1934-35.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

NINTH ANNUAL REPORT

OF

THE COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

FOR THE

Year ended 30th June, 1935.

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COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

NINTH ANNUAL REPORT FOR YEAR ENDED 30TH JUNE, 1935.

I. INTRODUCTION.

1. *The Council.*—The Council for Scientific and Industrial Research consists of the following members, viz. :—

(*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 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 1934–35, however, only one Session of the Council was held, viz., the 17th session, which took place at Melbourne in January, 1935. The session extended over three days and was opened by the Minister (Senator the Hon. A. J. McLachlan), who congratulated the Chief Executive Officer of the Council, Sir David Rivett, K.C.M.G., M.A., D.Sc., and the Chairman of the Victorian State Committee, Mr. W. Russell Grimwade, C.B.E., B.Sc., on the honours which had been conferred on them by His Majesty the King. The Minister also welcomed Mr. G. S. Colman, General Manager, Australian Estates and Mortgage Co. Ltd., Melbourne, who had recently been appointed as a member of the Council.

Senator McLachlan announced that the Commonwealth Government had decided to make a sum of £25,000 available for the erection and equipment of a Forest Products Laboratory, and a sum of £6,000 for a new laboratory at the Council's Viticultural Research Station at Merbein, and he expressed the appreciation of the Commonwealth Government and of the Council of the action of the Victorian Government in granting a lease, at a nominal rental, of a valuable site at South Melbourne for the Forest Products Laboratory building. He also referred to the very harmonious co-operative relations which existed between the Council and the State Departments of Agriculture and other State Departments and institutions, and he expressed the view that the Australian Council of Agriculture, which had recently been established by the Commonwealth Government, with the approval of the State Governments, would be of great help to the Council for Scientific and Industrial Research.

Dr. J. A. Gilruth, Chief of the Council's Division of Animal Health, Professor J. A. Prescott, Chief of the Division of Soils, Dr. A. J. Nicholson, Acting Chief, Division of Economic Entomology, and Mr. H. R. Marston, Acting Chief, Division of Animal Nutrition, attended during the course of the Council meeting. Dr. Gilruth discussed various matters relating to the work of his Division and gave an account of the results of the inquiries which he had been making into the question of the control of the rabbit pest. Professor Prescott gave an account of his recent visit to Europe. Dr. Nicholson outlined the more fundamental aspects of the blowfly and grasshopper problems. Mr. Marston discussed particularly the position of the work concerning phosphorus deficiency from the point of view of the Australian sheep industry, basing his remarks on a paper which he had recently contributed to a meeting of the Australian and New Zealand Association for the Advancement of Science. The general position regarding the major investigations of the Council was reviewed.

2. *The Executive Committee and the State Committees.*—The Science and Industry Research Act 1920–26 provides that the Executive Committee, which consists of the three members of the Council nominated by the Minister and appointed by the Governor-General, shall exercise

between meetings of the Council all the powers and functions of the Council. The sessions of the Executive Committee are ordinarily held each month, each session extending over three or four days. During the year 1934–35 the Executive Committee held 34 meetings, the last meeting in that year being the 310th since the creation of the Council in April, 1926.

A State Committee of the Council has been appointed in each State. The Council's Act provides that a State Committee shall consist of a Chairman and not more than fifteen members, exclusive of *ex officio* members. The Chairman is appointed by the Governor-General on the nomination of the Minister, and the State Government and the Australian National Research Council each has the right of nominating three members. In addition, the Chairman and nominated members have the right to nominate three members associated with industry and each State Committee is empowered to co-opt further members not exceeding six by reason of their special qualifications.

The main function of a State Committee is to furnish advice regarding the general work of the Council and regarding any particular matter of investigation of special interest to its State. The State Committees, moreover, perform a most useful and important function in establishing and maintaining close co-operative relations between the Council, on the one hand, and the State scientific and technical departments, State Universities and other scientific institutions, on the other. In a country like Australia where distances between the State capitals are so great, these local committees form an essential feature of a national organization such as the Council.

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

3. *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. Up to the present six of these Divisions have been formed, viz. :—

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

In addition the Council has established a Section of Food Preservation and Transport, of which the Officer-in-Charge is Dr. J. R. Vickery, M.Sc., Ph.D. and a Section of Weeds Investigations of which Mr. G. A. Currie, B.Sc., B.Agr.Sc., is in charge.

The Council's investigations into viticultural problems are under the charge of Mr. A. V. Lyon, M.Sc., and its citricultural investigations are under Mr. E. S. West, B.Sc., M.S.

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 the 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 Forest Products laboratory and 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 at a laboratory provided by the Queensland Meat Industry Board at Brisbane. There is a Research Station at Merbein, Victoria, for the investigation of problems of the dried fruit industry, while 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, the Universities, &c., while field experiments are carried out at various places in the Commonwealth.

4. *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 carried out by the Council's Standing Committee on Agriculture, which comprised amongst its members the permanent head of each State Department of Agriculture, and in the last Annual Report it was stated that the results of that Committee's work had been so satisfactory that steps were being taken to increase its status and to extend its sphere of usefulness.

In December, 1934, the Commonwealth Government convened at Canberra a Conference of Commonwealth and State Ministers on agricultural and marketing matters. This Conference decided to establish an Australian Council of Agriculture to have the following functions :—

(*a*) Generally to promote the welfare and development of agricultural industries.
(*b*) To arrange the mutual exchange of information regarding agricultural production and marketing.
(*c*) To co-operate for the purpose of ensuring the improvement of the quality of agricultural products, and the maintenance of high grade standards.
(*d*) To ensure, as far as possible, balance between production and available markets.
(*e*) To consider the requirements of agricultural industries, in regard to organized marketing.
(*f*) To promote the adoption of a uniform policy on external marketing problems, particularly those pertaining to the negotiation of intra-Empire and International Agreements.
(*g*) To consult in regard to proposals for the grant of financial assistance to agricultural industries.
(*h*) To consider matters submitted to the Council by the Standing Committee on Agriculture, the establishment of which is recommended in the following paragraphs.

In order to enable the Council of Agriculture adequately to perform its functions, it was decided that there should be a permanent technical committee to be known as the Standing Committee on Agriculture, whose duties, in addition to advising the Council on the matters outlined above in clauses (*a*) to (*h*) should 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.

The first meeting of the Australian Council of Agriculture was held at Canberra from the 28th to 31st May, 1935. At that meeting reports by the Council for Scientific and Industrial Research were presented on the following matters :—(*a*) Investigations into problems affecting the apple industry ; (*b*) the preservation and transport of oranges ; (*c*) the transport, maturation and storage of bananas ; (*d*) soil drift ; (*e*) the grasshopper pest ; (*f*) weed pests ; (*g*) seed testing ; (*h*) the Imperial Mycological Institute ; (*i*) the codling moth pest ; (*j*) tobacco, investigations, and (*k*) the reorganization of the work of the Council's Section of Food Preservation and Transport.

The first meeting of the reorganized Standing Committee on Agriculture was held in Sydney in April, 1935, and the second meeting at Canberra in the following month.

5. *Financial Provision for Research.*—The Council derives its funds from two main sources, viz., the Commonwealth Government and voluntary contributors. Funds from the latter source have reached a considerable total, particularly in recent years. A feature of these contributions is that they are invariably made for a specified period of years. Therein lies a recognition by the contributors of the need for planning and continuity in scientific research. As may be expected in these times, the collection by the persons concerned of contributions over a period of years not infrequently proves a difficult task, but it is noteworthy that in no case has there been a suggestion that the proposed period should be shortened.

In contrast with outside contributors, the funds provided by the Commonwealth Government have for some time been voted mainly from year to year. The Council was established about the middle of 1926. Two appropriations, each of £250,000, were made in successive years from surplus revenue and credited to the Science and Industry Investigation Trust Account which was created by the Council's Act. Owing mainly to the necessity to incur heavy initial capital expenditure on the erection and equipment of laboratories, the

amount at the credit of the Trust Account became exhausted in the early part of 1933. Since that time, the Council has been dependent on annual appropriations so far as the Commonwealth Government is concerned, though it is obvious that that method of financial procedure was not intended by the Commonwealth Parliament when it created the Council and made special statutory provision for the establishment of the Trust Account.

The Council would be placed in a much sounder position, and the general efficiency of its operations would be increased, if there were some definite policy for continuity in its financial arrangements. This could be effected either by the payment into the Trust Account from time to time of sums each sufficient for a period of years, or by the declaration by the Government of a decision to provide fixed annual sums over a period of years. At first sight the latter might appear to be a departure from conventional practice. However, within the last year or two the Government has set aside fixed annual sums for five years for certain special investigations, e.g., those in connexion with gold-mining, fisheries, tobacco, and citrus preservation, and it needs but a logical extension to the whole of the Council's work of the principle thus adopted to give to the Council a satisfactory degree of financial continuity which is denied it by the present method of annual appropriation.

The total expenditure by the Council on investigations since its inception until the 30th June, 1935, and the apportionment between the two sources dealt with in the foregoing are as follow :—

	£
Direct Parliamentary vote	724,334
Contributions	270,550
Total	994,884

It should be noted that the sum shown as contributed refers only to direct monetary assistance. The Council receives a great deal of assistance (e.g., gifts in kind, gratis provision of facilities, special discounts) the value of which it is not practicable to assess at all accurately in terms of money.

Details of the expenditure for the year ended 30th June will be found in Section XIII. of this report.

6. *Visits of Officers Abroad.*—In order to enable officers of the Council to maintain personal contacts with their colleagues abroad and to keep themselves thoroughly informed regarding the most recent advances in the branches of science with which they are particularly concerned, it is important that they should be afforded opportunities of making visits abroad from time to time. This is particularly desirable in Australia where scientific workers, owing to their comparative isolation, are in a more difficult position in this respect than workers in most other countries. During the year 1934–35 the Council was able to arrange for certain of its officers to make visits abroad and thus to obtain the first-hand knowledge of recent developments which is necessary to enable them to perform their respective duties in the most efficient manner practicable.

Professor J. A. Prescott, Chief of the Soils Division, returned in January, 1935, from a visit to Europe extending over a period of about nine months. Whilst abroad he visited a number of agricultural research institutions in Great Britain, France, Belgium and Germany, and attended the meeting of the International Society of Soil Science at Versailles. He also visited Russia, the original home of modern work on soil classification and obtained valuable information from the Dokuchaiev Institute of Soils, a section of the Institute of Geology, which in turn is one of the Institutes of the Russian Academy of Science recently transferred to Moscow. At the Institute of Soil Fertility he inspected the largest pot culture house in the world, a building which is some 400 to 500 feet long and which is used for the purpose of determining the fertilizer requirements of the different soils of the country.

Dr. L. B. Bull, who has been appointed Chief of the Divisions of Animal Health and of Animal Nutrition from 1st July, 1935, returned to Australia in June, after a visit extending over about eighteen months to Europe, America and South Africa. He established contacts with pathological and bacteriological laboratories in England and Scotland, and attended meetings of a number of scientific societies. He was present at the International Veterinary Congress held in New York in September, 1934, and on the continent of Europe he visited many research institutions concerned with investigations into animal health problems. On his return journey to Australia he spent some time at the Veterinary Research Station at Onderstepoort in South Africa, where he was able to obtain a large amount of valuable information in connexion with problems of outstanding importance to the cattle and sheep industries of Australia.

Mr. I. H. Boas, Chief of the Division of Forest Products, left Australia in March, 1935, primarily for the purpose of attending the Imperial Forestry Conference in South Africa in September, 1935. In order to maintain close contact with persons engaged in forest products research in other parts of the world, he travelled via America and England and visited the Forest Products Laboratories at Madison, U.S.A., at Ottawa and Montreal in Canada, and at Princes Risborough in England.

Mr. H. E. Dadswell, Senior Wood Anatomist in the Division of Forest Products, also left Australia in March, 1935, on special leave of absence, in order to advance his knowledge of recent developments in work on wood anatomy and fibre structure and to attend the First Conference of the International Association of Wood Anatomists to be held under the ægis of the International Botanical Congress at Amsterdam in September, 1935.

Mr. A. L. Tonnoir, Senior Systematic Entomologist in the Division of Economic Entomology, was also given special leave of absence. He left Australia in April, 1935, to visit entomological research institutions in England, France, Belgium and Germany, and to attend the Imperial Entomological Conference in London and the International Entomological Congress in Spain, both in September, 1935. Mr. Tonnoir will also obtain from authorities in Egypt and Algeria and from the International Committee on the Grasshopper Plague, which has its headquarters in London, full information regarding methods of control of grasshopper plagues.

II. PROGRESS AND DEVELOPMENT OF WORK.

1. *General.*—In all branches of the Council's work satisfactory progress was made during the year 1934–35. It is particularly gratifying to note that the Council has been so successful in establishing confidence in its operations that in the last financial year it obtained contributions from sources other than its ordinary vote from the Treasury amounting to no less than £41,349, and that it is estimated that these contributions for the current financial year will be increased to £56,391.

(i) *New Laboratories.*—The Government is making a sum of £25,000 available from the Unemployment Relief Funds for the erection of a new Forest Products Laboratory, and a sum of £6,000 from the same source for a new laboratory building at the Viticultural Research Station at Merbein. A beginning will soon be made on both these buildings. The Victorian Government has made available at a nominal rental a valuable site in South Melbourne for the Forest Products Laboratory. Mr. W. Russell Grimwade, C.B.E., B.Sc., the Chairman of the Victorian State Committee of the Council, has made a generous gift of £5,000 for additional plant and equipment for that laboratory. The University of Melbourne has offered to the Council the hospitality of the Veterinary Research Institute at Melbourne for the purpose of investigations into animal health problems and has also offered to co-operate with the Council and the Victorian Department of Agriculture in investigations into mastitis and other problems as the opportunity occurs. The Council has accepted these offers and hopes to be able to obtain funds for the erection and equipment at, or adjacent to, the Institute, of additional laboratories for bacteriological and pathological investigations.

(ii) *Fisheries Investigations.*—The Government recently decided to transfer its fisheries investigations to the Council. Arrangements are being made for building in Australia an exploratory fisheries vessel, to be used particularly for the purpose of ascertaining the commercial possibilities of utilising in Australian waters types of nets used elsewhere for catching surface-swimming fish. It is not the intention of the Government at present to undertake trawling investigations. A beginning will also be made on studies of methods for preservation of fish, not only by quick freezing methods but also by canning, smoking, curing, &c., and for the utilization of non-edible fish for the manufacture of fish meal, &c., for use as fertiliser.

Attention will also be 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.

(iii) *Ore-dressing Investigations.*—Another new development, the result of a special grant made by the Government, is that investigations are being undertaken by the Council, in co-operation with the Department of Metallurgy, University of Melbourne, the School of Mines and Industries, Adelaide, and the School of Mines, Kalgoorlie, into the most suitable and economical methods of treatment of gold-bearing ores. The fact that these facilities are appreciated highly by the mining industry is evident from the large number of samples which have been submitted for examination. The work is actively in progress at the three centres mentioned and a large number of ores have already been examined and reports issued thereon.

(iv) *Soil Drift.*—As a result of a request made to the Council by the Minister (Senator the Hon. A. J. McLachlan) to consider whether any action could be taken to combat the drift of soil in the arid and semi-arid parts of Australia, information and advice were obtained from a number of authorities in New South Wales, Victoria, Queensland, South Australia and Western Australia.

The various authorities consulted agreed generally that soil drift is due to a combination of factors, particularly destruction of pasture cover by rabbits, overstocking and drought. They also agreed that the matter is one which in recent years has reached somewhat alarming proportions. In some parts, extensive areas of country have already been abandoned owing to soil drift; in others there has been a very marked decrease in stocking capacity and production. This is particularly the case in the north-eastern parts of South Australia, where it is stated that hundreds of square miles of country, which formerly carried sheep and cattle, have been abandoned and are becoming a desert.

The matter was brought up for consideration by the Standing Committee on Agriculture, which passed a resolution urging that the problem be investigated by the Council. That resolution was approved by the Australian Council of Agriculture and arrangements have accordingly been made for an officer to make a survey of the problem, initially in certain districts in South Australia.

(v) *Grasshopper Pest.*—At a meeting of the Standing Committee on Agriculture held in December, 1934, consideration was given to the matter of carrying out certain fundamental investigations into the grasshopper pest. It was pointed out that grasshopper plagues have occurred over agricultural areas in several of the States at frequent intervals for many years past. With increased development of agricultural lands these invasions have become a very serious menace in recent years. When a wide-spread plague occurs, heavy losses in pasture and cereal crops are experienced, and considerable expenditure on control measures is necessary.

The Standing Committee passed a resolution requesting the Council to undertake investigations of the habits and ecology of the plague grasshopper, particularly with a view to obtaining definite information regarding the breeding grounds of the insects and the conditions which led to their development in plague numbers, and the devising, if possible, of methods of prevention or destruction in the localities where they breed.

The resolution of the Standing Committee was approved by the Australian Council of Agriculture and arrangements are being made for the investigations to be conducted in co-operation with the Waite Agricultural Research Institute of the University of Adelaide.

(vi) *Weed Pests.*—At the present time the investigations of the Council into weeds problems have been confined mainly to entomological control methods, that is, the introduction and distribution of insects which attack the plants in other countries. These investigations are being conducted by the Council's Division of Economic Entomology at Canberra where there are insectaries in which tests are conducted under strict quarantine conditions in order to ensure that none of the imported insects will attack any plants of economic value, and where (if such tests are satisfactory) supplies of the insects are bred for liberation.

In England, the Council has an officer working at the " Parasite Zoo " at Farnham Roval, which is the headquarters in England for the collection and investigation of insects which attack weed pests. The investigations in England have largely been concentrated on insect enemies of St. John's wort. Several different species of insects have been brought to Australia and large numbers of some of them have been liberated, but so far without successful results.

Another officer of the Council is located at Kansas in the United States of America, and is devoting special attention to insect enemies of Noogoora burr. He is also investigating insect enemies of bracken fern, mint weed, Mexican poppy, skeleton weed and ground cherry.

As many of Australia's weeds are natives of the Mediterranean region, arrangements have recently been made for an officer to be located at a laboratory at Hyères, in the South of France.

The Council is also co-operating closely with the Commonwealth Prickly Pear Board in certain investigations into the entomological control of Noogoora burr.

In the year 1934–35 the Council arranged for two of its officers (an entomologist and plant physiologist) to make a survey of the whole weed pest position and to prepare reports for the consideration of the Council and the Standing Committee on Agriculture. These reports were duly submitted and were brought before the Standing Committee which passed a resolution supporting the plan of work recommended on the reports and urging that the necessary funds be made available. This resolution was approved by the Council of Agriculture.

Steps have accordingly been taken to extend the scope of the work on the control of certain weeds, such as skeleton weed, Noogoora burr, bassia, Bathurst burr, ragwort and nut grass, and to undertake investigations of an ecological and agrostological character with a view particularly to obtaining control by such methods as pasture management and the competition of useful

plants which smother or crowd out the weeds. The work is being carried out in close co-operation with the State Departments concerned. As regards the lantana pest the Government has made additional funds available and an officer has been sent to Fiji to conduct investigations into certain insects which control the pest in that country and to obtain supplies of them for testing out in Australia.

It should be observed that the Council receives numerous requests from State Departments, organizations of primary producers and others to carry out investigations into the control of noxious weeds. The total sum at present available for this work is, however, scarcely sufficient to enable a really effective and thorough attack to be made on more than one or two weeds. If the weeds problem is to be tackled adequately a large sum of money will be required.

No information is available in Australia regarding the loss caused through weed pests. It has recently been estimated that in the United States of America weeds cost the farmer £600,000,000 a year.

(vii) *Preservation and Transport of Oranges.*—For some years past the Council has been conducting investigations into problems connected with the preservation and transport of oranges. The investigations, which were under the control of a Citrus Preservation Committee, were of a restricted nature owing to the fact that only a small sum of money was available for the purpose. Nevertheless a great deal of valuable information has been accumulated regarding maturity at time of picking in relation to storage life, and handling and conditions of storage of oranges, particularly Victorian oranges.

Consequent on the approval given by the Commonwealth Government for a grant of £2,000 per annum for five years for citrus preservation work, steps were taken by the Council, in consultation with the States concerned, to prepare a programme of work for extending the investigations of the Citrus Preservation Committee. The programme provides for investigations to be conducted on uniform lines at Newcastle, Melbourne and Griffith, and the work is now actively in progress at these three centres.

