been introduced into Australia from Hawaii, and after testing they will be sent to Queensland for liberation in the areas badly affected by nut grass.

(v) *Skeleton Weed* (*Chondrilla juncea*).—In the South of France a number of hemipterous insects have been found feeding on *Chondrilla*; but no insect of great promise for control has been found so far.

(vi) *Other Weeds.*—Insect enemies of Mexican poppy, ragwort, ground cherry, and thistles are being studied in Europe and in America.

3. *Chemical and Other Forms of Control.*—This is the phase of work which has undergone the greatest development during the period under review. The work is carried out in the Division of Plant Industry by officers of the section there.

An ecologist and an assistant ecologist are concerned chiefly with the control of weeds in pastures, the main objects of their work being to discover whether variation of the method, or intensity of grazing, or some other form of pasture management, will lead to the control of weeds of pastures. The problem is being analyzed from the point of view of the plant ecologist who regards weeds as competitors for water, nutrients, and light, with useful grasses and legumes. Detailed studies of the life history of each weed are carried out in pots in the greenhouse to supply a background of information on which to base field experiments.

A plant physiologist is studying the effect of spraying weeds with toxic materials. The greatest need is to devise a spray material which will not only penetrate into the plant, but will be translocated into the roots of deep-rooted perennial weeds and lead to their destruction.

(i) *Skeleton Weed.*—In collaboration with the bodies mentioned at an earlier stage in this Report a large number of experiments are being conducted as follows:—*At Canberra*: Life history studies to determine rate of growth of root and stem, time of seeding, response to nutrients, and position and character of food reserves throughout life of plant. Competition study to determine effect of weed growing in same container as wheat. *At Wagga:* Effect of known chemical plant poisons on skeleton weed applied at different times and at different strengths, and residual effect on soil (40 treatments). Effect of different times of cultivation on skeleton weed. Species trials to determine which pasture plants can compete successfully with skeleton weed, and combined factor experiments which include establishing competing plants, application of chemical manures, trials of herbicides, and trial of different times of cultivation.

(ii) *Galvanized Burr* (*Bassia Birchii*).—During the year an officer of the section surveyed some of the areas in which this weed is a serious problem and selected an areas in the St. George district of Queensland in which experiments are to be carried out. The projected experiments are designed to determine at what intensity of grazing *Bassia* will not spread, and also if resting the country will allow the pasture plants to compete successfully with the weed. The autecology and the synecology of *Bassia* will be studied by an officer stationed at Gatton College, Queensland.

(iii) *Nut Grass* (*Cyperus rotundus*).—This is a serious pest in maize and potato fields, more particularly in the Lockyer valley, Queensland. Experiments aimed at controlling it by means of arsenical, chlorite, and other sprays are being conducted at Gatton College in co-operation with the authorities there. Control by cultural operations, and by competing plants, are also being conducted at Gatton.

(iv) *Wild Turnip* (*Brassica Tournefortii*).—In Europe and America a large quantity of chemicals is used for control of cruciferous weeds in wheat. In Australia this practice has not been developed extensively. Experiments for control of wild turnip in wheat fields in Western Australia by spraying with sulphuric acid and with copper sulphate are planned for the present season. Costs and effectiveness of treatments will be determined.

(v) *Bulrush* (*Typha latifolia*).—This plant has become a serious pest in irrigation channels, more particularly in the Murrumbidgee irrigation areas of New South Wales. An officer of the section visited the areas during the year and on his recommendation an investigator is now being appointed for three years to determine if any means can be found to keep channels free from the pest. Reports on the methods of control of bulrush used in Europe and in America have been received from workers in these countries. The cost of the investigation is being met by the irrigation commissions concerned.

(vi) *Cape Tulip* (*Homeria collina*).—Pot and field experiments have been continued during the year. Competing plants have been successfully established in heavily infested areas in South Australia.

(vii) *Other Weeds.*—There are many other weeds of pastures that call for attention, but limited staff compels concentration on those already mentioned. The experiments with *Bassia* are intended to discover how far pasture management can control weeds in the drier areas. No experiments have yet been planned for control of weeds in sown pastures. The sowing of pasture plants to control St. John's wort is projected, and stimulation of competing vegetation with artificial manures will be tried in co-operation with the New South Wales Department.

VI. ANIMAL HEALTH AND NUTRITION INVESTIGATIONS.

1. *General.*—The Council's activities in the realms of animal health and animal nutrition have, since the appointment of Dr. L. B. Bull in 1935, been reorganized as a single Division. Although, thanks to the generous co-operation of State Departments and private individuals, investigations are in progress in all of the six States, the work of the Division is, broadly speaking, apportioned as follows:—In Queensland—research in connexion with the beef cattle industry; in New South Wales—research into the diseases, parasitic and otherwise, of sheep; in South Australia—nutritional research. The recently developed research institute in Melbourne, for the housing of which the Cabinet has provided £20,000, will be concerned primarily with animal health problems of the agricultural, as opposed to the pastoral, industry. Of these the problem of mastitis in dairy cattle is the most pressing and important.

The blowfly pest, as one of the factors most seriously affecting the health and productivity of Australia's flocks, must be a matter of direct interest to this Division. Hitherto blowfly research has comprised a section of the Division of Economic Entomology. The establishment of an Inter-Divisional Blowfly Committee to direct the programme of research has placed the blowfly investigations on a new and wider basis.

Reference was made in the previous annual report to the resignation of Dr. J. A. Gilruth, and his retention as Consultant to the Division of Animal Health; and the Council took the opportunity of recording its appreciation of his valuable services. Dr. Gilruth has now relinquished his position as Consultant; but, happily, his connexion with the Council has not been severed; for he has agreed to continue in his capacity as Chairman of the Joint Blowfly Committee and of the Inter-Divisional Blowfly Committee.

2. *Research Station at Townsville, Queensland.*—(i) *Pleuro-pneumonia in Cattle.*—Much of the work described in the last Report has since appeared in two Council for Scientific and Industrial Research Bulletins. The first, Bulletin 93, by Dr. A. W. Turner deals with the morphology and life cycles of the causal organism; the second, Bulletin 97, contains four sections, to wit, the promised report by Mr. A. D. Campbell and Dr. A. W. Turner on the complement-fixation test, with the confirmatory reports of Dr. H. R. Seddon and Dr. H. E. Albiston, together with a report by Mr. A. D. Campbell on the distribution of the causal organism throughout the body in animals naturally and artificially infected.

During the year the complement-fixation test has been applied by Mr. Campbell with marked success in the control of natural outbreaks of pleuro-pneumonia in and around Adelaide, South Australia. In the hands of Dr. H. W. Bennetts, who was sent to Townsville by his Government in 1934 to study the test at first hand, it has been successfully applied in the control of outbreaks near Perth, Western Australia, and has also made possible the safe transfer of large numbers of cattle from formerly prohibited northern districts to the southern markets. The test has furthermore proved invaluable as a research tool in the work on the artificial reproduction of the disease and on immunization. It is, however, essentially a test requiring a high degree of technical skill and a well-equipped laboratory, and for those reasons efforts are being made to evolve or apply other simpler tests and, if possible, one that can be applied by field officers to the animal itself, and not a blood specimen from it, thus removing a possible source of error through faulty identification.

Further work on the experimental reproduction of the disease by the insufflation technique suggested by Dr. Gilruth has again demonstrated that, when administered as a finely atomized spray of culture in the B.V.F.–O.S. medium, the causal organism of Nocard can, after an incubation period of 10–14 days, regularly reproduce the pulmonary disease. As in the natural disease, the cases produced are not always severe or extensive, but they always present the well-known pathological and histological features (with sequestrum formation as a common sequel), yield the causal organism in pure culture, give positive complement-fixation reactions, and have produced natural pleuro-pneumonia in untreated, in-contact animals.

The demand for the "culture vaccine" developed at the Townsville laboratory, and since manufactured at the Melbourne Laboratory for the Queensland Department of Agriculture and Stock, has rapidly grown at the expense of "natural virus," which is no longer stocked by the Department. Since its introduction, 50,000 doses have been issued with apparently satisfactory results. Work is now being carried out on the standardization of the vaccine. The field tests at Calliope, Queensland, referred to in the last report have yielded interesting results; but owing to the selection of a too lowly virulent test culture the results were not clear-cut. This is a difficulty inherent in the earlier method of testing for immunity to pleuro-pneumonia, but it is believed that it has largely been overcome by the use of the insufflation method. Fortunately, a partly similar immunity experiment was carried out simultaneously at Tooradin, Victoria, where the animals could be brought to the laboratory for testing by the new method. It has there been found that, whereas the older method of subcutaneous inoculation is unreliable, the new method, which more closely approximates to the natural method of infection, gives clear-cut results that demonstrate the efficacy of tail vaccination with the culture vaccine. These experiments are being extended and are designed to test the duration of immunity and the comparitive value of the usual single vaccination and a proposed double vaccination.

Among the aspects that are receiving attention are also the serotherapy and chemotherapy of pleuro-pneumonia.

(ii) *Peg-Leg Disease.*—The 1934–36 experiments have been concluded, and in spite of the interference caused by droughts, have yielded further evidence that cattle on the peg-leg areas (as typified by Helenslee) benefit markedly from the addition of phosphatic supplements to their rations. A new experiment is under way which aims at keeping cattle under observation for their whole grazing period from weaning to slaughter at meat works. It is considered that the effects of giving phosphatic supplements will be more striking under these conditions.

(iii) *Tick Fevers and Dipping.*—In common with the other investigations at Townsville this investigation, which is almost wholly limited to cattle as experimental animals, suffered an unavoidable set-back through the drought. Dr. Legg spent about three months at the Animal Health Station, Yeerongpilly, Queensland, where he initiated the new system of protective inoculation of cattle against the Queensland redwaters by means of pure strains of *Piroplasma bigeminum* and *Anaplasma centrale*, and immunized some valuable blood stock.

As a preliminary to the elucidation of the method of spread of *Anaplasma marginale* at the Townsville Laboratory, which is kept free of the cattle tick *Boophilus australis* var. *microplus*, an area has been double-fenced with a dog and a cattle-proof fence between which is a moat filled with disinfectant. By these means all possibility of the intervention of the dog tick *Rhipicephalus sanguineus* and crawling insects will be eliminated and only air-borne transmitters need be considered.

Infected and uninfected cattle will be maintained inside the area for a long period and if spontaneous transmission occurs the possibility of insect transmission will have to be further considered; if it does not the possibility that the dog tick might have been the unknown transmitter will be investigated.

During the year the problem of spontaneous oxidation of arsenical dipping fluids was investigated, and preliminary experiments showed that this could be corrected by adding milk sugar (lactose) to the dip in a concentration of 0.04 per cent. Further work will be undertaken to confirm this and test its durability.

3. *Zebu Importations.*—Since the issue of the last report, these animals have not been inspected by the geneticist; but he is visiting each property early in the next financial year, after which a progress report will be issued. From information supplied by owners, both original imported cattle and the cross-bred cattle are in good health.

4. *The McMaster Animal Health Laboratory.*—(i) *Parasitological Investigations.*—(*a*) *Observations on Viability and Resistance to Desiccation of Eggs and Larvae of Haemonchus contortus and Trichostrongylus spp.*—Dr. G. Kauzal continued the observations, which have now extended over several years, in regard to this matter. It is possible to finalize certain aspects of this work and to draw certain conclusions in regard to the infectivity of pastures with these parasites. It has been found that very brief periods of desiccation in sunlight are fatal to eggs of both species, while the survival of the infective larvae when exposed to desiccation is less than has previously been supposed. Where pastures are left unstocked from one to two months during periods of continuous dry weather the degree of infection with both these species will be very greatly reduced, and in the case of *Haemonchus contortus* complete eradication may be effected. The results obtained indicate that for the successful development of a high proportion of larvae of either species periods of some days of continuous rainy or cloudy weather are necessary. On the other hand brief showers which are followed by fine weather are of little importance in increasing the risk of infection to sheep.

It is thought that as a result of this work we will be better able to devise a scheme of prophylactic treatment in relation to climatic conditions.

(*b*) *Chabertia ovina.*—Investigation of the pathogenic importance of *Chabertia ovina* has been continued, and the pathogenic effect of infestation with immature parasites on the growth rate and health of lambs has been confirmed. It has not yet been possible, however, to throw any light on the pathogenic importance of the adult parasite owing to the difficulty of establishing lasting infections with it. Further investigations are now in progress in regard to this, while the problem of treatment of the adult infection will also be undertaken.

(*c*) *Nematodirus filicollis.*—Initial experiments in regard to the pathogenic importance of this species lends support to conclusions drawn from field observations, as also those recently made in New South Wales, that the parasite is relatively benign. Experiments are now in progress to determine whether massive infestations such as are not infrequently met with in the field may be of definite pathogenic importance.

(*d*) *Oesophagostomum columbianum.*—Work in regard to the method of treatment of *Oesophagostomum columbianum* and other large bowel parasites is being continued by Mr. H. McL. Gordon. An improved method of administering solutions of sodium arsenite in the form of enemas has been developed and trials of this method have been conducted in the field with the co-operation of Mr. N. P. H. Graham. Results from such trials have been most encouraging and recommendations have been made which, it is hoped will make possible the control of this infection in northern New South Wales and southern Queensland. In view of the laborious nature of the enema treatment, work is being continued on the subject of the oral treatment of Oesophagostomiasis.

(*e*) *The Treatment of Trichostongylosis.*—Mr. H. McL. Gordon has continued his investigation of this problem, and has carried out extensive tests of a large series of drugs for this condition. As a result of the work recommendations have been made for the employment of a combination of nicotine sulphate and copper sulphate, and such recommendations have already been adopted and widely applied throughout Australia. Other work is now being directed towards the raising of efficiency of treatment while at the same time lowering the toxicity of the nicotine preparations employed. It is gratifying to be able to report that in view of this work the pastoralist's position regarding the control of Trichostrongylosis is very greatly improved when compared with former years.

Following the demonstration of the efficiency of copper sulphate and nicotine sulphate as a curative agent an experiment was conducted to determine whether routine administration of these drugs would effectively prevent the development of symptoms of Trichostrongylosis in lambs exposed to heavy daily infection. It was demonstrated that routine treatments were highly effective, treated lambs showing no evidence of Trichostrongylosis while all controls died.

(*f*) *Passage of Fluids to the Ruminant Stomach.*—Further work was carried out in regard to this matter, and it was shown that satisfactory passage of solutions of copper sulphate to the abomasum could be obtained even where the volume of the solution was reduced to 5-10 ml. It was indicated that closure of the oesophageal groove is induced by contact of the solution with buccal mucosa. In view of this fact it was suggested that little loss of anthelmintic efficiency is likely to ensue where more concentrated solutions of copper sulphate are given than those usually employed in Australia. As a result of initial experiments with sheep infected with *Haemonchus contortus* this view was confirmed. It has, therefore, been recommended that 5 per cent. solutions of copper sulphate, and copper sulphate and nicotine sulphate, be employed in preference to the 2 per cent. solutions usually given in Australia. This measure should lead to greater convenience and ease in administration of anthelmintic preparations.

(*g*) *Influence of Iron Administration in Haemonchosis.*—The influence of the administration of iron in Haemonchosis was investigated, the drug being given either as a drench or in lick form to sheep exposed to experimental infestation with *Haemonchus contortus*. No conclusive results were obtained, however, owing to the variable susceptibility to infestation of the experimental sheep. A further experiment is now being undertaken.

(*h*) *Tick Paralysis in Dogs.*—Work on this problem was discontinued during the year, the final phase investigated being that of the duration of acquired immunity. It was found that the resistance of dogs previously exposed to repeated and massive infestation with adult female ticks declined markedly after a period of from eight to eleven months, though still being adequate to protect them from fatal attacks of the disease.

Following the demonstration of the curative value of the serum of dogs immunized to tick paralysis and the employment of such immune serum in over 150 cases in Sydney, arrangements were made for the production of this serum to be undertaken on a commercial scale by the Commonwealth Serum Laboratories in Melbourne. During the summer of 1935–36 the serum produced by the Commonwealth Serum Laboratories was available in Sydney.

(ii) *Parasitological Field Trials.—Merryville, Yass.*—During the year an experiment was initiated on Mr. W. T. Merriman's property, "Merryville," Yass, to determine the effect of the high plane of nutrition in sheep running on improved pastures on (*a*) super-fine wool character, and (*b*) parasitic infestation. Two experimental groups have been selected, one being run on improved pastures at the rate of two and one-half sheep per acre and one on natural pasture at the rate of one sheep per acre. The experiment was designed to throw light on the question whether super-fine Merino wool may be grown on improved pastures, while at the same time indicating whether the increased risk of parasitic infection on heavily improved pastures is counterbalanced by the great resistance of these sheep owing to improved nutritive conditions.

Frodsley, Tasmania.—An experiment is in progress on Mr. K. Brodribb's property, "Frodsley," Tasmania, which is designed to determine the effects of pasture management and varying periods of rotational grazing on (*a*) the degree of parasitic infection, and (*b*) wool production and body weight.

(iii) *Bacteriological Investigations.*—(*a*) *Foot-rot.*—Mr. W. I. B. Beveridge's investigation of this problem has been continued. He has shown that in all cases of naturally occurring foot-rot an organism, tentatively named the X organism, has been present. The cultural and morphological characters of this organism, which it is suggested is the primary cause of foot-rot, indicate that it is a spirochaete. The organism has been grown in purity but it has not yet been possible to set up foot-rot with pure cultures of the organism, nor by mixtures of this with cultures of *Bacillus necrophorus* or other organisms found in naturally occurring cases. The X organism has not been found to survive exposure in infective material taken from the feet of natural cases of foot-rot at room temperature for more than one week.

A series of experiments has also been carried out under field conditions to determine the maximum period for which swampy areas grazed over by sheep suffering from foot-rot will remain infective for healthy sheep. The result of these experiments indicates that contaminated soil, even though moist, loses its infectivity in less than three days. These investigations are being continued.

Field Trials in connexion with Foot-rot.—In view of Mr. Beveridge's demonstration of the fact that sheep apparently recovered from the disease may serve as carriers of infection from one outbreak of foot-rot to another, and the accumulation of evidence in the field that the disease is specifically sheep borne and not dependant on its persistence in the soil, a series of trials

has been initiated to demonstrate whether control and eradication may be effected by the complete elimination and isolation of all sheep showing active or latent lesions. Owing to the unfavorable season for foot-rot no definite evidence has yet been obtained from these experiments, though the indications so far support the views formed.

(*b*) *Caseous Lymphadenitis.*—Dr. H. R. Carne has continued his work on the bacteriology of the Preisz-Nocard bacillus and related diphtheroid bacilli. A series of papers dealing with this work is in preparation for publication.

(iv) *Genetic Investigations.*—A zootechnical study by Mr. R. B. Kelley of fertility and prolificacy in a long established flock of Australian Merino sheep has been completed. The report of this investigation discussed and assessed the relative importance of infective, environmental, and hereditary factors affecting the levels of fertility and prolificacy as disclosed by clinical examinations and by the breeding and other records of the flock, and shows that all three of these factors must be controlled for optimum results.

It shows that the degree of fertility is a heritable character probably dependant upon a small number of Mendelian factor pairs. It does not establish that twinning is wholly heritable; but multiple births are shown to be influenced by the female's age and to a very large extent by the environment, particularly the plane of nutrition prior to and during mating. Further, an hypothesis that endocrine disfunctions may be a cause of reduced fertility is given some support.

An experimental flock of approximately 400 ewes and an adequate number of rams has been established, and this work is now proceeding. The occurrence and duration of oestrus has been observed among three groups of ewes of two breeds and three proven levels of fertility all maintained in the same environment, and the observations have been associated with meteorological and other data. Hand and paddock matings, designed to investigate the effect of each of the three foregoing factors (infective, environmental and heredity) have been made within the flock. The relation of ovulation to oestrus has been established, and the extension and descent of the ovum has been followed. Similarly the rate of ascent of the spermatozoa in the female genital tract *post coitus* has been determined. A differential time of fertilizing-power for the spermatozoa of Dorset and Merino rams has been established and associated with duration of oestrus in ewes of these two breeds. The assumed polyoestrus character of Merino ewes and the periodic vaginal changes reported to be typical of phases of the ovarian cycle are being investigated.

5. *Animal Health Research Institute, Melbourne.*—The activities of the Division in Melbourne have been centred, as formerly, in the University Veterinary Research Institute through the courtesy of the University authorities and Dr. H. E. Albiston, Director of the Institute.

The Council was invited by the University to establish an Animal Health Research Laboratory in the grounds of the Veterinary Research Institute, and the existing buildings in the Hospital Block were made available. Some of these buildings have been adapted for temporary laboratory accommodation, and Dr. Albiston has continued to make available accommodation in his laboratory.

On account of the drought in northern Queensland, much of the work which would have been normally carried out at the Research Station at Townsville has been carried out in Melbourne. These activities and those connected with mastitis investigation have formed the main activities of the Division in Melbourne.

Approval has been given by Cabinet and money made available for the erection of a laboratory in the grounds of the University Veterinary Research Institute. A start has been made on the plans for this building and it is anticipated that building operations will commence early in the new financial year.

(i) *Pleuro-pneumonia in Cattle.*—Work on the experimental reproduction of the disease and on the testing of the immunity produced following tail inoculation with "culture vaccine" has been carried out with success in Melbourne, where somewhat better facilities exist than in Townsville, and where the advantages of working outside an enzootic area have been evident.

(ii) *Diseases due to Anaerobic Micro-organisms.*—During the year vaccine was prepared for experimental and field observations in Western Australia on the control of botulism in sheep, locally known as toxic paralysis. The inoculations and observations were carried out by officers of the Department of Agriculture of Western Australia The work has shown that it is possible to produce in sheep a strong immunity against the toxin of *Cl. botulinum* C, and that inoculated animals will in the majority of cases fail to develop symptoms of the disease. The complete results of the field observations are not yet available.

Attention has been given to the standardization of methods in the production of vaccines used in the control of black disease and entero-toxaemia of sheep. This work is not yet completed.

Mr. D. Murnane has continued his observations on the value of the vaccine (*B. necrophorus* anaculture) in the control of foot-rot in sheep and cattle. The vaccine appears to have little or no value in the control of the disease in sheep, but in cattle the results have been encouraging.

(iii) *Bovine Haematuria.*—Observations have been continued in co-operation with officers of the Victorian Department of Agriculture, and a survey of the areas in Victoria where the disease is enzootic is being made. The effects of top-dressing pastures with gypsum and superphosphate in the control of the disease are being studied on the experimental farm in Gippsland. Up to the present the animals have remained perfectly healthy.

(iv) *Caseous Lymphadenitis.*—Field observations on the control of the disease by protecting sheep off shears from contamination of wounds by soil have been initiated on several properties in different States. The results of these observations will not be available for about three years. The results of observations on the effects of vaccine in the control of the disease, which were initiated about three years ago, should be available shortly.

The laboratory work on the disease, which has been carried out by Mr. C. G. Dickinson in South Australia, has recently been transferred to Melbourne.

(v) *Bovine Mastitis.*—Following the arrangements made between the Federal Council of the Australian Dairy Cattle Research Association and the Council, a start was made on the investigation of the problem of mastitis in dairy cows on 1st April, 1935.

A suitable property on which to establish and maintain a dairy herd for observational purposes was selected by a special committee appointed by the Victorian Branch of the Research Association. The property known as Road's End and situated at Berwick was taken over on 1st July, 1935, together with a small amount of machinery, farm implements, and live stock, including eight heifers.

Mr. D. Murnane, Veterinary Research Officer of the Council, was appointed in charge of the farm.

The plan adopted was the establishment of a herd of milking cows of approximately 40 animals. We were fortunate in obtaining from Dr. Sewell, the owner of the property, eight heifers which were shown to be free from tuberculosis and contagious abortion. The herd from which these animals came had been free from these diseases for some years.

At the present time the herd consists of 49 cows, all of which have been tested for tuberculosis and contagious abortion and found free. Of the 49 cows, nine are the property of Dr. Sewell and are on loan for the five-year period, and three were generously donated by Mr. Kerr. The remaining animals have been purchased.

The equipment of the farm and the establishment of the herd have absorbed the larger part of the income during this year. The herd is being established in order that systematic observations on the bacterial flora of the normal udder can be carried out and that normal animals will be available for experimental purposes.

The plan and conduct of the investigation is controlled by the investigation committee. Mr. Munch-Petersen, assisted by Miss Clark, is responsible for the bacteriological examinations.

Systematic bacteriological examinations of the udders of the cows in the experimental herd are carried out. When a cow calves, and before the calf is allowed to suck, a specimen is collected from the teat canal of each quarter. Following this, bacteriological examinations are made daily of the secretion from each quarter. If the results show nothing of significance after a week, future examinations are continued at weekly intervals for the rest of the lactation period. Should the bacterial content of the milk increase or any other abnormality become manifest, daily examinations are immediately re-introduced.

The examinations involve the determination of the total number of bacteria present in each sample and the types of bacteria present. A count is also made of the number of cells present. This examination is carried out by Miss McLean, the officer in charge of the Victorian Milk Laboratory, which is under the direction of Dr. H. E. Albiston.

In addition to the systematic examination of the secretion of each quarter of every cow in production in the experimental herd, bacteriological methods adopted by workers in Great Britain and on the Continent in the differentiation and classification of Streptococci are being investigated. Close touch is being maintained with these workers overseas.

The next stage in the investigation is the systematic examination of the members of herds known to be affected with mastitis. A complete study of the disease in several selected herds will be carried out. Later it may be desirable to compare results obtained in Victoria with those to be obtained in other parts of the Commonwealth.

It is too early in the investigation to discuss results obtained.

(vi) *Myxomatosis of Rabbits.*—Sir Charles Martin has conducted for the Council and epidemiological study of the disease. The work was carried out in Cambridge at the Institute of Animal Pathology by the courtesy of Professor I. B. Buxton and the results are recorded in the Council's Bulletin No. 96. Permission has been given by the Director-General of Health for the importation of the virus and for the continuation of the experimental observations under quarantine.

6. *South Australia.*—Through the courtesy of the Board of Management of the Adelaide Hospital, Mr. C. G. Dickinson was enabled to carry on his laboratory studies there until April, 1936, when he was transferred to Melbourne.

(i) *Caseous Lymphadenitis.*—The epidemiological study has been continued and it has been observed that the Preisz-Nocard bacillus may be recovered from soil that has been kept free from sheep and other animals for a period of three years. During the three years' interval abnormally dry weather prevailed, and while the soil remained dry the micro-organism could not be detected. When normal moisture and temperature were restored, the micro-organism again appeared in sufficient numbers to be detected by the methods used. A second naturally occurring case of Preisz-Nocard infection in a cow was observed on the same property.

Serological studies have been continued, and the results have placed the identification of the Preisz-Nocard bacillus and its differentiation from other similar bacteria on a more satisfactory basis. Observations on the control of the disease have been carried out on another property, but results are not yet available.

(ii) *Bovine Haematuria.*—Observations have been continued on the effects of the application of gypsum to the soil on a farm on which the disease has been responsible for annual losses. Six heifers were placed on top-dressed pasture and six on untreated pasture in 1933. The animals on the top-dressed pasture have remained normal while three of those on the untreated pasture have shown signs of the disease. The observations are being continued. These observations are linked with those being made in Victoria, and more recently those in Tasmania, where the disease is found to be more widespread than was hitherto suspected.

A low urinary inorganic sulphur content has been a constant finding in animals grazed on farms on which the disease is more or less frequent in occurrence. We are indebted to Miss E. Bethell, biochemist in the University Veterinary Research Institute, for the chemical examination of numerous urines.

(iii) *Navel-ill of Foals.*—Observations on this disease have been restricted on account of the lack of material.

7. *Western Australia.*—Co-operation with the officers of the Western Australian Department of Agriculture has continued during the year.

(i) *Botulism (Toxic Paralysis of Sheep).*—A programme of work was drawn up by the Department in collaboration with the Division. The Division assisted the work by preparing a vaccine for experimental and field trials. The full results of the observations are not available, but progress reports indicated that the vaccine is capable of producing a strong immunity which will protect sheep against many lethal doses of the toxin. The disease has been found to be due to *Cl. botulinum* Type C in all cases so far investigated. The control of the disease by the use of supplementary feeding has also been investigated. The results of all this work will be recorded fully by officers of the Department of Agriculture.

(ii) *Gingin Disease (Ataxia in Lambs).*—More crucial experiments have been set up to determine the cause of this disease. The results of these experiments are not yet available.

8. *Tasmania.*—Co-operative investigations have been continued with the Animal Health Service of the Department of Agriculture.