The importance of including fruit from both the Murray Valley and Adelaide Plains districts of South Australia has not been overlooked, but as cold storage facilities for experimental work are not available in Adelaide, it has been arranged that the fruit from these districts shall be brought to Melbourne.

The investigations are under the general direction of an Advisory Technical Committee consisting of representatives of the Council and the three Departments of Agriculture. Moreover, a general co-ordinating Committee (which will meet only at infrequent intervals) is to be appointed, mainly for the purpose of obtaining the help of growers and others concerned with the citrus industry, and to facilitate transport and other arrangements. This Committee will include representatives not only of the Council and of the three State Departments of Agriculture, but also of the Federal Citrus Council, the Australian Citrus Export Association, the Overseas Shipping Representatives Association, and the Australian railways.

Arrangements have been made with certain shipping companies for experimental consignments to be sent to England and the British Food Investigation Board is co-operating in the examination of the fruit on arrival in that country.

(viii) *Mastitis Investigations.*—As a result of funds being made available by the Australian Dairy Cattle Research Association, the Commonwealth Government and the Victorian Government, investigations are being initiated into contagious bovine mastitis, a serious disease which is prevalent in dairy herds not only in Australia but thoroughout the world. Although investigations have been conducted in different countries, the problem in many of its aspects has not been elucidated. This is particularly the case in regard to the various causal organisms which have been incriminated, the means whereby infection is conveyed, and the preventive measures which can be adopted satisfactorily. In order exhaustively to study the problem as it concerns Australia, arrangements have been made with the University of Melbourne for laboratory accommodation to be provided at the Veterinary Research Institute, and a large dairy farm has been secured about 30 miles from Melbourne for field experimental work. An attempt will be made to establish at that farm a normal herd free from the disease. Such a herd would serve three purposes, viz. :—(*a*) It would enable the normal bacterial flora of the udder to be determined ; (*b*) it would afford a supply of normal animals of which there is a record of bacterial flora for the study of the epidemiology of the disease ; and (*c*) it would afford a clean herd of animals for other types of experimental work on the disease. A great deal of useful information regarding recent investigations into certain aspects of mastitis was obtained by Dr. L. B. Bull during his recent visit abroad. The investigations in Australia will be under his direct control, in association with officers of the University of Melbourne and the State Department of Agriculture.

(ix) *Rabbit Pest.*—During the year 1934–35 the Council gave further consideration to the question of whether, in the light of numerous efforts made by other bodies in the past, any good purpose would be served by a re-examination of the present position of the Australian rabbit problem. Many reports on the matter, published by States organizations and others, are available. There has, however, during recent years been an accumulation of practical experience which is worthy of close study, and the Council decided to seek from certain representative pastoralists authoritative statements of the conclusions to which experience had led them. These statements have been published in the Council's quarterly Journal.

Investigations into a virus disease known as myxomatosis are being conducted on behalf of the Council by Sir Charles Martin, C.M.G., F.R.S., &c., in the laboratories of the Departments of Pathology at the University of Cambridge. As yet there is no evidence to show how this disease will operate amongst wild rabbits, but the results so far obtained with colonies of tame rabbits are promising.

It is well known that efforts which have been made in the past to disseminate disease amongst rabbits have failed. The great difficulty is to get a disease which is invariably fatal when the rabbit becomes infected. Unless this is the case an immunity is developed and because of the tremendous breeding powers of the rabbit it is not very long before any early reduction in the numbers through the effects of the disease is fully restored.

Dr. L. B. Bull, who recently had an opportunity of making himself acquainted with the work which Sir Charles Martin is carrying out, has formed the opinion that there is no evidence to encourage an expectation that the virus could be used for the total eradication of rabbits in Australia, though he considers that it may prove to be a valuable adjunct to other methods. In particular it may enable the occurrence of rabbits in plague numbers in certain districts to be prevented. It may also help in the control of rabbits in the larger areas and in rough country in which they cannot be attacked in other ways.

Tests are now being carried out by Sir Charles Martin with a colony of wild rabbits and if the work proceeds satisfactorily it is proposed later to import the virus into Australia and to make arrangements for its culture and for the maintenance of the most virulent strains. It will also probably be necessary to carry out prolonged investigations in order to fix the relation between the infectivity and pathogenicity of the virus. When that has been done consideration will probably be given to the question of conducting a large-scale experiment for which purpose the use of a small island may have to be obtained.

An account of the work of the various Divisions, Sections, &c., of the Council during the year 1934–35 is given in later parts of this report. In the following paragraphs brief information is furnished regarding some developments of special interest during that year.

2. *Division of Plant Industry.*—(i) *Tobacco Investigations.*—A very interesting stage has been reached in the tobacco investigations which are being conducted by the Council's Division of Plant Industry. Firstly, as regards blue mould which is so serious a hindrance to the development of the tobacco-growing industry in Australia, the Division's investigations had previously shown that the disease could be seed-borne and that although it could be eliminated in the seed by treatment with dilute silver nitrate solution, even with clean seed there was considerable liability to infection in the seed bed. It has now been found, as a result of experiments at Canberra, that tobacco seedlings subjected to vapour from benzol during night time do not develop the disease. The State Departments of Agriculture are collaborating with the Council's officers in testing this process on a large scale and trials will be conducted from Queensland to Western Australia during the coming season. If these trials confirm the results of the work already done, tobacco growers will be able to obtain supplies of disease-free seedlings and the discovery will be of outstanding value to the tobacco-growing industry.

Secondly, as regards investigations into the aroma of Australian tobaccos, satisfactory progress has been made in the work which is being conducted at the Department of Organic Chemistry of the University of Sydney under the control of Professor J. C. Earl. The object is to obtain some chemical explanation of undesirable aroma. It has been shown that undesirable aroma is associated with alkalinity of the smoke and with high nitrogen content in the leaf. Many American tobaccos of good quality have high nitrogen content but they also have a high acid content, whereas Australian tobaccos of bad aroma are deficient in acids. It therefore appears that aroma is determined by the relation between amine and acid content. Nitrogen content is higher in young leaves and it is therefore preferable to harvest the leaves at as late a stage of maturity as possible. Owing to seasonal conditions in Australia, the leaves are ordinarily harvested at a somewhat early stage. If, however, the seedlings could be planted earlier, the leaves would reach a higher stage of maturity before being picked, and this might be possible if

the blue mould problem could be solved. There is, therefore, reason to believe that if treatment by benzol and other vapours is proved to be effective it will not only enable tobacco growers to obtain supplies of disease-free seedlings, but may also result in the production of leaf of improved aroma.

(ii) *Seed Testing.*—In November, 1934, contemporaneously with the first Australasian Seedsmen's Conference, a meeting of Commonwealth and State technical officers concerned with seed-testing was held in Melbourne to deal with methods and procedure in seed-testing and with seed standards. This was the outcome of consideration by the respective State Departments of Agriculture of a report on seed-testing technique prepared by Dr. B. T. Dickson, Chief of the Council's Division of Plant Industry, and of seed standards proposed by the New South Wales Department of Agriculture on behalf of the Standing Committee on Agriculture for guidance in the administration of Seeds Acts in force in the several States, particularly with a view to obtaining greater uniformity throughout Australia.

The meeting of officers was characterized by a free exchange of views and experiences, and resulted in a very satisfactory attack on the problems involved. The outstanding results were :—

(*a*) a close co-ordination of efforts on the part of all officers to elucidate some of the difficult germination and purity problems which constantly occur in seed-testing work ;

(*b*) agreement on closer uniformity in technique with respect to general methods of seed testing ;

(*c*) agreement on a series of seeds standards for use by the Commonwealth and State authorities charged with the responsibility of administering the Quarantine and Seeds Acts.

The report of the Conference of Seed Testing Officers was considered by the Standing Committee on Agriculture. It contained a number of resolutions which were adopted by the Standing Committee. The adoption of these resolutions will involve certain amendments, firstly, to the Commonwealth Quarantine Act so as to enable plant quarantine officers to deal with imports of certain seeds which do not at present come within the purview of that Act, and, secondly, to the State Seeds Acts so as to embody provisions which will conform with the standards and methods agreed upon by the Conference and adopted by the Standing Committee on Agriculture.

(iii) *Plant Introduction.*—In the Plant Intruduction Section of the Division of Plant Industry, 300 different species and strains of plants, grasses and legumes were introduced during the year 1934–35. According to whether they are more suited to southern or northern conditions they are first tested at Canberra, F.C.T., or at Gatton, Queensland. In the trials at the latter place, some grasses and maizes are giving particularly good results. One of the outstanding problems in connexion with plant introduction work is the discovery and acclimatization of a legume which will thrive in the summer rainfall regions of Australia, similar for example to subterranean clover which has been introduced so successfully into the winter rainfall areas of southern Australia. A relative of the so-called " Townsville lucerne " has been introduced by the Division of Plant Industry from Brazil (*Stylosanthes guyannensis*), and has shown remarkably promising growth in the sandy loam soils at Gatton. This plant is of special interest and importance since it is a perennial whereas Townsville lucerne is an annual.

3. *Division of Economic Entomology.*—(i) *Sheep Blowfly Investigations.*—The work of the Division of Economic Entomology on the blowfly problem has been directed mainly towards the discovery of means of preventing the attack of sheep by blowflies ; but the problem of cleaning up blowfly strikes when they occur has also received considerable attention. Numerous dressings commonly used by pastoralists, and also many other substances, have been tested by the Division but, until a few months ago, no dressing was found to have all the desirable properties.

To be satisfactory a blowfly dressing must not only kill the maggots present, but must also help to heal the wound, and render it no longer attractive to blowflies. Most dressings commonly used kill the maggots, but many of them also injure the delicate skin of the sheep, and this has been shown to increase the susceptibility of the treated area to blowfly strike. The few dressings commonly used which do not damage the sheep's skin have been found to be unsatisfactory for other reasons.

When investigating the effect of various chemicals on the attractiveness of baits, it was found that baits treated with glycerine or boric acid did not attract blowflies. For various reasons it was thought that a combination of these substances might form a satisfactory blowfly dressing. Over a hundred tests with such a dressing were accordingly carried out under rigorous conditions in the insectaries at Canberra, with most promising results.

The new glycero-boric acid dressing is a colourless, odourless, rather viscous fluid which is easily rubbed into the shorn area of a strike, and adheres readily to the fleece and skin. A few minutes after application the unpleasant normal odour of the strike is changed and becomes much less unpleasant. The maggots are killed rather slowly, twenty-four to thirty hours often elapsing before all are dead, but they cease to worry the sheep immediately the dressing is applied. The effect of the dressing on the strike wound is decidedly beneficial. The extension of damage to the skin is immediately arrested, and inflamed but unbroken skin becomes soft, flexible and healthy, without any sign of crust. As hydrolysis of the dressing proceeds, a fine deposit of boric acid is left over the skin surface. So far it has been found impossible to produce an experimental re-strike on a dressed area, even after liberal wetting, but the testing of this point is not yet completed.

In many respects the tests already carried out in insectaries are more rigorous than field tests ; but the value of the dressing must ultimately be determined by the results of extensive tests under normal station conditions. The manufacture of the dressing is being taken up by commercial interests.

(ii) *Termite Investigations.*—The method of using laboratory colonies of termites for timber testing has been brought to a satisfactory degree of accuracy, and can now be used in such a way that tests on the resistance of various species of timber to attack and on the effect of different methods of preservation against attack can be carried out much more expeditiously than was previously possible. A simple method of destroying certain mound-building species of termites by means of white arsenic has been devised and has proved to be highly efficient and extremely cheap. The same method has been shown to be satisfactory for the control of termites in timber provided that the place of application is dry.

(iii) *Weed Pests.*—Progress has been made in the work on the control of various weed pests by entomological means. As regards St. John's wort, during the past four or five years, large numbers of the beetle *Chrysomela* have been liberated, but owing to the climatic conditions in Australia and to the attacks of meat ants, ground spiders and other enemies, very few of them have survived. Attention is accordingly being given to other insects for some of which tests have already been completed to determine whether they will or will not attack any plant of economic value. Supplies of these insects are now being bred for liberation. A large number of burr-seed flies (*Euaresta aequalis*), which attack Noogoora burr and which were imported from America have been sent to Queensland and distributed by officers of the Commonwealth Prickly Pear Board ; other insects which attack this weed are under investigation.

Consignments of the cinnabar moth (*Tyria jacobaeae*), the larvae of which attach ragwort, have been liberated in Victoria, but it is yet too early to state whether they have become established or whether they are likely to exercise any effect in controlling the weed. Investigations are also in progress on a number of insects which attack other weeds.

4. *Division of Animal Health.*—(i) *Contagious Pleuro-pneumonia of Cattle.*—Striking advances with respect both to the scientific aspects of the work and to the practical application on the results have been made in the investigations which the Council is conducting on contagious pleuro-pneumonia of cattle, a disease which is of immediate importance in the northern cattle belt of Australia, though there is continuous danger of its introduction to other parts.

Although the contagious nature of the disease has been recognised for nearly a century, and although the specific cause (classed as a virus) was cultivated artificially many years ago, artificial transmission of the disease for experimental purposes had not previously been accomplished. The organism itself till quite recently was still classed amongst the viruses capable of passing through fine bacterial filters. The Council's researches at Townsville and Melbourne have demonstrated the precise nature of the organism, and a successful method has been devised of producing the disease artificially. The absence of such a method had been a stumbling block for many years.

In the past, protective vaccination has been effected by subcutaneous inoculation in the region of the tail with chest effusion from naturally contracted cases of the disease—so-called lymph or natural virus. This had to be used almost immediately after collection and was consequently of limited applicability. But now it has been demonstrated by the Council's investigators that artificial cultures are not only equally effective, but can be conserved for many months and thus used when and where necessary. Further, for the first time, it has been shown experimentally that this system of vaccination with artificial cultures confers a very definite immunity and very rapidly. That is to say, animals vaccinated with the cultures within a week resist the disease germs when they are inhaled experimentally, whereas those not vaccinated, but simultaneously exposed to the germs, contract the disease. Experiments are now in progress to determine the duration of the immunity conferred.

As is well known, cattle may be actually infected with pleuro-pneumonia and yet show no obvious symptoms whatever. Especially is this the case with cattle depastured in large paddocks where they cannot be closely examined. Such animals very often act as carriers of the disease. The development of a test which will enable them to be diagnosed is, therefore, of the utmost importance, particularly when it is desired to eradicate the disease from a herd or when cattle are transferred from one district to another. Such a test has been developed by the Council's investigators at Townsville. It is a variation of what is known as " the complement fixation test." Its value has been demonstrated experimentally not only at the Townsville Laboratory, but at the Veterinary laboratories of the States of New South Wales, Victoria and Western Australia. Furthermore, its accuracy has been checked by the examination of bloods of over 2,000 animals forwarded from the Launceston abattoir in Tasmania, a State which has never experienced pleuro-pneumonia. The value of the test has thus been exhaustively studied and it can be safely said that when properly conducted by skilled operators, it has a reliability approaching 100 per cent. Consequently, any plan of eradication will be materially aided by the adoption of this test. Furthermore, its application will enable a reasonable guarantee to be given that a consignment of cattle is free of carriers and, consequently, may be moved without risk of the conveyance of infection.

There is now considerable reason for believing that it may be practicable within a few years to eradicate pleuro-pneumonia from Australian herds.

(ii) *Internal Parasites of Sheep.*—Useful progress has been made in the investigation of internal parasites of sheep, this work being centred at the McMaster Animal Health Laboratory at Sydney. Experiments have amply confirmed the importance of adequate nutrition as a preventive, and it has been demonstrated that the withholding of food and water prior to drenching with specific drugs is unnecessary. New and more effective methods of administering anthelmintics have been devised. In particular, the discovery of the effect of solutions of copper sulphate on the closure of the oesophageal groove in the ruminant has led to important advances ; the result of such treatment is to facilitate the passage of the anthelmintic drugs directly into the fourth stomach, where they are efficacious, instead of first into the rumen or paunch where they become so diluted that their efficacy later is greatly diminished. This discovery has attracted a great deal of attention in other countries and is being widely applied.

(iii) *Entero-toxaemia of Sheep.*—This was originally considered to be a problem, mainly, if not entirely confined to Western Australia, where it was known as braxy-like or Beverley disease. Therefore, it was first investigated in that State.

The immediate cause was proved to be an anaerobic organism which was isolated, artificially cultivated, and proved to be capable of infecting sheep by ingestion under certain predisposing conditions. A vaccine was prepared which, on injection, confers a definite degree of immunity. The Western Australian research was followed by investigation of the lamb disease popularly known as " pulpy kidney." This disease had been suspected to be due to the same organism or, at least, one of the same class as that causing braxy-like disease. This has now been amply confirmed by the results of investigations conducted in Tasmania.

The disease in lambs has been found recently to be becoming more and more prevalent each year in the eastern States of Australia. The preventive vaccine is now made commercially by the Commonwealth Serum Laboratories and large quantities of it have been made available.

(iv) *Black Disease of Sheep.*—In previous reports, information has been furnished regarding the highly successful investigations carried out by the Division of Animal Health into the problem of black disease from which the loss in the principal States affected (New South Wales, Victoria and Tasmania) was estimated at £1,000,000 per annum, The preventive measures devised and recommended by the investigators are now being practised regularly by stockowners. The vaccine is manufactured commercially by the Commonwealth Serum Laboratories, and is in general use on many properties, particularly in Victoria and Tasmania.

5. *Division of Animal Nutrition.*—(i) *Coast Disease.*—Some interesting and important developments have resulted from the investigations into the so-called " coast-disease " problem in sheep, a disease which affects large areas of high rainfall country comprising over 2,000 square miles in South Australia alone, and extending to Victoria, Western Australia and King Island. The soils of these areas are highly alkaline, containing up to 80 per cent. of calcium carbonate. If sheep are left on this country for any length of time they become emaciated and anaemic and ultimately die. The only way of using such lands is by shifting the sheep periodically to the adjacent much poorer ironstone heath country. In 1929 the Division initiated an investigation into this problem based on the idea that the high quantity of calcium carbonate might render certain nutrients unassimilable by the sheep. The skeletons of sheep were examined and it was found that the bones were poorly calcified. It was then discovered that the blood phosphate increased as the disease progressed. This showed that the disease had nothing to do with

aphosphorosis. It was ascertained that doses of iron salts had no effect nor had bonemeal or compounds containing manganese, arsenic or copper. In 1934, the Division began a critical experiment to answer the question whether the disease is due to an excess of calcium carbonate or whether it is due to a deficiency. The salts of a number of elements such as nickle, zinc and cobalt, were added to the rations supplied to the animals, and the evidence clearly indicated that the disease is one of shortage of some element necessary for the production of blood. Field experiments had shown that impure iron oxide in the form of limonite would bring about some benefit. Limonite also contains many other elements in small quantities. Cobalt is almost invariably associated with it. Experiments with rats showed that cobalt increased in an extraordinary way the number of red corpuscles in the blood.

The investigations are not yet completed, but it appears not unlikely that the discovery of the highly beneficial effects of administering minute quantities of cobalt to affected animals may not only lead to the solution of the coast-disease problem, but may also throw considerable light on other nutritional disorders of stock.

(ii) *Drought Feeding.*—The investigations into the problem of the most economic and efficient method of feeding sheep in times of drought have now reached a stage at which they point the way to practical application. The work on energy metabolism of sheep, which had first been directed to the estimation of the energy necessary to keep the animal alive, has been extended so as to determine the maintenance requirements of the animal at different weights. The results were plotted in the form of a diagram from which the energy requirements necessary to maintain the weight of a sheep at any particular level can be read directly. The question then arose as to the most economic method by which the energy could be supplied in the form of feed. The net energy values have accordingly been worked out for different foods such as lucerne, hay, maize, wheat, oats and various concentrates, so that, according to market values and cost of transport, the most economic rations necessary to provide the requisite energy can be determined. There is still an amount of work to be done in this connexion, but it will not be long before drought feeding can be placed definitely on a scientific basis.

(iii) *Wool growth.*—Investigations conducted in the year 1934–35 have thrown further light on the processes concerned with the production of wool by merino sheep. They indicate that, when the consumption of protein by the sheep is low, the requirements of raw materials for wool production are best met by proteins of relatively high content of cystine (a sulphur-containing amino-acid of which there is a high proportion in wool fibre). They also show that the sheep cannot utilise for the purpose of wool growth sulphates or sulphur fed in its elementary form ; that is to say, it is incapable in its process of metabolism of synthesising the cystine which is necessary for wool production when the intake of protein is low. The sheep must, therefore, obtain the cystine preformed in the proteins of the fodder.

The results of field experiments conducted by the Division of Animal Nutrition have shown that pastures on highly leached soils which are low in phosphate and sulphur respond excellently when dressed with these two materials, but fail to improve if either is applied by itself. The economic response in sheep-carrying capacity and improved growth of wool which follows such manurial treatment has definitely been established.

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 1934–35 in the soil surveys of the Coomealla district of New South Wales and of Merbein in Victoria ; the survey of the whole of these irrigated areas will be completed in about two years' time.

In Tasmania the distribution of soil types has been defined. Work in that State has been concentrated largely on the red loam soils of the potato-growing districts in the north-west, particularly for the purpose of determining lime requirements. Further progress has been made in the systematic examination of soils in apple-growing centres.

The work on soil bacteriology has been developed, particularly with reference to the reclamation of alkaline soils and to the nitrogen fixing organisms of leguminous plants, such as subterranean clover and lucerne, both of which are important pasture plants in southern Australia.

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 the elucidation of many problems associated with water-logging, fertiliser trials, the planning of drainage systems, the opening of further areas for settlement, &c.

(ii) *Viticultural Research Station, Merbein.*—In previous reports of the Council reference has been made to the great improvements effected in the general standard of quality of the dried fruit crop as a result of the investigations at this Station into methods of processing dried fruits and into cultural and irrigation practices.

During the year 1934–35 attention was directed particularly to irrigation methods and to attendant problems in connexion with salt, seepage, agricultural drainage and the general preservation of soil fertility. This work is being carried out in close co-operation with State authorities and with various local committees. The results of the investigations are already being utilised in many areas and substantial improvements have been effected.

(iii) *Citricultural Research Station, Griffith.*—At this Station, which is situated in the Murrumbidgee Irrigation Areas, an investigation into the hydraulic principles and construction costs of a spray irrigation system was completed in the year 1934–35. This work has made possible the accurate planning of spray irrigation plants to meet any conditions of farm layout. Formerly the old trial and error methods of installation led to waste of money and effort. Spray irrigation is now used on several large farms on the Murrumbidgee Irrigation Areas and interest in this work is shown by enquiries from other districts.

The green manurial experiments with citrus have led to a marked increase in yields, and the practice of green manuring with a winter legume is now widely adopted on the Murrumbidgee Irrigation Areas. During the year important progress was made in determining the factors responsible for these increases. As a result of frequent soil samplings over a period of two years, the fluctuation of nitrate content in green manured soil has been followed, and it has been shown that under local conditions the variation differs widely from that characteristic of soils in England and in other parts of Australia. An elucidation of these features should lead to further improvement in manurial and cultivation practices.

7. *Forest Products Division.*—(i) *Permanent Laboratories.*—Reference has already been made to the arrangements for the erection of a permanent laboratory building for this Division and the gift from Mr. W. R. Grimwade, C.B.E., B.Sc., for the purchase of equipment for the new laboratories. The latter will enable a large size timber-testing machine for mechanical tests on heavy timbers and built-up structures to be purchased and installed, together with other modern equipment to replace present make-shift devices of limited utility.

(ii) *Kiln Seasoning of Timber.*—That the intensive campaign of education of the timber industry by trade circulars, lectures, seasoning classes, demonstrations, personal visits, and correspondence courses is bearing fruit is shown by the rapid expansion of kiln seasoning throughout Australia and the interest evinced in modern seasoning methods during the past year. The total number of plants at which kilns, veneer driers or drying rooms were operated increased in the year by over 25 per cent., and the total number of drying units by over 40 per cent. Most of the units were built to plans and specifications supplied by the Division. In Queensland, the number of units was more than doubled. A seasoning class held in Melbourne was so well attended that the class had to be divided and the course repeated, while well-attended classes were held in Sydney and Brisbane. Enquiries regarding the correspondence courses in seasoning increased greatly and the number of those enrolled more than doubled.

(iii) *Preservation of Telegraph Poles and Railway Sleepers.*—During the year co-operative arrangements were completed with the New South Wales Forestry Commission, the New South Wales Public Works Department, the Postmaster-General's Department, the New South Wales Railways, the Sydney City Council, and the Newcastle Electric Supply Department to make a comprehensive field test of *E. pilularis, E. maculata* and *E. saligna* in order to determine whether these species could by preservative treatment be made suitable for pole purposes and thus be used to supplement the dwindling supply of highly durable timbers.

On account of lack of hardwood forests in South Australia, a co-operative scheme has been arranged with the Postmaster-General's Department and the South Australian Woods and Forests Department for a test to be made under field conditions of *P. radiata* poles, large quantities of which will be available from plantations in that State.

Inspections of other pole test sites were made during the year. Results of considerable practical value have already been obtained, and the influence of this work is now being seen in the improved methods of treatment adopted by authorities using poles. Australia's pole bill (cost of poles only) is about £300,000 per annum, so that these activities are of considerable economic importance.

As in the case of poles, the future supplies of durable timbers for sleepers are causing concern, particularly in South Australia, and arrangements were made with the Woods and Forests Department and the Railway Department in that State for a test of 320 broad and narrow gauge sleepers of plantation *Pinus radiata.* The sleepers were seasoned and forwarded to Melbourne,

impregnated with preservatives in the pressure treatment plant of the Division and returned for installation. Later it was decided to extend the test and a further 480 sleepers have been cut and forwarded to Melbourne, where they are undergoing treatment. They will be installed later with 240 hardwood sleepers for comparison. In addition 52 sleepers (*P. radiata*) were similarly treated and forwarded to the Adelaide Tramway Trust. These are being installed with untreated and brushtreated red-gum sleepers for comparative purposes.

(iv) *Wood Taint in Butter.*—The casein-formalin spray treatment of the inside of butter boxes (for export) is now standard procedure with hoop pine. Several million sprayed boxes have been exported and the reports from London are highly satisfactory. It is estimated that the enhanced price obtained for the butter by taint elimination is at least 1s. per box, and as the cost of treatment is of the order of 1d. to 2d. per box, the nett benefits of the process will amount to hundreds of thousands of pounds.

(v) *Modern Timber Connectors.*—A development overseas is the use of a special type of timber connector to improve the efficiency of joints and fastenings in timber structures. With connectors, improved and more economical designs in timber are possible and structures normally built of steel can be fabricated more cheaply and conveniently in wood. Recently the Forests Department of Western Australia decided to erect a 100 ft. tower for forest fire control purposes, and a design for this in Jarrah, using timber connectors, was prepared by the Division. It was estimated that there would be a saving of from 20 to 25 per cent. as compared with the cost of a steel tower.

(vi) *Shrinkage of Timber.*—Study of the shrinkage of Australian timbers by the usual methods is made difficult owing to the occurrence of collapse. Damage by distortion and change in size from this cause are often much greater than that from true shrinkage. A technique using thin cross sections which do not collapse has been developed and, with due precautions, pieces about $\frac{1}{2}$ inch square can be studied. This gives a simple and rapid means of determining total shrinkages or the relationship between shrinkage and moisture content. Investigations to date have disclosed that collapse is a very much more common feature in the drying of timber than is generally realised.

(vii) *Paper Making Fibres.*—Pulps from Australian hardwoods have shown certain significant differences from those of the softwoods commonly used for paper making, particularly as regards the development of strength during beating. An investigation has, therefore, been commenced into the fundamentals of the chemistry and structure of pulp fibres from Australian timbers. This investigation is being carried out in co-operation with the Australian Paper Manufacturers Ltd., who have provided £400 per annum to permit the employment of a chemist to study the constitution and properties of the substances associated with the paper making qualities of the fibres.

8. *Food Preservation and Transport.*—(i) *Fruit.*—For some time past investigations into the storage and ripening of pears, particularly the delicate Williams variety, have been carried out in Melbourne by the Council in conjunction with the Department of Agriculture of Victoria. This work has now reached a stage at which it is possible to indicate fairly precisely the conditions to be maintained in order to ensure a good out-turn of the fruit exported to Great Britain. The laboratory investigations on the Williams variety have been extended to closely observed experimental shipments, and these have amply confirmed the results obtained by land storage experiments. Moreover, commercial shipments of this variety, in which the exporters and shipowners adhered closely to the conditions laid down by the investigators, have landed in excellent condition, whereas, in previous years, considerable wastage was usually to be expected. If the trade in the high quality Williams pear is to be extended, however, it seems probable that a suitable ripening treatment, found by laboratory experiments to be essential, will have to be practised on arrival of the fruit in Great Britain. While the necessary conditions are relatively simple to realize on a laboratory scale, a considerable amount of work will be required before the method can be applied successfully on a commercial scale.

Further experimental evidence, obtained both in the laboratory and by means of small experimental shipments to Great Britain, has confirmed the importance of the influence of maturity at the time of picking on the keeping quality of Washington Navel oranges. In general, there appears to be an increasing susceptibility to wastage in successive pickings made after mid-June, and, in fruit picked after mid-July, the onset of serious wastage during storage generally tends to be rapid. These results obviously have an important bearing on the growth of what appears to be an essential export trade, and official cognisance of them has apparently been taken in the drafting of regulations for the export of Navel oranges, which provide that the subsidy will only be paid on approved fruit exported before 15th July.

It has been reliably estimated that the production of Australian citrus fruit (chiefly oranges) in excess of local requirements will amount, in 1936, to over one million bushels. Apart from New Zealand, which could, if she so desired, absorb about 250,000 bushels, the only good overseas markets are Great Britain and, perhaps, Eastern Canada, export to both of which involves durations of storage in excess of six weeks in ships. Apart from matters of suitable quality and grading, exports to these countries have been retarded by frequent heavy wastage. Realizing this position the Council attached importance to the intensification of its work on the problem, and reference has already been made to the fact that the Commonwealth Government has provided additional funds for that purpose. Investigations have accordingly been commenced on fruit from the coastal and hills districts of New South Wales and the Murray Valley and Adelaide plains districts of South Australia, and the study of fruit from several important areas in Victoria and the Murrumbidgee district of New South Wales is being continued.

(ii) *Chilled Beef.*—Further investigations in connexion with the preparation and storage of chilled beef have yielded valuable data concerning the relationship between the initial contamination by micro-organisms responsible for spoilage and the extent and activity of that fraction of the micro-organisms in soil which can grow readily at temperatures of the order of 30° F. From micro-biological examinations of the soil from any locality in Queensland and northern Australia at any given time, it is now possible to predict, with a reasonable degree of accuracy, the probable average storage life of chilled beef prepared in that locality at the time of the collection of the soil samples. This assumes, of course, that standard methods of preparation of the beef are employed; in general, such is the case at the present time. The practical importance of this finding lies in the simplicity of the prediction from the relatively easy, regular examination of soil samples sent to the central laboratory, when compared with the only alternative, viz., the tedious sampling in the meatworks, from month to month, of numerous sides of beef prepared under standard conditions.

From recent experiments, it is obvious that the degree of dryness of the superficial tissues of chilled beef is one of the main factors controlling its storage life. It is known to exert a profound influence both on the loss of bloom of the meat and the rate of onset of microbial spoilage. No precise data are available concerning the rates of growth on tissues of different water content, at 30°F., of the chief organisms responsible for spoilage, and intensive investigations to determine such rates are now in progress. Moreover, there are few data concerning the physical factors governing the moisture content of the exposed tissues both during the cooling of the sides in the meatworks and during the compact storage in ships' cargo spaces. Some work has been carried out by the Council on the former aspect, and, in conjunction with the British Food Investigation Board, important experiments on shipments of chilled beef are now in progress to supply data on the relationship between the physical conditions during transport and the rate of loss of weight and bloom of the quarters. It seems certain that if the loss of moisture from the beef could be adjusted to pre-determined values, then a considerable advance would have been made towards solving the main technical problem of the chilled beef trade, viz., loss of bloom, as well as ensuring a greater degree of freedom from microbial attack.

9. *Other Investigations.*—(i) *Commonwealth Prickly Pear Board.*—The work of the Commonwealth Prickly Pear Board in the eradication of prickly pear continues to be most satisfactory. During the year 1934–35 *Cactoblastis* attacked the remaining areas of vigorous growth in south-western Queensland and north-western New South Wales, and great destruction of the pear has been effected. As regards pest pears of lesser importance, particularly the tiger-pear (*Opuntia aurantiaca*) and tree-pear (*O. tomentosa*), the Board has brought to Australia from South America supplies of certain insects which it is hoped will exercise control over these particular species. The reclamation for pastoral and agricultural purposes of land previously infected by prickly pear has been further advanced both in Queensland and New South Wales.

(ii) *Radio Research Board.*—This Board has maintained the high standards of its work in previous years. Investigations into problems concerned with fading are centred at the University of Sydney and involve extensive studies of the ionosphere. New methods of attack have been developed and considerable advances in technique have been effected. Work on atmospherics is centred at the University of Melbourne. The observations have afforded useful information regarding the meteorological conditions associated with atmospherics, which are due to lightning flashes.

(iii) *Mineragraphic Investigations.*—The mineragraphic work centred at the Department of Geology of the University of Melbourne is concerned with investigations of mineral associations in complex ores. The object of these investigations, which have now been linked up with the ore-dressing work, 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 occurrence

of such minerals cannot be determined by ordinary methods and can be observed only by microscopical examination of polished surfaces in reflected lights. The increased demands for this work have necessitated the appointment of an assistant officer.

(iv) *Fuel Problems.*—During the year 1934–35 Mr. L. J. Rogers, the Commonwealth Fuel Adviser who is attached to the staff of the Council, was occupied mainly in further investigations into the refining of Newnes shale oil. A small supply of motor spirit refined from Newnes crude petrol has been obtained and is being tested by the National Roads and Motorists' Association. Investigations have also been conducted into the preparation of bitumen from shale from Latrobe, Tasmania. The results of these investigations are promising from a technical point of view.

10. *Standards Association of Australia.*—The Council acts as a means of liaison between the Commonwealth Government and the Standards Association of Australia which was established in 1922 and is controlled by a body representative of governmental, manufacturing, commercial, professional and scientific interests. The funds of the Association are provided by grants from the Commonwealth and State Governments and by donations and membership subscriptions from industrial and commercial organizations.

Standardization is effected on a voluntary basis through the medium of Committees which are appointed by the Association and which are representative of manufacturers, distributors and consumers, and as a result nearly 300 Australian standard specifications prepared and accepted by the interests concerned have been issued. The effect of these national standards has been to co-ordinate the requirements of producers and consumers, to increase the efficiency of production, mainly through the adoption of mass production methods, and to decrease the cost to the consumer.

Close collaboration with standardization bodies in other parts of the Empire, and particularly with the British Standards Institution, has developed a valuable and cordial spirit of Empire co-operation.

In addition to the technical and commercial standards which have been issued by the Association, special reference may be made to the many valuable safety codes such as those which were issued during the year 1934–35 for lift installations and crane and hoist installations, and to the important work at present in hand for the preparation of standard conditions of contract for engineering works. During the year 1934–35 the Association, at the instance of the Standing Committee on Agriculture, carried out preliminary work with a view to applying standardization to machinery and appliances used by the primary industries and to the grading of primary products.

III. PLANT INVESTIGATIONS.

1. *General.*—During the year considerable attention was given to the problem of noxious weeds and, with a view to widening the field of research to include more work on the botanical side, arrangements were made for Mr. G. A. Currie, who had been in charge of the investigations into the entomological control of weeds, to be a joint officer of the Divisions of Plant Industry and Economic Entomology and thus to control and co-ordinate all weeds investigations under the general direction of the Chiefs of these two Divisions. Mr. A. B. Cashmore was appointed as ecologist and Mr. C. G. Greenham will undertake physiological studies of important weeds during the coming year.

In connexion with tobacco investigations, accommodation was provided for Mr. G. E. Marks at the McMaster Animal Health Laboratory, University of Sydney, in order to facilitate the co-ordination of the smoking tests and processing trials with the chemical studies in progress under the guidance of Professor J. C. Earl, D.Sc., at that University. An additional assistant pathologist was appointed for furthering disease studies which have reached an important stage and a technical officer was appointed to enable attention to be given to the problem of selection and breeding for disease resistance, particularly against downy mildew or blue mould.

The work of the Division has again been materially assisted by the co-operation and help rendered in many directions by State Departments of Agriculture, by the Waite Agricultural Research Institute and by many individuals. This is notably the case in connexion with the Department of Agriculture of New South Wales and Panlook Bros. Pty. Ltd. for tobacco investigations; the Departments of Agriculture of New South Wales and Western Australia and the Waite Agricultural Research Institute for wheat investigations; the Department of Agriculture, the Huonville and Moonah Cool Stores, the Electrolytic Zinc Coy., the University and individual growers in Tasmania, the Department of Agriculture of South Australia, the Committee of Direction of Fruit Marketing and Mr. St. John Pratt in Queensland for fruit investigations; the Queensland Agricultural High School and College for maize breeding and plant introduction trials; the New South Wales Department of Agriculture for skeleton weed

studies ; the Queensland Agricultural High School and College for nut grass control investigations ; and all Departments and many individuals for data in the preparation of the pasture map of Australia.

2. *Fruit Investigations.*—These cover work in Tasmania on non-parasitic diseases of apples, in South Australia on growth and bud development ; at the Citricultural Research Station, Griffith, New South Wales, on alternate cropping in Valencias ; at the Viticultural Research Station, Merbein, Victoria, on sultana vines ; and at Stanthorpe, Queensland, mainly on stock and scion relations for apples.

(i) *In Tasmania.*—The programme for 1934–35 was a continuation and extension of that of 1933–34. The main development was in gas storage work, and the initiation of respiration tests. The past three seasons have provided valuable climatic contrasts in the experimental area.

(*a*) *Identification of Disorders.*—A movement towards standardization of nomenclature of apple storage diseases has been started in co-operation with the New Zealand Department of Scientific and Industrial Research. Exchange of specimens (examined in quarantine in Tasmania) has shown that corky pit in New Zealand is identical with our internal cork.

A pit-like disorder developing in late-picked Cox's Orange Pippin and which is an early stage of a breakdown, has been provisionally called " fleck ". Another disorder, resembling and mistaken for bitter pit, is the so-called pit of French Crab. The lesions are a sequence to water-core, and develop either before or after picking. Their association is with crinkle rather than storage pit. The common tree pit or cork on Cleopatra and Sturmer in Tasmania is not identical with blotchy cork in Cleopatra in Western Australia. The former is associated with undesirable soil types, the latter with atmospheric dryness. The effect of crop and fruit size is identical in both. The pit developed in Tasmanian Cleopatra and Sturmer after picking is, in the main trees, pit which would have developed as such if picking had been delayed.

(*b*) *Disorders in Fruit on Trees.—Tree Pit.*—On the whole this disorder was less in evidence in 1935 than in the previous two years. Where it occurred seriously it was associated with inferior soil types. It occurred mainly on Cleopatra and Sturmer.

Internal Cork.—Though widespread, internal cork was less serious than in 1933–34. Some occurrences can be correlated with defective (hard pan) soil types or denuded soils. Varietal susceptibility varies greatly. Sturmer and Granny Smith are very subject to the normal, and Jonathan to the corky-core form. The most effective control at present available is to re-work or replace affected trees with resistant varieties such as Democrat, Crofton and Worcester Pearmain. Some growers have unfortunately re-worked affected Sturmers to the equally susceptible Granny Smith, with disastrous results.

The claim put forward byAtanasoff that this and other disorders which have been called bitter pit are of virus origin has received attention. The field evidence distinctly opposes such a cause. Grafting experiments, started in 1931, show no evidence of transmission in this way.

Water Core.—With an absence of days of high maximum temperatures in 1935, severe early water core in French Crab, Stone Pippin, &c., was less in evidence than in 1933–34. As a consequence, crinkle was also less severe. Late water-core was not uncommon in Jonathan, King David, French Crab, and Cox's Orange Pippin. In French Crab it frequently appeared as small infected patches in the flesh, which died and dried out either before or after picking. As usual, late water-core appeared first and most severely in the large fruits of trees with light crops.