(i) *Rotational grazing, Frodsley.*—The effects of rotational grazing of sheep on improved pastures in controlling parasitic infection and on the fleece and body weight are being studied. The first year's observations will not be available until October, 1936.

(ii) *Entero-toxaemia.*—Observations on the control of the disease by vaccination have been carried out at Frodsley. The results showed that of 1,800 vaccinated lambs, 2 per cent. died of entero-toxaemia; whereas of 500 unvaccinated control lambs, 11 per cent. died of the disease. The details of the observations will be published in due course.

(iii) *Bovine Haematuria.*—A survey of the disease is being made by officers of the Department, and material has been collected and forwarded to the Division for examination. This has supplemented our observations made on material collected in South Australia and Victoria. Macroscopic and microscopic examinations of diseased urinary bladders, as well as chemical and microscopic examinations of specimens of urine from herd in which the disease occurs, have confirmed our previous findings. It is proposed that observations should be made in Tasmania on the effect of top-dressing pastures with gypsum in the control of the disease.

9. *The Animal Nutrition Laboratory, Adelaide.*—(i) *Sulphr Metabolism in Sheep and its Relation to Wool Production.*—(*a*) *The Estimation of Sulphur and Cystine in Fodder Plants.*—The work on sulphur metabolism has been extended during the year. Critical examination revealed that the various methods for the estimation of sulphur in organic materials had many unsuspected limitations ; and it was concluded that the method in current use in the Nutrition Laboratory was the only one among the procedures examined which was capable of giving reliable results. In this method the organic material is ignited in oxygen confined at 20 atmospheres in a closed bomb. Besides the determination of the sulphur content, the total energy evolved on complete oxidation, and the total carbon in the sample, may also be estimated with precision and ease by this method.

Further work has failed to overcome the difficulties in estimating the amount of cystine present in fodders and excreta by chemical means. When attempts are made to hydrolyse such complex materials so as to liberate the amino-acids, the losses of cystine are so serious as to render subsequent determination impossible.

(*b*) *The Influence of Food Constituents on Growth of Wool.*—The effects on wool growth which follow the variation of the protein level and the energy intake of the sheep have been studied by a team of workers. The results will be discussed in more detail below.

(*c*) *Biological Assay of the Amount of Cystine in Fodders—Biological Value of Proteins.*—Miss M. C. Dawbarn, M.Sc., chemist of the Animal Products Research Foundation of the University of Adelaide, who is working in the Nutrition Laboratory, has succeeded in evolving practicable methods for the separation of the "B" accessory foodstuffs from contaminating materials containing cystine. Attempts to estimate the order of the amount of this amino-acid in foodstuffs by means of biological criteria, such as increase of rate of growth of young rats when such materials are added to cystine-poor diets, have been complicated in the past by our inability to produce a basal diet which is limited only by its low cystine content. Experiments aimed at perfecting the method are now being conducted. The estimation of the comparative biological value of proteins from different sources is fraught with the difficulties mentioned above. The technique for such determinations has been very much improved. This work is proceeding.

(ii) *Phosphorus Metabolism in Sheep.*—(*a*) *The Concentration and Distribution of Phosphorus in the Blood of Sheep.*—The data arising out of the work of the Division in connexion with the variation of the blood phosphate level of sheep grazing under natural conditions in Australia confirm the general conclusions advanced in previous reports. Rarely, if ever, during the thousands of determinations have levels been observed which would imply any serious degree of phosphorus deficiency in sheep on natural pastures.

(*b*) *The Influence of High Concentration of Calcium and Magnesium on the Assimilation of Phosphate by Growing Sheep.*—This experiment, outlined in previous reports, has now been completed. Administration, to sheep on an adequate ration, of 30 gm. of calcium and 10 gm. of magnesium as carbonates brought about no change other than the slight reduction of blood phosphate mentioned in the previous report. The individuals receiving the high amount of uncompensated alkaline earth elements did extraordinarily well during the whole two and a half years. At the end of this period they were significantly better grown than were the controls which had been fed on the same ration without added alkali, the average weight of the high alkali group being 62 kilos and that of the controls 52 kilos. At the end of the experiment the animals were slaughtered and their bones collected for histological and chemical examination. The bones of all animals were found to be well developed ; those of the high alkali group were decidedly heavier, being better calcified and of more dense texture than bones usually met with in sheep raised in what are considered ideal nutritive environments.

Examination of the content of the intestinal tracts confirmed our previous findings ; and it would seem that relatively huge quantities of alkaline earth elements in the diet bring about no change in the reaction of the material within the lumen of the bowel. Calcium was found to be absorbed in the duodenum and other portions of the small intestine only to be excreted in the caecum.

These findings provide an explanation of the unforeseen results, for phosphates are relatively soluble in media of the reaction and calcium concentration found in the intestinal contents, and would thus be readily assimilated. Relatively huge amounts of Calciferol (vitamin D.) would be necessary to overcome the effects of a similar high quantity of calcium in the diet of non-ruminant animals.

The results of this investigation suggest that sheep under natural grazing conditions in Australia could assimilate phosphorus as well from the relatively inexpensive ground rock phosphate as from more costly dicalcic phosphate.

(*c*) *The Comparison of Mono-, Di- and Tricalcic Phosphate as Sources of Phosphurus Supply for Sheep.*—Mention was made in the previous report of an experiment designed to further our knowledge of the extent to which sheep are able to assimilate phosphorus from mono-, di- and tricalcic phosphate. This has now been in progress for about eighteen months, during which time close observations have been made on fifty matched sheep confined in pens and fed on a ration rich in protein but containing only 0.6 gm. of phosphorus per day, a diet which should lead to symptoms of marked phosphorus deficiency if the usually accepted feeding standards are correct.

After eighteen months there is no significant difference between the growth of the animals in the groups on this diet supplemented with an extra gramme of phosphorus per day in the form of tricalcic phosphate (as bone meal or as Christmas Island rock phosphate) and those receiving the same quantity of phosphorus in the form of dicalcic phosphate. The animals in the group receiving a like amount of phosphorus as monocalcic phosphate in the form of commercial " super " have not done as well, presumably on account of the continual ingestion of 170 mg. of fluorine each day, which occurs as an impurity in the commercial " super " administered. The effects arising from the constant assimilation of the much smaller amounts of fluorine present in the Christmas Island rock, which carry 60 mg. of fluorine per day in the dose given, make themselves apparent in the condition of the enamel of the more recently erupted incisor teeth. This is pitted and eroded. However, no evidence of impairment of growth or of any untoward effect on the general well-being of any individual of this group is discernible.

Although the controls, which receive only 0.6 gm. of phosphorus per day in the basal ration, have done practically as well as the animals constituting the various phosphate-supplemented groups, there is a striking difference between the mean concentration of inorganic blood phosphate of the various treated and untreated animals. While, during the last twelve months, the level of blood phosphate of the animals on the basal diet has averaged less that 3.6 mg. of phosphorus per 100 cc., that of the animals receiving an extra gramme of phosphorus per day in any of the above-mentioned concentrates has continually ranged between 6.5 and 7.5 mg. per 100 cc.

The capacity of the sheep to assimilate phosphorus from these supplements is being investigated by the balance method with sheep that have been trained for over a year in the metabolism cages.

It is evident that sheep may do well while receiving much less phosphorus than is generally considered necessary ; and that when these minimum requirements are fulfilled further additions of phosphorus to the diet seem to exert no obvious beneficial effect either in growth, general health, or in the productivity of sheep.

(*d*) *Phosphatic Licks in the Pastoral Industry.*—A final pronouncement as to the desirability for continuing the almost general employment of phosphatic licks in the pastoral industry must await the findings of the series of critical field investigations which have been initiated during the last six months, and which will be continued and extended during the next two or three years. These tests are designed to estimate any benefit, even if this is small, which is brought about in sheep having free access to phosphatic licks while grazing under a diversity of conditions in Australia. The data from each experimental site will be augmented by observations on a third group which will receive approximately 1 gm. of phosphorus per day in the form of soluble phosphate in a drench. These experiments are referred to again below.

(iii) *The Energy and Protein Metabolism of the Merino Sheep.*— (*a*) *Energy Metabolism.*— The investigations on the energy transactions of sheep have been considerably extended during the year, when a detailed study of the relationship between the energy consumption and wool production was undertaken. Foodstuffs capable of increasing the energy supply of the ration were found to influence wool production only when added to rations relatively rich in protein, but which were in themselves incapable of meeting the full energy demands of the sheep. Under such conditions of feeding the animal utilizes the major quantity of the protein in the ration for energy production, and so reduces the amount of substrate capable of being transformed into wool.

The heat output of the experimental sheep on protein-poor diets was found to recede gradually from between 1,400 and 1,600 kilogramme calories per day to between 1,250 and 1,350 kilogramme calories per day after a year on the diet. During this time the wool production recedes to less than half the amount produced by sheep on diets containing ample protein but a similar amount of available energy. The respiratory quotient (the ratio of oxygen consumed to carbon dioxide produced) of sheep fed on the basal ration was found to be about 0.98. This basal ration of 1 kilo of a mixture composed of 60 parts of straw chaff and 30 parts of lucerne chaff afforded between 130 and 140 kilogramme calories of metabolisable energy per 100 grammes. An equivalent amount of available energy was computed from many trials to be present in 30 gm. of the sample of the protein (commercial gluten) that was used in the studies referred to in the next section of the report.

(*b*) *The Utilization of Protein and its Relation to Energy Consumption.*—Increasing the protein level of the diet from 60 gm. per day to 300 gm. per day was found not to bring about a material change of energy consumption of sheep fed at maintenance level. The appetite was found to be improved with the addition of protein to the diet; and at the higher levels no trouble would be experienced in enticing sheep to consume a much larger quantity of the ration than that given.

The effect on wool production brought about by varying the amount of protein in the ration, while keeping the metabolisable energy intake approximately constant, was studied during the year. This was accomplished by withdrawing an amount of the basal ration corresponding to the amount of metabolisable energy contained in the extra protein added. Change from a basal level of approximately 60 gm. of protein per day in the maintenance ration to approximately twice that level resulted in an increase in wool growth of 58 per cent. Change of level to three times basal brought about an increase of 95 per cent., and further change to an intake of 300 gm. of protein per day, approximately five times the basal level, was attended by an increase of 145 per cent. in the amount of wool produced. An intermediate period of three weeks was allowed to elapse between each change in diet to ensure that nutritive equilibrium would become established. Change back to the protein-poor basal ration from the one containing 300 gm. of protein per day caused wool production to recede steadily until, in the course of several weeks, it again reached the rate previously observed while on the basal ration. This suggests that considerable amounts of protein were stored while the experimental animals were receiving large amounts of it, and this was confirmed by the nitrogen and sulphur and energy balances which were conducted at each level of feeding.

The increase in weight of wool produced by the variation of this dietary constituent was accomplished by no less remarkable a change in quality. The mean fibre diameter of the shoulder wool of one experimental animal, for example, was observed to be $21.4 \pm 0.104\ \mu$ on the basal diet, $24.8 \pm 0.121\ \mu$ after the protein intake was doubled, and $25.0 \pm 0.118\ \mu$ when three times the basal amount of protein was consumed. An increase to $27.2 \pm 0.127\ \mu$ was observed when the animal received approximately 300 gm. of protein per day. In other words, the nature of the wool changed from 64–70's to 56's quality merely by altering the level of protein feeding. The application that these observations have in genetical studies is obvious. The animals used in the experiments were of the strong-woolled class. It is planned to extend these observations to Merinos of the ultra fine-woolled variety.

While increasing the protein level in a ration not quite sufficient to maintain the weight of the experimental sheep brought about a material increase in the production and alteration in quality of the wool produced, the changes were not of the same order as those discussed above, presumably because the sheep under such conditions utilizes the major quantity of the protein in its diet to fulfil its energy and so depletes the amount of raw materials available for the production of wool fibre.

(iv) *Secondary Anaemia in Sheep.*—Owing to the activities of investigators on other problems this work was not extended during the past year. Experiments have now been initiated to investigate the capacity of different dietary constituents to augment blood regeneration in sheep from which relatively large amounts of blood are taken each day.

(v) *The Effects of the Continual Ingestion of Fluorine by Sheep.*—The experimental investigations on the toxicogenicity of fluorine are now nearing completion. For over three years sheep have been fed in pens and dosed with varying amounts of fluorine and their behaviour closely observed.

Half of the experimental animals in each group have recently been returned to pasture for investigation of their capacity to recuperate after prolonged periods of fluorine ingestion, the other half have been killed and carefully examined at autopsy, when sections of organs have been taken to aid further search for pathological changes. The organs, bones, &c. of these animals were collected for the estimation of their fluorine content. Until this further work has been completed it is not possible to state definitely the effect of continual ingestion of doses ranging from 60 to 120 mg. of fluorine per day. Marked harm ensues from the continual ingestion of 160 mg. of fluorine per day over long periods.

At this present juncture it would appear that sheep receiving from 60 to 120 mg. of fluorine each day for periods up to three years suffer no impairment of general health and, although the animals receiving the largest quantity have consumed for a long time about twice the amount of fluorine which would be taken under field conditions in a lick composed of salt and Nauru rock phosphate, they have grown normally. Some individuals of the group receiving 60mg. of fluorine per day have erupted incisor teeth which are slightly mottled. The enamel of the teeth of those receiving 120 mg. of fluorine per day is severely eroded, and their teeth are in a like condition to those of animals receiving higher doses of fluorine.

Continual ingestion of 160 mg. of fluorine in Nauru rock phosphate and 170 mg. of fluorine in the form of Florida rock phosphate may very plainly exert a harmful effect, although two wethers in the latter group have apparently suffered no ill so far as general health and growth is concerned. The enamel of their teeth, however, is seriously mottled.

It is important to determine the rate and degree of recovery after the ingestion of fluorine is discontinued. Some preliminary information on this aspect of the problem has been obtained, and it was observed that the general effects of fluorine disappear soon after its ingestion is stopped. It is not improbable that sheep which continually ingest sufficient fluorine to lead eventually to chronic fluorosis, will suffer no untoward effect if the periods of fluorine intake are alternated with periods during which little or no fluorine is present in the diet, a state of affairs which may be met with when licks are offered under grazing conditions with alternating green and dry pasture due to seasonal changes.

It is of importance to note that pathological effects were observed not to appear until after a year of continual ingestion of relatively high doses of fluorine.

(vi) *Pasture Experiments at "Wambanumba," Young, New South Wales.*—The investigations on the effects of top dressing the natural pastures in this region with rock phosphate, with sulphur, and with rock phosphate plus sulphur have now been completed and the results are being prepared for publication.

A more or less complete story of the seasonal variation in composition of the pasture clips collected from quadrats distributed at random over the areas under observation is now available. This part of the investigation has involved some 2,000 separate chemical analyses of the dry and green herbage from each plot that were collected at bi-monthly intervals over a period of two-and-a-half years.

In previous interim reports it has been pointed out that in both yield and relative richness of nitrogen and inorganic constituents the pasture dressed with rock phosphate plus sulphur is superior to that from plots dressed with either fertilizer separately or to that from the control unmanured area. These differences have been maintained throughout the experiment so it is obvious that the effect is not a transient one.

The analyses of the dry herbage, or straw, from each plot have furnished much useful information on the variation in this phase of natural pastures which is so important in Australia. In general, it might be said that weathering agencies rapidly leach soda and potash from standing straw, while other inorganic constituents such as phosphates tend slowly to reach a relatively stable minimum concentration. The phosphorus content of the straw from the areas originally dressed with phosphatic fertilizers has been shown to be consistently about double that of the corresponding areas receiving no phosphorus. This higher phosphorus content was not accompanied with increased growth or nitrogen concentration which was observed in pastures that had received a dressing of elementary sulphur in addition to the rock phosphate. Graphical tabulation of the analytical results for nitrogen, phosphorus and calcium from any one area show, in general, a parallelism which suggest the mutual interdependence of these constituents. The fluctuations clearly reflect seasonal variations in growth. It is important from the nutritional point of view that the acquisition of these elements by growing herbage seems to be relatively sudden, that the maximum is soon reached and the decline rather gradual. The separate analyses of green and dry material in each case has served to emphasize these facts which are often obscured when the nutritive value of the pasture as a whole is considered. Detailed agrostological examination of the clips did not reveal that any marked alteration in botanical composition accompanied the various manurial treatments, but it is clear that practicable quantative methods for dealing adequately with such variable material are yet to be discovered.

Fluctuation of the blood phosphate concentration of sheep depastured on these areas was observed throughout the greater part of the period. The cogent findings were discussed in previous reports.

The sheep-carrying capacity of the area top-dressed with the rock phosphate-plus-sulphur mixture was continually very much higher than that of any of the other treated or untreated areas ; and the individuals in flocks on this paddock grew better and produced more wool per head. The paddock originally dressed with the mixture in 1930 is now the best on this type of country in this area. Consideration of the data arising from the experiment stresses the economic value of such treatment applied to highly leached soils which are deficient in both sulphur and phosphorus.

The results of the five years' work will soon be ready for publication.

(vii) *Coast Disease Investigations.*—(*a*) *General.*—The facilities at Robe, referred to below, have simplified the more intensive study of this malady. Young sheep were found to develop coast disease readily while depastured on the littorals of this region, and the disease progressed when they were transported to the laboratory, confined in cement-lined pens and fed on a ration of mixed hay grown on the calcareous sands immediately adjacent to the experimental areas,

supplemented with commercial gluten and watered with distilled water out of bituminised troughs. Under these more guarded conditions the animals were found to develop extreme symptoms rarely met with in the field. They exhibited marked signs of bloodlessness; and estimations of the oxygen carrying capacity of the blood showed that the haemoglobin may frequently fall to less than 30 per cent. of normal. Ewe weaners in this extreme condition were matched, and one of each pair drenched daily with a solution of inorganic salts containing 1 mg. of cobalt. Dramatic change immediately ensued. The appetite of the treated animals revived and within five weeks there was a 35 lb. difference in body-weight between them and their untreated controls. The latter died shortly after this period, following symptoms of extreme coast disease. Clinical symptoms and blood picture were observed to improve greatly in the dosed animals.

Microscopic examination of sections of the organs of animals which had died of coast disease revealed the organs to be loaded with an iron-containing degradation product of blood pigment, haemosiderin. This was noticeable especially in the liver and pancreas. A very great increase in the iron content of the livers was proven by chemical analysis. The copper content of the livers of " coasty " animals was found to be considerably reduced. Chemical methods for the estimation of minute amounts of cobalt in the presence of relatively large amounts of iron and other elements are being perfected with a view to examining the concentration of this element in the tissues of normal and of " coasty " animals. Further study of the blood shows the anaemia to be of the microcytic, hypochromic type. This work is being continued.

Little further headway has been made during the past year with the study of the ataxia of young lambs, which is often, though not invariably, associated with coast disease. Some lambs dropped at Robe, and which were given 10 gm. of limonite three times a week, have developed typical " rickets ", which is the vernacular description of the inco-ordination of gait exhibited by young lambs. This type of ataxia is the result of degenerative changes in the spinal chord. Study of this malady, which accounts for the loss of many young lambs, will be continued as opportunity offers.

(*b*) " *Hawk's Nest* ", *Kangaroo Island*.—During the past year the study of the growth of lambs and weaners receiving a supplement of Jansen's salt mixture was continued. These sheep showed improved growth and wool production when compared with the controls. At weaning the lambs receiving the supplement were 17 per cent. heavier; and they have maintained this advantage at shearing, when they were sixteen months old, and their fleeces were sounder and more attractive than those of the controls. A further group of lambs of the same drop, but from more healthy ewes, were run on improved pasture grown on a reputably affected area. As weaners these were definitely superior in size and wool production to those which received the Jansen's salt mixture and run on adjacent unimproved country. However, during the latter part of their second year the animals on the improved country have markedly deteriorated and at present are showing signs of incipient disease, while the controls receiving the salt mixture are healthy and vigorous. A salt lick based on the Jansen's salt mixture has been given by the owners to the " Hawk's Nest " flock sheep since May, 1935, and is considered by them to have brought about very great improvement in the health and productivity of their sheep. The ewes from the treated and control flocks have been mated so that observations may be continued on the second generation.

Experiments were commenced early in the autumn of 1936 with the object of finding more economical methods of establishing pastures on newly cleared ironstone soils of Kangaroo Island, and of determining the suitability of higher producing perennial grasses on soils of this type which have been carrying at least a moderately vigorous growth of clovers for some time. The areas selected for the purpose were at " Hawk's Nest " and on a closely related soil at Karinga, in the Hundred of MacGillivray, which has a rainfall of from 20–23 inches per annum.

(*c*) *Robe, South-eastern South Australia*.—Splendid facilities have been made available for the study of coast disease through the generosity of Mr. R. Dawson, who has a property on the deep calcareous littorals about four miles from Robe. The paddocks upon which the experiments are being conducted are situated on dunes that are composed of shell sands of aeolian origin extending to a depth of 30ft. or more. The soils are thus highly alkaline and contain about 66 per cent. of calcium carbonate. The experimental area has been cleared for many years, during which time it has been meticulously cared for. In this region a very limited number of edible herbage species occurs naturally, the associations consisting of practically pure stands of Madrid brome (*Bromus madritensis*) on the lower parts of the dunes, and hare's tail grass (*Lagurus ovatus*) on the higher levels which have not been ploughed. Legumes are extremely scarce and where they do occur they are weak and under-developed. While they are young and green these poor annuals will carry and fatten at least one sheep to the acre. However, both young and old sheep soon become lethargic and rapidly lose weight if continually depastured on these areas, and will die of typical coast disease if left there. This site, on which sheep become much more seriously affected than on the country already studied on Kangaroo Island, has provided a rapid means for the production of the malady and will thus facilitate the solution of the trouble.

Two groups of mature sheep were run on the area, one being offered a mixture consisting of equal parts of salt and Whangarei limonite. After a lapse of about six months this experiment was abandoned as the amount of the lick taken was insignificant and some of the sheep showed typical symptoms at this period. These animals were then divided into five matched groups, body weight, clinical symptoms and the degree of anaemia as judged by the concentration of haemoglobin in their blood, being taken as criteria. One group was dosed with 10 gm. of finely-ground limonite three times a week. Three other groups were treated at the same intervals with 50 mg. of iron as carefully purified ferrous ammonium sulphate, with a similar dose of iron plus 1 mg. of cobalt, and with 1 mg. of cobalt unaccompanied by additional iron, respectively. The fifth group, which was run under exactly identical conditions received no treatment; and all the animals have died after showing a gradual decline accompanied with marked anaemia. The cobalt-treated animals, although poor after a dry summer, are living and free from the typical symptoms of coast disease. It is evident that the amount of the "curative element" present in the limonite is insufficient to bring about marked benefit when fed at the above level, for some of the animals so treated have died, while others still living are more or less affected with the malady. Dosing with pure iron salts had no affect.

The field observations are being extended with a view to establishing the frequency of dosing necessary to prevent the onset of symptoms in young sheep continually depastured on areas affected with coast disease.

Comprehensive agrostological investigations have been started to determine, if possible, a means of establishing sown pastures of perennial grasses and legumes on the highly calcareous soils of the coastal regions; and species and manurial trials have been laid down on the areas under the Division's charge at Robe.

(viii) *Phosphatic Lick Investigations.*—(*a*) *Penola, South-eastern South Australia.*—Through the generosity of Mr. R. Rymill facilities have been made available on "Penola" Station for the establishment of a field experiment site. Areas sufficient to run two groups of 100 ewes and their lambs have been fenced on a tract of even type of grey silt country carrying one sheep to two and a half acres. The findings of our colleagues of the Division of Soils, who generously conducted a survey of the area, indicate that the herbage cover on this type of country is limited by the low level of phosphorus in the soil.

Ewe lambs from a large flock, ear-tagged as they were dropped, have been divided with their mothers into two flocks having the same age distribution. One flock will have free access to salt; the other will have continual access to a lick composed of dicalcic phosphate and salt. Half of the first flock will be drenched three time a week with sufficient potassium phosphate to provide 7 gm. of phosphorus per week, while half of the second flock will be similarly drenched with a quantity of potassium bicarbonate sufficient to suppy the amount of potassium administered to the others as potassium phosphate. The observations on general health, growth, wool production, &c. will be carried on for two and a half years, when the young ewes will be mated and the effect on fertility and on the growth and well-being of the second generation of lambs will be studied. Blood phosphates will be determined once each month during the course of the experiment.

(*b*) "*Manuka*", *Winton, Western Queensland.*—A similar trial has been started as a co-operative effort on the property of the Australian Estates & Mortgage Company at Winton, Western Queensland, where the effects of offering phosphatic lick *ad lib* to sheep grazing in that area will be studied. Mr. J. F. Kennedy, B.Sc., an officer of the Company, is in charge of the experiment.

(*c*) "*Wambanumba*", *Young, New South Wales.*—A trial planned along the same lines as the experiment at Penola has been started on the phosphorus-poor country at "Wambanumba".

(*d*) *Avondale, Merredin, &c., Western Australia.*—The Minister and Director of Agriculture of Western Australia have generously decided to extend the investigations in their State. Phosphatic lick trials, which conform with the general scheme, have been started at each centre, and are under direct control of officers of the Western Australian Department of Agriculture. These studies will considerably augment the experimental work of the Division.

VII. 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, twofold, 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 and manuring experiments and the ready application of results to similar soils mapped on the settlement.

Within the last few years the locking of the river Murray and the consequent maintenance of the river at a constantly high level appears to have played an important part in modifying the drainage régime of those settlements situated on the terraces adjacent to the main flood plain of the river. It has been found that the soil surveys are likely to prove of service in elucidating the problems involved and in elaborating measures for the protection of these settlements.

2. *Soil Surveys and Chemical Investigations of Soils.*—The Division has been concerned with work in three States carried out by its own or State officers and in the main connected with the more closely settled horticultural areas.

During the past year major field surveys have been in progress exclusively in New South Wales. Attention was directed to the Wentworth group of horticultural settlements at Curlwaa, Pomona, and Coomealla, and to the Murrumbidgee irrigation areas. Field work in this State has now been completed in so far as the principal developed areas are concerned. A reconnaissance of the Lake View extension of the Mirrool area was also carried out. Since September, 1933, when these surveys in New South Wales were initiated, the areas covered have been :—

Murrumbidgee Irrigation Areas (horticultural soils)	
Yanco	10,000 acres
Mirrool	6,000 acres
Lake View (reconnaissance only)	4,000 acres
Wentworth areas	
Coomealla	2,800 acres
Curlwaa	2,500 acres
Pomona	600 acres

The main concern of these 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 such as those at present being carried out under the direction of the Merbein Research Station and by the Research Branch of the Water Conservation and Irrigation Commission of New South Wales.

The laboratory work on the Wentworth settlements has also been completed.

In Tasmania, investigations have been initiated into the character of the red basaltic soils characteristic of the most fertile regions of the north coast of Tasmania. The method of approach has been to make a detailed survey of the most important and most characteristic area, that at Burnie, and to make more general systematic examinations of the other areas. On these soils, the most important economic questions include the value of liming and the establishment of pastures. Special attention has, therefore, been devoted to the lime status of these soils.

During the year laboratory investigations into the chemical and physical character of similar red basaltic soils collected some time ago in Queensland and New South Wales were completed.

In Western Australia, the 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. In view of the recent findings

with regard to the probable importance of cobalt in relation to both coast disease and the Denmark wasting disease, special attention has been devoted to the search for traces of heavy metals in these soils. Field work at Denmark was completed during the previous year and attention during the present year has been directed principally to laboratory investigations.

During the year contact was maintained with the Forest Department of Western Australia with reference to problems of pine nutrition and establishment, and also in connexion with soil surveys as an approach to the problem of site values. In association with the Department of Agriculture a soil and vegetation traverse was made in the pastoral semi-desert country between Meekatharra and Port Hedland.

3. *Bacteriological Investigations.*—The most recent development in the activities of the Division in the field of bacteriology has been the investigation of the nodule producing strains of bacteria associated with leguminous plants with special reference to subterranean clover and to lucerne. The variability of natural strains within the two bacterial species concerned has proved to be of great significance. A complete understanding of this variation is essential for the selection of the most highly efficient strains for use under field conditions.

Many of the naturally occurring strains of the organisms associated with clovers have proved to be relatively ineffective in their capacity to give to the host plant its optimum nitrogen supply. High infective virulence may not always be associated with high physiologic efficiency; and, since subterranean clover has not been observed in the field free of nodules, benefits can only be obtained when strains used for seed inoculation for field purposes possess an infective virulence sufficiently high to offset the competitive effect of strains less effective in their capacity to supply nitrogen to the host plant.

An important consideration in the extension of trials of seed inoculation in the field is that nodulation of the same or related legume species in the vicinity cannot be taken as final evidence that no benefits will be derived from the practice, for bounteous nodulation may be produced by relatively ineffective strains.

The study of variation, particularly of the clover organism, is being continued, and the differential influence of host plant species will also be given due consideration. It is hoped materially to improve the technique for selection of most suitable strains for commercial use and, in the case of both legume species, further to extend the knowledge of field conditions in relation to beneficial seed inoculations.

VIII. IRRIGATION SETTLEMENT INVESTIGATIONS.

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

1. *Introduction.*—The Viticultural Research Station at Merbein is centrally situated in respect to Murray Valley irrigation settlements of which dried fruits are the major products. The problems at present being investigated comprise principally the investigation of irrigation methods and the attendant problems in connexion with salt, seepage, agricultural drainage and the general preservation of soil fertility.

Cultural practices, including the training and pruning of vines, and the processing and packing of the dried fruit also form an important part in the programme of work. A limited amount of administrative work, in organizing and bringing into practice the results of research, is also undertaken in co-operation with the officers concerned in the various States and with primary producers' organizations.

While a number of short-dated problems of local interest to one or other of the various settlements arise, the chief activities of the Station are long-dated investigations of major problems.

The geographical range of the areas in which the investigations are carried out is necessarily wide, as each area may vary in such important particulars as soil type, availability of irrigation, method of irrigation, the crops grown, and the general environment. Thus to cover urgent inquiries sought in the different centres, organized investigations have been established in all Murray Valley fruit-producing centres from Woorinen (Victoria) to Mypolonga (South Australia), a total distance of over 300 miles.

2. *Results of Economic Interest.*—Much of the work in connexion with irrigation has been designed to secure further data on the important question of the preservation of soil fertility. Considerable advancement has been made by utilizing the results of irrigation, salt, and drainage investigations.

Over a period of years in the majority of irrigation settlements there has been an increasing area of land becoming wholly or partially unproductive. In recent years an awakened interest in this aspect of irrigation has arisen and a growing conviction, based on results of research and rural practice, that the capital lost by rendering land unproductive may be preserved.

Similarly, investigations into the production of grapes, the processing of the dried product, and the fumigation and care of the fruit during storage and transport, have now advanced to the point when the improvements suggested as a result of research are incorporated in many major routine practices.

(i) *Soil Preservation.*—Comprehensive surveys of free water in the subsoil, considered in relation to the condition of the plants grown and the irrigation methods employed, disclosed a close association between free subsoil water and loss of soil fertility. Correction is steadily taking place by a reduced application of irrigation waters, and the lowering or removal of established free water by agricultural drainage. These remedial measures are now well advanced in the Mildura district ; and organized drainage works are in course of construction in affected areas in Barmera and Waikerie, South Australia. In Nyah and Woorinen (Victoria), and Renmark and Berri (South Australia) the investigation of drainage problems is proceeding.

(ii) *Irrigation Method.*—The results of investigations dealing with the method of irrigation are also now being utilized, and substantial improvements have been effected in many areas. For example, the Red Cliffs settlement of Victoria (9,000 acres) is now being irrigated in less than three weeks, in contrast with a six weeks' community period in past years. Other settlements, principally Merbein (Victoria) and Berri (South Australia) are making progress in a similar direction. As such movements afford greater efficiency in irrigation service, accompanied by a decreased cost in each irrigation service and greater preservation of soil fertility, their importance cannot be too highly stressed. Annual losses occasioned by a prolonged inter-irrigation period have frequently been in evidence in the past, and have been largely avoided by present methods whereby more frequent irrigations are rendered possible. Improvements in irrigation practice are necessarily brought about slowly, as they involve determination of the methods for minimum efficient quantities of irrigation water, and, at a later date, structional alterations to distributing channels and appliances.

(iii) *Dried Fruit Products.*—Two marked disabilities of former years were associated with a lack of uniformity in the product, and inability to store or even to transport the products without serious losses from entomological pests of dried fruits. Both these disabilities are now of less concern. In recent years the fruit has been successfully held for periods up to 18 months, and the overseas realization for the Australian product has been satisfactory in comparison with competitive countries. Improved processing and packing methods, and the development of successful methods of combating dried fruit pests have contributed very largely to these successful results. Marked changes in the past year have been the standardization and adoption of a highly efficient fumigant (ethyl formate), and an extension of processing in the packing houses to include the application of oils at this stage to overcome the former variations resulting from application by the producers individually.

(iv) *Viticultural Studies.*—Viticultural studies of present commercial interest comprise systematic field experiments on shoot control, the relation of different types of shoots to the quality of the fruit, and in particular the balancing of fruiting wood in relation to the quantity, quality, and regularity of the crop. The results of this work have been recently circulated ; and the improved methods are being taken up by growers.

3. *Irrigation Problems.*—The problem of the preservation of the fertility of irrigated land is universal ; and special investigation of each soil type is necessary to establish appropriate methods by which land may be efficiently irrigated without adversely affecting productivity. The investigations outlined have been designed to improve faulty methods which have been used to the detriment of the soil for many years.

(i) *Method of Application.*—The rate and direction of soakage varies with each soil type ; and field experiments are being conducted to measure soakage accurately for determination of optimum spacing of furrows, period of soakage, and obviation of excess free water. These determinations are then utilized in laying out methods of irrigation on a series of small plots representing major soil types. The ultimate aim is to determine an effective method of irrigation which does not entail soil wastage. Plots for this purpose are located at Waikerie, Barmera and Berri (South Australia), and Red Cliffs, Merbein, Nyah and Woorinen (Victoria). In each case the work is carried out with the co-operation of the State officers concerned.

(ii) *Periodicity of Irrigation.*—The periods at which irrigation water is applied is of interest agriculturally to the extent that provision must be made to irrigate before soil water is depleted to the point that plants suffer, and of interest economically in that an unnecessary number of irrigations should be avoided. The investigation is a lengthy one, as it comprises not only soil moisture determinations but laboratory determinations of soil constants for interpretation of the soil moisture results. The general aim is to secure an interpretation of the soil moisture requirements, in reference to the plant growth and the season of the year, on each of the principal soil types. Six major soil types are at present utilized for the general investigation ; and one site for a special investigation of the physiological effects of heavy applications of irrigation water at the stage when the vines are flowering.

(iii) *Salt Investigations.*—An area of land on which the salt content prior to irrigation has been intensively mapped has now been irrigated for four seasons. The changed location of the salts resultant on irrigation has been mapped for each of the last four years. The data disclose

that the translocation of salt, and the preservation and improvement of soil fertility, bear a close relation to the method of irrigation, the quantity of water applied, and to agricultural drainage. The annual survey has disclosed fairly consistent results, and it is proposed that future surveys shall be carried out less frequently, probably at two or three year intervals. The work on the "salt field" has been intensified, and now includes the leaching of salts by heavy applications of irrigated water on drained soils, and the specific reactions to soil conditions and the growth of vines on a site where the quantity of water applied has been controlled, and the depth of drainage varied.

(iv) *Agricultural Drainage.*—A survey of the fluctuations of free subsoil water to a depth of 10 feet has been completed in selected regions in the Berri and Barmera areas (South Australia); and the work is now being extended to Waikerie and Renmark (South Australia) and Mildura (Victoria). Soil water movements in relation to agricultural drains have been recorded on selected sites in the Merbein district. The work carried out so far represents mainly an initial survey of the problem on which drainage systems now being commercially installed may be based; and on which more extended investigations now in progress were planned. Reclamation studies on a large scale are in progress in the Cardross section of Red Cliffs. The community drainage system in this section is one complete unit, over which the application of irrigation water, the discharge and quality of drainage water, and the length of internal drains, are being systematically recorded.

4. *Viticultural Problems.*—The investigation of viticultural problems is directed in two main directions. Fundamental research includes a study of bud development and the interaction on bud development of routine practices which affect growth. These practices include irrigation, winter and spring pruning, balance of fruiting wood, proportion to fruit and growth, and the application of fertilizers. This portion of the work is being carried out in co-operation with the Division of Plant Industry, and is a combined laboratory and field investigation. It is long-dated in that residual results disclosed in after years must be taken into account.

Field experiments, based mainly on trial and yield results, are also in progress, being directed to an examination of traditional practices, particularly in cases where practice varies within one district for no obvious reason. Pruning, cincturing, the balance of fruiting wood, regularity of yield, and reconstitution of old and damaged vines, are embraced in this work. A special inquiry has been initiated into the problem of the soil nitrogen, as it affects vines growing under irrigated conditions. This inquiry covers several phases. In the first place the seasonal changes in soil nitrate are being followed in manurial plots, subjected to various treatments. These include a comparison of the effect of the ploughing in of leguminous cover crops as against the application of inorganic nitrogenous manures.

Supplementary studies are designed to study the effect of the time of application of nitrogenous manures, with special regard both to soil nitrate content and the need of the vine. This work includes field and pot culture tests.

Leaching losses, both on a laboratory and on a large scale drainage scheme, are also being investigated. These preliminary data are tending to modify considerably our views regarding the manurial need of the vine. They indicate that absorption of nitrogen takes place over a considerable period and they tend to emphasize the fact that, if the practice of consistently ploughing in cover crops is adopted, there is a very considerably reduced necessity for applying supplementary manures.

5. *Fruit Processing.*—The incorporation of olive oil in the dips used prior to drying grapes has in the past been as "home made emulsions." Finer emulsions, prepared by proprietary firms, are now on the market, and the standardization of these preparations in the dips has been commenced. The inquiry is particularly necessary in the case of the "cold dip", as both the fineness of the emulsion and the quantity of oil used react markedly on the fruit during the drying period. As this work necessarily includes storage trials, periodic examination will be continued during the full period over which the fruit is sold. The complete investigation combines laboratory and field examination in respect to the chemical changes and composition of the fresh and dried grapes, and of the substances used in processing.

The measurement of moisture content, an important factor in keeping qualities, has been instituted by the standardization and incorporation in commercial practices of an electrical moisture meter.

A new fumigant, ethyl formate, has also been standardized, and is being used extensively throughout Australia.

6. *Pasture Plots.*—A series of pasture plots have been sown at the Research Station, Merbein, to demonstrate the type of pastures that could be established in the Mildura district, and to secure appropriate measurements as a guide to carrying capacity. It is considered that certain lands of marginal value within and around the settlements could be put to better use than at present, to provide grazing for working horses, and for the cows kept on some holdings for house supplies.

The pasture plots were established in September, 1935, on a basis of simple groups suggested as likely to be suitable to the district. In addition, a small series of lucerne plots have been established, for study of the different strains of nodule organisms on lucerne. This work is being carried out by Mr. Strong, microbiologist of the Council's Division of Soils.

7. *Co-operation with State Departments and Primary Producers' Organizations.*—The system by which the consideration of certain major problems and the initiation of research are jointly undertaken by the primary producers and officers of the State Departments concerned as well as of the Council has been continued. Investigational Committees, on which the staff of the Merbein Station is represented, comprise the following :—

Drainage Committee, Mildura District.
Interstate Fruit Processing Committee.
Nyah-Woorinen District Inquiry Committee.
State Irrigation Committee for South Australia.
Citrus Advisory Committee for the Lower Murray.
District Advisory Boards for Irrigation.

The work of Committees of this nature includes consideration of urgent problems, recommendations for improvement in method if sufficient information is available, and initiation of research. Arrangements are then made for the investigation of urgent problems at an existing institution, with due regard to prevention of overlapping of activities.

In connexion with the research sought by these Committees, the Merbein Station is engaged in problems relating to drainage, fruit processing, and irrigation.

8. *Financial Assistance.*—Various bodies connected with the dried fruit industry grant financial assistance to the Merbein Station. The total annual contributions now exceed £3,000. The contributing bodies include the Australian Dried Fruits Control Board, the four chief packing companies of the Mildura district, and the Nyah-Woorinen settlers. The 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 various experimental plots.

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

1. *General.*—The investigations at this Station, which is financed partly by the Water Conservation and Irrigation Commission of New South Wales, have yielded results of great value to the irrigation settlements, and useful progress has been made during the past year. The Station has also received valued co-operation from the Griffith Producers' Co-operative Co. Ltd. and from local growers, particularly with respect to the cold storage investigations being undertaken.

The Station has 34 acres planted to citrus, which comprise field experiments concerning fertilizers, green manuring, bud selection, irrigation methods, citrus preservation and other investigations.

The following account summarizes these and other laboratory and field investigations in progress.

2. *Green Manuring.*—It has been previously reported that winter green manure crops such as tickbeans (*Vicia faba*) have led to an increase in both the size and yield of orange trees. Summer-growing green manure crops such as cowpeas, lucerne or Bokhara clover have proved unsatisfactory owing to the competition of the green crops for soil moisture during the summer months.

The practical results of these experiments have been widely adopted on the irrigation settlements ; and since the results of these investigations were first published, the practice of winter green manuring has increased at the rate of about 33 per cent. each year. Whereas formerly practically no green manures were used, it is now the accepted practice on well managed orchards.

In an extension of these investigations, trials of various winter grown legumes carried out for some years, indicate tickbeans as being most suitable.

Fundamental investigations are in progress to determine the causes for the effect of green manures in increasing plant growth under the conditions of the irrigation area. Extensive studies of the soil nitrate content throughout the year revealed that nitrates are quite plentiful, even to considerable depths, both where the orchard soil is maintained in a state of clean cultivation and where green manures are used. In fact, more nitrates are present throughout the year in the clean cultivated plots than in the green manure plots. In addition, investigations have revealed that heavy dressings of non-organic nitrogenous fertilizers fail to have the same effect as green manures. Repeated green manuring has been found to alter the soil structure favourably, and has a slight though unimportant effect on the water holding capacity of the soil ; but both these physical effects are ruled out as explaining the marked effect on plant growth noted. Pot experiments, using ignited soil, show that wheat in the early seedling stage makes just as satisfactory growth where

mineral salts are added as where green leguminous plants are added. Within the course of a few weeks, however, plants in the soil devoid of organic matter show signs of distress, whilst those manured with the leguminous refuse show healthy growth and rapidly overtake them. This line of investigation is being followed up.

3. *Fertilizer Experiments.*—The fertilizer requrements of citrus trees are being studied both from the point of view of the effect on the size, yield and health of the trees, and of the quality and chemical composition of the fruit.

4. *Alternate Cropping of Valencia Oranges.*—The investigation of the objectionable cropping of the Valencia orange is being carried out in co-operation with the Division of Plant Industry. On the irrigation areas the Valencia orange tree bears heavy and light crops alternately. The fruit of the heavy crop is inclined to be undersized and that of the light crop overlarge and coarse. It has been found that partial removal of the newly set crop during the heavy crop year increased the setting and crop the following year. The heavier and the earlier the thinning, the greater the effect. The removal of the fruit as late as August will influence the blossoming and setting that occurs a few weeks later. The removal of part of the crop in January (just after setting) has only a small effect on the ultimate size of the remaining fruit. This suggests that the small size of the fruit of the heavy crop year is largely due to the heavy blossoming, and only to a small extent due to the maturing of the heavy crop.

The investigations are being continued and include studies concerning the effect of time of application of nitrogenous fertilizer.

5. *Cold Storage of Citrus Fruits.*—The citrus preservation work being carried out at Griffith forms part of the extensive investigations conducted at different centres by the Council, in co-operation with State authorities. The Station's investigations deal mainly with the effect of orchard environmental factors on the keeping qualities of oranges, and the variation in the keeping qualities due to environmental conditions.

Previous work has shown that the keeping qualities of oranges vary from farm to farm, and it is important to determine the relative influence of the large numbers of orchard factors concerned. The effect of different methods of green manuring and different irrigation practices are being studied. Such factors as time of picking, method of picking, and processing methods are also receiving attention.

A statistical study of the variability in the chemical composition of oranges was concluded.

6. *Frost.*—The frost menace is serious in many of the horticultural districts of the Commonwealth, and many aspects of the problem are studied at Griffith. Investigations concerning the influence of uncleared mallee scrub on the incidence of frost, and concerning methods of protecting young trees from frosts, have been referred to in previous reports.

A large portion of the horticultural section of the Murrumbidgee irrigation areas has been mapped according to the frost liability of the localities. Frost prevention by means of orchard heating are under investigation, and the use of chemical smoke screens for the same purpose has received attention. During the year a report was submitted to the New South Wales Water Conservation and Irrigation Commission on the frost liability of the Lake View mallee area, which it is proposed to develop for settlement.

7. *Permanent Pastures.*—A trial and local demonstration of permanent pastures has been laid down. These include variety mixture trials and fertilizer plots.

8. *Irrigation Investigations.*—Much of the widespread damage due to faulty irrigation can be corrected by following certain general principles, but often this can be done only within wide limits. Investigation and extension work is handicapped by pronounced lack of fundamental data on the complex relation between soil type, slope, length of run, flow and other factors in irrigation. The Research Station is concentrating on this aspect, and is working in close touch with the soil survey of the Murrumbidgee irrigation areas now being concluded by the Council's Division of Soils. The following outlines the chief aspects under investigation :—

(i) *Soakage Units.*—Investigations were conducted on a large number of methods for rapidly obtaining the soakage characteristics of soils on a quantitative basis. The soakage rate and profile were determined from cylinders or square boxes enclosing areas up to .25 square metre. These tests related to the effect of area, surface conditions, depth in soil, and general methods of obtaining uniform conditions for comparing soil types. The studies were extended to soakage from standard lengths of furrow designed to approximate actual irrigation conditions. The technique already developed for the further extension of these methods to large scale furrow irrigation has been outlined in previous reports.

(ii) *Study of Research Station Soils.*—Soakage unit tests on permanent green manure and lucerne plots cropped for some years showed marked variation in permeability due to cultural conditions. Under orchard conditions for a number of years, these moderately heavy soils became decreasingly permeable, especially under clean cultivation ; and difficulty is now

experienced in applying sufficient water in a reasonably short time. The same soil type under lucerne for several years, however, has a high soakage rate. The lucerne field has now been planted with citrus for duty-of-water investigations, and a long-range study has commenced to determine any subsequent changes in permeability.

Furrow tests are being conducted to ascertain the irrigation requirements of the Research Station soils. The technique and principles developed in detail here will facilitate the determination of the irrigation characteristics of other soil types on the area.

(iii) *Investigation of Lake View Mallee Soils.*—At the request of the New South Wales Water Conservation and Irrigation Commission, an investigation was commenced on the irrigation characteristics of a large area of mallee, which it is proposed to develop for settlement. The Division of Soils classified the land into six chief soil types, and, using .25 square metre soakage units, a rapid reconnaissance was made of these. A preliminary report has been submitted indicating the characteristic permeability and soakage profile of each type. From the soil survey and this irrigation data, future work will be concentrated on the three most promising types. For quantitative comparisons between these soils further tests will be conducted on locations selected to represent the range of soil variation in each type.

(iv) *Soil Salt Studies.*—The movement of the soil salt due to the soil moisture relationships is being studied by means of specially constructed columns of soil in its undisturbed state. Where a water table is maintained at 1 metre from the surface by the supply of water from below, salt has moved towards the surface. After two years no surface accumulation has occurred where a water table has been maintained at 50 cms. by addition of rainwater to the surface.

(v) *Other Irrigation work.*—A long term investigation has been commenced on the relation between moisture content and permeability. The significance of soil structure *in situ*, soil texture, and permeability is also being investigated.

IX. FOREST PRODUCTS INVESTIGATIONS.

1. *General.*—The outstanding feature of the year has been the gradual move towards completion of the new building in South Melbourne to house the Division's activities. It is anticipated that building operations will be completed before the end of August and the Division should be installed in its new home by the end of October ; though there will still remain much to be done before the work will be able to proceed smoothly.

A start has been made in moving some of the plant and erecting it in its new position ; but owing to many delays in the erection of the extensions to the main building, it has not been possible to make the progress planned. It is proposed to make the move without stopping the work of the Division as a whole. This will necessarily mean spreading the move over a long time, and, further, necessitates very careful planning. In selecting the site for the Division's permanent location, many factors had to be taken into account; and without a careful balancing of these, the opinion might be held that a larger site should have been selected. That there will be some inconvenience in the future, owing to the restricted area, is undoubted, but this was held to be of minor importance when compared with the advantages of the very central position, close to the centre of the timber industry. Such inconveniences as arise can be met, but the disadvantages of an unsatisfactory location cannot be removed.

Provision has been made for a four storey main building, of which three storeys have been erected. This will house the main storage rooms, administration, library, museum and laboratories for preservation, chemistry, physics, and wood structure. No attempt has been made to furnish these laboratories in an elaborate manner. The funds provided would only allow the provision of essential services, and the fittings, though good, are simple, and adequate for the requirements of the work.

In addition to the main building, there are four extensions. One houses the boiler equipment, seasoning, and preservation laboratories. A second provides for wood and metal workshops; a third forms the timber mechanics laboratory, and the 600,000 lb. testing machine provided from the generous gift of Mr. Russell Grimwade is being erected therein. The fourth extension will be a sawmill for handling the large size timber which is sent in for testing.

In this fine building, with room to work in comfort, and with excellent equipment, it is confidently hoped that the usefulness of the Division's work will be greatly extended, and certainly the comfort and convenience of the staff, which now numbers over 50, will be immensely improved.

The period of eight years in which the work has been housed in great discomfort has not been altogether a disadvantage. The staff has learned to make good use of such space and appliances as have been available and much valuable experience has been gained as to what is really essential. This led to a far more satisfactory and efficient design of the new buildings than would have been possible some years ago.

The Chief of the Division left in March for a visit to the main centres of forest products research in Canada, United States of America and England, before proceeding to South Africa to attend the fourth British Empire Forestry Conference. This was the first of such conferences at which any attempt has been made to give prominence to forest products research. On previous occasions, almost all the time has been spent on discussion of sylvicultural problems. Representatives of forest products research institutes in Canada, England, South Africa, Burma, Malay and Australia were present and had the first opportunity of jointly discussing their common problems.

One result was that it was found essential to recommend the calling of a special conference of forest products workers before the next general conference in 1940, especially to consider methods of standardizing certain methods of testing. It was further decided that a special committee should be set up to consider methods of preventing unnecessary overlap in the programmes of Empire laboratories. A beginning has been made in this direction.

Two very noticeable results of the deliberation of the general conference were the evidences of a growing understanding of the importance of forest products research in general forestry programmes and of a growing appreciation by the two main divisions of forestry of the other side of the work. And, further, the clear demonstration that existing statistics in regard to production, consumption, and marketing of timber are hopelessly inadequate and unable to present even an approximation to the true facts. Efforts are planned to improve this position.

Mr. S. A. Clarke, Deputy Chief of the Division, carried on the work during the Chief of Division's absence ; and as the new building brought a tremendous amount of additional work, he had to carry a very heavy burden.

In regard to exhibits of forest products, the Division for the first time in its history had a small display, illustrating some of its activities, in the Ideal Homes Exhibition, held at the Exhibition Building, Melbourne, from 21st February to 7th March, 1936. The space available was small, but into it was crowded material to show something on the methods of attack by white ants and how to prevent their damage in houses, a demonstration of the electrical moisture meter, and of the effect of using green timber in the construction of doors and other fittings, in comparison with kiln dried material. Other illustrations were given on methods of timber construction. The exhibit attracted a great deal of attention and led to many inquiries from interested visitors.

So successful was this effort, that it is planned to considerably extend this type of activity in the future, for no matter how widely publications are distributed, nor how many articles appear in the press, there still remains a large proportion of the population which is not effectively reached, and such exhibitions seem likely to prove a most satisfactory way of reaching many of these people.

Among other interesting lines of work developed during the year, a full study was made of the veneer and plywood industry in Queensland, with special reference to gluing practice. This survey led to recommendations for improvements in the industry.

The growing interest by large timber users in preservation processes has been a great encouragement to the Division to extend its investigations in this field. A large number of co-operative projects have now been initiated and these are being closely watched by a large number of interested inquirers. There can be no doubt that in a few years developments in this field in Australia will be similar to those which followed in the practice of seasoning as a result of the Division's work.

This latter continues to grow in every State, and there are now 376 kilns in operation in the Commonwealth, an increase of 58 for 1935–36. It is interesting to note that the President of the Royal Victorian Institute of Architects referred in his annual address to the influence that kiln seasoning and reconditioning had had in developing the use of local timbers. It is only a few years since most architects, builders, and many engineers looked upon kiln drying with suspicion and compared it unfavourably with what they called " natural seasoning."

Steady progress is being made in studying the physical and strength properties of our timbers. The volume of work yet to be done to fill in the gaps in elementary knowledge of these properties is very large, and years will pass before these somewhat tedious measurements can be completed. Progress reports will shortly be published covering data obtained up to the present.

It will not be many years before the regrowth timbers, which are being grown on cut-over forest areas, will necessarily form an increasing volume of the timber available. In anticipation of this period, extensive studies of the properties and treatment of such timbers are being carried out. The results of this work will form the basis of much of the future timber practice. It will be possible to begin to publish some results very shortly.

The work on fundamental paper-making properties of hardwood fibres, carried out in co-operation with Australian Paper Manufacturers Ltd., is progressing satisfactorily. Difficulties in the analytical procedure were met with in the early stages, and these have to be overcome before results of various treatments of pulps can be properly interpreted.

A promising field of investigation is an attempt to develop a plastic from sawdust. This is based on work begun at the Madison Laboratory. Some Australian timbers seem to offer particularly good possibilities in this direction.

In addition to developing suitable drying schedules and general advisory and educational services on seasoning, researches are being carried out on kiln aerodynamics, information on which is essential to improvement in kiln design. The first of a series of articles on this work has been published in the *Journal*, and others are ready for publication in future issues.

Grading studies in Tasmania and Victoria are now completed, and reports are being prepared. New South Wales and Queensland timbers will be studied in the coming year.

The erection of the first wooden fire tower using wood connecters in Western Australia has created a great deal of interest, and inquiries have been received for design of other towers. Preparations are well in hand for a series of tests on built-up columns, and await the erection of the 600,000 lb. testing machine. This form of construction is certain to develop greatly and proper design must be based on actual tests.

Among notable gifts received by the Division during the year, almost all the timber for the new building was donated. Thanks are due to the following for their splendid help :— Tasmanian Timber Organization, Western Australian Forests Department, Millars' Timber & Trading Co., State Saw Mills, Western Australia, Associated Country Sawmillers of New South Wales, Queensland Forest Service, South Australian Woods and Forests Department, Victorian Forests Commission, and Victorian Hardwoods Ltd. The Queensland Forest Service, in addition, made a grant of £250 to the Division, and the Queensland Plywood and Veneer Board repeated its donation of £100.

Thanks are also due to the Britsh Australian Tobacco Co. for the gift of several hydraulic presses for glue work, and also to the following who made donations to the Division :—Holden's Motor Body Builders, and Messrs. McLaren & Co. Pty. Ltd., Fitzroy.

The very happy co-operation existing in the past between the Division, the timber trades, Forest Services and overseas Forest Products Laboratories has been continued. It is not possible to single out any particular body as all have given valuable assistance to the extent of the calls made upon them.

2. *Wood Structure.*—(i) *Wood Anatomy.*—The work on the investigation of the structure of various Australian timbers and the development of identification methods has been continued. Following the adopted procedure of considering these timbers according to natural groupings, attention has been directed to the natural orders :—Cunoniaceae, Meliaceae, Sapotaceae, Ebenaceae, Styracaceae, Rutaceae and Coniferae. In the case of the Coniferae (covering all non-pored timbers), methods of identification were investigated for the separation of the Australian, New Zealand, and Northern Hemisphere species.

It is proposed to prepare for publication the information obtained on the anatomy of the woods of the Rutaceae, which family contains important timber producing species, e.g., silver ash, crow's ash, Queensland maple, and others of the genus *Flindersia*.

Further work along these lines has been directed to the intensive study of the various eucalypts and other timbers of the Myrtaceae in order to improve existing methods for their identification.

(ii) *Basic Density.*—In the further investigations of variations in basic density (oven dry weight and volume when soaked) within a tree and within a species, samples from six trees of red tulip oak (*Tarrietia argyrodendron* var. *peralata*) and from 27 trees of spotted gum (*Eucalyptus maculata*) were studied. In the spotted gum particularly there was but little variation, 80 per cent. of the results falling within a narrow range. The remaining 20 per cent. were obtained from the wood taken with a radius of 4 cm. from the pith. Outside that zone the density was found to be remarkably uniform.

In connexion with routine identification work, basic density determinations were carried out on the woods of the Rutaceae and Meliaceae.