(*c*) *Storage Disorders.—Storage Pit.*—In the 1935 experiments storage pit was practically confined to Cox's Orange Pippin. As in previous seasons it occurred seriously in the fruit from lightly cropped trees and was relatively unimportant in fruit from trees with heavy crops. Pit liability is greatest in soils of poor physical type. The early picking of the most advanced Cox's Orange Pippin and Ribston Pippin for early export is the main cause of the high incidence of bitter pit in early boats of each season. Light crop fruit is always the most advanced in size and ground colour, and constitutes the greater part of the early pickings. The high pit and breakdown liability of such fruit makes it most undesirable for export. Experience indicates that few Cox's from good crops and suitable for export are ready for picking before the third week of February to the first week of March according to the earliness or lateness of the season.

Jonathan Spot.—This occurred on Jonathans and Scarlets, liability increasing with the red colour of the fruit. Cool storage promptly after picking largely controlled the incidence. Delay in cool storing increased its incidence, especially when over one week.

Low Temperature Breakdown.—Both in 1934 and 1935 this disorder was practically confined to Cox's Orange Pippin among the varieties tested, in marked distinction to 1933 in which C.O.P.

Scarlet, Jonathan, French Crab and Sturmer were seriously affected. Breakdown was greatest in the presence of pit and water core, and at the higher storage temperature (38° to 40° F.) was largely confined to fruit so affected.

The investigations have indicated a very definite association between relative liability to low temperature breakdown, the level of titratable acidity, and the temperatures during January and February. Support for this association is to be found in data from other countries. On the basis of the temperatures and results of acidity tests, a prediction was made in February, 1935, that the general keeping quality of Tasmanian apples would be good. This prediction was confirmed not only by the results of experiments and by the out-turn of locally stored fruit, but also by reports on exported shipments. If further work confirms the possibility of predicting the relative liability to low temperature breakdown, the presence of which is the main factor in determining the general storage capacity of Tasmanian apples, a very important advance will be made. With such knowledge available early in the season, it would be possible to adjust the picking programme and storage temperatures to offset the liability to a considerable extent.

Pit Breakdown.—In 1935 this was practically confined to Cox's Orange Pippin, especially fruit from lightly cropped trees.

Water Core Breakdown.—This occurred in late pickings of Cox's Orange Pippin and in Jonathan picked after the third week of March. It also occurred seriously in commercial Jonathan and King David picked in April and May. There is no doubt that water core is a major cause of the wastage in Tasmanian Jonathan and King David, and even in Scarlet which is so common in mainland markets from May each season. Water core will induce breakdown in these varieties at any temperature, whilst at low temperatures it increases the liability of the fruit to low temperature breakdown. Though widely accepted elsewhere, this association has been neglected in Australia and Tasmania. It has an important bearing on fruit inspection. Inspection of these varieties can have little value unless the cutting of a reasonable number of fruits be made compulsory, except in the case of more or less immature fruit.

Brown heart.—Gas storage trials started in 1934 were extended in 1935 to cover Jonathan French Crab and Sturmer. They are designed to ascertain the safe upward limit of respired carbon dioxide in ships' holds. They will be continued and extended at least until a season is experienced in which low temperature liability is high. The results so far obtained indicate that at 32° to 34° F. the critical percentage of carbon dioxide varied between 5 and 15. Of the three varieties, Jonathan has so far been the least and French Crab the most susceptible.

Alcoholic Poisoning.—A disorder identified as the " alcoholic poisoning " of M. Thomas, just as brown heart is his " aldehyde poisoning," and due to a deficiency of oxygen in the storage air, has occurred in 1934 and 1935 in association with brown heart. Though developing independently of brown heart, the relative liability of the varieties tested has been the same.

(*d*) *Chemical and Physiological Tests.*—The tests on acidity, refractive index, &c., of 1934, were continued in 1935 with the omission of electrical conductivity. The results confirmed those of the preceding seasons. Wastage-susceptible varieties, particularly in relation to low temperature breakdown, had a higher level of total acidity and soluble carbo-hydrates than those less susceptible. Fruit from light crops were higher in the same respect than that from heavy crops grown under similar conditions. Further, the general level of acidity, &c., has been highest in seasons of poor keeping. The level for the fruit of a given tree has varied with the season and the size of the crop. The tests have been based on individual tree samples, taken weekly or fortnightly, which between mid-January and June amounted to several hundreds.

(ii) *Growth and Bud Studies.*—A report on co-operative work with the Department of Agriculture in South Australia dealing with the process of fruit bud formation in Cleopatra, Jonathan, Dunns' and Granny Smith apples grown in the Blackwood district was published in the Journal of Agriculture of South Australia. As an outcome of these and previous studies in growth and fruit bud formation it has become increasingly apparent that fruit bud differentiation is conditioned, not so much by the environmental conditions which obtain during the period of differentiation or even for some time prior to differentiation, but rather by the nature and inter-relationships of previous growth phases in the development of the tree. Attention is therefore being directed to a study of the fundamental phases in shoot growth and development and their relation to environmental conditions. Preliminary experiments in this connexion have been made using the sultana grape vine as a convenient plant for the purpose. It has been shown that shoot growth is not continuous throughout the season, but occurs in definite cycles, some of which are unrelated to changes in environmental conditions. Further investigations are designed to determine the relation between response to changes in environmental conditions and these fundamental or internal growth phases.

(iii) *Investigations in Irrigation Areas.*—In continuance of the investigation of the problem of alternate bearing in Valencia oranges in the Murrumbidgee Irrigation Area, further thinning experiments on a commercial scale have been carried out. The results of these and previous experiments have been published in the Council's quarterly Journal. It has been found that fruit thinning sufficiently early in the " on " season (January-March) will increase the amount of blossom formed and considerably increase the crop of the following " light " year. During the last few years, however, it has become a prevalent practice in this area to leave the fruit on many trees until very late in the season, thereby obtaining certain economic advantages in marketing. Harvest is made several months after the natural maturation of the fruit. It remains to be determined whether this practice is likely to offset the effect of early thinning.

At Merbein, Victoria, further experiments have confirmed the findings previously reported that summer pruning or topping of the shoots of mature sultana vines is not a beneficial practice. Increased crops result during the first and second seasons of treatment, but thereafter owing to decreased starch storage the vines are weakened and yield diminishes. Correlation studies between shoot growth, starch and nitrogen accumulation, and fruit bud formation have indicated that vigour of shoot growth early in the season is associated with starch accumulation and fruit bud formation. Stimulation of shoot growth early in the season is evidently to be desired under the climatic conditions obtaining at Merbein. It has yet to be determined how late in the season it is desirable to encourage the vegetative growth of the shoots. Renewal of shoot elongation very late in the season (April) actually lowers the amount of starch stored in the canes, and thereby reduces their quality as bearing wood for the following season.

(iv) *Investigations in Queensland.*—A nursery experiment area of two acres was cleared and fenced at Stanthorpe on the Government Reserve and is now available for planting. The year's work mainly consisted in surveying orchards and in propagating material. The stocks recently imported from East Malling rooted well in the stoolbeds and give promise of satisfactory propagation in the district. The stooling ability of four Merton stocks was examined and as a result one was rejected. Selected local stocks were propagated and certain of them retained for experimental work.

A survey of the rootstocks in use in the Stanthorpe district shows that 93 per cent. of the trees examined are on Northern Spy stock. Among the 7 per cent. other stocks a promising unknown one has been observed and from it a clonal race is being established.

3. *Wheat Investigations.*—As noted in previous reports the programme of wheat investigations includes studies of flag smut, root-rots, disease resistance, yield, quality and drought resistance. In connexion with the last the immediate object of the investigations is not so much to develop wheats suitable for dry areas as it is to determine methods of measuring drought resistance capacity with a view to utilizing such methods in bringing about improvements in yield and quality.

(i) *Flag Smut.*—Investigation of distortion and spotting of wheat seedlings infected with flag smut was continued and some of the results were published in the Council's quarterly Journal. The occurrence of the symptoms showed plainly that wheat varieties, whether " susceptible " or " resistant" were all equally susceptible to infection when germinated under the soil temperature and moisture conditions ordinarily prevailing during the sowing season. Evidently resistance as ordinarily understood is resistance to the development of the usual field symptoms. Variation of the temperature conditions after germination appeared to be the principal factor influencing the extent of the damage caused by the disease. Experiments involving controlled soil and air temperature conditions are in progress. Another interesting and significant effect of flag smut, not hitherto reported nor apparently suspected, is the reduction of the root system of infected plants.

In the course of analysis of data collected in previous years it has been found that a test for reaction to flag smut in the F2 generation and subsequent selection of the healthy plants is useless from the point of view of obtaining resistant strains. It is evident from the analysis that the first test should be made in the F3 generation and selection based on the results of the progeny tests therefrom.

An experiment has been set up to determine whether there is any association between yielding ability and reaction to flag smut, using the F3 generation of crosses Cadia-Geeralying, Federation-Nabawa and Nabawa-Bobin.

(ii) *Root-rots.*—During November, 1934, a tour was made through parts of the Riverina, Mallee and Wimmera to make observations on certain environmental factors and to collect specimens for further study of the distribution of the causal organisms. Microscopic and cultural work on the collections confirmed the results of previous surveys in which it was found that the three organisms commonly associated with the disease are not restricted to special zones, but may be found together in wheat fields in any section of the areas visited.

The present knowledge indicates that little, if any, help towards the solution of the problem may be expected from studies of comparative resistance, since no resistant varieties have been found in this group of diseases. The distribution of organisms in the field, as noted already, would complicate breeding for resistance, even assuming it were possible.

Work on *Wojnowicia graminis* was continued during the year. The results show that even though widely distributed it is of little, if any, economic importance. A paper on this organism in relation to the foot rot problem is approaching completion. Greenhouse and field studies of the pathological conditions with which *Fusarium culmorum* and *Ophiobolus graminis* are associated are being continued. This group of diseases is proving extremely difficult to understand and therefore progress is slow.

(iii) *Yield.*—The variety experiments in which approximately one hundred varieties were grown at Canberra, Wagga, Adelaide and Merredin, were reasonably successful. Dry weather interfered with the early plantings at Merredin and Adelaide, more particularly the former. Data on many plant characteristics were obtained and these are in the process of analysis. Similar experiments with improved technique were laid down at the same stations this year.

Experiments have been commenced to determine the value of highly fertile soil and of wide spacing for differentiating varieties and strains with respect to yield.

Further work on the analysis of yield in wheat varieties has been continued and supports the conclusions previously reported.

Investigations on plot technique have yielded useful information for the conduct of future experiments.

The work on inheritance of yield of the preceding year has been a continuation and development of that of the year 1933–34. The broad objects of this work are (1) to study the inheritance of yield, and its components, in wheat, and (2) to obtain information whereby wheat breeding technique may be improved.

(iv) *Drought Resistance.*—The use of salt and sugar solutions as selective agents for breeding drought resistant types has been suggested by certain Russian workers. This was tried with a salt solution on an F2 generation of the three crosses Hope-Gluyas, Comeback-Clarendon and Canberra-Clarendon, at Canberra. The plants derived from seeds which were germinated in the salt solution gave a definitely inferior yield to those which were germinated in water. This, however, may have been merely an immediate result of the treatment. In order to test this further the F3 generation of this material is being grown at Merredin.

The work on the water relations between the plant and the soil and other factors mentioned in the previous report were completed and repeated on the same varieties during the past year. It was found that the general level of the " bound " water in the leaves, during the dry period October and November, was highest in the variety Currawa, lowest in Major, and intermediate in Federation.

Three varieties of wheat were employed in transpiration studies, listed in order of their reputed drought resistance, viz., Steinwedel, Federation, and Bena. Under conditions of optimum soil moisture, the order of magnitude of the transpiration rate was Steinwedel, Federation, and Bena. Under conditions of soil drought Steinwedel reduced its transpiration rate by more than either of the other two varieties, and Federation to a greater extent than Bena, suggesting that drought resistance lies in the ability to reduce water loss once wilting has commenced. Samples were taken for their water content after various periods without water, and a statistical analysis of the figures obtained shows that on the whole there was more moisture in the leaves of Steinwedel over the whole period than for Federation or Bena, and that for the same period the leaves of Federation contained more moisture than those of Bena, the results supporting the transpiration studies.

4. *Plant Introduction.*—During the year 300 plants, chiefly grasses and legumes, were brought in for trial, making the totals 902 for grasses and 879 for legumes. According to whethes they are more suited to southern or northern conditions they are first tested at Canberra, F.C.T., or Gatton, Queensland, and later if suitable, in other areas. The importance of this work, particularly in the case of legumes for northern areas, calls for the use of a trial area considerably further north.

In plot trials at Canberra such grasses as *Agropyron cristatum, Festuca elatior, F. Mairei, Bromus inermis,* &c. have demonstrated their persistency and palatability. Hairy Peruvian, Chinese and Cape varieties of lucerne continue to give good yields and sulphur clover (*Trifolium ochroleucum*) made the best showing among clover introductions. Among other promising legumes are *T. repens giganteum* (from Russia), Kenya clover (*T. Johnstoni*), *T. tumens* and *T. canescens* from Transcaucasia. A noteworthy incident of the trials was the fact that *Lespedeza striata* (common Japan clover) and *L. stipulacea* (Korean Japan clover) re-established themselves at Canberra from seed produced there in the summer of 1933–34.

In tests conducted at Gatton, *Digitaria pentzii* (woolly finger grass) and *Brachiaria brizantha* are particularly promising grasses with a dozen others quite good. The guinea corns Kaura, Fara Fara and Jar Dawa have also given striking results. Among the legumes the outstanding features were the remarkably promising growth, in sandy loam soil, of *Stylosanthes guyannensis*, a Brazilian perennial pasture legume, and the differences shown between different species and strains in *Lespedeza* with respect to self regeneration. An interesting fact is the use now being made of crotalarias, distributed originally from the Division, in the cultivation of pineapples on certain soils in Queensland.

Steps have been taken to multiply seed of the varieties for which the more promising results have been obtained, so as to meet the increased demand for supplies. During the year 1934–35, 223 samples of seed were distributed, making the total to date 1,442 lots of seed throughout the Commonwealth.

The plot of pyrethrum was continued under natural climatic conditions, giving an average yield of 765 lb. dried heads per acre as against 760 lb. for 1933 and 1,190 lb. for 1932.

5. *Agrostology.*—(i) *Detailed Study of Introduced Grasses.*—Special attention was again paid to the grasses noted in the previous report, and a pamphlet has been prepared for publication on *Brachypodium phoenicoides.*

Root studies of *Agropyron cristatum* and *Agropyron intermedium* grown in Duntroon red soil were carried out during the year. The roots of the former are on the whole evenly and vertically distributed, and reach a depth of four feet; secondary roots, at right angles to the primary roots, occur near the surface but no rhizomes develop. The roots of the latter grass spread to a width of 4 feet and penetrate to a depth of 3½ feet and a good development of rhizomes occurs. The root development of both grasses fits them well for pasture purposes, the rhizomes of *A. intermedium* favouring it more from this standpoint.

Seed germination studies and selection of strains have been carried out with *Phalaris coerulescens*, *Brachypodium phoenicoides*, *Festuca Mairei*, *Agropyron cristatum*, and *Agropyron intermedium*. Optimum temperature for germination of seed of *Ehrharta erecta* was found to be 29°C.

(ii) *Native Grasses.*—Observations made during the study of Kangaroo grass (*Themeda australis*) led to the conclusions that (1) though this grass (like many other Australian plants) normally reproduces very badly, it fully re-establishes itself in the community during occasional "irregular" seasons (seasons of good summer rainfall); and (2) whereas plants normally do not produce flowering shoots during their first year of growth, yet many plants grown from seed produced in an "irregular" season develop flowering shoots in a succeeding "irregular" season.

In studies seeking to determine the effects of soil aridity on the growth and xerophily of *Themeda australis* the following conclusions were arrived at:—(1) The rate of growth is approximately the same for both 70 per cent. and 45 per cent. soil saturation, but plants in soil 40 per cent. saturated grow at half this rate, this suggesting that there is a critical soil saturation (just above 45 per cent.) which exerts a profound influence on plant growth, and (2) under constant atmospheric conditions, increase in the water content of the soil (above the critical value of 45 per cent.) has no effect on either growth rate or transpiration. Arising from this is the strong suggestion that both growth and transpiration are controlled by the water-supplying-power of the soil in that it affects the water-balance of the plant.

Root studies of *Themeda australis*, grown in soil of sandstone talus slope origin, showed that the grass has a horizontal root spread of 6 feet and a penetration of 4 feet. There are a large number of surface roots as compared with the deep penetrating roots. The primary roots that do penetrate come out horizontally for about a foot from the plant before moving vertically. Directly beneath the plant the roots penetrate to approximately 18 inches. The type of root system renders *Themeda australis* unlikely to withstand heavy grazing.

(iii) *Plot Studies.*—Studies of persistency, palatability and productiveness are being carried out on swards of some 50 grasses and a paper has been published dealing with results over a period of two and a half years for 22 of them. In another study the inter-relations of individual grasses and legumes in sixteen mixtures subjected to differential mowing and pasturage are being determined at Duntroon, F.C.T.

(iv) *Pasture Map of Australia.*—The preparation of the base map, showing the various zones into which the plant cover of the Commonwealth has been classified, is completed and the descriptive text to accompany the map, having been reviewed by the several State authorities, is being prepared for printing.

(v) *Standardization of Common Names.*—The common names used for grasses and legumes grown in Australia have been tabulated and standard names suggested for adoption. Upon the receipt of the views of all States the names will be presented for publication.

(vi) *Lists of Introductions.*—During the year a record in chronological order was completed of cereals, grasses, legumes and miscellaneous forage plants introduced by the State Departments of Agriculture during the last 25 years.

6. *Noxious Weeds Investigations.*—Weeds have become increasingly important through natural spread, and attention has been focussed on the problems of control. A report was prepared, dealing with the general position and especially with the most important weeds, embodying proposals for future work. These have been considered by the Executive Committee of the Council and the Standing Committee on Agriculture and steps taken to prosecute investigations into some of the most pressing problems.

(i) *Skeleton Weed* (*Chondrilla juncea*) has become much more prevalent of recent years, especially in the Wagga district. A joint committee of the New South Wales Department of Agriculture and the Council prepared plans for experiments on control at the Wagga State Farm from a chemical and cultural point of view. More recently other experiments have been set out and a study of the life history of the weed has been commenced, together with investigations seeking an efficient herbicide or other means of control.

(ii) *Nut Grass* (*Cyperus rotundus*).—A comprehensive set of tests, both of cultural and chemical methods of control, was prepared for the Principal of Gatton College, Queensland, and after consideration it was decided that they would be tried on a suitable area on the College holding.

(iii) *Noogoora burr* (*Xanthium pungens*).—Burrs of this weed were collected in 1929 and kept dry until October, 1933, when they had a germination of 84 per cent. They were then buried at a depth of one foot and a sample taken a year later (October, 1934) gave a germination rate of 40 per cent.

(iv) *Other Weeds.*—With the transfer of the officer concerned work on Cape tulip (*Homeria collina*), which was commenced in South Australia, is being continued in Canberra.

A major feature of the programme for the future has to do with weeds of pastures notably such as *Bassia Birchii* and the various burrs.

7. *Tobacco Investigations.*—(i) *Diseases.*—(*a*) *Downy Mildew or Blue Mould.*—As experience in north Queensland had shown that copper emulsion and colloidal copper sprays were effective in controlling this disease, they were tried at Ashford in co-operation with the New South Wales Department of Agriculture, at Deniliquin, New South Wales, and at Wangaratta, Victoria. Bordeaux mixture was also used. In general, the sprays were not as effective as under north Queensland conditions, although useful control was obtained with copper emulsion and colloidal copper.

Tests of the Bathurst type of seedbed in which the air temperature is not allowed to fall below 45°F. were made at Ashford, New South Wales, and Wangaratta, but the seedlings grown in them were attacked by downy mildew.

The occurrence and progress of the disease at Canberra, Ashford, Deniliquin and Wangaratta, were studied in order eventually to determine the meteorological conditions which favour serious outbreaks of disease in seedbeds.

As the disease is less serious in some areas than in others, data on epidemic potentiality were obtained for a few districts. The aim of these investigations is to determine the areas where growers can raise seedlings with a reasonable prospect of successful results. Overwintering diseased plants were again prevalent early in the season, and later on, downy mildew was epidemic on *Nicotiana glauca* at Cobram, Victoria. The disease was also found on this host at Charters Towers, Queensland, in August.