(iii) *Causes of Brittleness.*—Investigations have been commenced to determine the relationship between brittleness and wood structure. It has been found that " broken fibres " are of common occurrence in the brittle heart of numerous species of eucalypts, and that minute compression failures are also present in the same areas. It has also been found, however, that these features are associated with brittleness in the case of numerous timbers other than eucalypts. Thus, it is apparent that " brittle heart " is more widespread in Australian timbers than was realized. Experiments have shown that it is common in the various species of young eucalypts grown in South Africa.

The nature of the brittleness developed in wood which has been subjected to high temperatures is being investigated. From results available to date, it seems that " broken fibres " are not associated in general with brittleness due to causes other than " heart ".

In furtherance of these investigations, attempts will be made to examine the nature of the actual failures in the fibres themselves.

(iv) *Compression Wood.*—Further investigations have been made of compression wood in hoop pine. The most interesting fact revealed was that the area of supposedly normal wood opposite to the compression wood zone was full of macroscopic and microscopic compression failures. Broken fibres were also found to be numerous in this area. In following up these points, samples from a very young tree of *P. radiata* (3-4 years) in which compression wood had been artificially produced, were examined. While in this case the area opposite the compression wood did not give broken fibres of the same nature as those found in the hoop pine log, there were indications of fibre weaknesses and of cross breaks in the cell walls.

(v) *Paper-making Fibres.*—Numerous determinations have been made of the length and breadth of the fibres from various sulphate pulps prepared from different species of eucalypts, and the ratios of length to breadth compared. It was found that jarrah pulps which gave trouble in paper-making had the lowest ratio, approximately 35 to 1, which is lower than is usual in eucalypt fibres.

The effect of the addition and removal of wood gum on the beating properties of fibres from *E. sieberiana* was followed microscopically. The type of fibrillation caused by the beating was markedly different in the case of fibres from which the wood gum had been removed. This difference was also apparent when fibre swelling tests were carried out. The removal of the wood gum reduced the swelling propensities.

(vi) *General.*—The Senior Wood Anatomist, who was absent during 1935 on special leave, attended the meetings of the International Wood Anatomists' Association, held under the aegis of the International Botanical Congress in Amsterdam during September, 1935. He also visited the Forest Products Laboratories in Great Britain, United States, and Canada, the Yale School of Forestry and the Imperial Forestry Institute, investigating latest developments in the study of wood anatomy.

Arrangements have been made for the exchange of authentic wood samples with the idea of building up the Division's collection of world timbers.

During the year, the services of the Section were called on for 220 identifications, as well as for the distribution of general information on wood structures and botanical and trade names.

3. *Utilization.*—In the Utilization Section, timber grading projects have been intensively developed. Field work initiated in Western Australia and continued in Victoria in previous years was extended in 1935–36 to South Australia, Tasmania and New South Wales. The collection of data on the defect characteristics of sawn timber and sleepers proceeded in order to give a broad view of the qualities found in typical supplies of the principal Australian timbers. Sawmill outputs were sub-divided into both product classes and quality classes. From records of the limiting defects, the distribution into standard grades was determined, and the effect of amending the defect limits was gauged by determining the grade re-distributions. It was found that strict application of standard grades would severely limit the production of the products they are intended to cover, and that the trade placed a rather liberal interpretation on the defect limits to increase the yields. None of the standard specifications proposed to date appeared to be observed strictly by producers or insisted upon by consumers. Modified limits have been tried with the principal timbers, and those showing promise of simplifying or improving grading practice will be tried out on all timbers embraced by the grades. This method of approach to the formulation of rational grades will, it is hoped, largely supersede the former method of deciding defect limits without the necessary guides to their effect on timber utilization.

The secretarial work for the Standards Association's Timber Sectional Committee was continued. During the year draft Australian standard grading rules for hardwood paving blocks and for *Pinus radiata* milled floorings, linings and weatherboards were issued for public comment. Progress was made in drafting specifications for milled products of New South Wales and Queensland timbers and further steps taken in preparing specifications for doors, window sashes and frames, mouldings, joinery stock, plywood and solid core stock. The important question of standardising the common names of the principal timbers of Australia also received the consideration of Committees in three States.

Preliminary consideration was given to surveying the uses of timber in building construction. Timber does not enjoy a popularity as a material of construction commensurate with its many excellent technical properties. Emphasis tends to be placed on its disadvantages rather than on its advantages. How far the limitation of use is due to faulty construction, to imperfect preparation, or to unwarranted prejudices are questions which are of outstanding significance to the timber trade. Already improved seasoning and grading has regained some lost ground, especially for local flooring and joinery timbers, but, as yet, little progress has been made in developing methods for cheaper or sounder construction, or in improving the finished appearance of wooden structures. Liaison has been maintained with the Building Industry Congress.

Further study was made of factors affecting sawmilling efficiency. Output tables for a range of tree and log sizes were constructed, and the grades from a number of pruned plantation softwood trees compared with unpruned. The economical size of log for one softwood operation was indicated. Descriptions of equipment and sawing methods in a large number of sawmills were accumulated, and these will be used in the development of more efficient sawmills. Two sawmills and a veneer plant were designed during the year, and enquiries answered relating to bandsaws, portable power felling saws, tractors, end-matching machinery, box book slicers, and sawdust burners.

The inquiries on timber utilization problems received from correspondents and visitors steadily increased. Contacts with the trade were extended to embrace a larger number of manufacturers and users of wooden products. Among the diverse inquiries received were those for timbers suitable for agricultural implements, berry baskets, blind rollers, boats, butter boxes, cricket bats, croquet mallets, cross arms, fabric rollers, fancy veneers, flooring of factories, mining timbers, motor truck bodies, pencils, presentation tables, salt tanks, stocking forms, turnery, vats and window sills. Conversely, other inquirers required to know the uses to which various species were suited.

4. *Timber Seasoning.*—Laboratory work occupied the chief place in the activities of this Section; but trade contacts and educational work were not in any way neglected. The work done at the laboratory was mostly in connexion with the development of suitable schedules for the kiln seasoning of Australian timbers, and at the request of various timber organizations. An outstanding feature of this work was the attention paid to the seasoning of timber from immature trees of various *Eucalyptus* species, the object of the work being the more efficient utilization of forest thinnings. Queensland and New South Wales timbers have received most attention during the year. An interesting problem has been the development of a satisfactory seasoning technique for wooden windmill bearing blocks.

Some advances have been made regarding details of commercial kiln design and construction and in connexion with the fundamental problems of kiln aerodynamics.

A new project was commenced relating to changes in moisture content of kiln dried material shipped from Western Australia to Victoria. The results so far obtained indicate that no appreciable change is likely to occur.

Trade contact work has been confined for the most part to visits in and around Melbourne, to interviews at the laboratory, and to answering numerous written requests for information. The shortage of staff occasioned by the absence abroad for eight months of the year of the Senior Seasoning Officer made it necessary to curtail visits to interstate plants. During the year, nearly 60 new kilns were installed in Australia, most of these being in Queensland and Tasmania. There is, however, no indication as yet of a surplus of kiln dried material on the market.

Educational work was carried out through the medium of correspondence courses, lectures, demonstrations, and the publication of articles relating to seasoning. During the year three visitors spent varying times with the Section undergoing training as kiln operators.

5. *Timber Physics.*—During the year a large amount of routine work, mainly on the determination of shrinkages, fibre saturation points, and densities of Australian timbers, and on the establishment of species correction figures for use with electrical moisture meters has been carried out. The work has covered nearly 200 different species.

A considerable advance has been made in connexion with the problem of fundamental shrinkage, and the investigations carried out included the effect on shrinkage of such factors as subjecting both green and air dry material to high temperatures and using various air drying temperatures and rates. The results of the work of the last two years on the question of fundamental shrinkage have been collected together in form for publication. Additional equipment, recently obtained, will enable this study to be pursued in even greater detail.

The number of "blinker" electrical moisture meters in use in Australia has increased during the year from 103 to 133. With the object of improving the batteries used with these meters, the Division, in co-operation with a dry-battery manufacturer, is carrying out tests with specially prepared light duty units. Already promising results have been obtained; and it seems probable that a battery will shortly be available which, for use in "blinkers," will have double the life of the present unit.

The method developed by the Division of using electrical moisture meters for testing veneer sheets has been the subject of considerable interest. The fact that veneers used for their cabinets are tested for moisture content by this method has been made a feature by a large firm of manufacturers.

A further extension to the utility of electrical moisture meters has been made in connexion with the testing of pole timbers to determine their suitability for certain preservation treatments. Also an investigation of the possibility of using electrical moisture meters for determining moisture contents above the usual upper limit of these instruments, that is 24 per cent., has shown that a relatively simple design of instrument could be used to obtain a close approximation to moisture contents between 24 per cent. and 40 per cent.

A working plan has been prepared and equipemnt obtained for a comprehensive investigation of the more fundamental aspect of collapse and its removal. Material for these tests is being prepared, and the work will probably occupy a considerable amount of the time of the Section during the coming year.

6. *Wood Chemistry.*—(i) *Introduction.*—The work of this Section has been directed to an increasing extent toward investigations in to the fundamentals of paper-making from the eucalypt woods. This work was inaugurated in co-operation with the Australian Paper Manufacturers Ltd., in February, 1935, and besides proceeding according to a broad working plan, has involved a number of other important projects. Chief among these has been a comprehensive review of the existing analytical methods for pulps. The study of the lignin determination has reached a stage which may be left, at any rate, until a more satisfactory definition of lignin is evolved.

(ii) *The Identification of Wood by Chemical Means.*—The examination of the alkalinity of the ashes of 40 light coloured woods of the genus *Eucalyptus* has been completed, and the figures obtained will be found to be a valuable aid in identification. A preliminary examination of the aqueous extracts from the same woods has been carried out.

(iii) *A Study of the Lignin Determination.*—As already stated, this study is regarded as having reached a definite stage and a publication has been issued covering the latter portion of the work (Pamphlet No. 62—*The Chemistry of Australian Timbers: Part 5—A Study of the Lignin Determination III.*, by W. E. Cohen). This has been mainly concerned with the influence of furfural-yielding substances on the lignin yield, and the use of sodium sulphite for removing kino-like substances from eucalypt woods.

(iv) *The Formation of Plastics from Wood.*—An attempt has been made to apply to Australian timbers the methods for preparation of wood plastics developed by the United States Forest Products Laboratory, Madison, Wisconsin. No very marked success has been obtained using a preliminary hydrolysis, and little actual binding occurred in the finished article. However, an examination of the unhydrolysed sawdust has indicated the possibility of preparing well bonded products from certain species. At present a systematic study is being made of the optimum conditions for the moulding of articles both from coarse sawdust and from sawdust ground in the impact mill. This material is not pre-treated and the products obtained would appear to have commercial possibilities, on the one hand as a fibre board, and on the other, for the production of cheap moulded articles.

(v) *Pulp and Paper Investigations.*—Under the main working plan, logs from two trees of *E. sieberiana* have been obtained. Representative sections from the larger tree have been chemically examined, and Australian Paper Manufacturers Ltd. have carried out pulping experiments on some of these, using a small rotary digester which has been recently designed and installed at their laboratory. Analytical work on these pulps is proceeding.

During the earlier part of the year, the examination was undertaken of the chemical composition and wet-beating properties of samples of a Eucalyptus sulphate pulp treated in a number of different ways. These indicated a relationship between wood gum content and wet-beating properties, although this relationship was not necessarily proportionate. Following upon this result, a further experiment was carried out which involved the extraction of wood gum from one pulp and addition to another, and consideration of the strength development of the pulps on beating. The results of this work indicate superior strength development of the pulps to which wood gum has been added. It now appears possible to some extent to correlate wood gum content with pulp strength development on beating, and this work will be extended in the near future.

An investigation was also undertaken into the difficulties experienced in sheet formation with pulp from *E. marginata*; but it was not found possible to correlate the defective paper-making qualities with chemical analysis. There are indications that the cause may be a lower ratio between fibre length and diameter than is usual in eucalypt fibres.

(vi) *The Methods of Wood and Pulp Analysis.*—Minor investigations have been made into the determination of chlorine and copper numbers, and a further investigation has been undertaken into the use of chlorine gas and chlorine water in determining Cross and Bevan cellulose.

The mannan determination has so far been found unsatisfactory when applied to eucalypt woods and pulps, and will be investigated further. Considerable work has been carried out on the pentosan determination which is regarded as being of major importance. This work is incomplete and will be pursued during the coming year.

Ritter's method for the determination of holocellulose in woods has not been found applicable to eucalypt woods, and various alternatives are being investigated.

The method for the determination of arsenic in treated woods was finalized and published in the Journal of the Council (Vol. 9. No. 1, February, 1936).

7. *Timber Mechanics.*—The work of this Section for the year under review may be classified under six headings :—(i) Steam bending of wood, (ii) Minor tests on all authentic samples received by the Division, (iii) Comprehensive standard tests on selected species, (iv) Tests on built-up structures and structural sized members, (v) Special tests, and (vi) Design of timber structures.

(i) *The Bending of Wood.*—The experimental bending machine was completed, and a start made on systematic tests of red tulip oak (*Tarrietia argyrodendron* var. *peralata*). The results to date indicate that this species bends better than most Australian timbers, but that it is inferior in bending properties to such overseas species as elm, ash, hickory, or beech. Arrangements have been made to conduct systematic tests on all species received at the laboratory for standard tests. In this way a fund of information on the bending properties of Australian species will be obtained.

(ii) *Minor Tests on Australian Species.*—Toughness, hardness, and small static bending tests are made on all authentic specimens received at the laboratory. Samples from 230 species have been tested to date, and the results are almost ready to publish, but some gaps have yet to to be filled.

Tests were made on several trees of spotted gum (*E. maculata*) from Queensland and from New South Wales. The Queensland grown material was very hard, dense, strong, and tough, and was quite different from the lower density New South Wales grown timber, which was lower in all strength properties. In toughness the Queensland timber was about 20 per cent. lower than American hickory ; but the lighter New South Wales material resembled imported ash rather than hickory in this respect.

Some tests on Yellowwood (*Flindersia oxleyana*) showed that it was very similar in static properties to American hickory, but was not nearly so tough.

(iii) *Standard Mechanical Tests.*—The tests on the immature mountain ash (*E. regnans*) that were started some time ago were completed and are ready for detailed analysis. Preliminary results indicate that the mechanical properties of the immature wood are very satisfactory, and that reconditioning does not seriously affect the strength.

Arrangements have been made to test thoroughly the mechanical and physical properties of immature spotted gum (*E. maculata*) from Queensland. The test material has been converted into specimens, but no tests have yet been carried out.

A start was made on the testing of the air-dry specimens of karri (*E. diversicolor*). It is expected that the tests will be completed early next year.

The work on South Australian *P. radiata* was completed by the testing of five 42-year old trees from Bundaleer. A table of average figures has been prepared, and detailed results will be published next year.

The testing of green red tulip oak (*Tarrietia argyrodendron* var. *peralata*) specimens has been completed, but the results have not yet been computed.

A final report on the strength of mallet (*E. astringens*) was prepared. This species has outstanding strength properties, being much superior to American hickory in static strength, and only about 12 per cent. lower in shock resistance. In view of the extensive planting of mallet by the Western Australian Forests Department, these results are very satisfactory.

The tests on green material from eighteen trees of cypress pine (*Callitris glauca*) have been completed ; and preliminary analysis has shown that the clear wood has high static strength properties.

The results of tests on dry material showed that the shock resistance of mountain hickory (*Acacia penninervis*) decreases on drying. However, even when dry, it is quite tough, and the close similarity to American hickory in static properties make it a suitable substitute for that species for many purposes.

(iv) *Tests on Structural Sized Members.*—Tests have been carried out on green scantlings of cypress pine, hoop pine, and Victorian hardwood. These tests showed that in Victorian hardwood, even the most serious defects from the point of view of bending strength hardly affect the stiffness, which is the prime consideration in small house construction.

A short series of tests was carried out to determine the effect of notching the ends of beams and joists. The results showed that the weakening effect due to notching can be greatly reduced by bevelling off the notch by means of a straight saw-cut.

Practically no information is available on the strength of built-up timber columns. This type of column is widely used in modern timber structures, and information on their design is urgently needed. Forty built-up columns have been prepared and are being allowed to dry out before testing.

(v) *Special Tests.*—An increasing interest in the use of modern timber connecters is becoming evident. Very little information on their behaviour with Australian hardwoods is available, and to remedy this arrangements have been made to carry out a very thorough series of tests covering all conditions likely to be encountered in practice. These tests will be started as soon as the new 600,000 lb. testing machine is erected.

A short series of tests was carried out to determine the cause of longitudinal splitting of Tasmanian hardwood motor body stock. The trouble was eventually traced to seasoning checks, caused by improper drying conditions.

A series of tests was made to determine the influence of high temperatures on the strength of glued joints in motor body stock. These showed that temperatures over 200° F. for one hour or more seriously reduce the strength of the joint.

At the request of the Standards Association of Australia, arrangements have been made to conduct an exhaustive series of tests on the factors affecting the holding power of coach screws, spikes, &c.

The sagging of timber beams is an important feature in the design of timber structures. Very little information is available, and arrangements are being made to investigate the matter with the object of providing engineers with suitable design data.

A mathematical investigation is being made into the causes of compression failures and star shakes in living trees. Because of the aniso-tropic nature of wood, this offers considerable difficulties, and necessitates a close study of the complete theory of elasticity.

(vi) *Design.*—The 100 foot fire tower for the Western Australian Forests Department was erected during the year, no unusual difficulties being encountered, thus showing that from a constructional point of view split-ring connecters can be satisfactorily used with Australian hardwoods.

A B-class radio station is considering the erection of a 300 foot timber radio tower; and a request has been made to the Division for assistance in the design.

As regards equipment the 600,000 lb. testing machine has arrived and will be erected as soon as the new laboratory is completed. By designing the foundation as a large reinforced concrete beam, it was possible to arrange for bending loads of 300,000 lbs. to be applied up to spans of 33 feet. Pressure of work has necessitated the purchase of another small testing machine and accordingly arrangements have been made for the purchase of a 20,000 lb. Universal machine.

8. *Wood Preservation.*—(i) *Introduction.*—The work of the Preservation Section has steadily increased, and investigations of two new lines of work, namely gluing and pathology, were commenced. In spite of the increased staff, however, the work has developed to such proportions, particularly with regard to minor miscellaneous problems, that a complete re-organization and replanning of projected research is desirable, and will be undertaken during the coming year.

(ii) *Field Investigations.*—The testing of treated and untreated wooden products is an essential part of wood preservation work. Such tests are the only ones which permit an evaluation of different preservatives and of different methods of treatment. Their further value as a means of education to timber users has been amply exemplified during the past few years, more visitors being taken to inspections of the service test lines and more inquiries being made in regard to them. As a result, the knowledge of wood preservation is spreading rapidly, and already many large timber using authorities are adopting or have adopted practices which have been indicated on field inspections.

Sleepers.—In Western Australia some of the fluarized karri sleepers have been renewed. In many cases the deterioration appears to have been accentuated or caused by the extensive checking of the sleepers, with the resultant exposure of untreated wood below the impregnated layer. The treatment of *P. radiata* sleepers for testing in South Australia was completed, and the various sections on the railways and tramways are now being laid. Considerable interest has been evinced in this test, and more recently a number of *P. radiata* sleepers were impregnated in Victoria for use in the Ballarat Tramways. The latter sleepers were treated with creosote oil using a hot and cold bath (open tank) process. Most satisfactory and encouraging results were obtained, and a suitable heating and cooling period was developed which resulted in a combination of good penetration and low absorptions, the latter being in the nature of 8 lb. per cubic foot of wood. The simplicity of the equipment necessary makes the treatment of *P. radiata* easy, and there should be the possibility of the development of a demand for this treated wood.

In Victoria there is considerable anxiety on the part of the Railways and the Forests Commission regarding the supply of durable hardwood sleepers in the future. A conference of interested parties was held and arrangements made for a comprehensive test of the suitability of various less durable timbers both treated and untreated.

Poles.—The treatment of pole timbers has continued to create considerable interest. Installation of a pole test at two different sites in New South Wales was completed, there being a total of 165 pole stubs at each locality. The timbers being tested are classed as the less durable, large supplies of which are, or will be, available in the near future. In Victoria some of the

treatments are already commencing to show signs of failure, and the use of one of these particularly has been abandoned in practice. The practice of brush treatment of poles near the ground line and puddling of the soil with creosote oil has been commonly used, but little information was available regarding the necessity for re-treatment. Tests indicate that with two initial brush coats followed by puddling of half gallon of creosote per pole, re-treatment at two yearly intervals is essential. This period has now been adopted commercially by some of the larger pole users. The value of *P. radiata* as a pole timber is being investigated, and a number of poles has been installed under service conditions in South Australia. The ease of working and lightness in handling were favorably commented upon, and their behaviour in service is awaited with great interest.

Of recent years the method of charring and creosote spraying and puddling of both standing and new poles has been adopted rather extensively by various pole using authorities; but no information is available regarding the increased life to be expected from the treatment. Recently, in co-operation with the Postmaster-General's Department, field tests were inaugurated, a number of partly decayed service poles being treated, while a corresponding number or untreated matched controls were left for comparison.

Posts.—The treatment of fence posts is of considerable economic interest, and a further field test was begun in New South Wales. In Western Australia and New South Wales thinnings of various species have been used, and the results available to date in Western Australia indicate the satisfactory nature of some of the treatments.

(iii) *Treatability of Australian Timbers.*—Investigations of the treatability of Australian timbers using the various known pressure processes, and the hot and cold bath process, have shown that the penetration of the true wood of Australian hardwoods with either oil or water-soluble preservatives is extremely difficult, and in a large number of cases impossible. With a few species some degree of penetration is possible; but this is restricted generally to the ends, and the small number of species that can be treated and attendant difficulties of seasoning, particularly with reference to timbers liable to "collapse", render the future development of pressure treatment very uncertain. Considerable time has been spent abroad studying the factors affecting the penetration of preservatives in truewood, and before progress on the treatment of truewood in Australia can be made, extensive work will be necessary along these lines, work which will probably be long and tedious.

Recent developments, particularly in Germany, have been towards the treatment of green timber. Preliminary treatments on three species of hardwoods have shown that penetration can be obtained in green truewood, the penetration being somewhat variable. The time factor is long. The actual absorptions of preservative are still unknown. Sodium fluoride has given the best results, but field tests of round fence posts treated with this preservative by the hot and cold bath process and containing about $\frac{1}{2}$ lb. of dry salt per cubic foot of wood are commencing to deteriorate after relatively few years of service. A further investigation of green timber treatment is necessary, studying particularly the effects of concentration and temperature.

(iv) *Lyctus Investigations.*—The main laboratory investigations into the effect of pore size and starch content on susceptibility to Lyctus attack were completed last year. Nearly all Australian commercial hardwoods have a pore size which makes them susceptible to attack. It was also found that there is an apparent minimum starch content necessary for Lyctus attack. A comprehensive laboratory test on the effect of the impregnation of susceptible sapwood of *E. obliqua* with various chemicals has been completed and the results published. Three common, cheap, and easily available inorganic chemicals (namely, sodium fluosilicate, zinc chloride, and borax) were found to give good results. Of these three, sodium fluosilicate appears to be the most satisfactory. A concentration of only 1/40 lb. per cubic foot of wood was sufficient to prevent Lyctus attack. A study of the Lyctus problem has indicated that for veneer timbers particularly, treatment with chemicals appears to offer the greatest possibility of commercial success. Experimental treatments of standing trees did not give satisfactory results, the distribution of the preservative from the area of application being limited. For veneer treatment, three methods of treatment are available, namely, treatment of the log, green veneer, or dry veneer; and work along these lines is now being planned and material collected.

The production of starch-free timber is of great commercial value for the effective utilization of many Australian timbers. For purposes other than high grade, such as veneers, isolation of sapwood stock, and treatment with chemicals does not appear to be practicable. The survey, in co-operation with the Forests Commission of Victoria, of the variation in starch content of the sapwood of the main commercial species of timber in Victoria has given promising results. Several species, both mature and immature, have been found over the period of test to contain insufficient starch to render them susceptible to attack, and the utilization of their sapwood is thus possible for furniture and other purposes. Other species have been found to be susceptible over the whole period of the test; while others, due to confusion in the method

of marketing, have received the name of being very subject to Lyctus attack, whereas investigations have shown that only a small percentage of the trees have a starch content sufficiently high to allow of Lyctus larvae development. The test is being continued for a period of at least eighteen months when definite results can be published regarding the susceptibilities of the various species being studied.

Experiments on the control of the starch content of living trees and logs have been undertaken, but in no case has complete success been attained. Bark and sap ringing do not appear to be practicable, the reduction in starch content due to bark ringing being nil; while with sap ringing after a period of four months it was apparently only slight. The tests are being continued. Log storage with restricted drying results in some definite starch resorption; but the results obtained to date have been variable, some pieces giving almost complete resorption while others were practically unchanged.

(v) *Pathology.*—A detailed investigation has been commenced of the causes of "heart" in the various Australian hardwoods. Preliminary investigations of material readily available appeared to show that it was of fungal origin, and its presence was noted in both immature and mature trees of various species. Material for a detailed study was collected from mountain ash (*E. regnans*). Cultural and microscope examinations were made. Three basidiomycetes have been isolated from the region of heart, but it is possible that these may be secondary, as detailed examinations of large numbers of sections have failed to reveal the presence of fungal hyphae in typical heart. Truewood has been inoculated with the fungi isolated and an attempt will be made to induce "broken fibres", a condition always associated with heart. Studies of a similar nature are now being made with *E. sieberiana*, and somewhat the same results are being obtained. A careful investigation has been made of the preparation and staining of sections for fungal hyphae, the best results being obtained from Cartwright's method using safranin and picroaniline blue.

(vi) *Gluing.*—A study was made of the manufacture of plywood at the various mills in, or in the vicinity of Brisbane in an endeavour to discover the causes of the variation in the quality of the plywood produced and to suggest means for improving the standard. A comprehensive report is being prepared and will be forwarded to Queensland.

The gluing of silky oak, using animal glue, was investigated, and schedules developed for both kiln and air-dried stock, back and quarter sawn. No differences were noticed between kiln-dried and air-dried stock, although complaints had been made that kiln-dried stock could not be glued satisfactorily.

It is planned to make a full investigation of the gluing properties of Australian timbers, and in the new laboratories special gluing equipment is being included. The hydraulic presses have been donated by the British Australian Tobacco Company, Melbourne.

(vii) *Miscellaneous.*—A very large number of inquiries regarding various aspects of wood preservation, gluing, and painting of wood were received and attended to, the total number being 550. A lecture on Lyctus borers was given to the Furniture Section of the Victorian Chamber of Commerce.

X. FOOD PRESERVATION INVESTIGATIONS.

1. *General.*—In the Annual Report for 1934–35 it was briefly mentioned that the Council was taking steps to secure central laboratories in Sydney for the Section of Food Preservation. The Sydney Metropolitan Meat Commissioner has generously made available to the Council portion of an existing building and a small block of land. In conjunction with the New South Wales Department of Agriculture, plans and specifications of the proposed laboratories have been prepared and it is expected that building operations will commence early in the next financial year. The laboratories have been planned with the view to carrying out extensive investigations in the preservation and transport of meat and meat products, fish, and fruit and fruit products. It is proposed, however, to continue, for some time to come, the investigations on chilled beef at the Brisbane Abattoir. This decision was reached following the promise of a generous annual grant of money by the Queensland Meat Industry Board.

Investigations on the preservation of citrus fruit have been reorganized by the Council under the direction of the Citrus Preservation Technical Committee on which the Council and Departments of Agriculture of New South Wales, Victoria and South Australia are represented. On this account it has been possible to initiate and co-ordinate extensive investigations in each of the three States, and already a clearer picture of the nature and causes of several forms of wastage has been obtained.

The adequate organization of food preservation investigations inevitably involves co-operation with many widely separated organizations. It is pleasing to record that excellent co-operation has obtained with the several State Departments of Agriculture on various fruit

nvestigations, and with the British Food Investigation Board on problems of overseas transport. Valuable help in the investigations on chilled beef has also been given by the operators of many meat export works, who, often at great inconvenience, have made available facilities for large scale tests of the results of laboratory findings.

2. *Chilled Beef Investigations.*—(i) *General.*—Most of the technical difficulties, with the exception of loss of bloom, which have led in the past to unsatisfactory shipments of chilled beef, have now been removed. To create an efficient industry, however, and to provide a wider margin of safety than exists at present, many investigations are being pursued at the Council's laboratory at the Brisbane Abattoir with the object of defining more precisely the optimum conditions to be adhered to in the preparation, cooling, and transport of the beef. Considerable progress has been made, and scientific explanations of many hitherto obscure phenomena are now forthcoming. In the near future three publications will be issued covering, in detail, all phases of the preparation on the slaughter floor, the cooling of sides, and the storage of quarters.