In October, 1935, 1924 experiments were begun on the use of vapours of various hydrocarbons for the control of downy mildew. Many substances were tried, the best results being obtained with benzol and toluol. Following many laboratory experiments a large scale trial was set up in the autumn in the tobacco-growing area at Eurobin, Victoria, in a battery of commercial frame seedbeds, each measuring 20 x 6½ feet. Different concentrations of vapour were obtained by varying the area of benzol or toluol exposed to evaporation. Despite the fact that the seedlings were heavily inoculated three times during the trial no downy mildew occurred in those seedbeds where the proportion of two square inches of evaporating surface of benzol to one square foot of seedbed was maintained. Where lesser quantities were used, some disease occurred and where excessive quantities were used, plant growth was adversely affected. All plants in the control beds were killed by the disease.

This method of prevention of the disease necessitates the construction of frame seedbeds and very careful attention to seedlings to obtain a full stand of plants. It is considered that the cost will not be excessive. Experiments under spring conditions are, however, necessary before the methods can be recommended for use on a commercial basis.

It would be possible to prevent outbreaks of downy mildew by the use of resistant varieties, but as the commercial varieties grown in Australia are so closely related to each other and all are susceptible they are comparatively useless for breeding purposes. With this in mind the Standing Committee on Agriculture recently decided to ascertain whether funds could be provided for an exploration to be made in Central and South America for the purpose of collecting possible resistant strains of *Nicotiana* species and *N. tabacum* varieties.

(*b*) *Leaf-spot or Frog-eye* (*Cercospora nicotianae*). The field studies at Mareeba were concluded in August, 1934, and further experimental work was continued in the laboratories at Canberra. As mentioned in the previous annual report of the Council, the use of disease free seedlings is essential for the control of this disease under north Queensland conditions.

Attempts at control in the field are seldom, if ever, effective in themselves, but may assist in checking the spread of the disease if unfavorable weather conditions occur. Priming of diseased leaves is strongly recommended in other countries for the control of this disease, but under north Queensland conditions, it is only partially effective, even though done early in crops where comparatively few diseased plants occur. It is useless in mature crops when conditions are favorable to an epidemic. The results of this investigation will be published at an early date.

(*c*) *Other Diseases.*—Virus diseases were increasingly noted in two States and a condition known as field dwarfing occurs in several States, due possibly to any one of several causes. Attention will be given to these during the coming season.

(ii) *Smoking Tests.*—Adequate quantities of leaf representative of the 1933–34 crop in each important tobacco-growing district have not been received from all States and so full continuity in smoking tests and processing trials cannot be maintained. The grades being supplied fall mainly into the medium pipe type.

(iii) *Curing Experiments.*—The experiments inaugurated in 1932 were continued and somewhat extended during the past season and the leaf has been packed for ageing. Smoking tests on leaf from previous trials showed that in 47 instances samples cured by a ten-day process were better than a six-day process while in nine instances they were equal. It is to be recalled that the leaf used was heavy-bodied and tended to be immature at harvest.

(iv) *Chemical Investigations.*—Continuing the studies of smoke from " good " and " bad " leaf, as determined by smoking tests, confirmation was obtained of the fact reported last year that smoke from bad leaf is alkaline. Since the alkaline substances contain nitrogen and must be derived from the breaking down of nitrogen constituents of the leaf it may be assumed that a high nitrogen content relative to organic acids and sugars is indicative of poor tobacco. Preliminary studies support this view.

Chemical analyses of leaves in all stages of development have been commenced and these, while not yet complete, show that during maturation on the plant there is an extensive degradation of protein substances into water-soluble materials which migrate via the midrib into the stem. A similar breaking down occurs during the curing processes but no way of exit from the leaf is available, since the leaf is no longer on the stalk. Consequently, harvesting too early anchors an excessive amount of nitrogenous substances in the leaf and, although they may be changed during curing, they are not removed. These tentative conclusions call for much more work and a closer scrutiny of all changes occurring during growth and curing.

8. *Pea Disease.*—Continuing the work on root rot of peas in Tasmania, the organism causing the major losses was studied in pure culture and its pathogenicity tested under various conditions in the greenhouse and field. Under conditions in Canberra the addition of urea to infested soil significantly reduced the extent and severity of the disease. Trials are now being made in the pea-growing districts of Tasmania with a view to determining whether this fertilizer will give field control of the disease.

9. *Needle-fusion of Pines.*—Neither grafting experiments nor trials of the transference of Chermes insects have yet given evidence upon which to determine whether this disease is due to a virus or not, but by analogy with known virus diseases of trees, it may be that the development of symptoms will require more than one year. Of several hundred seedlings, now two years old, grown at Canberra from seed collected from diseased trees, only one has shown symptoms of needle-fusion.

The possibility that the disease may be due to some mineral deficiency is in mind and various substances are being added to the surrounding soil, or plugged into the trunk or injected in dilute solution into the transpiration stream. Progress in this investigation will necessarily be slow.

10. *Fungal Discolouration of Paint.*—Fungal discolouration of painted surface is one of the relatively minor applied mycological problems under investigation. Originally begun because of its being widespread in Brisbane and certain other places in Queensland, it now commands

more interest on account of the discolouration of oiled calico covers of tobacco seedbeds in Canberra and the Ovens River Valley. Seed bed covers in the latter area are useless after a season's wear, owing to the reduced translucence caused by discolouration. The exposure of painted wood panels in a similar construction may expedite the work in the general problem. The panels now being exposed in Brisbane at the University of Queensland are designed to indicate to what extent variations in the vehicle may influence the intensity of discolouration.

11. *Maize Breeding.*—A general report on the maize breeding work being conducted at Gatton was published in the Council's quarterly Journal. The work continues to be promising and crosses which were superior in 1934 were again superior this year. Selection in "sib-crossed" lines is being continued.

12. *Herbarium.*—Acknowledgment is made to Canon C. E. Burgess of Goulburn for the gift of a collection of Hawaiian ferns from a standard set collected by D. D. Baldwin. Over 200 specimens were poisoned, mounted and incorporated in the Herbarium during the year.

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 the 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 in 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.

Progress during the year 1934–35 has been mainly in three directions, in the improvement of methods of investigation, in the application of the results of research to the practical control of pests, and in the expansion of work on particular investigations.

In the last annual report, mention was made of the importance of developing reliable methods for investigating biological problems. Since then, the method of using laboratory colonies of termites for timber testing and the methods of testing traps and baits for blowflies have been brought to a satisfactory degree of accuracy and put into practical use in testing work. The method of field testing of timber samples for termite damage has been greatly improved and should shortly become a reliable working tool. Methods of producing artificial blowfly strikes on sheep in the insectary have been so improved that it is now possible to produce any number of strikes on any merino sheep at any time of the year, irrespective of the condition of the sheep or of the season. These advances have made possible a great deal of applied research that was previously out of the question; some of them have already borne fruit in practical control.

Progress in the application of the results of research to the practical control of pests is shown in the development of an improved dressing for the treatment of blowfly strikes, in the development of a cheap and efficient method of destroying white ants in mounds and in timber, in the control of garden snails, and in the control of silverfish in houses. A small but useful achievement in the field of biological control has been the establishment and distribution of the parasite of the greenhouse white-fly. The most important expansion of activity has taken place in the noxious weeds investigations which have been widened to include cultural and chemical as well as entomological control, and also to include the study of certain important weeds that were being investigated previously. These investigations are now administered jointly by the Division of Economic Entomology and the Division of Plant Industry. The research into pasture pests has also been expanded to include a more thorough investigation of plague grasshoppers, and at the request of the Department of Agriculture of Victoria, an investigation of the Oriental peach moth has been commenced.

2. *Noxious Weeds Research.*—A survey was made during the year in the whole weeds problem of Australia, as a result of which sixteen weeds have been selected as of major importance, and arrangements have been made for the expansion of the investigations so as to include all phases of weeds research. The work abroad has been extended by the establishment of a field station in the south of France, where the search for natural enemies of many important weeds of Australia can be most effectively undertaken.

(i) *St. John's Wort* (*Hypericum perforatum*).—Further consignments of *Chrysomela hyperici, Chrysomela brunsvicensis, Lathronympha hypericana, Aphis chloris* and *Anaitis plagiata* were sent from England to Australia during the year, and an additional insect, *Depressaria hypericella* was also introduced, while observations were commenced on a Buprestid beetle, *Agrilus hyperici,* which attacks St. John's wort in the south of France. Adults of *Chrysomela hyperici* and *Ch. brunsveicnsis* were liberated in Victoria, but subsequent observations indicate that few survived. Starvation tests of *Aphis chloris* and *Anaitis plagiata* have been completed, and these species will be liberated when sufficient numbers are available.

(ii) *Noorgoora Burr* (*Xanthium pungens*).—Over 13,000 *Euaresta aequalis,* imported from America, have been sent to Queensland and distributed there by officers of the Prickly Pear Board. In starvation tests in Australia, it has been found that the adults of *Baris callida* will feed on artichoke leaves if nothing else is available, and the previous observation that *Cylindrocopterus adspersus* would feed on sunflower and Jerusalem artichoke has been confirmed. Liberation of these insects will therefore not be considered at present. Another insect, *Epiblemma strenuana,* is being studied in America ; tests so far carried out suggest that it feeds exclusively on *Xanthium* species.

(iii) *Ragwort* (*Senecio jacobaea*).—Consignments of *Tyria jacobaea* have been liberated in Victoria. It is not yet known whether this species has become established.

(iv) *Other Weeds.*—The life-histories of numerous insects which attack Mexican poppy (*Argemone mexicana*) and ground cherry (*Physalis lanceolata*) in America are being studied. Both these species are weeds of some importance in Australia. Inquiries made in Russia indicate that some 40 species of insects are known to attack skeleton weed (*Chondrilla juncea*) in that country. It is not yet known whether any of these are effective in destroying the plant.

3. *The Buffalo-fly Pest* (*Lyperosia exigua*).—An investigation in Western Australia has shown that the buffalo-fly has not extended its range during the past four years, its southern limit being still at Wallal. The country to the south and south-east of Wallal is too arid and the cattle population too discontinuous to favour further spread, even with mobs of travelling stock. Danger to the south-western part of the State is for practical purposes restricted to the possibility that the fly may be transported by ship from the endemic areas in the north. Stringent precautions against either adult flies or puparia in dung being brought ashore at Fremantle should consequently be maintained. These precautions are the more necessary, as it was found that the country south of Perth, and particularly the strip of coastal diarying country between Perth and Busselton were eminently suitable for the propagation of the fly.

The liberation of parasites in Queensland, North Australia and Western Australia has been mentioned in previous reports. No evidence was found at Broome of any appreciable reduction of buffalo-fly abundance, but it is proposed to carry out a survey of fly and parasite incidence in north Australia next autumn before forming an opinion on the results of liberations.

4. *The Sheep Blowfly Pest.*—(i) *Studies of the Flies.*—Recent work in Western Australia has shown that *Lucilia cuprina,* the most important primary sheep fly, is now widely distributed in that State from Wallal in the north to Mount Barker in the south and as far east as Lake Mason. It has also been found in north Australia and in north-west Queensland. There is good evidence that the extension to the remoter districts has been recent, and has been due partly to travelling fly-struck sheep and partly to natural dispersal. Studies of hibernation indicate that *Lucilia sericata* is better adapted to live in cold climates than *L. cuprina,* and that both are better adapted to cold climates than the hairy-maggot-fly, *Chrysomyia rufifacies.* Nutritional studies have been continued and it has been found that adult female flies require repeated feeds of protein in order to continue maturing eggs throughout life ; this protein may be obtained from meat juice, but not from moistened fleece. The findings of Hobson in England that certain bacteria synthesise accessory food factors necessary for the growth of maggots have been confirmed.

A satisfactory method of testing having been developed, considerable attention has been paid to the study of substances which attract or repel blowflies. The objects of this work are, firstly, to discover precisely what chemical compounds attract *Lucilia cuprina* to the live sheep ; secondly, to make baits more specifically attractive to *Lucilia cuprina* ; and thirdly, to throw

light on substances that may be used for treating carcases, for jetting or dipping sheep, of for the treatment of struck sheep. With these objects in view, some hundreds of experiments have been carried out with natural baits, with standardized baits treated with various chemicals, with baits in which natural bacterial decomposition has been replaced by controlled chemical decomposition, with fractions obtained from natural baits by various physical and chemical means, and with individual chemical compounds that are known to occur in the decomposition of proteins. This work is in a comparatively early stage, but promising results have already been obtained. Relatively simple attractive fractions have been produced; the suggestion has emerged that attractiveness may be bound up with the sulphur linkage in protein; substances have been discovered that may be more efficient that sodium sulphide for treatment of baits; and indications were obtained which led to the development of an improved dressing for treatment of struck sheep.

(ii) *The Problem of Susceptibility.*—Numerous anatomical, physiological and pathological conditions of the sheep are now known to influence its susceptibility to blowfly strike, but the mechanism of their operation has in many instances not been clearly understood. In order to elucidate these mechanisms, it was first necessary to reduce the production of experimental strike to its simplest possible terms. This has now been done, with the incidental result that the amount of experimental work that can be done in a year has been more than doubled. It has also supported two conclusions, viz., (*a*) that the primary factor in susceptibility is the presence of free moisture in the fleece and on the skin; and (*b*) that the other factors mentioned above operate either by supplying the moisture or by ensuring its retention long enough for the area to become attractive and the maggots to become established, or by shortening the period for which the skin must remain wet. Quantitative work has shown the importance of those factors which influence attractiveness to the flies, for it has been found that there is a direct relation between the number of eggs placed on an area and the probability that a strike will develop.

(iii) *The Prevention of Strike.*—(*a*) *Carcass Disposal.*—This method of reducing the abundance of blowflies may be usefully employed in open, heavy carrying country, in which dead animals may be found and treated without undue expense or difficulty. Numerous experiments have been carried out and have shown that inefficient treatment with poisons results in an increased emergence of primary flies, that most poisons are spread through the carcass not by natural diffusion nor by the primary maggots, but by the secondary hairy maggots, that thorough application of a poison to every part of a carcass is necessary in order completely to prevent emergence of blowflies, and that sodium fluoride as a powder, or sodium arsenite in solution, are still the best substances known for treatment of carcasses.

(*b*) *Trapping.*—The experiment at Therribri, New South Wales, has been completed, but that at Cranmore Park, Western Australia, could not be finished last season owing to the absence of strike. The results of these experiments to date strongly suggest that intensive trapping does reduce the incidence of strike, but they do not indicate whether trapping is an economically practicable control measure. They do, however, justify further investigation of traps and baits. Field studies indicate that satisfactory results can be obtained only by using large traps containing large chemically treated baits. Poisoned baits so far studied have not proved satisfactory, few primary flies being destroyed, but a new method of attracting and poisoning flies has been evolved and is being tested.

(*c*) *Management in Relation to Control.*—Field investigations in Western Australia have shown that given adequate knowledge of local conditions of sheep-raising and management, the incidence of strike may frequently be reduced by judicious alterations in station procedure. Thus, in certain districts losses from strike have been minimized by altering shearing dates. These studies have also indicated the relative value of various control measures under different station conditions, but a great deal more field work in different parts of Australia is necessary before the results of laboratory studies can be efficiently applied to general station practice.

(*d*) *The Mules Operation.*—This operation, devised and recently improved by Mr. J. H. W. Mules of South Australia, has been investigated by Seddon at Nyngan and more recently under station conditions in South Queensland. It consists of various procedures, the most important of which is the removal of the folds of loose skin on either side of the crutch. The operation improves the conformation of the sheep, and is simple, cheap and practicable. Its influence on susceptibility to strike is being investigated.

(*e*) *The Selection of Resistant Sheep.*—The influence on susceptibility to strike of certain hereditable characters of the sheep, such as conformation of the crutch (Seddon *et al.*) and wool colour, have been demonstrated. Thus, during the past two years, the wrinkly (C class) Merino sheep in the Canberra experimental flock proved to be nine times as susceptible to field strikes as the plain bodied Merinos (A class). Also, Polwarth sheep have been shown to be as little liable to

crutch strike as the plainest of the Merinos. The selection of sheep relatively resistant to strike would be easy, were it not for the fact that, under present conditions of sheep-raising, some of the more susceptible types of sheep are widely regarded as of super commercial quality in other respects. A satisfactory compromise can be reached only when the knowledge of the practical grower and that of the laboratory worker are brought together. This it is proposed to attempt next year.

(iv) *The Treatment of Strike.*—New dressings for the treatment of strike have been developed and tested under insectary conditions. These dressings consist of various esters of glycerine and boric acid. They are non-irritant to the skin, kill the maggots slowly but effectively, protect the strike wound and assist healing, and under the conditions of the experiments, effectively prevent restrike for a considerable period. Field tests have been arranged, and it is understood that production by commercial firms will shortly be undertaken.

5. *Blood Parasites of Cattle.*—Experiments reported last year as in progress have been completed, and have confirmed the conclusion that, under the conditions of the experiment, *Anaplasma marginale* was not transmitted by the stable-fly (*Stomoxys calcitrans*), nor by the common March-fly (*Tabanus circumdatus*), nor by a needle used in such a way as to simulate the bite of these flies. It is, however, transmissible by needle puncture, when the punctures are deep and the intervals between stabbing the infected donor and stabbing the healthy recipient are very short. Pure strains of *Anaplasma marginale*, *A. centrale*, and *Theileria mutans* have been maintained by sub-inoculation at Canberra, but the pure strain of *Piroplasma bigeminum* died out and an attempt to re-establish it failed, the parasites not surviving the journey from Townsville. An experiment is being arranged to determine whether the premunity to this parasite formerly established has disappeared with the dying out of the infection.

6. *Orchard and Fruit Pests.*—(i) *Peach Moth* (*Cydia molesta*).—Funds for this investigation were made available by the Canned Fruits Control Board and the Commonwealth Bank (Rural Credits Development Fund). Damage is caused partly by the larvæ tunnelling into young growing tips of the trees, but chiefly by invasion of the fruit, particularly the late canning varieties, the loss to the growers for the season 1933–34 being estimated at £70,000. Four or five broods are produced in a season. The female moths live from thirteen to 33 days and produce from 30 to 150 eggs, development from egg to adult requiring about 36 days in mid season. Larvæ of the earlier broods form cocoons high in the trees, but those developing later in the season descend to the trunk or the ground to form overwintering cocoons in which they hibernate until the following September. As the newly hatched larvæ reject the material which they bite off in gaining entrance to the twigs or fruit and as the older larvæ are protected by the plant tissues, control by means of sprays is difficult. Poor results were obtained with sprays of lead arsenate and with hydrated lime, but a dry-mix lime sulphur spray proved moderately useful and nicotine sulphate (Black Leaf 40) gave decidedly promising results, which it is proposed to follow up next season. Bandages placed round the trunks of the trees trap many larvæ that are descending to form over-wintering cocoons, and deep cultivation of the ground also destroys a number of over-wintering cocoons, as does attention to props and cases in which they are often found sheltering, but other mechanical methods of control have not given hopeful results. Native parasites attack the late broods fairly heavily but do not operate at all in the early and middle parts of the season. It is therefore proposed to introduce from America an Ichneumon parasite, *Macrocentrus ancylivorus*, which is most active during the warmer months.

(ii) *Thrips Investigations.*—The investigations on the apple-blossom thrips (*Thrips imaginis Bagnall*), referred to in the previous annual report, have been continued. Daily counts of the numbers of *Thrips imaginis* recorded in flowers in South Australia and Victoria during the past year have supported earlier interpretations relating to the correlation of meteorological events with fluctuations in the numbers of this species; in particular they emphasize the influence of the autumn weather on the "autumn rise" in numbers and the significance of this relation to the extent of the "first spring rise" the following spring. When the "autumn rise" is "large" a significant "first spring rise" may be expected; with an early and sustained warm spring the insects may increase to economic numbers. It has been shown that moderately hot days with temperatures about 75 degrees Fahrenheit or over are necessary for active movement and flight of the insects. The species may over-winter as dormant adults in sheltered situations, or as pupae in the soil. The weather during the autumn and spring did not favour the occurrence of the insects in economic numbers during the spring of 1934.

Experiments have demonstrated that the reproductive activity of *T. imaginis* is negligible when the insects have not access to flowers; pollen appears to be a necessary part of their food for this purpose. This affords one explanation of its decrease in numbers during the dry summer months, due to the scarcity of flowers, although temperature and humidity are favorable.