The Section is the only existing organization in a position to apply the results of scientific investigations to meatworks' practice. In this regard, therefore, it has been necessary for the Council slightly to modify its usual policy of leaving to other organizations the application of existing knowledge. In accordance with this position, therefore, the Section has undertaken eight surveys of three chilled beef exporting works, at the request of the authorities concerned. In each report to the firm or organization concerned modifications of procedure and equipment have been suggested, and these have usually been put into operation immediately.

(ii) *Control of Initial Contamination.*—The commencement of experimental work to investigate the possibilities of using some form of radiation to control the initial contamination on chilled beef was mentioned in the last Annual Report. Extensive and detailed studies have since been made on most of the types of organisms responsible for spoilage of chilled meat. These have resulted in the acquisition of much valuable information as to the characteristics of these organisms in their reactions to radiation. Representing bacteria, yeasts and moulds, these organisms exhibit wide differences in the amounts of energy necessary to bring about a complete kill when they are grown on agar. The largest amount needed, however, is still comparatively small, and would not in itself present any obstacle in the commercial application of this method. However, information obtained from a semi-commercial storage experiment, and confirmed by subsequent experiments, revealed the fact, among others, that for amounts of energy sufficient to obtain a 100 per cent. kill of the most resistant types of organisms when grown on agar, or around 99 per cent. of bacteria grown on meat samples, kills of a lower order—roughly 60 per cent.—were obtained when meat contaminated in the course of normal slaughter floor practice was used. Careful studies of the " aboriginal " organisms as brought on to the slaughter floor by the animals, however, showed that the minimum energy requirement to obtain a complete kill on all the " culture " organisms, except some very resistant moulds, was quite inadequate in the case of the slaughter floor organisms where " mixed " infections exist in their " aboriginal " form. Increase of the input energy, therefore, as might be expected, increased the percentage kill, but not to the desired level. The reason as to why the eminently successful laboratory findings are not so far capable of completely satisfactory transfer to slaughter floor practice is not immediately apparent ; but intensive investigations are now being made with the objective of discovering this reason. These studies are being conducted partly at the Council's Laboratory, and partly at the Brisbane General Hospital, and the Physics Department of the University of Queensland. At the two latter laboratories experimental facilities for certain phases of the work have courteously been placed at the Council's disposal.

The types of micro-organisms found on carcases immediately after slaughter and dressing are similar to those found on the hair and hides of the live animals. There is, however, a difference in the relative percentages of yeasts contained in the microbial populations ; and these percentages are always higher on the carcases than on the hair and hides or in the surface soil in the vicinity of the meatworks. The difference has now been accounted for, though not, as yet, quantitatively, in the course of a series of laboratory experiments. Under certain conditions, blood and/or fresh tissues of the carcases exert a selective lethal action on the micro-organisms present in soil, and under the conditions of these experiments yeasts show a relatively greater survival than bacteria.

(iii) *Cooling of Sides of Beef.*—For the purposes of experimental work, the cooling of sides to the temperature of transport (30° F. approximately) may conveniently be divided into two phases. The first covers the first 20 to 24 hours of chilling ; and by the end of this period the mean temperature of the surface tissues should have fallen to 32° F. (approximately). The second phase covers the subsequent 48 to 72 hours of hanging in the chilling rooms. Complete biological and physical data have been obtained for the second phase, and it is now possible generally to correlate the biological and physical data. Moreover, predictions can now be made of the optimum physical conditions to be maintained during this

phase in various types of chilling chambers. Although extensive data have been obtained for this first phase, it has not yet been found possible to correlate the biological data with the rather complex physical conditions. Until such a correlation can be obtained, it will not be possible to give an answer to the important question of the most desirable rate of cooling; upon this value depend the designs to be adopted in the construction of new chilling rooms.

(iv) *The Relationship between Microbial Growth and Moisture Contents of Muscle Substrate.*—Experiments have been carried out to determine more precisely the rates of growth of various micro-organisms on ox muscle held in air having various aqueous vapour pressures at 30.2° F. During the course of all experiments the water content of the muscle was in equilibrium with the aqueous vapour tension of its storage atmosphere.

For two genera of bacteria which were studied, a decrease in the water content within the limits of growth affected mainly the lag phase and only slightly the rate of generation during the logarithmic phase of growth. For three genera of asporogenous yeasts, both the generation period and the lag phase were extended considerably before growth ceased.

The principal bacterial genus *Achromobacter* had the lag phase extended from one to seven days by decreasing the water content from its normal value (300 per cent. of dry weight) to 105 per cent. without any appreciable extension of the generation time. A further decrease in the water content to 90 per cent. extended the lag phase to sixteen to twenty days and increased the generation period by 50 per cent. No growth has been recorded at 85 per cent. water content in an atmosphere of 96 per cent. relative humidity.

Two species of the genus *Pseudomonas* had the lag phase extended by five days when the water content was reduced to 240 per cent. in an atmosphere 99 per cent. saturated. No growth was observed on muscle with 145 per cent. water in an atmosphere of 98 per cent. relative humidity.

All species of yeast have shown strong growth down to 60 per cent. water content in 93 per cent. saturated atmospheres; but on muscle of this water content the lag phase and the generation time are both extended two to three-fold. Below this water content, growth is weak but continues down to 45 per cent. water (90 per cent. relative humidity) when the generation time may be increased to ten times the value on moist muscle.

The results of this work will shortly be published.

(v) *Overseas Transport Experiments.*—Further tests on experimental consignments of chilled beef have been carried out with the view to obtaining additional data concerning the relationship between rate of loss of weight and loss of bloom. Preliminary experiments have also been performed to study the factors controlling loss of weight in a wide range of cargo spaces. While valuable empirical data have been obtained and applied in commercial shipments, the experiments have served to emphasize that more precise data on the factors controlling loss of weight (i.e., relative humidity and rate of air movement over the quarters) must be obtained before the rate of loss of weight can always be adjusted to the optimum value indicated by the above experiments.

In conjunction with the experiments on the relationship between the rate of microbial growth and the moisture content of muscle substrate, the moisture contents of surface tissues from various parts of hindquarters and crops are being obtained before shipment and at discharge in England. Data have been obtained for seven shipments; but the experiments must be continued for some time before it is possible to indicate, with confidence, the general extent of the changes in moisture contents during transport overseas of the beef.

(vi) *Thermal Death Points of "Low Temperature Type" Micro-organisms.*—Following the observations which indicated that certain low-temperature micro-organisms were killed in soils after exposure to temperatures exceeding 98° F., certain pure strains of these organisms were subjected to heat under varying experimental conditions and confirmation has been obtained of the lethal effects of these strains of temperatures from 98° F. upwards.

A study has been commenced of the forms of the curves of disinfection by heat for certain strains of *Achromobacter* and yeasts.

(vii) *Sterilization of Wraps used for Chilled Beef.*—Occasional reports on shipments of chilled beef on arrival in England have indicated considerably higher contamination by moulds than would be expected from observations on such beef prior to wrapping and shipment. The possibility of infection of the carcases from the wraps used for covering the beef has suggested itself. In commercial practice it is customary to sterilize such wraps by subjection to dry heat; and experiments have been commenced in order to determine the conditions which are necessary to effect a complete kill of the "low temperature type" micro-organisms which may be present on these wraps. Preliminary experiments have shown that the spores of many "low temperature type" moulds are killed after an exposure of two hours at a temperature of 131° F.

(viii) *The Action of Micro-organisms on Fat.*—By growing many strains of *Achromobacter*, *Pseudomonas*, and asporogenous yeasts on a synthetic medium containing 80 per cent. by volume of beef fat, it has been found that the power of liberating fatty acids from this fat is by no means conferred generally on every strain. The contention of English investigators that the extent of the production of free fatty acids is a convenient index of microbial spoilage of fatty tissues cannot be substantiated. The results of this work have been published in the Council's *Journal* (9 : 107, 1936).

An examination of the end-products of the action of micro-organisms responsible for taint in fatty tissues has been commenced.

(ix) *Studies of Loss of Bloom.*—Projected studies in this field, mentioned in the last Annual Report, have been held in abeyance pending the making of satisfactory instrumental arrangements essential to the exact specification of colour. It is confidently believed that a new instrument which is now being constructed containing modifications, stipulated by this laboratory, of the recent Donaldson colorimeter, will meet the demands made by this special investigation. The ability exactly to specify colour changes which influence appearance of the meat, and therefore prices on the English market, is of the greatest importance to studies both in storage experiments here and during transport of chilled beef to England. During the year a Zeiss microspectroscope, and a Spekker photometer to operate in conjunction with a Hilger quartz spectrograph (the loan of which has been courteously made by the Department of Chemistry of the University of Queensland) has been added to the equipment assembled essentially for bloom investigations.

One quite obscure problem of importance is the occurrence of grey fat, the greyness appearing towards the end of the storage period. Careful experimental work has been done, and is being continued, to discover how far, if at all, this greyness is dependent, as has been suggested, on some change involving blood pigments derivable from the haemoglobin present in such vascular structures as ramify the fat tissues. The results obtained to date, however, do not lend support to such a cause for greyness.

3. *Citrus Preservation Investigations.—(Supervised by the Citrus Preservation Technical Committee).*—(i) *General.*—Co-ordinated experimental work in three States was commenced in May, 1935 ; and the appointment of a citrus research officer to act as the Committee's executive proved most valuable in enabling these widespread activities to be efficiently organized, and in establishing uniformity of experimental procedure, particularly in chemical determinations and classifications of wastage.

The Washington navel and common orange programme for 1935 was concluded in October, and provided a basis for a further series of experiments which were drawn up in Melbourne in January, 1936. The Valencia orange and grapefruit experimental work for the season 1935–36 was brought to a satisfactory conclusion, and the results are being prepared for consideration at the forthcoming meeting of the Committee.

The 1936 navel and common orange, and mandarin programme was commenced during April of this year and is proceeding satisfactorily.

(ii) *Investigations by the Citrus Research Officer (in conjunction with the New South Wales Department of Agriculture).*—A survey of the principal citrus packing houses of New South Wales, Victoria, and South Australia was made in September and October, having regard chiefly to current methods of handling the fruit in an endeavour to assess their effect upon subsequent storage life.

Owing to the high percentage of mould wastage recorded in fruit from the Gosford district, an appreciable amount of time has been spent in an endeavour to elucidate the reasons underlying the poor keeping quality of fruit from this district. It would appear that the high degree of atmospheric contamination at Gosford by blue and green mould is due to a favourable combination of humidity and temperature. The methods of transport and handling generally are conducive to wounding of the fruit, and apparently the high humidity renders the rind more peculiarly liable to wounding than the dry atmospheres of the inland districts. The nett effect is that fruit is wounded and inoculated prior to packing and subsequent mould wastage is inevitable. As a result of recommendations made to the authorities controlling one packing shed in the district, the amount of contamination within the shed has been reduced from an average count per plate of 82 to one of six using ten minute exposures. Actual investigations into wounding show that it is possible by suitable modifications to reduce the more serious " rub " type by 60 per cent.

Future work in the Gosford district should aim at the elimination of wounding, as far as possible, since it is practically impossible to exclude mould from the orchards. In addition, an endeavour should be made to find an effective sterilizing agent to protect such wounds as do occur ; and it is hoped in this connexion that the use of nitrogen trichloride may prove effective.

The results of the investigations carried out during the past year would seem to indicate that the material from the Gosford district used in the land storage experiments provides an unsound basis for experimental work. Consideration is, therefore, being given to the desirability of more detailed investigations of pre-storage factors, and these should preferably be studied at an experimental packing house established within the Gosford area.

(iii) *Citrus Investigations, Melbourne (in conjunction with Victorian Department of Agriculture).*—(*a*) *Storage of Washington Navel and Common Oranges.*—Navel, Joppa, Parramatta, and Siletta oranges from Gosford lowlands and highlands, and the Hills district (New South Wales); navel oranges from Berri and Adelaide Plains (South Australia); and from Merbein and Lockington (Victoria) were picked on 14th May, 21st June and 21st July (approximately). The fruit from New South Wales was stored at 34°, 37°, 40°, 45°, and 50° F., and from the other States at 40° F.

In addition, samples of each picking from Berri were sweated in the shed for one and two weeks respectively, and from Gosford for two, four, and seven days at 70° F. and 66 per cent. humidity prior to storage at 40° F. Fruit grown on rough lemon, *Citrus trifoliata*, sweet orange, and pomelo stocks was selected from the experimental orchard at Berri on 21st June and stored at 40° F.

The respiratory activity of most units was determined at 40° F.

In general, the storage temperature of 40° F. did not give satisfactory results, as the storage life of the fruits was prematurely terminated by the development of storage spot. The optimum storage temperature was dependent on the locality from which the fruit was picked and the maturity of the fruit at the time of picking. The optimum for fruit from the Victorian districts appeared to be lower than that from the South Australian districts which in turn was lower than that from New South Wales. The common oranges from New South Wales appeared to require a higher storage temperature than the navel oranges. The optimum storage temperatures for the New South Wales fruit used in 1935 were as follow:—

1st picking	50° F.
2nd picking	45° F.
3rd picking	40° F.

The palatability of the juice and the texture and colour of the rind were improved to a marked extent by storage at 50° F. The experiments carried out this year do not confirm the opinion generally held in the fruit trade that the flavour of the orange does not improve after picking. It has not been possible to detect any difference either in colour or in palatability between fruit which had changed from green-yellow, slightly acidic and fair flavour to deep orange, sweet and excellent flavour by being stored at 50° F., and comparable fruit in which such changes had been effected on the tree.

When the storage life of the fruit was not prematurely terminated by the development of a low temperature disorder, loss of palatability was the limiting factor, and this was followed by mould development.

The chief defects of the rind responsible for wastage were storage spot, scald, goose-flesh, and skin collapse. Storage spot of both the lateral and stem-end types occurred chiefly in early picked fruit and at 40° F. Its development was largely controlled by the use of higher storage temperatures and to some extent by sweating at 70° F. prior to storage at 40° F. Both scald and goose-flesh are low temperature disorders which occur at 37° F. and 34° F. respectively, and they may therefore be controlled by the use of higher storage temperatures.

Skin collapse was the main cause of wastage in fruit from the Berri district; but as it occurred subsequent to loss of palatability it is apparently only a normal disorder of the last stages of senescence.

The main effect of shed sweating was to reduce the subsequent length of storage life by the length of the sweating period. In some cases sweating at 70° F., however, was effective in controlling subsequent storage spot.

The fruit from the rough lemon and *Citrus trifoliata* stocks appeared to have a much shorter storage life than that from the sweet orange and pomelo stocks, but this may have been due to differences in the maturities at the time of picking.

(*b*) *"Gas" Storage of Washington Navel Oranges.*—An experiment on the "gas" storage at 45° F. of Washington navel oranges from Gosford (New South Wales) has given the following results:—

Storage Atmosphere % CO_2.	Storage Life. (weeks).	Flavour at end of "life."
0	10	Stale
5	6	Sickly, unpleasant
10	6	"Burning"
15	4 (or less)	"Burning"

These results indicate that adequate ventilation is probably as essential for oranges as it is for plums (*see* below).

(*c*) *Chemical Work on Navel Oranges.*—A considerable number of analyses on oranges from several districts have been carried out at picking and during subsequent storage. The methods of determining the juice content have been compared, and extraction by hand pressure on a standard cone adopted as the standard procedure. A definite correlation has been obtained between the juice content and the specific gravity of the fruit.

The acidity of the juice appears to be a factor in determining the quality and subsequent storage life, though it is only one in a series of great complexity. The acidity is definitely related to the taste of " sourness " or " sweetness," more closely than is the Brix : acid ratio ; and sourness is practically lost when the acidity of the juice falls below about 22 ml. (titration of 10 mls. of juice with 0.1N NaOH). In addition to acidity, palatability is determined by the amount of " orange flavour", which is not subject, however, to precise determination. From experience in tasting oranges of known acidity, the conclusion is drawn that fruits very high and very low in acidity require a stronger orange flavour to become palatable than those of intermediate acidity. A complex relation between acidity and storage life at 40° F. is also indicated, in that oranges of high acidity have a greater tendency to acquire storage spot (a form of low temperature injury). This relation is only made evident when equally coloured oranges, or oranges picked at the same time, are compared by calculating partial correlation co-efficients.

The loss of acid in store has been found to be independent of temperature between 40° F. and 50° F. The rate of loss is subject, however, to the considerable individual variation, 0.35 ml. to 0.7 ml. per week. The rate of loss of sugar in the rind also appears to be independent of temperature between 40° F. and 50° F.

During storage in air the rise in the alcohol content of the juice is associated with the final stage of fermentation, when the alcohol has reached concentrations about 0.1 per cent. After " gas " storage a considerably higher alcohol content (0.16 per cent.) has been found.

(*d*) *Storage of Valencia Oranges.*—Valencia oranges were picked from Merbein and Lockington (Victoria) in October and December and stored at 37° and 45° F. ; from Berri and the Adelaide Plains (South Australia) in October and December and stored at 40° F. ; and from the Gosford Lowlands in August and October and stored at 37°, 40° and 45° F. The respiratory activity of fruits from the above districts and from clean cultivation and lucerne plots in Griffith was also determined at 40° F.

Both pickings from Merbein and Lockington gave good results at 37° and 45° F, the storage life in both cases being approximately the same at both temperatures and being terminated by loss of palatability.

Storage spot occurred subsequent to loss of palatability, and this rind defect, which is apparently a normal disorder of the last stages of senescence, has been classed as " late storage spot " to distinguish it from the "early storage spot" which was mainly responsible for the wastage in the navel oranges. This latter type prematurely terminates the normal storage life of the fruit, which is still very palatable at the time of the occurrence of this rind defect.

Both pickings from the Berri district and the second picking from the Adelaide Plains gave good results at 40° F., the storage life being terminated by loss of palatability. The first picking from the Adelaide Plains, however, developed early storage spot at 40° F.

Scald and early storage spot occurred in both Gosford pickings at 37° and 40° F. respectively. The storage life at 45° F. was terminated by loss of palatability which was followed by the development of black spot, stem-end and *Penicillium* rots.

It was possible to correlate the storage results with the respiratory activity, as the sudden arrest in the downward drift of the respiratory curve corresponded with the termination of the storage life.

(*e*) *Acidity and Flavour in Relation to Storage Life of Valencia Oranges.*—In Valencia oranges a relation between juice content and specific gravity of the fruit has been obtained similar to that found for navels. The first picking of Valencia oranges was obtained at the end of September, when they had reached the maximum of colour development. In these oranges the influence of acidity is generally the same as in navels, except that in most samples the acidity is considerably lower ; and the storage life at 40° F. is usually limited not by storage spot but by loss of palatability. In some cases oranges in store were unpalatable or " flat " through lack of acid rather than through absence of " orange flavour ", which was demonstrated by restoring palatability to the juice through addition of citric acid.

(*f*) *Storage of Grape Fruit.*—Fruit from the Victorian districts of Lake Charm and Irymple was picked in September and October and stored at 40°, 45° and 50° F. In addition, fruit of the second picking from Irymple was sweated for seven days at 70° F. prior to storage at 34°, 37°,

40°, 45° and 50° F. The optimum storage temperature for fruit of both pickings from both districts was from 45° to 50° F. ; storage spot developed at lower temperatures. Sweating was not effective in controlling subsequent storage spot at temperatures below 45° F., and did not decrease the subsequent storage life at 45° and 50° F.

The fruit of both pickings from the Lake Charm district developed wastage from mould attack almost immediately after picking, while both lots from Irymple were in good condition for three months after picking. The fruit from Lake Charm may mature much earlier than that from Irymple, and earlier pickings are being made this year to determine this point.

(iv) *Overseas Experimental Shipments of Citrus Fruit.*—During 1935 two experimental consignments of common oranges and three of Valencias were forwarded to England for examination by officers of the British Food Investigation Board. The reports on these, and on several commercial shipments, have been received, and in general they confirm the results of the land storage investigations. These experiments must be continued for several years before it is possible to issue an authoritative report.

In one shipment a multi-point distance temperature indicator was installed as an initial stage in a survey on the physical conditions obtaining in ships' cargo spaces stored with oranges.

(v) *Preservation of Citrus Juices.*—During the year some attention has been given to the matter of the preservation of citrus juice. A summary of the methods employed was made and by-products factories in three centres have been inspected. The methods of preservation in each case consists merely in expressing the juice and storing in a cask after the addition of appropriate amounts of sulphur dioxide. Orange juice so preserved exhibits a very definite bitter flavour and difficulty is experienced, after some months of storage, in the appearance of an unsightly precipitate which is possibly pectinous in nature.

4. *Non-tropical Fruit Investigations (in conjunction with the Victorian Department of Agriculture and the Biochemistry Department, University of Melbourne).*—(i) *Storage of Jonathan Apples.*—Storage, maturity, locality, and respiration experiments were conducted with Jonathan apples from the Victorian districts of Red Hill, Somerville and Harcourt. The first pick was made when the ground colour of the skin was green-yellow and the second when yellow. The fruit was stored at 32°, 34° 37° and 40° F. and examined at regular intervals for breakdown, scald, &c. In addition, small lots were subjected to delayed storage for various intervals at 65°, 55°, 45° and 37° F. prior to final storage at 32° F. It was hoped that some of the delayed storage treatments might be effective in controlling the development of scald. Respiration experiments were conducted at 65°, 55°, 45°, 37° and 32° F. in order to correlate the storage results with the metabolic drift towards senescence. It was found that the maximum development of scald occurred in those samples which had been delayed four days at 65° F. prior to storage at 32° F. The incidence of scald development decreased as the period of delay was increased. From the respiration results it appeared that the fruit was most susceptible to scald when passing through the climacteric. It was observed that scald occurred mainly at 32° F., and to some extent at 34° F., in fruit from Harcourt and Red Hill districts at the green-yellow stage of maturity only. It was also related more to picking time than to the actual stage of maturity as judged by colour at the time of picking. For example, apples which were green-yellow when picked in late March developed scald but those of similar colour (at time of picking) three weeks later did not develop scald. Scald is apparently a low temperature disorder which affects certain fruits and the development of which may be largely controlled by certain delayed storage treatments prior to storage at 32° F. or by the use of a storage temperature of 36° F.

Breakdown occurred mainly at 32° and 40° F. and it is apparent, therefore, that both the "low temperature" and "senescent" types were present. Unfortunately it was not possible to make examinations after removal from store and thus differentiate between the types.

Experiments have been designed this year to confirm the above results. Larger units have been selected from the Red Hill district, and facilities have been provided so that the fruit can be examined after removal from store. The sugar and acid content and palatability of the juice will be determined at regular intervals.

(ii) *The Effects of Relative Humidity and "Gas" Storage on the Development of Scald and Breakdown in the Jonathan Apple.*—During the 1935 season the effect of humidity and "gas" storage on the development of soft scald and breakdown in Jonathan apples was investigated at 32° F. and 37° F. At 32° F. less scald, and at 37° F. less breakdown, developed at the lower humidity. An atmosphere containing 5 per cent. carbon dioxide did not affect the incidence of these disorders in the more mature apples, but reduced the development of breakdown in apples of the first picking. With atmospheres containing 10 per cent. carbon dioxide "brown heart" began to appear. "Gas" storage also slightly counteracted the effect of high temperatures on subsequent development of soft scald at 32° F.

Apples from the first picking were kept at 65° F. for varying periods up to 12 days, and then stored at 32° F. both in air and in 10 per cent. carbon dioxide. The following results were obtained :—

Days at 65° F.	Percentage soft scald at 32° F. (at 26th July, 1935).	
	Air.	10 per cent. carbon dioxide.
..	11	..
3	18	..
6	16	..
9	1	28
12	3	..

The apples developed a maximum liability to soft scald in air after three to six days at 65° F. ; but in 10 per cent. carbon dioxide the maximum liability to scald was reached after nine days at 65° F.

The colour corresponding to the stage of maximum liability to scald is about 2–3 in the pear colour chart. The pressure does not fall in the period over which the picking extended, and is independent of maturity.

The only chemical determination which has been correlated with the colour is the cane sugar : acid ratio. This ratio is approximately 6.0 at picking, when the apples are most liable to soft scald. The starch content appears to be quite unrelated to the colour at picking or the maturity (as judged by liability to scald and breakdown). A definite positive correlation has been obtained between the acidity and starch content at picking, indicating that the disappearance of starch is associated with the level of acidity, which varies in different years.

(iii) *The Storage of Pears.*—In 1935, three pickings were made of Williams, Howell, Bosc, Packham, Josephine, Winter Nelis and Winter Cole pears from the Doncaster district. The fruits were stored at 37° and 32° F. and samples were removed from store to ripening temperatures at regular intervals. Delaying the picking time merely had the effect of reducing the subsequent storage life by the extra length of time the fruit had been allowed to remain on the tree. It was observed that all the varieties except the Williams ripened satisfactorily over a wide range of temperatures and the best flavour was produced in fruit of the third picking. The development of the yellow colour in the Packham and Josephine varieties occurred only at temperatures below 50° F. The maximum length of time each variety could be stored at 32° F. and still ripen satisfactorily on removal from store was as follows :—

Variety.	Maximum duration of storage months.
Williams	3
Howell	4
Bosc	$4\frac{1}{2}$
Packham	5
Josephine	6
Winter Cole	7
Winter Nelis	7

The length of storage life of each variety was reduced by a month by storage at 37°F Similar maturity and storage experiments are now in progress.

A bulk ripening experiment was conducted with Williams pears at 65° F., and it was observed that there was no appreciable difference in temperature between individuals in different positions in the cases. In general, a three day treatment at 65° F. was sufficient to enable normal ripening to proceed afterwards at 45° F.

(iv) *The " Gas " Storage of Pears.*—The storage life of Williams pears in an atmosphere containing 10 per cent. carbon dioxide at 32° F. has been found to be practically the same as in air, although in the " gas " stored pears, the full flavour persisted for a little longer. A few of these pears were affected by " brown heart " ; hence a concentration of 10 per cent. carbon dioxide is apparently too high, and the optimum concentration is probably a little lower.

(v) *Colour and Pressure Tests in Relation to the Storage of Pears.*—Determinations of colour and pressure tests at picking and during subsequent storage have been continued with seven varieties of pears. Colour charts have been prepared containing a series of colours, ranging from 1 (deep green) to 5 (full yellow), based on plates in Maerz and Paul's " Dictionary of Colour ".

All pears at picking have colours corresponding approximately to No. 1. Very immature samples were a little greener than colour 1, and those at the last picking had colours between 1 and 2. The differences in pressure at picking were insignificant, except in the case of the Josephine variety.

In the storage trials conducted in 1935, the end of the storage life was reached at approximately the following colours :—

Variety.	Temperature of Storage.	
	32° F.	37° F.
Williams	3	3
Howell	3–4	3–4
Bosc	1–2	>5
Packham	2	4
Josephine	3–4	>5
Winter Cole	2–3	4
Winter Nelis	2–3	2–3

Only with the Williams and Howell varieties was a definite full colour obtained, independent of temperature. In the other varieties, colouring was relatively inhibited at the lower temperature, and the life was over at a much greener stage. The fall of pressure is dependent on temperature to an even greater extent, and is less definitely related to the end of the storage life.

From experiments conducted during 1936, it is apparent that the relation of colour to storage life is also subject to seasonal and locality influences, as the Williams pears from Shepparton have coloured and softened more rapidly than usual in store, and did not reach the end of their life until full yellow colour (>5) was reached. With these pears a study has been made of the change in colour and pressure at temperatures from 32° F. to 75° F., and the effect of delayed storage at the higher temperatures on the colouring, softening, and storage life at 32° F. In all these treatments the colour was related approximately to the subsequent storage life at 32° F., with certain definite exceptions, as shown below :—

Colour.	Immediate Storage at 32° F.		Two days' delay at 65° F.	
	Storage life (weeks).	Pressure (5/16 inch plunger).	Storage life at 32° F. (weeks.)	Pressure.
1	13	21	..	..
2	10	20	5½	14
3	5½	18	4	4
4	3	16	2½	4
5	1	14	1	4

In delayed storage at summer temperatures the colour may only have developed to No. 2 ; but this initial exposure to high temperatures accelerates subsequent colouring with associated reduction of the storage life. The pressure at the same time falls rapidly to 4 lb. below which it is unable to fall at 32° F. In commercial practice, when Williams pears are shipped partly coloured, the cause of such an advanced condition is invariably delay in cooling, and pears even slightly coloured will have a very short storage life. Delayed cooling would be indicated by lower pressures at shipping, and even more by the extremely low pressure to be expected on subsequent discharge in England.