Experiments have been made with several insecticides with the aim of protecting fruit blossom from thrips attacks; adequate field trials have not been possible owing to the scarcity of thrips. Dusts containing kaolin or talc with from 10 to 15 per cent. derris and from 5 to 10 per cent. pyrethrum have given promising results with restricted tests. The possibility of using oil emulsions containing these insecticides has been explored.

(iii) *Codling Moth* (*Cydia pomonella*).—A committee representative of the Council and the State Departments has been formed to co-ordinate existing work and plan future investigations.

7. *Field Crop and Pasture Pests.*—(i) *Clover Springtail* (*Sminthurus viridis*).—The predatory mite *Biscirus lapidarius* is now established in South Australia, Victoria and Tasmania. Information received from Western Australia and Tasmania indicates that it is decidedly effective in parts of those States.

(ii) *Underground Grass Grub* (*Oncopera*).—A careful study has failed to reveal any useful characters by which the various species of *Oncopera* can be recognized in the larval stage. This is unfortunate, as identification of the dominant species early in the season would be of material assistance in attempts to establish parasites. Only small supplies of *Hexamera* were available in New Zealand this year, and conditions in Tasmania were unfavorable for liberation. Attempts to establish these flies were therefore confined to certain places in Victoria and to Duntroon, Federal Capital Territory. Information is not yet available about the field liberations, but the parasites do not appear to have survived in the insectary. In view of the difficulty of transporting these parasites in good condition, a study of food requirements and satisfactory caging conditions is being made with suitable Australian species of *Tachinidae*. Another Tachinid fly, *Hystricina lupina*, has recently been found in numbers in New Zealand. Should it prove to be a parasite of Hepialidae, attempts will be made to establish it in Australia. Arrangements are also in hand for the introduction of the Common Toad, *Bufo vulgaris*, which may be expected to feed on *Oncopera* larvæ.

(iii) *Grasshopper Investigations.*—Preliminary studies have been in progress for some time, and have been directed chiefly to the accurate identification of the more important Australian species, and to life-history studies of the commoner species which occur at Canberra. Investigations of the recent swarms showed that a large proportion of the females were infertile, which together with the very heavy mortality that occurred in the young hoppers of the second generation and a high parasite incidence, helps to explain the rapid abatement of the plague that occurred at the end of the season. A study of the effect of dry conditions on the eggs of some common species has been commenced. Results so far obtained suggest that the eggs of *Gastrimargus musicus*, an abundant, widely distributed species, are more resistant to drying than those of the plague grasshopper, *Calataria terminifera*. The Australian Council of Agriculture has recently recommended that the Council's work on this problem be extended, and with this end in view inquiries are being made in Egypt, Algeria and South Africa, where important grasshopper investigations are in progress.

8. *Termite* (*White Ant*) *Research.*—(i) *The Direct Control of Termites.*—Results previously reported on the control of *Eutermes exitiosus* in mounds by means of white arsenic have been confirmed, and the method has been put into practical use. It has proved to be highly efficient and extremely cheap, The same method has also been shown to be satisfactory for the control of termites in timber, provided the place of application is dry. It is now proposed to extend the investigation to other mound-building species, including those which attack pastures.

(ii) *Field Testing.*—The method of testing materials for resistance or susceptibility by placing them in the ground in the vicinity of mounds of wood-eating termites, has proved to be unsatisfactory, the results obtained from tests extending over several years being frequently so variable as to be quite unreliable. The reasons for this variability have now been determined, and improvements have been made in spacing the test samples, in treatment of the ground around the mound, and in protecting the test area, as a result of which improvements, a much more uniform attack on the samples has been obtained. This method of testing is very convenient, and there is now reason to hope that it will prove reliable. Most of the tests recorded last year are still in progress.

(iii) *Standard Laboratory Colonies.*—It was reported last year that a considerable degree of uniformity had been obtained in laboratory colonies set up for testing small samples of timbers and other materials. By careful attention to detail, as for example, by regulating the ventilation of the colonies at a selected optimum value, variation in initial population, variation in final population at the end of three months, and variation in timber consumption have all been reduced satisfactorily. Practical tests of various materials are now in progress, including Canadian Western Red Cedar, King William Pine, and composition telephone cable conduit.

(iv) *The Ecology of Termites.*—(*a*) *Mound Populations.*—The total population of an average mound of *Eutermes exitiosus*, measuring about 4 feet across the base by 1 ft. 6 in. high, was found to be about 1,800,000 termites, weighing over 17 lb. Of these approximately 1,560,000 were workers, 200,000 were soldiers, and 40,000 were nymphs which would emerge from the mound when swarming occurred. The mound is rarely fully occupied, a considerable proportion of the community working in galleries away from it except in the very coldest weather.

(*b*) *Temperature.*—The temperature within a mound is maintained by the living termites at a fairly high level, which varies with the season and with the diurnal changes in external temperature. As a colony of termites dies, the temperature gradually falls until it is the same as the surrounding soil. Temperature records are therefore now used to determine whether a mound is suitable for experimental use. These studies have also shown that the temperature selected for maintenance of the laboratory colonies is satisfactory.

(*c*) *Moisture.*—The relative humidity of the atmosphere within the populated mounds is very high, exceeding 95 per cent.; it varies slightly from mound to mound and in different parts of the same mound. The moisture content of mound material varies from a maximum at the centre of the mound to a minimum in the surface layer. Each of the three main inner regions has a characteristic moisture content, which is roughly proportional to the amount of masticated wood and excrement incorporated in its walls and which is maintained at a fairly constant level by the termites irrespective of season and rainfall.

9. *Pine Chermes.*—Further attempts have been made to establish *Leucopis obscura*, *Exochomus quadripustulatus*, and *Hemerobius stigma* on *Chermes* infested pines in the field and in the insectary. *Exochomus* was established in the insectary and bred slowly, but no success appears so far to have attended the field liberations. Lime sulphur sprays have, however, given satisfactory control of *Chermes* in field tests, both on seedlings and on older plants; the method of spraying seedlings before transplantation may help materially by overcoming heavy infestation of new plantations.

10. *Oak Scale.*—(*Asterolecaneum variolosum*).—The parasite *Habrolepis dalmani* has been established at Launceston, so there will be no need for further introductions. *Habrolepis* is a slow breeder, and it will be some years before it can make its presence felt.

11. *Greenhouse White-fly* (*Trialeurodes vaporariorum*).—The parasite *Encarsia formosa*, was introduced from New Zealand during the year. It quickly became established in a glass-house, and later on white-fly in the open and in the insectaries. Parasitism of the white-fly has been heavy, and there has been no difficulty in maintaining adequate cultures of the parasite throughout the colder months. Supplies have been sent to the Departments of Agriculture of New South Wales and Victoria, and cultures are being maintained at Canberra, for supplying other institutions when required.

12. *Bee Research.*—The purpose of this work was to discover satisfactory pollen substitutes which could be fed to the bees during periods when natural pollen is deficient. Last year satisfactory laboratory tests were made with an artificial pollen, and a large scale field experiment was set up this year in order to test the pollen substitute critically under practical field conditions. Unfortunately, conditions became unfavorable for the experiment, and it had to be abandoned. Several apiarists in New South Wales and Queensland have, however, used the pollen substitutes with considerable success.

13. *Pests of Stored Foodstuffs.*—Cultures of the important pests, *Plodia interpunctella*, *Ephestia cautella*, and *E. elutella* are being maintained in the laboratory for experimental purposes. It has been found that the larvæ can easily penetrate ordinary wrapping materials, such as tinfoil, aluminium foil, and greased paper, and that wire gauze of not less than 18 meshes to the inch is necessary in order to keep them out. The use of electrocuting and fan traps for the control of these and other factory pests is being investigated in Melbourne. An experiment is being undertaken to test a method recently devised in America for the control of the grain weevil, *Sitophilus oryzae*. The method is to treat the grain with calcium carbonate. The results so far obtained indicate that the weevils prefer wheat to polished rice and that the increase in weevil infestation is much smaller in the treated grain than in the untreated grain.

14. *Mound Ants* (*Iridomyrmex detectus*).—Tests of various insecticides, fumigants and baits have been made on about 140 mounds. No completely satisfactory method of control for general use has been devised, but fumigation with carbon bisulphide has given fairly good results, while calcium cyanide is useful for treating small mounds.

15. *Silverfish* (*Ctenolepisma longicaudata*).—These insects have become increasingly important as pests of houses, offices and libraries in Canberra. Various poisoned baits were tested without success, but eventually very good results were obtained with a bait composed of a mixture of flour paste, sugar and barium fluosilicate spread on cards.

16. *Garden Snails.*—The good results obtained last year from dusting with calcium arsenate have been confirmed and satisfactory kills have also been obtained with improved poison baits. By using these methods in appropriate situations together with sodium fluoride on neighbouring rank herbage, effective control of garden snails should be quite practicable.

17. *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 2,000 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 Acridoidea, Tachinidae and Tabanidae. In the work on the Acridoidea, great assistance has been received from Professor Sjostedt of Stockholm, and the collection now contains 116 of the 430 recognized Australian species. Other systematic work undertaken has included a revision of the Dipterous genus *Fergusonina* and further revisional work on the termite genus *Eutermes*. 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. A problem of some importance to bee-keepers is the formation of galls on eucalyptus trees, with a consequent reduction in the available honey and pollen. It has been found that these galls are caused by various species of the fly genus *Fergusonina*, working in association with Nematode worms, and the details of the association have been investigated. Few life-histories of Australian March flies (Tabanidae) are known. During the year, the breeding grounds and early stages of *Scaptia auriflua* have been discovered ; this species belongs to an important group of Tabanidae, of which previously nothing was known. The insect which produces " scribbles " on eucalyptus trees has been discovered ; it proved to be a moth belonging to the family Elachistidae. Other life-histories studied include various Rhyphidae, *Calliphora tibialis*, which parasitises earthworms, and *Locustivora* sp. which is parasitic on the plague grasshopper.

18. *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. During the year, Tachinid parasites of *Gonipterus*, Tachinid parasites of the larvæ of *Paropsis hymenopterous*, and egg parasites of *Paropsis*, and *Thynnidae* were successfully sent to New Zealand. The first three are for the control of pests of eucalyptus trees, and the *Thynnidae* are for the control of curl-grubs. Consignments of parasitised eggs of *Gonipterus* were also sent successfully to South Africa.

19. *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. ANIMAL HEALTH INVESTIGATIONS.

1. *General.*—Reference has already been made in this report to the appointment of Dr. L. B. Bull, D.V.Sc., as Chief of the Divisions of Animal Health and Animal Nutrition. Prior to his appointment by the Council, Dr. Bull was in charge of the Government Laboratory of Bacteriology and Pathology at the Adelaide Hospital and was closely associated with certain investigations conducted by the Council.

The Council is gratified that it has been able to retain the services of Dr. J. A. Gilruth, who was formerly the Chief of the Division of Animal Health, as consultant to that Division, and it desires to place on record its appreciation of the valuable services rendered by him during the period for which he occupied the former position. His wide knowledge of animal health problems, his practical experience in veterinary matters, his scientific attainments and his administrative ability, combined to make his services of particular value to the Council during the initial period of the organization and development of the work of the Division. The activities of the Division are of a complex and widespread nature, extending from northern Queensland to the eastern and southern States, to Tasmania and to Western Australia. During the period for which Dr. Gilruth was Chief of the Division of Animal Health, notable advances were made in the work. Several problems of great economic importance and of scientific interest were solved and the results are now being applied extensively. The Division has established international reputation for the high quality of its scientific work.

2. *Research Station at Townsville, Queensland.*—(i) *Pleuro-pneumonia in Cattle.*—The investigation into the development and application of a complement-fixation test for the diagnosis of contagious bovine pleuro-pneumonia, that was discussed in the last report, has been very

satisfactorily concluded and an exhaustive report has been prepared on the technique of the test, the interpretation of the re-action and the use of the test both in experimental work and the control of the disease. Its reliability and freedom from false results have been amply demonstrated not only by the elaborators of the test (Mr. A. D. Campbell and Dr. A. W. Turner), but also by Dr. H. E. Albiston in Victoria and Dr. H. R. Seddon in New South Wales.

The morphology and phylogenetic relationships of the causal organism has been studied in the living state by observation under dark-ground illumination, and the conclusion reached that it is no filtrable virus in the strict sense, but a delicate, long, branching, serophilic micro-organism, with several alternative methods of reproduction and a marked tendency to produce filtrable forms ; the suggestion has been offered to set up within the class Schizomycetes a new order Borrelomycetales, containing a family Borrelomycetaceæ and a genus *Borrelomyces* to include it and the closely related organism of contagious agalactia of goats.

The above study has in turn led to the development of methods of staining the causal organism and thus demonstrating it microscopically in the tissues of infected animals, a procedure that is expected to help considerably in the elucidation of the exact method by which the organism gains entrance to the body and multiplies therein. The demonstration that goats and sheep are susceptible to the micro-organism, at least when administered subcutaneously, has opened up a wider field for experiment.

One of the most puzzling aspects of pleuro-pneumonia has been hitherto the alleged impossibility of experimentally reproducing it in all its clinical and pathological features, and, therefore, the final proof that Nocard and Roux's organism (referred to above as *Borrelomyces*) is the causal organism of the disease has been lacking. All doubts have now been removed by Mr. A. D. Campbell and Dr. J. A. Gilruth working at the Melbourne Veterinary Research Institute where they have repeatedly produced typical pleuro-pneumonia in cattle by exposing them to an atmosphere in which was suspended finely atomized culture, prepared from strains of the organism isolated and repeatedly sub-cultured for over twelve months. The cultures used have been grown in the B.V.F., O.S. medium elaborated by Turner, Campbell and Dick.

Cultures in this medium have also been extensively used as vaccine against pleuro-pneumonia, ingested subcutaneously at the tip of the tail by the well-known Willemsian method, as mentioned in the last report. Arrangements are now in force whereby the Townsville Research Station prepares and distributes pleuro-pneumonia vaccine on behalf of the Queensland Department of Agriculture and Stock. Over 10,000 doses were sent out from Townsville during the year 1934-35, which is a slight decrease over last year, this being wholly referable to the intense drought and the consequent restriction in the transfer of stock.

Experiments both by exposure to natural infection at Townsville and to artificial infection by the inhalation method at Melbourne have demonstrated the value of this vaccine as a preventive. It has all the advantages and none of the disadvantages of the " natural virus," although it may also occasionally produce excessive reactions. Work is proceeding on the reduction of virulence of the vaccine in the endeavour to make the " culture vaccine " less severe than the " natural virus."

A question of great practical importance is the duration of immunity, concerning which very little controlled experiment has been performed in the past. With the active help and provision of 332 head of cattle by Mr. J. L. Wilson of Calliope, an experiment has been commenced to determine this point, and at appropriate intervals batches of vaccinated and unvaccinated animals will be tested for resistance to the disease.

(ii) *Peg-Leg Disease.*—Since the last report, the projected work on the confirmation and extension of the 1933–34 experiments was commenced on a more satisfactory scale under conditions more closely approaching grazing conditions. The disastrous drought, however, nearly caused the total abandonment of the work for the year ; it was necessary to disband some of the groups for several months and remove them to the vicinity of water, and one group, designed to test the preventive value of licks, is still disbanded. Accordingly, this phase of the investigation has suffered a considerable set-back, but efforts are being made to recommence sections of the experiment as environmental conditions permit.

(iii) *Tick-Fever and Dipping.*—In the last report it was stated that experiments were being conducted to determine whether inoculation of cattle with *Anaplasma centrale*, obtained from South Africa, would protect them from subsequent infection with the virulent Australian strains of *Anaplasma marginale*. These experiments have shown convincingly that a very considerable measure of protection is afforded.

Dr. Legg has proceeded temporarily to the Animal Health Station, Yeerongpilly, Brisbane, to prepare reservoirs of *Piroplasma bigemium* and *A. centrale*, which will be used by the Queensland Department of Agriculture and Stock to supply blood for vaccinating stock against the three forms of tick-fever in Queensland, viz., infections by *P. bigeminum*, *Babesiella bovis* and *A. centrale*.

The insidious natural spread of *A. centrale* among cattle at the Townsville station, kept absolutely free of all ticks by regular dipping, has led to the recognition of the possibility that biting winged insects or crawling insects may be acting as the vectors. Accordingly, plans are being prepared for the erection of an insect-proof isolation block for the satisfactory maintenance of reservoirs and of experimental animals.

3. *Zebu Importations.*—On a recent inspection, the Council's geneticist (Mr. R. B. Kelley) found all the imported cattle in good condition, notwithstanding the severe drought which had been experienced in the various districts wherein they are located. One hundred and thirty-nine calves had been born in the experimental herds up till the end of June, 1935, and a number of mated cows had not then calved. On the property near the Gulf of Carpentaria, which had experienced the most prolonged dry weather, the owners reported that the cross-bred calves "were remarkably well grown and much bigger than the British breeds of the same age." At the coastal station where regular weighings are possible, the average weights of the half-bred calves exceeded those of the pure-bred Herefords of comparable age by 90 lb., while the three-quarter-breds (three-quarter British, one-quarter Zebu) were, on the average, 50 lb. heavier than the best Hereford calves on the property. It is too early, however, to draw any definite conclusions.

Copies of progress reports on these experiments are issued annually, and are available to those specially interested.

4. *McMaster Animal Health Laboratory.*—Work at this Laboratory, which is situated in the grounds of the University of Sydney, is concerned mainly with investigations into sheep parasites. The field station at Hinchinbrook has proved to be very valuable for the purpose of these investigations and particularly in the supply of experimental animals free from parasites.

It is generally recognized that the merino sheep, compared with breeds developed for their mutton qualities, have a relatively low fertility. Frequently the lambing percentage is under 60, and occasionally it may be well under 50. While much may depend on seasonal and environmental conditions, there is more than a possibility the cause may be chiefly genetic in origin. Selection, which has been greatly, if not entirely, responsible for the enormous increase of fleece weight and corresponding wool production during the past 50 years, has been directed mainly towards an improvement of wool both in quality and in quantity. Comparatively little attention has been paid to fertility or fecundity. This is becoming more and more recognized by prominent stud breeders. Hence a detailed study of all present and past data available, supplemented by experimental work along approved genetic principles was decided upon by the Council.

Through the courtesy of the owners of a long-established merino stud flock, facilities were afforded for a study of the breeding records. Mr. R. B. Kelley, Geneticist on the staff of the Division of Animal Health, accordingly conducted a thorough examination of the available data, and it is anticipated that the results will be of great importance in connexion with experimental work which has now been initiated at Hinchinbrook and which is being carried out in co-operation with the Australian Pastoral Research Trust.

Experiments in regard to fertility and fecundity of sheep are being carried out in the United States of America, South Africa and Russia, and the Division of Animal Health is in close touch with the investigators in these countries. Important experiments regarding the artificial insemination of sheep, and preliminary observations regarding the various conditions in both rams and ewes which may conduce to infertility have been conducted by Dr. Gunn of the Veterinary School, University of Sydney, in consultation with the Division of Animal Health. A comprehensive report has been prepared by Dr. Gunn and will be published as one of the Council's Bulletins.

Experiments at Frodsley Station, Tasmania, the property of Mr. K. Brodribb, have been continued. The main object of these experiments has been to determine exactly the effect, both medicinal and nutritional, of anthelmintic treatment of, and preventive measures on, wool growth and character. During the year 1934–35 a field trial was conducted at this place for the purpose of determining the value of supplementary feeding on development and on resistance to parasites.

These experiments confirmed those previously conducted and demonstrated again the value of nutrition adequate to maintain the young animal in a continual stage of growth, in establishing a definite resistance to many internal parasites such as those of the stomach, the small intestines and the lungs, as well as increasing the wool yield both in bulk and character.

(i) *Parasitological Investigations.*—The prospects of eventual control by medicinal treatment of the small intestinal worm *Trichostrongylus* spp., a very important parasitic infestation, have been materially strengthened as a result of the progress made in the investigations during 1934–35. It has been discovered that, by the use of solutions of copper sulphate, the efficacy of anthelmintic drugs could be very materially increased by controlling the passage of fluids through the ruminant stomach. Attention was accordingly concentrated on the possibility of utilizing copper sulphate

as a vehicle to carry other drugs directly to the abomasum (or fourth stomach) and thence to the small intestine. Definite evidence of efficacy was obtained with copper sulphate and nicotine sulphate, and with copper sulphate and carbon bisulphide. The latter combination, however, proved too toxic for general use. By the use of copper sulphate and 40 per cent. commercial nicotine sulphate, in slightly larger doses than have been previously recommended for sheep, definite efficacy against these parasites was obtained. Although work on the control of Trichostrongylosis is being continued, in view of the urgent need for some form of treatment, an initial recommendation has been made that copper sulphate and nicotine sulphate should be administered conjointly.