(vi) *Experimental Consignments of Williams Pears sent to England.*—In 1934 and 1935 experimental consignments of Williams pears were forwarded to London and examined there by officers of the British Food Investigation Board. The results of these shipments gave good confirmation of the results of the land storage experiments conducted in Victoria. This work has advanced to a stage where it is now possible to judge fairly accurately the mean temperature conditions prevailing throughout the period of transport from an examination of the condition of the fruit at discharge.

Early in 1936, a further experimental consignment was forwarded to England and a ten-point distance temperature indicator was installed in the cargo space.

(vii) *Storage of Peaches.*—Previous experiments have indicated that peaches can be picked just prior to full ripeness but still firm, and yet this immature fruit can be ripened at 65° F. with good flavour and juice. Fruit from the Doncaster district was picked firstly when 50 per cent. coloured and firm, and secondly when fully coloured and firm ; it was stored at 32° and 34° F. The varieties selected were Zerbe, Smith, Millicent, and Crawford. After a certain period in store the fruit did not ripen normally on removal to 65° F., being devoid of flavour and juice and later developing a red discolouration of the flesh. The maximum length of time the fruit could be stored at 32° F. and still ripen normally on removal was seven weeks (approximately) in the first

picking of the Zerbe, Millicent, and Smith's varieties, and nine weeks in the Crawford variety. Fruit of the second picking had a storage life approximately a week less; and storage at 34° F. had the effect of reducing the storage life by a week in both cases. These results indicate that, of the varieties tested, the Crawford is the only one which may be exported successfully overseas without resorting to "gas" storage methods.

The problem of picking maturity in peaches is important, as very immature peaches never become palatable, and over-mature fruit has a very short storage life. Determinations of ground colour and pressure are of little value in determining the degree of maturity; the mature fruit may be distinguished by the greater development of "blush." Work with the Smith and Crawford varieties has indicated that the more mature peaches have a higher Brix : acid ratio, and a much lower catalase content than the immature peaches.

(viii) "*Gas*" *Storage of Peaches.*—Experiments on the "gas" storage of four varieties of peaches at 32° F. and 34° F. have yielded promising results, the storage life of each variety being increased. Atmospheres containing 4 per cent., 8 per cent., and 12 per cent. of carbon dioxide were used, and the following results obtained :—

Variety.	Storage Life (weeks).							
	At 32° F.				At 34° F.			
	Air.	4% CO_2.	8% CO_2.	12% CO_2.	Air,	4% CO_2.	8% CO_2.	12% CO_2.
Zerbe	7	8½	8½	8½	6	6	8	8
Smith's Seedling ..	6	8½	9½	6	5	6½	6½	5½
Millicent ..	7	7½	9	9	6	7	8	8
Crawford.. ..	9	11	13	12	7	8	9½	9½

The best results were obtained by using an atmosphere containing 8 per cent. carbon dioxide at 32° F. Under these conditions Zerbe, Smith's Seedling and Millicent peaches kept for about nine weeks, and Crawford peaches for thirteen weeks. As these conditions are probably not deleterious for Williams pears and grapes, such fruits could be kept in the same chamber with peaches in "gas" storage.

Attack by brown rot, which arises in the orchard, has been found to be a serious problem with peaches even in "gas" storage. Some Zerbe peaches in "gas" storage were exposed to iodine vapour by placing solid iodine in the bottom of the container. This treatment stopped the development of brown rot, but resulted in serious injury to the fruit.

(ix) *The use of Iodized Wraps for Peaches during Storage.*—Iodized wraps were prepared according to the recognized method and their effect on controlling brown rot was studied. The results indicated that iodized wraps were only partially effective in controlling brown rot development, but they have the effect of injuring the fruit, and also rendering it inedible. The use of iodized wraps is, therfore, not recommended in the storage of peaches.

(x) *The Storage and Export of Plums.*—The experiments conducted in 1935 indicated that plums could be picked in an immature condition and ripened at temperatures from 45° to 65° F. As the fruit was than picked in one stage of maturity only, the experiments gave no indication of the exact stage of immaturity in which plums should be picked. A progress report of last year's experiments was published in the *Journal of the Victorian Department of Agriculture*, and export regulations were based mainly on the findings expressed in this publication. As a result the outturn of cargoes of plums has been most encouraging; and, in general, good prices have been realized.

For experiments carried out in 1936, the fruit was picked in three stages of maturity, (*a*) fully green, (*b*) one-third natural colour, and (*c*) two-thirds natural colour. The fruit was selected from the Doncaster and Shepparton districts, and the following varieties were stored at 34° and 32° F., viz., Grand Duke, President, Coe's Golden Drop, Jefferson, Magnum Bonum, King Billy, Diamond, October Purple, Narrabeen, Satsuma, Wickson, Washington, and Ballena.

In the Japanese varieties good results were obtained with all three pickings; but in general, fruits of the third picking were the most palatable. The length of storage life of these varieties did not exceed seven weeks at 32° F., and their export overseas does not seem very practicable.

In the European varieties, the development of colour and size appears to occur simultaneously; and thus very immature plums are undeveloped and will not ripen with full flavour and juice. These plums should, therefore, be picked when fully coloured and grown, but still firm; the minimum size should be 1¾ inches. It must be stressed that these remarks apply to varieties which are to be sold for dessert purposes, for in the case of the Grand Duke, which is an excellent cullinary variety, good prices have been obtained in London this year for small immature fruit.

The European varieties consist of yellow and dark fruit. The dark varieties are the more favoured in London and of these the King Billy possesses the best qualities for export. This variety is a seedling of the Grand Duke variety, has excellent flavour, and has a storage life of nine weeks at 32° F. Unfortunately only a few trees of this variety are grown in Australia. The Grand Duke variety has a storage life of eight weeks at 32° F., and is of very fair flavour. Coe's Golden Drop is the best of the yellow varieties tested, being of excellent flavour and having a storage life of nine weeks at 32° F. The Jefferson has very fair flavour, and a storage life of eight weeks at 32° F. In all cases the storage life of the fruit was terminated by loss of flavour and lack of juice, internal browning of the flesh then following.

Early in 1936, an experimental consignment of the Narrabeen and Grand Duke varieties was forwarded to London ; and a multi-point distance temperature indicator was installed in the cargo space in which the fruit was stowed. After discharge, the fruit was examined by officers of the British Food Investigation Board who will report on the nature and extent of any defects.

(xi) *Observations on the Maturity of Plums at Picking.*—The relation of the colour and the pressure test to the picking maturity was found to depend on the variety. In the yellow varieties the change in colour and pressure was considerable during the picking period. In the blue and red varieties there was little change in the ground colour and pressure, the change being mainly in the over-colour. Immature plums, particularly in the case of the Grand Duke variety, failed to develop sufficient juice and flavour on ripening, and gave high readings with the pressure tester. The plums which developed satisfactory quality invariably registered pressures between 11 and 14 lb., using a plunger $\frac{5}{16}$ inches in diameter.

It has been shown in the case of President plums that the sugar and acid content both have a tendency to increase with maturity, hence the sugar : acid ratio is practically independent of maturity.

(xii) *" Gas " Storage of Plums.*—Experiments have been continued on the " gas " storage of plums, using the method of reduced ventilation. The fruit has been kept in atmospheres containing 5 per cent. and 10 per cent of carbon dioxide, the oxygen content being correspondingly reduced. Most of the plums were stored at 32° F., a few varieties being also stored at 37° F. The results obtained are as follows :—

Variety.	Storage Life (weeks).					
	At 32° F.			At 37° F.		
	Air.	5% CO_2.	10% CO_2.	Air.	5% CO_2.	10% CO_2.
Ballena	6	6	6	3	4	6
Satsuma	8	8	8	..	..	..
October Purple	5	5	5	..	..	..
President	6	4	4	$2\frac{1}{2}$	2	2
Grand Duke	9	7	7	6	5	5
Narrabeen	6	>4	>4	..	..	..
King Billy	9	>4	>4	..	..	..
Magnum Bonum	9	5	>5	..	..	..

In no case is there a decided advantage in the use of " gas " storage ; and in most varieties the storage life is definitely reduced by this treatment. In the storage and transport of plums, therefore, the carbon dioxide should be kept as low as possible through adequate ventilation. When the air surrounding a case of plums is free from carbon dioxide it has been found that there is no appreciable accumulation of this gas within the case.

(xiii) *The Storage of Grapes.*—The Waltham Cross, Red Malaga, Purple Cornichon, Ribier, Red May, Red Prince and Gianette varieties from the experimental farm at Rutherglen were picked in two stages of maturity, (*a*) slightly acidic but just edible, and (*b*) three weeks later. The fruit is being stored at 32° F., and samples are being removed at regular intervals and examined after one week at atmospheric conditions. The fruit was carefully picked and handled prior to cool storage, and, in consequence, wastage through mould and dehiscence of berries has only occurred subsequent to loss of palatability. The Red Prince, Red Malaga, and Gianette appear to be the best of the above varieties.

(xiv) *" Gas " Storage of Grapes.*—Early in 1936 experiments were commenced on the storage of Purple Cornichon grapes held at 32° F. in atmospheres containing 5 per cent. and 10 per cent. carbon dioxide. At intervals bunches were removed to a store at room temperature for examination. While the results so far obtained can only be regarded as preliminary, there are

indications that the optimum concentration of carbon dioxide is between 5 per cent and 10 per cent. As compared with the controls stored in air, grapes stored in 10 per cent. carbon dioxide remained fresh for a somewhat longer period, but there was a tendency, in a few bunches, for an " off " flavour to develop.

(xv) *The Treatment of Grapes with Sulphur Dioxide.*—The treatment of grapes with sulphur dioxide has been investigated in the following manner. Atmospheres containing approximately 15 and 30 parts per million of sulphur dioxide have been maintained continuously around Purple Cornichon grapes by exposing them to a current of air in equilibrium with solutions containing the above concentrations. Treatment even with the lower concentration was definitely injurious, the storage life being reduced to only a month owing to discolouration and development of mould. Grapes given an initial treatment with sulphur dioxide for a week at 32° F. and then kept in air did not differ significantly from the control grapes in storage life. Similar initial treatments have been applied in California to grapes carried at somewhat higher temperatures ; and it is claimed that it checks the rapid development of mould which is liable to occur in storage.

5. *Banana Investigations.*—(i) *Investigations into Black-end and Squirter Diseases (at the Queensland Department of Agriculture).*—During the past year, the incidence of black-end and the causal organisms involved have been normal, with the exception that black-end due to *Thielaviopsis paradoxa* was recorded more frequently. Squirter was responsible for a considerably smaller loss of fruit than usual.

Investigations of the strains and saltants of *Gloeosporium musarum* has been partially completed. One strain appears in such a high percentage of cases that it can be assumed to be the only one of economic significance. The other forms are of interest from a mycological point of view and their pathogenicity is being recorded.

Direct control by treatment of the fruit has received less attention than previously. On the other hand, considerable attention has been given to determining the reason for the failure of the common fungicides to control black-end. After treatment with mercuric chloride, formalin, or alcohol the germination of *Gloeosporium musarum* spores on the side of fruit was very similar to that obtained on slides. In most instances complete sterilization was obtained, thus eliminating the possibility that failure to wet the surface is an important consideration in these fungicides.

The use of fungicides on fruit with added spores of *Gloeosporium* showed that their effectiveness in preventing anthracnose decreased with the time elapsing between inoculation and treatment. The severity of anthracnose, its early appearance and the number of points of origin in inoculated circles in this experiment were closely parallel to results from inoculations with varying strengths of spore inoculum, showing that the longer the interval elapsing before sterilization the greater the survival due either to penetration or to increasing resistance of the appressoria. Attempts to estimate the effect of fungicides on " germination " of appressoria have so far met with little success.

Inoculations into green fruit in the field suggest that infection can take place through injuries before the fruit is mature. In order to test the conclusion (reached from plantation observations) that a relationship existed between the amount of black-end and cultural practices, samples of fruit were obtained from a number of plantations and the black-end occurring was compared with the plantation conditions. The results obtained show that the mean percentage of black-end varies with the number of dead leaves per plant. Fruit from plantations with an average of up to three dead leaves per plant gave significantly less black-end than plantations with a greater number. This fact is of considerable importance in connexion with the application of practical control measures, and is connected with the abundance of *Gloeosporium* pustules on dead and dying leaves which are apparently the source of infection.

Two cases of fruit were used to test a 3 per cent solution of Shirlan XP18 as a control fungicide for a squirter. Complete control was obtained with both lots, but unfortunately only a small percentage of squirter occurred in the control fruit. As the direct application of fungicides appears to be of little use in connexion with the control of black-end, a repetition of some of this work will be necessary in order to see whether more satisfactory results can be obtained in the control of squirter.

(ii) *Investigations into the " Rubbery " Condition (at the Biochemistry Department, University of Melbourne.)*—During the summer months the " rubbery " condition occurs frequently in certain consignments of bananas, and appears usually to be associated with " full " fruit from maiden plantations established on " forest soils."

Supplies of fruit, arranged by the New South Wales Department of Agriculture, are being obtained regularly from the Tweed River district (New South Wales), and also from a few affected plantations in Queensland. This fruit is forwarded to Melbourne for ripening, examination and chemical analyses. Owing to the spasmodic occurrence of the " rubbery " condition, insufficient data have yet been obtained to justify any conclusions being drawn concerning its precise nature and cause.

6. *Liaison Work in England.*—The Council has continued to maintain an officer in England for the purpose of assisting in the co-ordination of the work of the Section of Food Preservation and the British Food Investigation Board, and also to carry out examinations of experimental consignments of perishable foodstuffs where it is unnecessary to seek the co-operation of the Board. During the year 1935–36, the liaison officer has examined, and obtained data on, many consignments of chilled beef and has assisted in the examination of several cargoes of oranges, pears and plums.

XI. OTHER INVESTIGATIONS.

1. *Commonwealth Prickly Pear Board.*—The control and eradication of prickly pear by *Cactoblastis cactorum* has been advanced appreciably during the year. In Queensland, the vigorous secondary growth, that in most districts followed the collapse of the original prickly pear, has now been destroyed. Except for small areas of damaged plants here and there, the dense primary pear of the major pests, *O. inermis* and *O. stricta*, is a thing of the past. The extensive brigalow and belar scrubs, and the more heavily timbered forest lands, are almost free from pear infestation. Very little growth of any kind is apparent over large tracts of country. Regrowth has been reduced to light scattered proportions, with restricted patches, varying from a few to a few hundred acres, of heavier growth at intervals.

On open forest country and on improved pastures, the appearance of scattered seedling pear has continued on the marginal lands fringing the former heavy pear areas. It is known that prickly pear seeds are viable for many years. Hence, from seeds now dormant in the ground, seedlings will develop, in all probability, for some considerable time.

The great reduction in the prickly pear infestation has brought a corresponding decrease in the *Cactoblastis* population. The enormous concentrations of the insect, that were a feature of the mass onslaught on the dense pear, are no longer seen, for the reason that the available food-supply is limited. It is, however, gratifying to report that, wherever there is regrowth or seedling pear, even of a very scattered nature, *Cactoblastis* is well-established, and in the denser patches of prickly-pear it is abundant. Indeed, its survival in those sections where the pear growth is very sparsely scattered calls for favourable comment.

The position in the north-western pear country of New South Wales is very similar to that in Queensland, except that there is rather more regrowth in certain sections. In the Hunter River district, the primary pear is being steadily reduced and regrowth is being destroyed. There are, however, many areas of resistant pear on timbered hills and ridges where progress has been slow and will continue to be very gradual until the removal of the trees effects an improvement in the succulence of the prickly pear. This problem of the food supply being unsuitable to the requirements of *Cactoblastis* is again encountered on similar hard country in the Bingara-Inverell district. Many land-owners in this sector have destroyed the timber on considerable areas, and *Cactoblastis* has brought about excellent destruction on the recently improved land.

The development for pastoral and agricultural purposes of former dense pear country, made available through the agency of *Cactoblastis*, has made steady advancement. Throughout the Queensland pear territory, destruction of unwanted timber, erection of new fences, provision for water storage, and other improvements are evidence of new areas being added to the sheep and cattle grazing industries. In those sections where closer land settlement can be undertaken more new settlers are building homes, growing crops, sowing fodder grasses, and increasing their dairy herds.

With regard to the lesser pest pears, a Longicorn beetle, *Lagochirus funestus*, has been introduced from Mexico, and is being reared in numbers and liberated in areas of the tree pears *O. tomentosa* and *O. streptacantha*. The Argentine cochineal, *Dactylopius confusus*, is proving very destructive to the tiger pear, *O. aurantiaca*, and promises to control this troublesome plant.

Attention has been devoted to the insect enemies of *Bassia* and related plants. On behalf of the Council, further liberations and controlled experiments have been conducted with the Noogoora burr seed-fly, *Euaresta aequalis*.

Concerning overseas investigations, prickly pear work in Mexico and the Argentine was completed during the year, and the two officers were released for the study of *Xanthium* insects. Field surveys dealing with the *Xanthium* have been made over wide areas in the United States. and Mexico. Two entomologists are now occupied in the United States with various insect enemies of these plants. Another officer has conducted *Xanthium* investigations in the Argentine, and at present is undertaking similar survey work in Brazil and Paraguay.

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 Department of Defence and the Commonwealth Meteorological Bureau have also assisted in various ways.

The ionospheric and fading work of the Board, which is centred in the University of Sydney, has been continued. Since a large percentage of radio communication is by reflection from one or other of the reflecting layers of the ionosphere, a knowledge of the diurnal and seasonal changes

of conditions in these regions is obviously of importance. In addition, the radio methods developed for ionospheric observations have enabled many deductions to be made concerning the nature, pressure, temperature, and ionization of the gases present in the region between 50 and 250 kilometres above the earth—matters of which are of importance to the meteorologist. The examination of data obtained in this work has lately enabled some order to be found in what hitherto appeared to be conflicting results from other sources of evidence such as meteor trails, aurorae, and luminous night clouds. The results of these considerations have recently been embodied in a paper prepared by officers of the Board and read before the Royal Society in London (see *Proc. Roy. Soc.* A., 154 : 755, 1936).

On the atmospheric side, the close connexion found between moving sources of atmospherics and cold fronts over the Australian Bight in the summer of 1934–35 suggested a continuation of the work to determine the possible value of atmospheric direction-finders for weather forecasting, especially for south-eastern Australia. Accordingly a twelve months' test was initiated in August, 1935, the Commonwealth Meteorological Bureau having arranged to co-operate with the Board's investigators, who are accommodated in the University of Melbourne. The results have not yet been finally considered, but evidence has been obtained leading to the conclusion that, at any rate under the conditions that applied in the summer season of 1935–36, the radio methods are not of much meteorological value. An investigation has now been decided on with the object of determining the total energy radiated in the "radio" portion of the spectrum by the average lightning flash. The necessary apparatus is still under construction. In addition to the total energy radiated, it is hoped to obtain some additional information regarding the wave form of atmospherics.

3. *Mineragraphic Investigations.*—Mineragraphic investigations are concerned with elucidating the mineral associations in complex ores. Many valuable minerals occur in opaque particles of microscopic size which may only be observed by the microscopical examination of polished surfaces in reflected light. With the aid of suitable mounting mediums the minerals in a mill product or flotation concentrate can similarly be determined ; and the investigation of losses in milling can frequently be assisted by the direct observation of the valuable minerals in mill products and tailings. Special methods of preparation of specimens are required as well as special methods of identification of the minerals ; and these are employed by the Council's investigator, Dr. F. L. Stillwell, and his assistant, Dr. A. B. Edwards.

During the past year information relating to the occurrence of gold in ores from Glenloth, South Australia, Cobar, New South Wales, Nullagine, Western Australia, and Misima, Papua, has been supplied to the South Australian section of ore dressing investigations. In each case particles of gold have been observed with the microscope, and photographed in their association with pyrite, chalcopyrite, pyrrhotite, stibnite, and quartz. The gold content of chlorinated residues from Charters Towers was determined to be largely due to particles of gold embedded in roasted particles, and thus inaccessible to direct cyanidation. Relationships of the stannite and galena in tin ore from the Conrad mine, Howell, New South Wales, have been described ; and the silver bearing mineral, tetrahedrite, was found to be so intimately associated with both stannite and galena that its separation by flotation from either stannite or galena is impossible.

The Victorian section of ore dressing has been supplied with information relating to the occurrence of gold in auriferous quartz from Sloane and Scotchman's at Stawell, and in ore from the Firebrace Reef at Granya in Victoria, and in arsenical ore from Auburn Falls and from Nukinenda Creek in Queensland. The examination of flotation concentrates from Firebrace Reef, before and after roasting, indicated that some of the gold occurs as inclusions in particles of pyrite and arsenopyrite, and that, after roasting, they may persist as inclusions in particles of hard iron oxide.

The mineral content of a series of samples from a Wilfley table at the Maude and Yellow Girl G.M., Glen Wills, was determined, as well as the mineral content and gold in a flotation concentrate. This information was utilized in the experimental tests in ore dressing which led to the successful methods of treatment at present in use at the mine.

Auriferous antimony ores from South Costerfield, Hoddle's Creek (near Warburton), and North Drummond (near Malmsbury), all in Victoria, have been examined. At South Costerfield, small particles of gold occur in quartz, in stibnite, and to a lesser degree in pyrite. At Hoddle's Creek the ore contains a little arsenopyrite in addition to pyrite, and gold is embedded in the stibnite. At North Drummond the proportion of arsenopyrite to stibnite is much greater ; and arsenopyrite occurs both as coarse crystal and fine particles embedded in stibnite. Small particles of gold measuring .06 x .05 mm. and .04 x .014 mm. were observed to be embedded in stibnite.

A comprehensive study of the iron ores of the Middleback Ranges, Eyre Peninsula, South Australia, has been carried out by Dr. A. B. Edwards. Eleven bodies of pure bedded hematite ore occur, generally in synclinal structures, in association with aluminous schists and banded hematite quartzites. Massive, schistose, and powder ores occur in close association, the schistose and powder ore resulting from the leaching of hematite-rich quartzites or schists. Microscopical

study reveals that the ores and associated rocks are probably altered sediments. The iron minerals are hematite with minor amounts of magnetite and limonite; but the bulk of the hematite was formerly present as magnetite. The alteration of magnetite to hematite is due, in part if not wholly, to the action of descending surface waters. The descending solutions have sometimes carried manganese in solution; and at the Iron Monarch a considerable concentration of manganese minerals has resulted. The manganese, thrown down in gel form, gave rise first to psilomelane, often unusually rich in iron. This has in part crystallized as veins of pyrolusite (MnO_2), and to a less extent as braunite ($3Mn_2O_3MnSiO_3$), and manganite (Mn_2O_3,H_2O). The iron in the gel has crystallized as a second generation of magnetite, giving rise to magnetic manganese ore. The distribution of the manganese has been partly controlled by the disposition of bands of impervious clay schist in the ore body.

A study of the occurrence of the rare nickel arsenic sulphide, gersdorffite, in the Hecla adit, NE. Dundas, Tasmania, has been concluded. Gersdorffite is limited to an isolated segregation in a narrow lode which consists largely of siderite with disseminated sulphides of iron, copper, zinc, and lead. An interesting feature of the vein is the presence of an assemblage of rare lead minerals, including the lead antimony sulphides, jamesonite, and bournonite, and the corresponding lead bismuth compounds, cosalite and aikinite.

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

4. *Ore-dressing Investigations.*—In 1934 the Government decided to grant the Council £5,000 per annum for a period of five years in order that research work of value to the gold-mining industry of Australia might be undertaken. The Government's decision was the result of a growing belief that, provided adequate technical assistance was made available towards the solution of the metallurgical problems involved, deposits now unworked could be brought into profitable production, and those worked into still more profitable production.

In planning and carrying out the investigations thus rendered possible, the Council has been particularly fortunate in obtaining the co-operation of existing metallurgical laboratory organizations and the advice of many prominent metallurgists and mining authorities in Australia. A portion of the grant is being devoted to an intensification of the mineragraphic work carried our by Dr. Stillwell. The greater portion of it, however, is being used to finance the ore dressing tests mentioned in the previous Annual Report. These tests are conducted at the Kalgoorlie School of Mines Metallurgical Laboratory of the Western Australian Department of Mines, at the Bonython Metallurgical Laboratory of the South Australian School of Mines and Industries, and at the Metallurgy School of the University of Melbourne, all of which bodies are affording the Council most useful co-operation in the way of providing the Council's investigators with laboratory accommodation, direction, &c.

This ore dressing work is being directed by the Mining Advisory Committee and its three Sub-committees, one of which is located at each of the three co-operating laboratories. The personnel of these various bodies is given in the Appendix to this report.

Under the scheme that has been put into practice it is open for any leaseholder to request that his ore be tested. Prior to agreeing to such tests the Council needs to be assured that the ore sample it receives is representative of a sufficient tonnage of ore to warrant the examination. When this assurance is forthcoming, the work is put in hand. It consists of such operations as tests of grinding, straking, flotation, cyaniding, &c. During the year under review 70 reports of tests on different ores were completed. These concerned samples from the following localities :—Bethanga (Victoria), Auburn Falls (Queensland), Snake Valley (Victoria), Stawell (Victoria), Granya (Victoria), Daylesford (Victoria), Glen Wills (Victoria), Yeppoon (Queensland), Tennant's Creek (Northern Territory), Glenloth (South Australia), New Cobar G.M. (New South Wales), Norseman (Western Australia), Kalgoorlie (Western Australia), Southern Cross (Western Australia), Spargoville (Western Australia), White Hope G.M. (Western Australia), Mt. Magnet (Western Australia), Rothsay (Western Australia), Ora Banda United Mines (Western Australia), Burbanks Birthday G.M. (Western Australia), Chadwin (Western Australia), Yellowdin (Western Australia), Paddington (Western Australia), Davyhurst (Western Australia), Roebourne (Western Australia), Laverton (Western Australia), Leonora (Western Australia), Mt. Ida (Western Australia), Ora Banda (Western Australia), Hampton plains (Western Australia), Meekatharra (Western Australia), Cave Rocks (Western Australia), Youanmi (Western Australia), Menzies (Western Australia), Coolgardie (Western Australia), Ravensthorpe (Western Australia), South Boulder (Western Australia), Mt. Wallbrook (Western Australia), Gullewa (Western Australia), Higginsville (Western Australia), Peak Hill (Western Australia), Boogardie (Western Australia), Idaho Lease (Western Australia), Riverina G.M. (Western Australia), Marvel Loch (Western Australia), Charters Towers (Queensland), and Nullagine (Western Australia).

The number and variety of the foregoing reports are evidence of the wide extent to which the facilities available for the work are being used by the gold-mining industry generally.

5. *Standards Association of Australia.*—The Standards Association of Australia, for which the Council is the means of liaison with the Commonwealth Government, reports a successful year of activity over a widening field of operations. Some new Committees have embarked upon important undertakings in response to urgent representations from departmental and public utility authorities; and some Committees which had been operating on a reduced basis have resumed normal activity. Investigations into problems associated with primary industries have indicated the possibilities of extending the Association's usefulness in that direction. These advances have been made possible by the further partial restoration of the Commonwealth Government's grant to its former proportions, and increased financial support from other sources. With a continuation of this improvement in financial backing a much wider range of activity, that should have an influence on the development of industry, is possible. Co-operation with other standardizing agencies throughout the Empire and in other countries has been maintained and consolidated, and now constitutes a major branch of the Association's functions.

6. *Fuel Problems.*—The Newnes Investigation Committee has completed its inquiry into the project for reviving the shale oil industry. In January, 1936, the Committee presented to the Governments of the Commonwealth and New South Wales a supplementary report amplifying to some extent its original report of April, 1934. The additional information contained in the recent report is largely the result of a further inquiry into the quality of the products mentioned in the Council's last Annual Report, and now completed.

A comprehensive report has also been received from Messrs. R. Crichton and H. R. J. Conacher, of Scottish Oils Ltd., who investigated the project on behalf of the Anglo-Iranian Oil Company.

After consideration of these reports, the Commonwealth Government has invited applications for taking over the Newnes-Capertee shale field, under conditions granting the successful tenderer exemption from excise for a period of twenty years.

Since the completion of the Committee's inquiry, Mr. L. J. Rogers, who is normally attached to the Council for Scientific and Industrial Research, has been engaged in advising the Government on a number of current problems in fuel technology. He has witnessed a series of road tests of a motor vehicle using alcohol as fuel, and has submitted a report upon the economics of preparing alcohol from surplus wheat.

7. *Fisheries Investigations.*—In the last Annual Report reference was made to the Cabinet's decision of the 29th July, 1935, as a result of which the Council assumed responsibility for the recently initiated fisheries investigations, originally entrusted to the Development Branch, Prime Minister's Department. The programme of research will comprise work under the following main heads:—

(i) Exploration of fishing grounds by a specially designed vessel.

(ii) Experiments in canning; and the determination of the chemical composition of fish thought to be suitable for the manufacture of fish by-products.

(iii) Tests of methods of curing and preserving fish, especially the more common varieties.

(iv) Marine biological investigations, including research into the life histories, distribution, &c., of economically important fishes.

As fisheries investigations, except perhaps of a somewhat isolated nature, mark a new departure in scientific work in Australia, and as they can be prosecuted only if properly trained men are available for the work, active research along the various lines planned must of necessity develop somewhat slowly.

As there appears to be no one in Australia with an intimate practical knowledge of the development of similar research in other countries, and who is adequately qualified to take charge of the organization and development of the fisheries research work in Australia, inquiries have had to be made in other countries in order to ascertain whether the services of a suitable expert can be obtained. It is hoped that an appointment will be made before long. In the meantime steps are being taken to form the nucleus of a staff of trained investigators.

A graduate of an Australian University has been appointed by the Trustees of the Science and Industry Endowment Fund as a Senior Research Student to undergo a special course of training in fisheries investigations over a period of two years. The appointee left Melbourne in March last ; and after a period at the Torry Research Station, Aberdeen, he will receive further training at the Low Temperature Research Station, Cambridge, and later probably at the Prince Rupert Fisheries Experimental Station, British Columbia, and at the Halifax Fisheries Experiment Station, Nova Scotia. It is hoped to appoint, at an early date, another Australian graduate to undertake a special course of study in certain branches of fisheries investigations.

Fisheries Research Vessel.—Tenders for the construction of the proposed fishery investigation vessel have been received and considered, and that submitted by the Melbourne Harbour Trust Commissioners has been accepted. All the preliminary work in the way of preparing detailed drawings, the placing of orders for material, &c. is now progressing satisfactorily. The vessel, which will be built of steel, will be powered with a Diesel engine, and equipped with wireless and automatic depth-recording apparatus.

The vessel, which will be specially equipped for the capture of pelagic, or surface-swimming fish, will be of a type new to Australia, though many similar vessels are employed, particularly on the Pacific Coast of America, in connexion with the pilchard, mackerel, salmon, and tuna fisheries. In addition it will be equipped with a Danish seine net for the capture of demersal or bottom-dwelling fish, such as flathead. It will also serve to investigate reefy or rocky grounds by means of hand lines and long or set lines.

The sole aim of the vessel will be to gather data leading to the commercial development of our marine resources. Whilst provision is being made for scientific work abroad, the vessel will be a practical fishing craft from whose work fishermen and others in Australia will be able to assess the possibilities of developing phases of the fishing industry which, though neglected in Australia, are intensively prosecuted abroad. The vessel will in no way compete with commercial fishing interests. It is not its purpose to return to port with large catches; but provision has been made for the storage of such quantities of fish as may be necessary for tests on shore.

It appears that aerial observations of the occurrences and movements of pelagic fish might greatly assist the work of the investigation vessel ; and arrangements have been practically completed for test flights during next October over the waters off the South Coast of New South Wales and North-eastern Tasmania. The Council is deeply appreciative of the co-operation of the Defence Department which has agreed to provide the necessary equipment and personnel. If the test flights are successful, consideration will be given to the extensive use of aerial observations of pelagic fishes in future in conjunction with the investigation vessel.

Fish Preservation Investigations.—As regards investigations into problems connected with the preservation by quick freezing, canning, &c., arrangements have been made for experimental work to be carried out by the Council's Section of Food Preservation and Transport at laboratories and experimental cold chambers to be erected in Sydney. Unfortunately, owing to delay in getting possession of the building in which the laboratory and chambers are to be erected, it will not be possible to make a start on this work until early in 1937.

Smoking and Curing.—The Council is sending to the Torry Research Station, Aberdeen, sufficient quantities of chips and sawdust of six selected Australian woods to enable careful tests to be carried out in order to determine their value for the smoking and curing of fish.

The Council is also endeavouring to secure the services of a skilled fish curer in order to carry out work in regard to the best varieties of fish for curing, improved methods of technique, &c.

Chemical Analyses of Fish.—Analysis of fish are important from three points of view, viz. :—(*a*) the oil content of fish liver and the vitamin content of the oil ; (*b*) the utilization of non-edible fish, &c., for the manufacture of products such as fish meal ; and (*c*) preservation by quick freezing or other methods.

It is hoped to complete arrangements for this work to be commenced at an early date in co-operation with the Department of Chemistry of the University of Melbourne.

8. *Biometrical Work.*—With the gradual extension of the work of the Council, the use of statistical methods has been steadily increasing. In every Division investigations are being carried out which involve the use of biometrical principles to a greater or less extent. In quantitative experiments not only must measurements be made with the utmost precision possible, but an index must be given of the accuracy of the results. This can be done only when the planning and execution of the experiments is statistically sound. Throughout the Division of Plant Industry the services of the biometrician are being used continuously in connexion with work on genetics, plant pathology, physiology, and weed control investigations. In the Entomological Division

biometrical work has been done in connexion with tests of effectiveness of trapping in controlling blowfly strike, with termite investigations, and in experiments on the development and control of fruit pests. Since the biometrician is stationed in Canberra, closer touch can be kept with the work of these two Divisions than with the others.

In order to keep in contact with officers other than those in Canberra, occasional visits are paid to other centres. Several weeks were spent during this year at the Research Station at Merbein, where many experiments of a statistical nature are being conducted, both in soil investigations, and on the behaviour and treatment of vines. The time selected for this visit was the late summer, when the work was still in progress in the field, so that an examination could be made of the methods adopted both in the field work and in the analysis of the results. Advice on statistical methods is given by correspondence to officers in other places, both within and without the Council.

A course of lectures on biometrical methods is being given for the staffs of the Divisions of Plant Industry and Economic Entomology.

In view of the increasing demand for expert advice in biometrical questions, and consequent call on the services of the biometrician, Miss Barnard has been appointed to assist in the work. She is at present training in England, and will join the Council immediately after her return in August. At the McMaster Laboratory in Sydney, the biometrical work is now being carried out by Miss Turner.

9. *Soil Drift Investigations.*—In the latter part of 1935 an officer of the Council carried out an extensive tour of the arid pastoral areas of South Australia. During the recent run of drought years these regions have suffered marked deterioration through the destruction of much of the perennial vegetation, and through wind erosion of the surface soil, which is accompanied by the liberation of loose drifting sand. In the so-called " bush " country, where the perennial vegetation comprises dwarf shrubs of the genera *Atriplex* and *Kochia* (which act as a fodder reserve for stock in addition to providing a protective cover to the soil), the primary cause of the trouble has been overstocking in the lean seasons. Rabbits, however, have been an important factor in the prevention of the natural regeneration of various tree and shrub species, notably the mulga. They have also been a contributory cause in the loss of stability of certain areas of sandhill country. In view of the adverse climatic conditions and the exceedingly low capital value of the land, no great hopes can be held out for the success of remedial measures such as the introduction into the affected areas of soil-binding plants, or the artificial seeding of denuded patches. During good seasons the erosion danger will be in abeyance, and the vegetation may be expected to recover to a certain extent ; but the spread and intensification of the trouble can only be prevented during future droughts by a radical alteration of the general stocking policy.

10. *Bureau of Information.—The Science and Industry Research Act* 1920–26 provides for the establishment of a Bureau of Information for the collection and dissemination of information relating to scientific and industrial matters. Although such a Bureau has not yet been established as a separate section or part of the Council's organization, a large number of inquiries for information on a diversity of subjects are received and dealt with each year. Some of these inquiries concern problems which are actually under investigation by the Council's officers. In such cases, full information can generally be given. Many of them, however, relate to matters which are not being investigated by the Council ; these are dealt with either by personal interview or by letter as fully as possible, using the resources of the Council's staff and libraries and, where necessary, obtaining the required information from outside sources. The following is a selection from the list of subjects not directly under investigation by the Council and concerning which information has been supplied during the past year :—

(i) *Primary Industries.*—Potato starch and other by-products, power alcohol from maize, apples, &c., dewoolling sheep skins, canning of oysters, bugle lilies, arsenic in dips, guinea grass, maize storage, fibre from banana leaves. bleached wheat, wild mint, sulphur as insecticide, concentrated meats, cassava starch, putchuk root, dehydrated potatoes, hemp, blackberry control, sericulture, tung oil, derris root, soya bean, cheese, Spangenburg process, and *Phormium tenax.*

(ii) *Industrial Minerals.*—Shale oil, elementary sulphur from ores, gem stones, alunite, kaolin, quartz crystals, and zircon.

(iii) *Manufactures.*—Soap, felt hats, insulating lining brick, sulphuric acid plant, plaster of Paris, coloured brick, rock cork, nicotine sulphate, office pastes, cold cure rubber, pyrethrum, lime sulphur, German silver, chromium plating, cordial manufacture, potash from felspar, artificial flowers, mirrors, Y alloy, papain and plastics.

(iv) *Miscellaneous.*—Grass tree resin, water divining, power from wind, producer gas for tractors, mutton bird oil, preservation of cinematograph films, control of mistletoe, patent sail, patent engine, evaporation of stored water, tidal power, Burrawang palm, patent head-light, acoustics, and brining of cherries.

XII.—FINANCIAL MATTERS, STAFF, AND PUBLICATIONS.

1. *Finance.*—The statement of expenditure from 1st July, 1935, to 30th June, 1936, is as follows :—

	£	£	£
1. Salaries and contingencies	..	..	15,710*
2. Remuneration of Chairman and Members of Council	..	..	2,144†
3. Investigations—			
(i) Animal Problems—			
(*a*) Sheep diseases : footrot, black disease, preputial disease, caseous lymphadenitis, enterotoxaemia, pregnancy disease and equine navel ill ..	1,704		
Less contribution from the Australian Pastoral Research Trust	232		
		1,471	
(*b*) Parasitology	5,045		
Less contributions from the Australian Pastoral Research Trust	623		
		4,422	
(*c*) Caseous lymphadenitis (New South Wales)	..	1,159	
(*d*) Biochemical Problems	..	1,035	
(*e*) Bovine haematuria and caseous lymphadenitis (South Australia) ..	..	826	
(*f*) Tick and tick fevers, pleuro-pneumonia, &c.	9,122		
Less contributions from Queensland Government, Council of Agriculture, Brisbane, and part proceeds from sale of vaccine	2,826		
		6,296	
(*g*) Entero-toxaemia (Braxy-like disease), Moora (Gingin) disease, Ataxia in lambs, &c. (Western Australia) ..	..	302	
(*h*) Mastitis (Victoria)	4,773		
Less contributions from Australian Dairy Cattle Research Association and part Berwick Farm Revenue	4,773		
		..	
(*i*) Rabbit myxomatosis	75		
Less contributions from Council of Advice, Rabbit Destruction Fund	75		
		..	
(*j*) Genetics (New South Wales and Queensland)	1,837		
Less contributions from the Australian Pastoral Research Trust	450		
		1,387	
(*k*) Haematuria (Victoria and South Australia)	..	99	

* 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.

	£	£	£
(i) Central Office—			
Annual	3,862		
Capital	3,438		
		7,300	
		24,298	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..		4,000	
			20,298
(ii) Plant Problems—Division of Plant Industry—			
(*a*) Central Laboratory—			
Annual	5,839		
Capital	376		
		6,215	
(*b*) Experimental plots		508	
(*c*) Plant pathology		2,547	
(*d*) Plant genetics		3,175	
(*e*) Plant introduction		1,336	
(*f*) Agrostology		1,105	
(*g*) Plant physiology		1,034	
(*h*) Noxious plants		1,544	
(*i*) Fruit problems		1,227	
(*j*) Experimental Farm, Duntroon		427	
(*k*) Potato Virus Studies		290	
(*l*) Plant Introduction Garden, Gatton, Queensland		229	
(*m*) Plant Introduction (State Farm, Middle Queensland)		192	
(*n*) General botany		722	
(*o*) Apple root stocks, Stanthorpe, Queensland	517		
Less contributions from Committee of Direction of Fruit Marketing, Brisbane, Queensland	435		
		82	
(*p*) Tobacco Investigations	5,826		
Less contributions from Tobacco Trust Fund	5,826		
		..	
			20,633
(iii) Entomological Problems — Division of Economic Entomology—			
(*a*) Central Laboratory—			
Annual	4,026		
Capital	653		
		4,679	
(*b*) Agricultural Entomology and Museum		1,592	
(*c*) Agricultural Entomology (Orchard and Fruit Pests)		93	
(*d*) Agricultural Entomology (Grasshopper Investigations)		961	
(*e*) Noxious weeds		2,965	

	£	£	£
(*f*) Veterinary Entomology	3,627		
Less contributions from Australian Pastoral Research Trust	48		
		3,579	
(*g*) Forest Entomology	..	2,891	
(*h*) Oriental Peach Moth	422		
Less contributions from Department of Agriculture, Victoria	422		
		..	
			16,760
(iv) Animal Nutrition—			
(*a*) Central Laboratory	6,328		
(*b*) Waite Institute	1,950		
(*c*) Field Station, Young, New South Wales	194		
	8,472		
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	3,000		
		5,472	
(*d*) Field Station, Kangaroo Island, South Australia	200		
Less contributions from the Australian Pastoral Research Trust	88		
		112	
(*e*) Drought feeding experiments at Waite Agricultural Research Institute, Glen Osmond, South Australia	1,158		
Less contributions from Australian Pastoral Research Trust	518		
		640	
(*f*) Field Experiments on Phosphorus Deficiency, South Australia ..	233		
Less contributions from the Australian Pastoral Research Trust	225		
		8	
(*g*) Agrostological Investigations at Waite Agricultural Research Institute, Glen Osmond, South Australia	..	528	
(*h*) Survey of Coast Disease	..	306	
At Waite Institute in co-operation with Carnegie Institute and Adelaide University— Mineral deficiencies in pastures	2,057		
Less contribution from Carnegie Institute	1,127		
		930	
			7,996

	£	£	£
(v) Horticultural Problems of the Irrigation Settlements—			
Citricultural—			
(*a*) Research Station, Griffith—			
Salaries and incidentals ..	4,405		
Capital	478		
	4,883		
Less funds provided from Station Revenue ..	95		
	4,788		
Less contributions by New South Wales Water Conservation and Irrigation Commission	1,200		
		3,588	
Viticultural—			
(*b*) Research Station, Merbein—			
Salaries and incidentals ..	5,316		
Capital	783		
	6,099		
Less funds provided from Station Revenue ..	40		
	6,059		
Less contributions by Dried Fruits Control Board and Australian Dried Fruits Association ..	1,715		
		4,344	
(*c*) Ripening, processing, &c., of vine fruits, Mildura district ..	839		
Less contributions by Irymple Packing Pty. Ltd., Mildura Co-op. Fruit Co., Red Cliffs Co-op. Fruit Co. Ltd., and Aurora Packing Pty. Ltd. ..	839		
		..	
			7,932
(vi) Soil Problems—			
(*a*) Investigations at Waite Institute, Irrigation Areas and Tasmania—			
Salaries, &c.	5,752		
Capital	13		
		5,765	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)	..	2,500	
			3,265
(vii) Food Preservation and Transport—			
(*a*) Meat and fish investigations (Brisbane Abattoir)	2,847		
Less contributions by Queensland Meat Industry Board	439		
		2,408	

	£	£	£
(*b*) Banana investigations (Queensland University)	1,673		
Less contribution by Commonwealth Banana Committee	1,673		
		..	
(*c*) Banana investigations (Melbourne)	13		
Less contribution by Committee of Direction of Fruit Marketing	13		
		..	
(*d*) Non-tropical fruits (Melbourne) ..	..	1,090	
(*e*) Citrus preservation	..	2,039	
(*f*) Engineering problems	..	736	
(*g*) Adviser on Food Preservation ..	..	307	
		6,580	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	..	2,000	
			4,580
(viii) Prickly Pear—			
(*a*) Grant for investigations	..	4,500	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	..	4,500	
(ix) Forest Products—			
(*a*) Central Laboratory—			
Annual	7,246		
Capital	1,656		
		8,902	
(*b*) Seasoning	..	1,034	
(*c*) Preservation	..	1,938	
(*d*) Chemistry	..	1,164	
(*e*) Wood Anatomy	..	1,435	
(*f*) Timber Mechanics	..	1,289	
(*g*) Timber Utilization	..	1,257	
(*h*) Timber Physics	..	746	
(*i*) Grading Studies	..	975	
(*j*) Queensland Timber Problems ..	73		
Less contribution by Lands Administration Board, Brisbane, Queensland ..	73		
		..	
(*k*) Plant for new Laboratory ..	2,639		
Less contribution by Russell Grimwade, C.B.E. ..	2,639		
		..	
(*l*) Pole Tests in New South Wales ..	58		
Less contributions by Sydney Municipal Council, Newcastle Municipal Council and Department of Public Works, New South Wales	58		
		..	
(*m*) Pole Tests in Victoria	..	28	
(*n*) Paper Pulp	334		
Less contribution by Australian Paper Manufacturers Ltd.	334		
		..	

	£	£	£
(*o*) Railway Sleepers	60		
Less contribution by South Australian Railways ..	60		
		..	
(*p*) Plywood and Veneer Investigations	62		
Less contribution by Queensland Veneer Board ..	62		
		..	
		18,768	
Less sundry cash donations		52	
		18,716	
Less contribution from Commonwealth Bank (Rural Credits Development Fund)..		1,500	
			17,216
(x) Mining and Metallurgy—			
(*a*) Mineragraphic Investigations		753	
Less contribution by Australasian Institute of Mining and Metallurgy..		360	
			393
(xi) Radio Research—			
(*a*) Melbourne and Sydney Universities	4,606		
Less contributions by Postmaster-General's Department	3,447		
		1,159	
(*b*) Advisers on Radio Research		89	
			1,248
(xii) Library		..	1,007
(xiii) Gold Mining—			
(*a*) Mineragraphic Investigations (Melbourne University)		682	
(*b*) Ore Dressing (Melbourne University) ..		1,429	
(*c*) Ore Dressing (Adelaide School of Mines		832	
(*d*) Ore Dressing (Kalgoorlie School of Mines		1,003	
(*e*) Advisory Committee		61	
			4,007
(xiv) Fisheries Investigations		1,557	
Less contribution by Development Branch, Prime Minister's Department		1,557	
(xv) Apple and Pear Investigations		4,953	
Less contribution by Department of Commerce		4,953	
(xvi) Miscellaneous—			
(*a*) Bee Investigations	70		
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	70		

	£	£	£
(*b*) Thrips Investigations	611		
Less contributions from the Thrips Investigation League	611		
		..	
(*c*) Watery Whites in Eggs Investigations	15		
Less contribution by Egg Producers' Council ..	15		
		..	
(*d*) Tomato Wilt Investigations ..	..	216	
(*e*) Various	..	705	
			921
Total of Item 3—Investigations	..	..	106,256

2. *Contributions.*—The following statement shows the receipts and disbursements during the year 1935–36 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 1934–35.		Expenditure 1935–36.
	£		£
Commonwealth Bank (Animal Health, Horticultural, Food Preservation and Transport, Prickly Pear and Forest Products Investigations)	17,500	..	17,500
Commonwealth Bank (Erection of Drought Feeding Building)	5	..	..
Commonwealth Bank (Bee Investigations)	162	..	70
Postmaster-General's Department (Radio Research) ..	3,447	..	3,447
Australian Pastoral Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,520	..	2,429*
New South Wales Water Convervation and Irrigation Commission (Maintenance of Griffith Research Station)	1,200	..	1,200
New South Wales Water Conservation and Irrigation Commission (Cumbungi Investigations)	200	..	..
Department of Commerce (Fruit Problems, Tasmania)	112	..	112
Queensland Government (Animal Health Investigations—Cattle Research)	4,388	..	2,905†
Council of Agriculture, Brisbane (Animal Health Investigations—Cattle Research)	686	..	686
Australasian Institute of Mining and Metallurgy Mineragraphic Investigations)	360	..	360
Dried Fruits Control Board (Dried Fruits Investigations)	1,899	..	1,699
Australian Dried Fruits Association (Frost Investigations, Merbein)	15	..	15
Australian Dairy Council (Wood Taint in Butter Investigations)	20	..	..
Queensland Meat Industry Board (Food Preservation Investigation)	439	..	439
Sir MacPherson Robertson (Entomological Investigations)	183	..	..
Thrips Investigation League (Thrips Investigations) ..	611	..	611
Messrs. Allen-Liversidge (Aust.) Ltd. (Forest Products Investigations)	12	..	12‡
Commonwealth Banana Committee (Banana Investigations)	1,908	..	1,673
Carried forward	35,667	..	33,158

* Includes £245 on account 1934–35 expenditure. † Includes £775 on account of 1934–35 expenditure. ‡ This contribution was credited to Publications Vote.

	Receipts including balances brought forward from 1934–35.		Expenditure 1935–36.
	£		£
Brought forward ..	35,667	..	33,158
Revenue Fund—Oonoonba Research Station (Animal Health Investigations)	551	..	10
Revenue Fund—Griffith Research Station (Citricultural Investigations)	1,856	..	95
Revenue Fund—Berwick Farm (Mastitis Investigations)	469	..	284
Revenue Fund—Merbein Research Station (Viticultural Investigations)	2,007	..	40
Plywood-Veneer Board, Queensland (Forest Products Investigations)	200	..	62
Lands Administration Board, Queensland (Special Forest Products Investigations)	323	..	73
Russell Grimwade, C.B.E. (Forest Products Investigations)	5,000	..	2,639
Committee of Direction of Fruit Marketing (Apple Root Stocks Investigations)	435	..	435
Tobacco Trust Fund—Prime Minister's Department (Tobacco Investigations)	11,686	..	5,826
New South Wales Department of Agriculture (Meat Investigations)	2,500	..	..
Department of Commerce (Apple and Pear Investigations)	20,000	..	4,953
Mildura Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	331	..	323*
Irymple Packing Co. (Dried Vine Fruits Investigations Merbein)	331	..	323*
Red Cliffs Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	331	..	323*
Aurora Packing Co. (Dried Vine Fruits Investigations, Merbein)	331	..	323*
Australian Dairy Cattle Research Association (Mastitis Investigations)	4,750	..	4,750†
Australian Pastoral Co. (Animal Health Investigations, Noondoo)	78	..	78‡
Carnegie Institute (Mineral Deficiencies in Pastures Investigations)	1,127	..	1,127
Council of Advice, Rabbit Destruction Fund (Work on Rabbits)	300	..	75
Dr. Georgina Sweet—Balance of Grant (Animal Health Investigations)	75	..	..
Jericho Wool Committee, Jericho, Queensland (Sheep Research)	4	..	..
McLaren & Co. Pty. Ltd.	11	..	..
Holden's Motor Body Builders (Forest Products Investigations)	37	..	..
Department of Agriculture, Victoria (Oriental Peach Moth Investigations)	422	..	422
Committee of Direction of Fruit Marketing (Banana Investigations)	13	..	13
Newcastle Municipal Council (Pole Tests in New South Wales	20	..	
Sydney Municipal Council (Pole Tests in New South Wales)	40	..	58
Department of Public Works, New South Wales (Pole Tests in New South Wales)	20		
Australian Paper Manufacturers Ltd. (Paper Pulp Investigations)	511	..	334
Carried forward ..	89,426	..	55,724

* Includes £113 on account 1934–35 expenditure. † Includes £261 on account 1934–35 expenditure. ‡ Expenditure on account 1934–35.

	Receipts including balances brought forward from 1934–35.		Expenditure 1935–36.
	£		£
Brought forward	89,426	..	55,724
South Australian Railways (Treatment of Railway Sleepers)	95	..	60
Egg Producers' Council (Watery Whites in Eggs) ..	17	..	15
Development Branch, Prime Minister's Department (Fisheries Research)	1,557	..	1,557
Revenue Fund—Ore Dressings	57	..	..
Revenue Fund—Mining and Metallurgy	3	..	..
Senator C. Hardy (Forest Products Investigations) ..	11	..	11
C. H. Tutton Ltd. (Forest Products Investigations)	21	..	21
Sundry Contributors (Forest Products Investigations)	28	..	22
	91,215	..	57,410

3. *Staff.*—The following is a list of the staff of the Council as at the 30th June, 1936. The list does not include typistes, laboratory assistants and labourers, &c.

1. Head Office Staff.

Chief Executive Officer—Sir David Rivett, K.C.M.G., M.A., D.Sc., F.A.C.I.
Secretary—G. Lightfoot, M.A.
Assistant Secretary and Editor of Scientific Publications—G. A. Cook, M.Sc., B.M.E., A.A.C.I.
Chief Clerk and Accountant—H. P. Breen, L.I.C.A.
Biologist—F. N. Ratcliffe, B.A.

Library—

Librarian and Scientific Assistant—Miss E. Archer, M.Sc. (On leave abroad)
Assistant Librarian—Miss A. L. Kent.
Assistant Librarian—Miss F. V. Murray, M.Sc.

Accounts, Staff, Stores—

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

Orders and Transport—

J. M. Derum.
J. J. Foley.

Records—

P. Domec Carré.
W. Gillespie.
P. Knuckey.
F. Butler.
R. McVilly.
A. Patterson.

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—K. Prowse.
Junior Assistant—S. Young.
Clerk, Division of Animal Health and Nutrition Headquarters, Melbourne—H. T. Chadwick.

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, Animal Nutrition Laboratory, University of Adelaide.

Western Australia—

Associate-Professor G. Tattersall, University of Western Australia, Crawley, Western Australia.

Tasmania—

F. J. Carter, c/o. Premier's Office, Hobart, Tasmania.

3. Australia House, London.

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

4. Division of Plant Industry.

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, B.S.A., M.S.A., Ph.D.
Assistant Plant Introduction Officer—J. F. Miles, B.Agr.Sc.
Assistant Botanist—C. Barnard, D.Sc.
Assistant Plant Pathologist—J. G. Bald, M.Agr.Sc., Ph.d.
Assistant Plant Pathologist—W. L. Geach, B.Sc.
Assistant Plant Pathologist—W. V. Ludbrook, B.Agr.Sc., Ph.D.
Assistant Plant Pathologist—F. W. Hely, B.Sc.Agr.
Assistant Plant Introduction Officer—W. Hartley, B.A., Dip.Agr.
Assistant Plant Geneticist—H. F. Smith, B.Sc.(Agr.), M.S.A. (On leave abroad).
Junior Research Officer (Genetics)—S. G. Gray, B.Sc.Agr.
Assistant Research Officer (Genetics)—K. Loftus Hills, B.Agr.Sc.
Assistant Botanist (Agrostological Investigations)—Vacant.
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.
Chemist—E. H. Kipps, B.Sc.
Librarian (part time)—Miss F. Stops, B.A.
Assistant Research Officer (Weeds)—A. B. Cashmore, B.Sc.Agr.
Assistant Research Officer (Weeds)—R. Roe, B.Sc.Agr.
Assistant Plant Pathologist—J. M. Allan, B.Agr.Sc.
Research Officer (Tobacco)—G. E. Marks.
Assistant Research Officer (Tobacco)—A. V. Hill, B.Sc.Agr.
Assistant Research Officer (Tobacco)—G. H. Marks.
Technical Officer (Tobacco)—E. T. Bailey, B.Sc.

At University of Sydney—

Adviser on Chemical Problems of Tobacco Investigation—Professor J. C. Earl, D.Sc., Ph.D., F.I.C.
Chemist (Tobacco)—A. J. Tow, B.Sc.

At Queensland Agricultural College and High School, Gatton, Queensland—

Assistant Plant Geneticist (Pasture Plant Breeding)—C. S. Christian, B.Sc.Agr., M.Sc.
Assistant Botanist (Agrostological Investigations)—T. B. Paltridge, B.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. (Seconded to Department of Commerce for fruit inspection work, London).
Assistant Plant Physiologist—D. Martin, B.Sc.
Junior Plant Pathologist (Apple diseases)—N. H. White.

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.
Chemist—J. S. Hosking, M.Sc.
Chemist—A. Walkley, B.Sc., B.A., Ph.D.
Technical Officer—P. D. Hooper.
Soil Microbiologist—T. H. Strong, B.Agr.Sc.
Junior Field Officer—J. G. Baldwin, B.Agr.Sc.
Junior Field Officer—G. D. Hubble, B.Agr.Sc.