In view of the absence of marked intestinal lesions in Trichostrongylosis, and the fact that death usually appears to follow from the effects of persistent diarrhœa, an experiment is being conducted to determine whether the course of the disease may be influenced by the action of certain bacterial agents, such as *Bacillus ivitoxicus*, Bennetts, the causal agent of entero-toxæmia.

An attempt was made to immunize sheep against Trichostrongylosis by the intradermal inoculation of infective larvæ. The experiment was carried out only on a small number of sheep and the results were inconclusive.

Further work was carried out on the treatment of the sheep nodule worm (*Oesophagostomum columbianum*) by oral administration of drugs. No reasonable degree of efficiency was obtained with any drugs, or combination of drugs, administered in this way. Attention was, therefore, directed to their administration by enemata. Eventually, a method of administration of sodium arsenite by means of the automatic bluestone drenching gun, was developed. This gave very satisfactory experimental results, while reports of its use in the field have been confirmatory. Following this work we are advised that graziers for the first time are hopeful of controlling and even eradicating *Oesophagostomum columbianum* in parts of northern New South Wales and southern Queensland, where the parasite is one of the serious factors which have led to the discontinuance of sheep breeding.

Investigations into the pathogenic importance and treatment of *Chabertia ovina* have shown that this parasite, particularly in its immature stages, may be serious for young sheep. Such work is of interest because of its high incidence in certain parts of the southern States. It has been found that the enema method of treatment is also effective against *C. ovina*, though its use in this connexion has not, so far, been officially recommended.

Observations on the resistance of the eggs and infective larvæ of the large stomach worm (*Hæmonchus contortus*) and the small intestinal worm (*Trichostrongylus*) to varying conditions of moisture and desiccation have been continued. The general resistance shown by both eggs and larvæ of *Hæmonchus contortus* was considerably less than has been suggested elsewhere. The eggs failed to develop when exposed to desiccation in shade or sunlight, while larvæ exposed to desiccation in sunlight were practically all killed within one month. Though *Trichostrongylus* proved more resistant, experiments offer striking evidence of the value of relatively short periods of continuous desiccation in diminishing larval infestation of paddocks. When watered at weekly intervals, whether in shade or sunlight, the viability of the larvæ of both parasites was greatly increased. Some evidence has also been obtained regarding the concentration of larvæ on sheep camps and drainage areas, and observations on this aspect of the problem are being continued.

In view of the recent demonstration in Brazil and elsewhere of the importance of an adequate iron intake in the treatment of human beings infected with certain blood sucking parasites of the alimentary tract, it was considered desirable to determine, if possible, whether this factor might influence the resistance of sheep to the effects of the large stomach worm, *Hæmonchus contortus*. The necessary experimental sheep are being infected artificially and the influence of iron in various forms on the development of Hæmonchosis will be noted.

The results of an investigation into the influence of low phosphorus intake on the resistance of sheep to *Hæmonchus contortus* were inconclusive owing to the difficulty of securing suitable growth on the artificial diet supplied, whether in animals on low phosphorus intake or on a narrow or wide calcium and phosphorus ratio. Certain animals proved relatively resistant to Hæmonchosis irrespective of the mineral intake.

(ii) *Tick Paralysis of Dogs.*—Investigations were continued during the spring and summer of 1934–35, temporarily ending in January through the impossibility of obtaining further supplies of adult ticks.

(*a*) *Tests of Serum.*—A large series of natural cases of tick paralysis were treated with the serum of dogs immunised to tick paralysis. The results obtained were, in general, considered very satisfactory and treatment of experimentally induced cases of the disease supported the opinions obtained as to the value of the serum as a curative agent. This work has now reached the stage

when it could be handed over to the Commonwealth Serum Laboratories, as considerable difficulty would be experienced by our laboratory in undertaking the production and supply of sufficient quantities of serum for commercial purposes.

(*b*) *Tests of Tick Repellants.*—It was found that derris root, applied either as a watery suspension, or as a powder, proved highly lethal for both ungorged and semi-gorged ticks, and that it remained active on the coat of dogs for four days from the time of application. In view of the fact that ticks do not usually cause paralysis until the fifth day of attachment, it is considered that the application of derris in solution, or as a powder, will confer a great measure of protection. Although some dogs have shown a slight susceptibility to the toxic effects of the drug when used as a powder, this method of prophylaxis has been widely availed of both in New South Wales and Queensland. Reports received have been generally satisfactory.

(iii) *Bacteriological Investigations.*—(*a*) *Foot-rot.*—Work on this problem was in abeyance owing to the absence of Mr. W. I. B. Beveridge, whose services were on loan to the Australian Pastoral Company for the year under review. Since his return to the McMaster Laboratory the work has been recommenced.

(*b*) *Caseous Lymphadenitis.*—During the absence of Dr. H. R. Carne, investigations into this problem were continued by Dr. D. A. Gill. Attention was primarily devoted to the possibility of recovering the bacillus of Preisz-Nocard from the alimentary tract of sheep and also from soil samples from properties on which a high incidence of the disease occurred. That the organism could be recovered from the bowels of sheep was confirmed.

The experiment conducted on Hinchinbrook to determine the possibility of infection occurring in lambs protected from shearing shed risks by being shorn at grass and with all precautions, while running with infected ewes, was concluded. It was shown that a considerable incidence of the disease could occur in such lambs, again emphasizing the possibility of paddock infection.

(iv) *Contagious Bovine Mastitis.*—During the year, a summary of the literature on mastitis, involving the abstracting of over 2,000 papers (in different languages), was compiled by Mr. E. Munch-Petersen and issued to the principal institutions engaged in investigation of the disease. The summary has been very well received and will prove of material value. Information has already been given in this report regarding the co-operative investigations into mastitis initiated in Melbourne.

5. *The Veterinary Research Institute, University of Melbourne.*—In Melbourne, the laboratory research activities of the Division have been, as formerly, conducted at the Veterinary Research Institute of the University of Melbourne through the courtesy of the University authorities and of Dr. Albiston, the Director of the Institute.

(i) *Foot-rot.*—Field tests of vaccine (*Bacillus necrophorus* anaculture) were repeated during the winter on farms in different parts of Victoria. On one large dairying property where the disease is extremely pervalent in cows, the results appear to be very satisfactory, although in the case of sheep so far they have not been so encouraging.

Field tests of the curative value of footbaths of copper sulphate and of formalin solutions following effective preparation of the affected feet have confirmed the opinion that reasonably good results follow such treatment, provided it is carried out in accordance with the recommendations. Further laboratory work is in progress in connexion with the determination of the primary infecting agent.

(ii) *Preputial Disease.*—For a time, work was in abeyance on account of lack of suitable cases. Recently, however, outbreaks have been reported from the western district of Victoria, flocks have been inspected, cases have been brought to the laboratory, and work has been resumed.

Ewes of a flock in which a large percentage of wethers were affected were examined for ulceration of the vulva, a complaint first brought under notice by Mr. J. H. W. Mules of Adelaide. Approximately 5 per cent. of those examined showed a mild ulcerated area. The cause is being investigated. The lesions were invariably confined to those organs which were abnormal in shape, i.e., in which the tip of the vulva was distorted. However, it is not suggested at this stage that the two diseases are necessarily due to the same organism or, indeed, that they have any connexion with each other.

(iii) *Arthritis in Lambs.*—Further observations have been made. Methods of infection, not previously recorded, have been established. While it is considered that the chief mode of infection is via the umbilicus, or " marking " wounds, it has been demonstrated that lambs are easily infected by ingestion or via the conjunctiva. A short paper by Mr. D. Murnane will appear in the next issue of the Council's Journal.

(iv) *Black Disease.*—Considerable attention has been devoted to improving methods of preserving toxicogenicity of strains of the causal organism (*Bacillus œdematiens*) with definite results. It is important that the toxicity of organisms used in the preparation of the vaccine should be maintained. In the modification of the toxin and the improvement of the vaccine, work is progressing.

(v) *Infectious Entero-toxæmia* (*Pulpy Kidney of Lambs*).—Further observations have been made in connexion with outbreaks in the field and the testing of the toxicity of bowel contents from affected animals has been continued. It has been found repeatedly that the degree of toxicity varies considerably with the animal, and with the portion of the small bowel from which the specimen is taken—usually being greatest in the lower part. A large scale field vaccination test is in progress to ascertain whether vaccination of the pregnant ewe confers any appreciable immunity on the subsequently born lamb, and a supporting laboratory test for the same purpose is being carried out by Mr. D. T. Oxer at the Commonwealth Serum Laboratories.

(vi) *Coast Disease.*—Further observations regarding the incidence in Victoria indicate that the disease occurs on certain coastal areas but in a form milder than that generally experienced in South Australia. An experiment is in progress on one property to determine more exactly the effect of certain treatment, which appeared to be indicated as a result of the examination of the flock.

(vii) *Bovine Hæmaturia.*—Observations have been made on further affected farms, and urine samples have been collected and analyzed. Animals on the experimental farm in Gippsland are under regular observation, and urine samples are tested periodically. It is, as yet, too early to arrive at any conclusions.

(viii) *Caseous Lympadenitis.*—Soils from sheep camps from two sources have been tested (by animal inoculation) for the presence of the causal organism (*C. ovis*). Both proved negative.

(x) *Pregnancy Paralysis of Ewes.*—The examination of internal organs from affected ewes has been carried out as opportunities presented themselves. This year very little trouble from this source has been reported.

This complaint of ewes in an advanced state of pregnancy, it is interesting to note, was first described by Dr. J. A. Gilruth over 30 years ago as common in certain districts of New Zealand. The exciting cause was obscure but the high condition of the animals, combined with the bearing of well developed twin fœti, were found to be definitely predisposing factors, while forced exercise and the provision of laxative succulent feed were preventive. Twenty years elapsed before the disease was described as existing elsewhere, and then by Sir John McFadyean in England. During the past decade it has been reported in almost every sheep-breeding country. Various causes have been ascribed as operative and exhaustive investigations have been undertaken. The definite and exciting cause still remains obscure. The terminology is, however, now extensive. At the recent meeting of the Australian and New Zealand Association for the Advancement of Science in Melbourne, Dr. Gilruth gave a *résumé* of the literature on the subject when a special committee of veterinary investigators in the various States and New Zealand was established to co-ordinate further investigations.

A large-scale field experiment, using 300 ewes, was carried out at the State Research Farm, Werribee, in an endeavour to confirm or disprove the theories that overfeeding or underfeeding, shortly before lambing, are causative or contributing factors, but results were negative.

6. *Western Australia.*—During the year 1934–35 the Council contributed to the cost of certain investigations in Western Australia by defraying half the cost of Dr. Bennetts' salary, and the expenses, travelling, &c., incurred in their prosecution. The following is a *résumé* of the work undertaken by Dr. Bennetts.

(i) *Entero-toxæmia.*—Field observations continue to indicate that vaccination is a successful means of prevention, and the number of sheep inoculated last season again showed an increase.

An experiment carried out at the Avondale State Farm, Beverley, demonstrated that effective immunity does not persist for more than twelve months after inoculation. A further experiment to determine the degree of immunity, three, six and nine months after vaccination, is now in progress.

(ii) *Gingin Disease.* (*Ataxia in Lambs*).—Recent observations reveal that the condition is much more widely distributed than hitherto realised, and it is probably closely related to the so-called rickets in foals (and calves) which occurs on the same properties. Ataxia has been encountered in a district (Margaret River) unassociated with limestone. There is evidence that considerable areas in the south-west, adjacent to the coast, which are now used largely for dairying, would be unsuitable for the breeding of sheep and horses. The solution of the problems of ataxia in lambs and rickets in foals is, therefore, an urgent economic necessity. The etiology is still obscure.

Experiments carried out at Gingin and Dandarragan in 1934 confirmed previous evidence that the administration of a lick, containing ammonium chloride, to ewes during the gestation period prevents the development of ataxia in the progeny, and that it exerts a favorable influence on the health and development of the lambs from ewes so treated. The use of the lick during the present season is not proving very satisfactory. Further investigation is, therefore, being conducted.

Very definite results have been obtained with foals. Ammonium chloride suitably administered (in water or supplementary feeds) has apparently prevented and also cured the so-called rickets of foals. A detailed clinical and pathological investigation of this condition has been arranged.

(iii) *Botulism.*—Owing to the pressure of routine work (notably extensive application of the pleruo-pneumonia complement-fixation test) it was impossible to carry out the projected bacteriological and pathological work during the year 1934–35. This condition is associated with the ingestion of rabbit carrion, although other sources of toxin have been suspected in certain cases. Rabbit droppings, from two properties where the disease was occurring, were tested for toxicity by feeding to laboratory animals and sheep, but with negative results. Field evidence on several properties has been adduced and strongly supports the contention that the consumption of water contaminated by carrion may lead to an incidence of botulism in sheep, horses and poultry. A number of samples of water were obtained and fed daily to guinea pigs, i.e., for periods up to fourteen days at the rate of from 20 to 35 c.c. per day. With fourteen samples from various sources (tanks, soaks and wells) the experimental animals died after showing the syndrome of botulism, thus supporting field evidence incriminating the water supply. It has not yet been possible to otherwise demonstrate the presence of toxin in water, but the investigation is proceeding.

An intensive investigation of botulism in sheep embracing experimental, bacteriological and pathological work, is projected for the coming season. This work will be supplemented with nutritional investigations designed, *inter alia*, to determine practical means of prevention of sarcophagia (flesh-eating).

(iv) *Poisonous Plants.*—Poisonous plants have been a source of grave economic loss since the inception of settlement in this State, and toxic plants must always be considered as a possible cause of any unusual stock mortality. The majority are native and the knowledge of their toxicology is very incomplete.

During 1934, in co-operation with the Government Botanist of Western Australia, an experimental investigation was commenced. Fifty-one species were tested on sheep at the Avondale State Farm. Thirty-seven plants which were tested belonged to the closely related genera *Gastrolobium* and *Oxylobium*, the toxic species of which are, with one exception (*G. grandiflorum*), confined to Western Australia. During the year 1934–35 positive results were obtained with *Euphorbia eremophila* which has long been suspected both in Western Australia and in the eastern States, and *Stypandra imbricata* (blind grass). It is hoped in the near future to publish a Bulletin giving a comprehensive account of the poisonous plants of Western Australia, but considerable additional investigations (supplemented with chemical work) will be necessary before knowledge of the native toxic plants is complete.

(v) *Parasitological Investigations.*—Considerable difficulty is experienced in the rearing of Merino weaners in many districts. This is attributed to small trichostrongyles, and to nutritional factors largely resulting from climatic influences. The investigation of this problem has been mostly confined to observations made from time to time.

Monodontus trigonocephalus (hookworm in sheep) has been detected on properties in the south-west and the distribution of this parasite will be investigated.

7. *South Australia.*—At Adelaide, the work initiated by Dr. L. B. Bull and Mr. C. G. Dickinson has been continued by the latter since Dr. Bull's departure abroad and his appointment to the staff of the Council.

(i) *Caseous Lymphadenitis.*—Immunological studies have shown that an immune serum can be produced in sheep by repeated inoculation of heat-killed organisms, and experiments are now in progress in the endeavour to produce immune sera in other animals. Such sera are of laboratory importance only at present. Immune sheep's serum, so far, has not conferred even a passive immunity when injected into guinea pigs. However, guinea pigs are so extremely susceptible to this infection, by infinitesimal doses of culture, that in immunity experiments with them minimum infective doses are difficult to measure. Hence, experiments are being pursued on white rats, which are much less susceptible.

Investigations on allergia reactions have been continued. One product of the bacillus has given such results that the production of a diagnostic agent seems to be possible.

One small field experiment, in which wethers, marked in the usual way as lambs, were shorn regularly for three years with blade shears thoroughly disinfected after each sheep was shorn, has been concluded. In this lot, the incidence of the disease was less by 50 per cent. than in the general flock. Unfortunately, through some misunderstanding, the number available for examination at the end of the three years was much less than originally set aside for the experiment, and were too few for accurate estimation of the value.

Another experiment has been commenced in order to check observations regarding wound contamination from infected sheep camps after shearing.

Routine examination of soils and faeces from the affected property, which with its flock is kept under fairly constant observation has been conducted, as well as periodical palpation of superficial glands of the sheep.

(ii) *Navel-ill of Foals.*—This has been reported as a serious affliction during recent years on certain properties, and an investigation was agreed to, provided cases were made available. Only two cases were, however, reported, and only one could be examined. The exciting cause was determined to be *Streptococcus pyogenes*, which was isolated and cultivated from the navel lesion, infected joints, liver abscesses and the urine.

(iii) *Bovine Hæmaturia* (*Redwater*).—Routine examinations have been made of urines from two affected farms on which soil treatments are being conducted. The only indications so far obtained are that regular top-dressing with superphosphate results in a decrease of the incidence in cows. Careful microscopical examination of bladder lesions from typical cases has in no case shown the presence of Entamœbæ, as reported in similar lesions by Datta in Bombay, or fluke eggs, as reported by MacGregor of Calcutta. It is interesting to note, however, that hæmaturia, prevalent in certain parts of India, is evidently identical with that found in Australia, while the predisposing environmental conditions are often very similar.

In certain experimental work on coast disease and on ataxia of lambs, Mr. Dickinson has been in close co-operation with officers of the Council's Division of Animal Nutrition.

8. *Tasmania.*—Direct investigations have been confined to the experimental work in connexion with internal parasites at Frodsley, reference to which has been made under the activities of the McMaster Laboratory.

Some financial assistance is rendered to the Animal Health Branch of the Department of Agriculture for its pathological and bacteriological work.

In conjunction with Mr. Symonds, B.V.Sc., Manager of the Municipal Abattoir, the staff prepared samples of blood from over 2,000 Tasmanian cattle for testing at Townsville by the special test for contagious pleuro-pneumonia, as a check on results obtained from herds which might conceivably have been at some time exposed to infection.

Certain preliminary observations have been made on Waratah horse disease, suspected to be due to the ingestion of indigenous species of Senecio, and a feeding trial is in progress.

A special investigation by the State Veterinary Officers on supplementary feeding and lick provision for sheep on lines discussed with the Council's Division of Animal Health has been commenced. From this, important information of general value is expected.

VI. ANIMAL NUTRITION INVESTIGATIONS.

1. *General.*—During the past year, some of the researches on the nutrition of the sheep have reached a stage where conclusions may be drawn and findings, which have direct bearing on the pastoral industry have resulted.

Further investigations into the nature of the substances which supply the raw material for wool growth have made it clear that the existing chemical methods for the estimation of cystine are not satisfactory when applied to fodders, and it is not yet possible to determine the amount of cystine ingested by the sheep and so directly settle the much debated question as to whether the animal organism or its intestinal flora may produce this amino acid from the other sulphur containing dietary constituents.

The question of the metabolic inter-relationship between methionine and cystine is still unsettled. Study of this problem, which is fundamental to the understanding of wool production, is being continued, and attempts are being made to prepare diets which are complete in all but their cystine content and suitable for small laboratory animals which will be used for the experiments.

Further study of the relationship between protein intake and wool production has proved the importance of this constituent in the diets of wool sheep, and the work on the energy metabolism of the merino has provided data from which minimum maintenance rations may be computed. The observed fact that wool growth may be increased by 40 per cent. when extra protein is fed

to mature ewes which have been receiving protein poor rations that contained just sufficient digestible energy for their maintenance, confirms the previous suggestion of the importance of providing a suitable supply of protein when hand-feeding flocks during drought or when supplementing the supply provided by pastures of low protein content. The projected study of the relative capacity of proteins from different sources to enhance wool growth in merino sheep when on protein poor rations, should indicate the most economic procedure to adopt in those areas in Australia which suffer seasonal shortage of fodder.

The effects of the recent drought in western Queensland are sufficient to recall the urgent necessity for the conservation and storage of such valuable concentrates as maize until such times as the flocks, grazing on areas of uncertain rainfall, are again threatened with extinction. Investigation of the means of preservation of such materials is one of primary importance to any scheme which might aim at providing some measure of insurance against the serious economic losses which follow periodic drought.