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).

At University of Tasmania—

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

6. Irrigation Settlement Problems.

At Commonwealth Research Station, Griffith—

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

At 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.
Assistant Research Officer—D. V. Walters, B.Agr.Sc.
Junior Research Officer—A. L. Tisdall, B.Agr.Sc.
Technical Officer—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 and Nutrition.

At Commonwealth Offices, Melbourne—

Chief—L. B. Bull, D.V.Sc.
Consultant—J. A. Gilruth, D.V.Sc., M.R.C.V.S.

At Melbourne University Veterinary Research Institute—

Chief Bacteriologist and Officer-in-Charge—A. W. Turner, D.Sc., D.V.Sc.
Senior Veterinary Officer (Mastitis Investigations)—D. Murnane, B.V.Sc.
Senior Veterinary Officer (Bovine haematuria, Caseous lymphadenitis)—C. G. Dickinson, B.V.Sc.
Senior Veterinary Officer (Pleuro-pneumonia)—A. D. Campbell, B.V.Sc.
Assistant Bacteriologist (Mastitis)—E. Munch-Petersen, M.Sc., Ph.B., M.I.F., F.L.S.
Technical Officer—Miss C. E. Eales, B.Sc.
Technical Officer—Miss S. E. R. Clarke, B.Agr.Sc.
Biological Assistant—Miss J. Maclean, B.Sc.

At Townsville (North Queensland) Cattle Research Station—

Veterinary Officer—J. Legg, B.Sc., D.V.Sc., M.R.C.V.S. (Seconded from the Queensland Department of Agriculture and Stock)
Assistant Bacteriologist—A. T. Dick, B.Sc.

At F. D. McMaster Animal Health Laboratory, University of Sydney—
Chief Parasitologist and Officer-in-Charge—I, Clunies Ross, D.V.Sc.
Senior Research Officer (Geneticist)—R. B. Kelley, B.V.Sc.
Assistant Parasitologist—G. Kauzal, D.V.Sc.
Assistant Parasitologist—H. McL. Gordon, B.V.Sc.
Assistant Veterinary Officer (Foot rot, Caseous lymphadenitis, Parasitological Investigations in field)—W. I. B. Beveridge, B.V.Sc.
Assistant Bacteriologist—J. A. Dumaresq, B.V.Sc.
Assistant Research Officer (Chemistry of Wool)—M. R. Freney, B.Sc.
Assistant Research Officer (Physiologist)—R. H. Watson, B.Sc.Agr.
Field Officer—N. P. Graham, B.V.Sc. (Seconded to Australian Pastoral Research Trust)
Technical Officer—E. Parrish.
Assistant Technician—H. Munz.
Secretary and Statistician—Miss H. A. Newton-Turner, B.Arch.

At Animal Nutrition Laboratory, University of Adelaide—
Chief Nutrition Officer and Officer-in-Charge—H. R. Marston.
Chief Assistant—J, Ward Walters.
Senior Research Officer (Metabolism)—E. W. Lines, B.Sc.
Assistant Research Officer (Chemist)—R. G. Thomas, B.Sc.
Assistant Research Officer (Biochemist)—J. W. H. Lugg, D.Sc., A.I.C., A.A.C.I.
Assistant Research Officer (Biochemist)—I. W. McDonald, B.V.Sc.
Assistant Research Officer (Biochemist)—H. C. Moore, B.Sc.
Assistant Research Officer (Agrostologist)—D. S. Riceman, B.Agr.Sc.
Junior Research Officer—H. J. Lee, B.Sc.
Technical Officer—J. D. O. Wilson.
Technical Officer—F. C. Farr.
Statistical Recorder—G. W. Bussell.

At Waite Agricultural Research Institute—
Assistant Research Officer (Mineral requirements and field work)—A. W. Pierce, B.Sc.

8. Mineral Deficiency of Pastures Investigation.

At Waite Agricultural Research Institute—
Analytical Chemist—R. E. Shapter, A.A.C.I.
Agronomist—C. M. Donald, B.Agr.Sc.

9. Division of Economic Entomology.

At Canberra—
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.Agr.Sc., D.Sc.
Entomologist (Termite Investigations)—F. G. Holdaway, M.Sc., Ph.D.
Assistant Entomologist—Miss M. Fuller, B.Sc.
Assistant Entomologist (Grasshopper Investigations) K. H. L. Key, M.Sc., Ph.D.
Investigator Sheep Blowfly Problem (Sheep husbandry and Fleece classing)—J. H. Riches, B.Sc.Agr., Ph.D. (Seconded from Division of Animal Health and Nutrition)
Assistant Entomologist (Blowfly Investigations)—Mrs. M. J. Mackerras, M.Sc., M.B. (on leave abroad).
Assistant Entomologist (Orchard Pests)—G. A. H. Helson, M.Sc.
Junior Research Officer—F. J. Gay, B.Sc.
Assistant Entomologist—T. G. Campbell.
Technical Officer—T. Greaves.
Librarian (part-time)—Miss F. Stops, B.A.
Junior Research Officer—R. V. Fyfe, B.Sc.Agr.

At Farnham House Laboratory, England—
Entomologist—S. Garthside, B.Sc.Agr., M.Sc.

At Hyeres, France—
Junior Research Officer—F. Wilson.

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

10. Division of Forest Products.

At Head Office, Melbourne (temporarily)—

Administration—

Chief—I. H. Boas, M.Sc., A.A.C.I.
Deputy Chief—S. A. Clarke, B.E., A.M.I.E.(Aust.).
Librarian and Records Clerk—Miss M. I. Hulme.

Chemistry Section—

Officer-in-Charge—W. E. Cohen, D.Sc., A.A.C.I. (on leave abroad).
Chemist (Acting Officer-in-Charge)—A. W. Mackney, M.Sc.
Chemist (Paper Pulp Investigations)—Miss T. M. Reynolds, M.Sc., Ph.D.
Technical Officer—A. G. Charles.

Seasoning Section—

Office-in-Charge—C. S. Elliot, B.Sc. (On leave abroad).
Assistant Research Officer—G. W. Wright, B.E.
Technical Officer—J. T. Currie.

Preservation Section—

Officer-in-Charge—J. E. Cummins, B.Sc., M.S., A.A.C.I.
Assistant Research Officer—S. F. Rust, M.Sc.
Assistant Research Officer—H. B. Wilson, B.Sc., A.A.C.I.

Wood Structure Section—

Officer-in-Charge—H. E. Dadswell, M.Sc., A.A.C.I.
Assistant Research Officer—Miss A. M. Eckersley, M.Sc.
Technical Assistant (part-time)—Miss J. Ellis.
Technical Assistant (part-time)—Miss J. Galbraith.

Timber Mechanics Section—

Officer-in-Charge—I. Langlands, B.E.E.
Assistant Research Officer—R. S. T. Kingston, B.Sc., B.E.
Technical Officer—A. L. Gunn.

Timber Physics Section—

Officer-in-Charge—W. L. Greenhill, M.E., Dip.Sc.

Timber Utilization Section—

Officer-in-Charge—R. F. Turnbull, B.E.
Assistant Research Officer—F. E. Hutchinson, B.Sc.For., M.N.Z.I.F.
Assistant Research Officer—A. J. Thomas, Dip.For.
Assistant Research Officer—W. R. Ferguson, B.E.

Computation Section—

Technical Officer—B. Whitington.

Maintenance Section—

Technical Officer—S. G. McNeil.

11. 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.
Investigator—A. R. Riddle, B.A., M.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 Department of Agriculture, Brisbane—

Mycologist (Banana Investigations)—R. S. Mitchell, B.Sc.Agr., Dip.Agr.

At Department of Agriculture, Sydney—

Assistant Research Officer (Citrus Preservation)—L. J. Lynch, B.Agr.Sc.

At Australia House, London—

Assistant Research Officer—N. E. Holmes, B.E.E.

12. Radio Research.

At University of Melbourne—
Research Physicist—H. C. Webster, M.Sc., Ph.D.
Assistant Research Physicist—A. F. B. Nickson, B.Sc.
Assistant Research Physicist—F. G. Nichols, B.Sc.

At University of Sydney—
Research Physicist—A. L. Green, M.Sc., Ph.D., A.M.I.R.E.
Research Physicist—D. F. Martyn, A.R.C.Sc., D.Sc., Ph.D. (On leave abroad).
Research Physicist—G. H. Munro, M.Sc.
Research Physicist—J. H. Piddington, B.Sc., B.E.
Assistant Research Physicist—W. G. Gordon, B.Sc.

13. Ore Dressing Investigations.

At University of Melbourne—
Assistant Research Officer—J. G. Hart.

At School of Mines, Adelaide, South Australia—
Assistant Research Officer—L. M. Abell.

At School of Mines, Kalgoorlie, Western Australia—
Assistant Research Officer—G. H. Payne, B.Sc.

14. Other Investigations.

Mineragraphic Investigations—
Investigator—F. L. Stillwell, D.Sc.
Assistant Research Officer—A. Edwards, Ph.D.

Fisheries Investigations—
Adviser (part-time)—Professor W. J. Dakin, D.Sc., F.L.S., F.Z.S.
Fisheries Officer—S. Fowler.
Clerk (Records, &c.)—R. D. Elder.

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

(i) *Bulletins.*

No. 91—Further Investigations into the Transport of Bananas in Australia ; by E. W. Hicks, B.A., B.Sc., and N.E. Holmes, B.B.E.

No. 92—The Apple Growing Soils of Tasmania—
Part 1.—A General Investigation of the Soils ; by C. G. Stephens, M.Sc.
Part 2.—A Soil Survey of Part of the Huonville District ; by J. K. Taylor, B.A., M.Sc. and C. G. Stephens, M.Sc.

No. 93—Studies on Contagious Pleuro-pneumonia of Cattle.
1. A Study of the Morphology and Life Cycles of the Organism of Pleuro-pneumonia Contagiosa Boum (*Borrelomyces Peripneumoniae*) Nov. Gen.) by Observation in the Living State under Dark-ground Illumination ; by A. W. Turner, D.Sc., D.V.Sc.

No. 94.—Fertility in Sheep. Artificial Production of Seminal Ejaculation and the Characters of the Spermatozoa Contained Therein ; by R. M. C. Gunn, D.V.Sc., B.Sc., B.Sc.(Agr.), M.R.C.V.S.

No. 95.—Radio Research Board ; Report No. 9—
(1) A Study of Magneto-Ionic Theory of Wave Propagation by Means of Conformal Representation ; by V. A. Bailey, M.A., D.Phil., F.Inst.P.
(2) Dispersion and Absorption Curves for Radio Wave Propagation in the Ionosphere according to the Magneto-Ionic Theory ; by D. F. Martyn, Ph.D., A.R.C.Sc., F.Inst.P.
(3) A Temperature Compensated Dynatron Oscillator of High Frequency Stability ; by J. H. Piddington, B.Sc., B.E.
(4) The Amplification of Programme Transients in Radio Receivers ; by Geoffrey Builder, Ph.D., F.Inst.P.
(5) A Multi-Range, Push-Pull, Thermionic Voltmeter ; by Geoffrey Builder, Ph.D., F.Inst.P.
(6) The Graphical Solution of Simple Parallel-tuned Circuits ; by Geoffrey Builder, Ph.D., F.Inst.P.
(7) An Electrical Harmonic Analyser of the Fundamental Suppression Type ; by J. H. Piddington, B.Sc., B.E.

No. 96.—Observations on *Myxomatosis Cuniculi* (Sanarelli) Made with a View to the Use of the Virus in the Control of Rabbit Plagues; by Sir Charles J. Martin, C.M.G., D.Sc., F.R.S., &c.

No. 97.—Studies on Contagious Pleuro-pneumonia of Cattle:

II. A Complement-fixation Reaction for the Diagnosis of Contagious Bovine Pleuro-pneumonia; by A. D. Campbell, B.V.Sc. and A. W. Turner, D.Sc., D.V.Sc.

II. (*a*) Observations on the Diagnosis of Bovine Contagious Pleuro-pneumonia by means of the Complement-fixation Test of Campbell and Turner; by H. R. Seddon, D.V.Sc.

II. (*b*) The Complement-fixation Test for Pleuro-pneumonia; by H. E. Albiston, D.V.Sc.

III. A Cultural Study of the Distribution of the Specific Organism, *Borrelomyces peripneumoniae*, throughout the Body in Animals Naturally and Artificially Infected; by A. D. Campbell, B.V.Sc.

No. 98.—Cercospora Leaf-spot (Frogeye) of Tobacco in Queensland; by A. V. Hill, B.Agr.Sc.

No. 99.—A Survey of the Pastures of Australia; Embodying Ecological Information and Discussions Explanatory of the Accompanying Pasture Map of the Commonwealth; by A. McTaggart, Ph.D.

No. 100.—Radio Research Board: Report No. 10.

(1) A Directional Recorder for Atmospherics; by W. J. Wark, M.Sc., R. W. Boswell, M.Sc., and H. C. Webster, Ph.D., F.Inst.P.

(2) Observations of Atmospherics with a Narrow Sector Directional Recorder at Canberra; by G. H. Munro, M.Sc., A.M.I.E.E., W. J. Wark, M.Sc., and A. J. Higgs, B.Sc.

(3) Characteristics and Distribution of Sources of Atmospherics; by G. H. Munro, M.Sc., A.M.I.E.E., W. J. Wark, M.Sc., and A. J. Higgs, B.Sc.

(4) Sources of Atmospherics Over the Tasman Sea; by R. W. Boswell, M.Sc.

No. 101.—Radio Research Board: Report No. 11.
The Temperatures and Constituents of the Upper Atmosphere; by D. F. Martyn, Ph.D., A.R.C.Sc. and O. O. Pulley, Ph.D., B.E.

(ii) *Pamphlets.*

No. 56.—The Occurrence of Bovine Babesiellosis in Northern Australia; by J. Legg, B.Sc., D.V.Sc., M.R.C.V.S.

No. 57.—Tests of the Efficacy of the Oxy-Acetylene Scouring and Charring Process for Sterilizing Partly Decayed Poles. (Division of Forest Products—Technical Paper No. 18); by J. E. Cummins, M.Sc.

No. 58.—Certain Aspects of Investigations on Black-end Disease of Bananas in Australia; by Shirley Hoette, M.Sc.

No. 59.—A Study of Persistence in certain Introduced Pasture Grasses; by A. McTaggart, M.S.A., Ph.D.

No. 60.—A Report on a Survey of Weed Problems in Australia; by G. A. Currie, B.Sc., B.Agr.Sc.

No. 61.—A Discussion of Special Tests on the Compressive Strength of Green Karri (*Eucalyptus diversicolor*): (Division of Forest Products—Technical Paper No. 19); by Ian Langlands, B.E.E.

No. 62.—The Chemistry of Australian Timbers.
Part 5.— A Study of the Lignin Determination. III. (Division of Forest Products—Technical Paper No. 20); by W. E. Cohen, D.Sc.

No. 63.—Studies of Five Introduced Grasses; by A McTaggart, Ph.D., W. Hartley, B.A., T. B. Paltridge, B.Sc., and H. K. C. Mair, B.Sc.

No. 64.—Soil Drift in the Arid Pastoral Areas of South Australia; by F. N. Ratcliffe, B.A.

(iii) *Trade Circulars.*

No. 29.—Gluing Practice, Part 3—Vegetable, Vegetable-Protein, Liquid and Blood-Albumen glues.

No. 30.—Chemical Utilization of Wood.

No. 31.—Gluing Practice, Part 4—Artificial Resin Glues (in press)

(iv) *Quarterly Journal.*

Vol. 8, No. 3, August, 1935.
Vol. 8, No. 4, November, 1935.
Vol. 9, No. 1, February, 1936.
Vol. 9, No. 2, May, 1936.

(v) *Annual Report for the year ending 30th June*, 1935.

XIII. ACKNOWLEDGMENTS.

The development and expansion of the Council's activities have depended very materially on the assistance and co-operation of numerous organizations and individuals, to which reference has been made in several sections of this report. This assistance has been rendered in many ways, including the provision of laboratory accommodation and other facilities, contributions in money or in kind, and by active co-operation in investigations and experiments. The Council desires to express its thanks for the invaluable help it has so received, and in particular desires to record its gratitude to the various State Departments, particularly those of Agriculture, to the Universities, to such bodies as the Commonwealth Bank (Rural Credits Development Fund), the Australian Pastoral Research Trust, the Australian Dairy Cattle Research Association, the Thrips Investigation League, the Dried Fruits Control Board, the Queensland Meat Industry Board, the Australian Dried Fruits Association, and to the many other bodies, companies, and individuals to which it is indebted for assistance. The Council also wishes to acknowledge the assistance it has received from its State Committees and other Committees, whose members have placed their knowledge and experience so freely at its service.

(Signed) G. A. JULIUS, Chairman.
A. E. V. RICHARDSON. } Executive Committee.

G. LIGHTFOOT, Secretary,
25th September, 1936.

APPENDIX.

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

COUNCIL (AS AT 30th JUNE, 1936).

Executive.

Sir George A. Julius, Kt. B.Sc., B.E. (*Chairman*).
Sir David Rivett, K.C.M.G., M.A., D.Sc. (*Deputy Chairman and Chief Executive Officer*).
Professor A. E. V. Richardson, M.A., D.Sc.

Chairman of State Committees.

Professor R. D. Watt, M.A., B.Sc. (New South Wales).
Russell Grimwade, C.B.E., B.Sc. (Victoria).
Professor H. C. Richards, D.Sc. (Queensland).
T. E. Field (South Australia).
E. H. B. Lefroy (Western Australia).
P. E. Keam (Tasmania).

Co-opted Members.

Sir David Orme Masson, K.B.E., M.A., D.Sc., L.L.D., F.R.S.
Professor E. J. Goddard, B.A., D.Sc.
Professor H. A. Woodruff, M.R.C.V.S., &c.
G. S. Colman.

STATE COMMITTEES (AS AT 30th JUNE, 1936).

New South Wales.

Professor R. D. Watt, M.A., B.Sc. (*Chairman*).
E. C. Andrews, B.A., F.G.S.
Professor Sir Henry E. Barraclough, K.B.E., V.D., B.E., M.M.E., M.Inst.C.E., M.I.Mech.E.
Professor W. J. Dakin, D.Sc.
C. H. Hoskins.
The Hon. Sir Norman 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.
Sir Frederick McMaster, Kt.
R. J. Noble, B.Sc. (Agr.), M.Sc., Ph.D.
E. D. Ogilvie, B.A.
Professor T. G. B. Osborn, D.Sc.
Professor J. D. Stewart, M.R.C.V.S., B.V.Sc.
G. D. Ross.
Professor J. C. Earl, D.Sc., Ph.D., F.I.C.
F. J. Walker.

Victoria.

Russell Grimwade, C.B.E., 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, L.L.B.
Professor W. N. Kernot, B.C.E., M.Mech. E., M.Inst.C.E.
Emeritus-Professor Sir Thomas R. Lyle, M.A., D.Sc., F.R.S.
Emeritius-Professor Sir David Orme Masson, K.B.E., M.A., D.Sc., LL.D., F.R.S.
H. A. Mullett, B.Agr.Sc.
F. J. Rae, B. A., 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.
Professor H. A. Woodruff, M.R.C.V.S.
Associate-Professor W. J. Young, D.Sc.
G. S. Colman.

South Australia.

T. E. Field (*Chairman*).
E. H. Bakewell.
Professor Kerr Grant, M.Sc., F.Inst.P.
W. A. Hargreaves, M.A., B.C.E., D.Sc., F.I.C.
J.H.Gosse.
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.
T. M. Hardy.

Queensland.

Professor H. C. Richards, D.Sc., (*Chairman*).
Professor H. Alcock, M.A.
Professor L. S. Bagster, D.Sc
J. D. Bell.
E. Graham.
J. B. Henderson, O.B.E., F.I.C.
T. L. Jones.
Professor E. J. Goddard, B.A., D.Sc.

QUEENSLAND—*continued.*

A. J. B. McMaster.
Professor J. K. Murray, B.A., B. Sc.Agr.
Professor T. Parnell, M.A.
W. L. Payne.
R. Veitch, B.Sc.Agr., B.Sc.For., F.E.S.

WESTERN AUSTRALIA.

E. H. B. Lefroy (*Chairman*).
F. G. Brinsden, M.I.M.M., M.Aust.I.MI.
Professor E. de Courcy Clarke, M.A.
J. D. Hammond.
S. L. Kessell, M.Sc., Dip.For.
A. L. B. Lefroy.
Professor G. E Nicholls, D.Sc., A.R.C.Sc., F.L.S.
Professor J. E. Nichols, M.Sc., Ph. D.
Professor A. D. Ross, M.A., D.Sc., F.R.S.E., F.Inst.P.
E. S. Simpson, D.Sc., B.E.
G. L. Sutton.
Professor H. E. Whitfeld, C.B.E., B.A., B.E., M.I.M.M., M.I.E.Aust.
Professor N. T. M. Wilsmore, D.Sc., F.I.C., M.I.Chem., E.
P. H. Harper, B.A.

TASMANIA.

P. E. Keam (*Chairman*).
N. P. Booth, F.I.C.
Professor A. Burn, M.Sc., B.E.
F. H. Foster, B.M.E., A.M.I.E.Aust.
Professor A. L. McAulay, M.A., B.Sc., Ph.D., F.Inst.P.
D. O. Meredith, A.Inst.M.M., M.I.E.Aust., M.A.C.S.
A. K. McGaw.
W. E. MacLean, M.I.E.Aust.
F. H. Peacock.
R. O. Shoobridge.
S. W. Steane.
F. E. Ward.

COMMONWEALTH RESEARCH STATIONS, MERBEIN AND GRIFFITH—COMMITTEE OF CONTROL.

B. T. Dickson, B.A., Ph.D. Chief Division of Plant Industry, C.S.I.R. (*Chairman*).
Professor J. A. Prescott, D.Sc., Waite Agricultural Research Institute, University of Adelaide.
A. L. Johnstone, Commonwealth Dried Fruits Control Board.
P. Malloch, Commonwealth Dried Fruits Control Board.

COMMONWEALTH RESEARCH STATION, MERBEIN—ADVISORY COMMITTEE.

D. C. Winterbottom, Mildura Packers' Association (*Chairman*).
A. R. McConchie, State Rivers and Water Supply Commission, Red Cliffs, Victoria.
A. Lever, Mildura Shire Council
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, Griffith, New South Wales.
J. A. Lockhead, Mildura Shire Council.
A. E. Cameron, Red Cliffs Settlement.
J. Gordon, Citrus Growers' Association, Merbein.
W. Heaysman, Cardross Horticultural Society.

COMMONWEALTH RESEARCH STATION, GRIFFITH—ADVISORY COMMITTEE.

F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, Griffith, New South Wales (*Chairman*).
A. G. Kubank, Murrumbidgee Irrigation Rice Growers' Co-operative Society.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
T. T. Morley, Griffith Producers' Co-operative Co. Ltd.
L. J. Rydon, Yenda Producers' Co-operative Society Ltd.
E. S. West, B.Sc., M.S., Commonwealth Research Station, Griffith.
V. C. Williams, Murrumbidgee Irrigation Areas Research Bureau, Griffith.

CITRUS PRESERVATION TECHNICAL ADVISORY COMMITTEE.

J. R. Vickery, M.Sc., Ph.D., Section of Food Preservation and Transport, C.S.I.R. (*Chairman*).
Associate-Professor W. J. Young, D.Sc., University of Melbourne.
E. S. West, B.Sc., M.S., Commonwealth Research Station, Griffith, New South Wales.
C. G. Savage, Director of Fruit Culture, Department of Agriculture, New South Wales.
R. J. Benton, Fruit Instructor, Department of Agriculture, New South Wales.
F. M. Read, M.Agr.Sc., Chief Inspector of Horticulture, Department of Agriculture, Victoria.
J. Hepburn, Manager, Government Cool Stores, Melbourne.
A. G. Strickland, M.Agr.Sc., Chief Horticultural Officer, Department of Agriculture, South Australia.

RADIO RESEARCH BOARD.

Professor J. P. Madsen, B.E., D.Sc., Department of Engineering, University of Sydney (*Chairman*).
H. P. Brown, M.B.E., M.I.E.E., Postmaster-General's Department.
Electrical-Commander F. G. Cresswell, Department of Defence.
Professor T. H. Laby, M.A., Sc.D., F.R.S., F.Inst.P., Department of Natural Philosophy, University of Melbourne.

MINERAGRAPHIC COMMITTEE.

Professor E. W. Skeats, D.Sc., A.R.C.Sc., F.G.S., Geology School, University of Melbourne.
W. E. Wainwright, A.S.A.S.M., M.Aust.I.M M., M.Am.I M.M., Australian Institute of Mining and Metallurgy.

FRUIT PROCESSING COMMITTEE.

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Chairman*).
W. R. Jewell, M.Sc., Research Chemist, Department of Agriculture, Victoria.
A. G. Strickland, Chief Horticultural Officer, Department of Agriculture, South Australia.
C. G. Savage, Director of Fruit Culture, Department of Agriculture, New South Wales.
D. Quinn, Department of Agriculture, Victoria.
E. S. West, B.Sc., M.S., Commonwealth Research Station, Griffith.

SUPERVISORY COMMITTEE ON WEEDS INVESTIGATIONS.

B. T. Dickson, B.A., Ph.D., Chief, Division of Plant Industry, C.S.I.R.
A. J. Nicholson, D.S.c., Chief, Division of Economic Entomology, C.S.I.R.
G. A. Currie, B.Agr.Sc., D.Sc., Officer-in-Charge, Weeds Section, C.S.I.R.

B.—Committees Controlling Work in which the Council is Co-operating.

SCIENTIFIC PUBLICATIONS COMMITTEE.

H. J. Sheehan, Secretary, Commonwealth Treasury (*Chairman*).
Sir David Rivett, K.C.M.G., M.A., D.Sc., Council for Scientific and Industrial Research.
W. G. Woolnough, D.Sc., Geological Adviser to the Commonwealth.

CATTLE RESEARCH ADVISORY COMMITTEE.

(For Townsville Station).

E. E. D. White, Queensland United Graziers' Association (*Chairman*).
J. L. Wilson, Queensland United Graziers' Association.
F. M. Bell, Queensland United Graziers' Association.
R. C. Philp, Queensland United Graziers' Association.
N. Bourke, Queensland United Graziers' Association.
E. W. Archer, Queensland United Graziers' Association.
P. A. Brown, Queensland United Graziers' Association.
Professor H. C. Richards, D.Sc., University of Queensland.
E. Graham, Department of Agriculture and Stock, Queensland.
A. H. Cory, M.R.C.V.S., Department of Agriculture and Stock, Queensland.

C.S.I.R. FOOD PRESERVATION COMMITTEE—QUEENSLAND BRANCH.

E. F. Sunners, Queensland Meat Industry Board (*Chairman*).
Associate-Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne.
J. R. Vickery, M.Sc., Ph.D., Food Preservation and Transport Section, C.S.I.R.
Professor L.S. Bagster, D.Sc., University of Queensland.

C.S.I.R. FOOD PRESERVATION COMMITTEE—QUEENSLAND BRANCH.

Fruit Preservation Research Sub-Committee.

Professor L. S. Bagster, D.Sc., Department of Chemistry, University of Queensland (*Chairman*).
Associate-Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne.
H. Barnes, Acting Director of Fruit Culture, Department of Agriculture and Stock, Queensland.
T. E. Maloney, Commissioner's Inspector, Queensland Railways, Brisbane.
J. R. Vickery, M.Sc., Ph.D., Food Preservation and Transport Section, C.S.I.R.
C. G. Savage, R.D.A., Director of Fruit Culture, Department of Agriculture, New South Wales.
H. A. Stevenson, Banana Growers' Federation, New South Wales.

ADVISORY COMMITTEE ON FRUIT COOL STORAGE INVESTIGATIONS.

Associate-Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne (*Chairman*).
S. Fish, M.Agr.Sc., Department of Agriculture, Victoria.
F. M. Read, M.Agr.Sc., Horticultural Division, Department of Agriculture, Victoria.
J. R. Vickery, M.Sc., Ph.D., Food Preservation and Transport Section, C.S.I.R.

COAST DISEASE COMMITTEE.

J. A. Gilruth, D.V.Sc., M.R.C.V.S., Division of Animal Health and Nutrition, C.S.I.R. (*Chairman*).
L. B. Bull, D.V.Sc., Chief, Division of Animal Health and Nutrition, C.S.I.R..
Professor J. A. Prescott, D.Sc., Chief, Division of Soils, C.S.I.R.
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