Investigation of the concentration of blood phosphate of sheep grazing under different conditions showed that the flocks which have been continuously depastured on areas where the soils are very low in phosphorus did not evidence any signs of phosphate deficiency even at the end of summer when the only available fodder was dry standing grass straw of relatively low phosphorus content and of poor nutritive quality.

These observations, together with data collected in former years, have led to serious doubt as to the validity of the widespread idea that phosphatic supplements for grazing sheep are almost universally necessary in Australia. The results of experiments suggest that any increased production which might be brought about by offering phosphatic licks to sheep on natural pastures in Australia are not likely to be commensurate with the expenditure.

It is projected to put this view to critical test in the field where it is proposed to measure the effects of supplying phosphatic licks to sheep grazing under a wide diversity of natural conditions.

The experimental work on phosphorus metabolism suggests that if phosphatic supplements are found to benefit the flocks, then finely ground rock phosphate will provide their requirements as efficiently as will the more expensive manufactured concentrates, and the observations on the effect of fluorine ingestion indicates that rock phosphate from either Curacoa Island or Christmas Island may safely be employed for the purpose.

An experiment, designed to contrast the availability of phosphorus from bone meal, rock phosphate, dicalcic phosphate and commercial superphosphate, has been started and the observations will be extended over the next two years.

The field work at Wambanumba, Young, New South Wales, has added much to our knowledge of the variation in composition of natural pastures, and of the effects on sheep carrying capacity which supervene on top dressing them, and in turn of the effects on wool production in flocks depastured on the treated areas. Five years' study of the carrying capacity of the areas treated with sulphur and rock phosphate and of the growth and fleece production of sheep depastured on them, makes it clear that the productivity of highly leached soils, which are poor in phosphorus and in sulphur, is not materially benefited by dressing either with phosphorus or with sulphur alone. When, however, these two materials are used together, the response in growth and composition of the pastures is sufficient not only to more than double the carrying capacity but also to increase the growth and wool production of the flocks grazed thereon.

Further experimental work has clarified the understanding of the malady which affects sheep grazing on the blown shell sand soils of the coastal regions of southern Australia. It is now amply proved that the disease is one of progressive anæmia which is fatal to sheep depastured for any considerable period on badly affected country. There is little doubt that the anæmia is of nutritional origin and is of a type which is not benefited by dosing with iron either alone or in combination with copper, manganese and liver therapy. The discovery that minute traces of cobalt salts will bring about dramatic improvement in affected animals confined under laboratory conditions, has indicated a means of approach to a practical solution of the problem. It is not at present possible, however, to state definitely whether the disease is due to a deficiency of this element in the pastures of the affected country. Licks composed of limonite and salt were found to benefit sheep grazing on the coastal littorals. More experimental work is desirable before any definite recommendations as to the control of the disease may be made.

During the year, it was definitely established that the ataxia which accounts for the deaths of many lambs bred on the coastal country is distinct from coast disease. The etiology of this fatal disease of young lambs is still obscure.

During the year, investigators from other institutions and laboratories have spent periods of study in the Nutrition Laboratory. Among these were Dr. E. J. Underwood of the Department of Agriculture, Western Australia ; Mr. S. W. Josland, B.Sc., of the Wallaceville Veterinary Laboratory, Department of Agriculture, New Zealand ; and Mr. J. F. Kennedy, B.Sc., of the Research Department of the Australian Estates and Mortgage Company, Melbourne. It is again a pleasure to acknowledge the friendly co-operation of our colleagues in other Divisions and in the University of Adelaide, and to thank the many individual pastoralists and pastoral firms for their inspiring interest and material help.

2. *Individual Investigations at the Laboratories of the Division.* (i) *Sulphur Metabolism in Sheep and its relation to Wool Production.* (*a*) *Estimation of Cystine in Fodder Species.*—Further critical examination of the chemical methods in current use has made clear that they are inadequate when applied to impure proteins and fodder materials. The analyses reported in the literature need considerable revision, and at present it is not possible to estimate the amount of cystine ingested in the fodder and so carry out direct experiments on the extent of utilization of this amino-acid by the sheep.

The proteins of several important fodder species have been isolated, and attempts are being made to purify them and to determine their cystine content by modifications of existing methods.

(*b*) *Balance Experiments and Investigations on the Influence of Food Constituents on Growth of Wool.*—The effect on wool growth of merino sheep, which is brought about by increasing the level of protein ingestion while keeping the gross energy intake constant, is in the course of being studied as a preliminary to a more extensive investigation into the capacity of proteins from different sources to support fleece production. This project will be referred to in more detail in a later part of this report.

(*c*) *Biological Assay of the Amount of Cystine in Fodders—Biological Value of Proteins.*—The estimation of cystine in fodders and pasture plants by chemical means is not feasible in our present state of knowledge, and it would seem that much further work is necessary before the natural distribution of this important constituent of wool is settled. The procedures for assay of fodder materials by biological means has been given some attention. The early difficulties which were encountered when attempts were made to supply the full complement of " B " accessory food factors without at the same time adding considerable quantities of cystine to the dietary of the experimental laboratory animals has now been overcome, and the study of the comparative nutritive value of fodder proteins and of the capacity of cystine to supplement them when fed at low levels, has been undertaken as a collaborative effort between the Nutrition Laboratory and the Animal Products Research Foundation at the University of Adelaide.

(ii) *Phosphorus Metabolism in Sheep.* (*a*) *The Concentration and Distribution of Phosphorus in the Blood of Sheep.*—Extension of the investigation of the mean blood phosphate concentration of similar groups of sheep grazing at Wambanumba, Young, New South Wales, on a series of natural pastures which have received different manurial treatment, has confirmed our previous findings. It has shown that the blood phosphate is maintained at a level which would imply that the phosphorus requirements of the animals are being fulfilled by the pasture on the singularly phosphorus deficient soils of that region, and that even at the end of a dry summer, when the animals subsisted on the standing grass straw, the average phosphate concentration of their blood was found to be above 4.0 ml. per 100 ml. Moreover, at this period of the year, no significant difference was observed between the concentration of blood phosphate in the group on the unmanured area and that in the groups which had been continuously depastured on top dressed areas which grew pastures containing much more phosphorus than those of the control areas. It would seem then that sheep under natural grazing conditions in Australia are extraordinarily economical in those metabolic transactions which involve the assimilation and utilization of phosphorus, for they are able to satisfy their requirements from pastures in which the phosphorus content, as judged from chemical analysis of pasture clips, is low.

During the past year, the relationship between the secretion of saliva, time of feeding and the level of blood phosphate, was investigated in pen-fed and grazing sheep, and the observation of the considerable diurnal variation of the concentration of this constituent in the blood, which was referred to in the previous report, was confirmed, and considerable information as to the cause of it was gathered.

(*b*) *The Influence of High Concentration of Calcium and Magnesium on the Assimilation of Phosphate by Growing Sheep.*—The observations have been extended on the group of sheep referred to in the previous report which have received each day 30 gms. of calcium and 15 gms. of magnesium, as the carbonates, superimposed on an adequate ration. These animals have continued to do as well as the normal control group. After one year had elapsed, the phosphorus content of the ration was reduced from 1.6 gms. per day to slightly less than 0.8 gm. This

change was accompanied by a small reduction of the blood phosphate. However, the mean concentration of inorganic phosphate of the blood is maintained at a level which indicates that even when the amount in the dietary is low, sufficient phosphorus is assimilated from the food to maintain full requirements of these animals. The animals receiving extra vitamin D as 5 ml. of cod liver oil each day, are not significantly different from those consuming the highly alkaline ration. Autopsy of representative animals after they had been fed in this way for twelve months, revealed that the skeletons of all were well calcified and that notwithstanding the consumption of relatively enormous quantities of calcium and magnesium, their bones were of normal dimensions, and actually contained more ash than those of the normal controls.

The results of a study of the reaction of the materials undergoing digestion at different levels of the intestines of these sheep, have thrown considerable light on the physiological mechanism of absorption of phosphate by the ruminant, for the intestinal contents were found not to be strongly alkaline as has hitherto been supposed, but proved to vary little from true neutrality if carbon dioxide loss was prevented. Phosphates are appreciably soluble at this reaction and there is little doubt that they are absorbed in this State.

Further study of the intestinal contents indicated that, while calcium is absorbed in the upper end of the small intestine and excreted again into the lumen of the bowel at the level of the caecum, phosphorus was observed to be steadily absorbed throughout the whole length of the gut.

The observed fact that sheep absorb phosphate normally when it is fed together with very large excess of calcium and magnesium carbonates, would suggest that the prevailing idea that the ruminant is unable to assimilate phosphorus as efficiently from the relatively insoluble tricalcic phosphate as from dicalcic or monocalcic phosphates, is not justified. For this reason, a comprehensive pen-feeding experiment was started in November, 1934, to determine the comparative capacity of various economically feasible phosphatic concentrates to supplement phosphorus deficient but otherwise adequate rations. Fifty pen-fed lambs are being studied in five matched groups and, by means of these, the effects of feeding the major quantity of their phosphorus requirements as bone meal, Christmas Island rock phosphate, dicalcic phosphate, and commercial super are being investigated. Food intake, growth, wool production, blood phosphate level and chemical and morphological examination of the skeletons of the individuals of each group are being used as criteria. In addition to these data, the lowest level of added phosphorus from each of the above-mentioned sources which will ensure a positive balance of this element in growing and in mature sheep, is being estimated in animals confined in balance cages.

After seven months, there is no significant difference between the groups receiving bone meal, dicalcic phosphate or Christmas Island rock phosphate. The group receiving their phosphorus as commercial super is not doing as well as the others. The high fluorine content of the latter supplement is the possible cause of this. These experiments will be continued for two more years.

(iii) *The Energy and Protein Metabolism of the Merino Sheep.* (*a*) *Energy Metabolism of Fed Sheep.*—The major proportion of the work in this field was devoted to perfecting the apparatus and the further development of the technique of indirect calorimetry. During the hot weather of November-December, 1934, it became apparent that it was desirable to institute some control of the atmospheric conditions within the chamber where the experimental animals are confined during the estimations. A device for cooling and absorbing the moisture from the air was constructed and placed in circuit and by this means the wet bulb temperature within the chamber may be maintained below 20°C. even in the hottest weather. Temperatures and humidity above this were observed to raise the metabolic rate of the experimental animals from 6 to 8 per cent. Combustion tests with alcohol and acetone proved that satisfactory recovery of the energy burned within the chamber is attained and investigation of the effect of variation in ventilation rate on the validity of the results shows that the apparatus functions within the permissible limits of error. A unit has been built for taking a relatively large aliquot sample of the gases issuing from the chamber and, in series with this, an apparatus has been connected which burns the combustible gases and collects the water vapour and carbon dioxide arising from this combustion. The energy lost as methane may thus be computed. A small apparatus was also incorporated in this chain to provide a gravimetric check upon the volumetric estimation of carbon dioxide produced by the animal.

The total heat production of sheep may be estimated with considerable precision and satisfactory energy and carbon balances have now been made.

(*b*) *The Utilization of Protein and its Relation to Energy Consumption.*—It has been found that merino sheep may be maintained at a weight of from 38 to 40 kilos. on a diet containing 65 gms. of crude protein (N x 6.5) and digestible material equivalent to 1800 calories. The wool

production under such conditions is reduced to rather less than half of that grown under ideal feeding conditions. It was found that the effect of approximately doubling the protein in this ration by the addition of 60 gms. of gluten, while keeping its gross energy content constant by withdrawing an amount corresponding in energy content to the added protein, was to bring about a very striking effect on the wool growth. The wool production was increased over 40 per cent. by such means, and while metabolic rate was raised about 8 per cent., the increased digestion of energy producing materials from the ration more than compensated for the energy loss under these conditions, and the animal gained in weight. Much time has been spent in the perfecting of technique, but, although these investigations are only in the early stages, critical experiments already confirm the contention that the protein content of the dietary is of major importance in wool production.

(iv) *Secondary Anæmia in Sheep.*—Extension of the observations on the effect of hæmorrhage on sheep show conclusively that they are able to withstand the loss of up to 60 ml. of blood each day when pen-fed on a mixture of lucerne hay and oaten hay chaff (1:2). Increased metabolic rate was found to accompany the blood letting under these conditions and this was compensated by greatly increased consumption of food.

A study of influence of various nutrients on the capacity of the sheep to regenerate blood has been started, and the effects which follow continual letting of blood from normal sheep pen, fed on fodder which has been grown on the highly calcareous soils of the coastal region of South Australia, are being investigated.

(v) *The Effects which supervene on the continual Ingestion of Fluorine by Sheep.*—After two and a half years, the experimental sheep which have ingested from 115 to 150 mg. of fluorine per day are now showing definite symptoms of chronic fluorosis. Some of them refuse their full ration and are no longer maintaining weight. The most recently erupted teeth are eroded and malformed and exostoses of the bones of the lower jaws may be detected on palpation. Post mortem examination of an animal that had ingested 150 mg. of fluorine per day for two years and which had developed complete anorexia, revealed the cause of its decline to be the overgrowth of two molars which prevented normal closure of the other teeth. Apart from the chalky outgrowths of the jaw and long bones, this was the only pathological finding. No signs of chronic toxic condition were discernible when sections of the liver, kidney and spleen were microscopically examined.

The groups which have received up to 80 mg. of fluorine each day have continued to do as well as the control sheep.

The findings confirm the tentative conclusions which were mentioned in the previous report, and it would seem that phosphatic supplements having a fluorine : phosphorus pentoxide ratio of less than 0.04, might be fed to sheep with confidence that no untoward effects of chronic fluorosis will ensue.

The early stages of fluorosis in sheep are easily detected on examining the teeth, and periodic search for these signs should be made in flocks which have access to phosphatic licks of unknown origin.

3. *Field-Stations.* (i) *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 been continued. Chemical analyses of bi-monthly clips taken from quadrats distributed at random over the areas under observation have now been completed to cover the year June, 1933 to June, 1934. The increased production on the area top-dressed with sulphur plus rock phosphate was maintained throughout the period. The better growth of fodder was accompanied by higher nitrogen and mineral content of the pasture, and this is in striking contrast with the lower figures obtained for the pastures of the other areas. Nitrogen, calcium and phosphorus content of the clips from all areas were roughly parallel throughout the season, reaching a maximum in October and falling to a minimum in April. This applies more particularly to the green fodder, but with certain reservations, the analyses of the dry material separated from the respective clips show the same features, so that throughout the season, the dry straw from the area treated with phosphate and sulphur was found to be superior in mineral content and nitrogen to that of the other plots.

The average phosphorus content of the clips was increased 70 per cent. in the pastures which developed on both of the areas which received dressings of rock phosphate. This increased phosphorus content was not accompanied by any augmented growth or increase in nitrogen content of the pasture which developed on that area to which the phosphate alone was applied. When accompanied by sulphur, the yield nitrogen content and consequent sheep carrying capacity were all materially augmented. No very obvious change resulted in the pastures of the area treated with sulphur alone. The seasonal fluctuations in the content of other inorganic

constituents such as silica, magnesium, manganese, potassium, sodium, &c., have likewise been determined, but the results do not lend themselves to concise presentation at this stage of the investigation.

All areas were stocked with discretion and, throughout the two years of observation, the number of sheep carried by the area to which the mixture of phosphate and sulphur had been applied was more than double that carried by the control, sulphur dressed and phosphate dressed areas, respectively and, in spite of this heavier stocking, the growth and wool production of the sheep which had developed on the area since birth, were superior to those of the other groups. The investigations will be continued until October, 1935, after which the conclusions will be prepared for publication.

(ii) *Coast Disease Investigations.*—In the previous report, the initiation of a new series of experiments at Hawk's Nest, Kangaroo Island, was mentioned. These were planned to determine whether the malady which affects sheep which are depastured on certain tracts along the coast of South Australia, is brought about by the complication of the assimilation of essential elements through the ingestion of large quantities of calcium carbonate which abounds in the affected soils, or whether the pastures which develop on these coastal littorals are lacking in certain materials necessary for the well-being of the grazing flocks.

A group of 20 ewes in lamb was offered a lick composed of protein and a salt mixture containing small amounts of arsenic copper, zinc, manganese, nickel and cobalt, besides those elements usually considered essential for the maintenance and growth of animals. The behaviour of these ewes and their lambs was contrasted with that of a similar group which received salt and bone meal, and another which had access to salt and dicalcic phosphate. All groups were run under identical conditions on coasty country. Although the number of lambs dropped was similar in all three groups, the number raised by the ewes receiving the mineral mixture was nineteen as compared with the twelve which survived in each of the other groups. The lambs of the former group have all grown well and have remained healthy during the first year of observation. The growth of the lambs comprising the latter groups was not as good. Many of them are stunted while others are showing signs of ill-health.

The findings from these experiments suggest an absolute deficiency of some essential element or elements in the fodder, and the observed fact discussed elsewhere in this report, that sheep may ingest large quantities of calcium and magnesium carbonates without untoward effect, lends support to this hypothesis. Experiments in the previous year indicated that no benefit followed the ingestion of pure iron slats by affected animals.

However, a lick composed of salt and finely ground limonite originating from the ironstone nodules of the adjacent healthy areas was found to benefit sheep grazing on coasty country at Antechamber Bay, Kangaroo Island. Limonite from diverse sources has been demonstrated to contain many other elements besides hydrated iron oxide, and small quantities of nickel, cobalt, manganese, vanadium, copper, &c., have been isolated from natural limonite by chemical means.

The untoward symptoms of advanced coast disease have been shown by more intensive laboratory study to be due primarily to extreme anæmia. The hæmoglobin content of the blood of seriously affected animals was found in some cases to be lower than 3.5 gms. per 100 mls. (estimated by the oxygen carrying capacity) which is less than 25 per cent. of that found in the blood of normal healthy sheep. The hæmoglobin content of the blood of sheep which shew the early clinical symptoms of the malady, however, is not often materially altered, although the volume of blood is apparently reduced and the animals appear anæmic.

It was found that sheep which had developed the disease while on the affected country, continued to exhibit the progressive symptoms when confined in cement-lined pens and fed on hay produced on the coastal littorals. This observation has facilitated the research during the last year.

Study of such animals showed that the anæmia was not benefited by injection of relatively massive doses of active liver extract (campolon) either alone or in conjunction with iron therapy. Immediate improvement in food intake and rapid increase in body weight, hæmoglobin and apparent volume of blood, was observed to supervene on dosing with minute quantities of cobalt salts.

The tentative conclusions which might be drawn from these findings are that the fatal lethargic wasting malady of sheep grazing on the highly calcareous littorals along the coast of South Australia is brought about by a deficiency of an element or elements in the pastures, and experimental observations would suggest that the missing factors are necessary adjuvants for the production of the respiratory pigment of the blood. Minute doses of cobalt salts seem either to replace or supply this deficient factor. Whether or not the disease is one of cobalt deficiency is still unsettled.

The investigations both in the laboratory and the field are being extended. The metabolism annexe has been enlarged to contain a further sixteen cement-lined pens so that the intensive study of the malady may be facilitated, and further field work has been initiated on the badly affected coastal tracts at Robe in the south-east of South Australia.

During the year, it was demonstrated that the ataxia which accounts for many lambs in the region of the coasty country, may occur on areas upon which sheep do not develop coast disease. In 1933, a flock of 50 ewes was purchased and depastured at Wight's Selection on Kangaroo Island, where a high incidence of ataxia was reported in previous years. The first lambs dropped were healthy and all developed free from disordered gait. The ewes were again mated and it was observed that a large proportion of the 1934 lambs developed the malady. Careful search failed to detect any poison or fungus infected plants on the area where the ewes were grazed.

Subdural inoculation of a suspension of the spinal cord of an affected animal failed to transmit the disease, nor did injection of massive doses of serum taken from a case in which the disease had not proved fatal in the previous year, have any effect on the progress of the malady.

There seems little doubt that the ataxia originates from causes which are distinct from those which produce coast disease.

4. *Mineral Content of Pastures and Pasture Improvement.*—The co-operative investigations carried out by the Council for Scientific and Industrial Research, the Carnegie Trust, and the University of Adelaide on the mineral content of pastures have been extended to include the investigation of various phases of pasture improvement. Interdependent investigations in the field, laboratory and pot culture houses have been continued to determine the soil and plant relationships fundamental to grass land improvement.

The investigation of the influence of natural pastures on the carrying capacity, live-weight increase, and wool yield of merino sheep over a three-year period, and the changes in the chemical and botanical composition of the pasture under grazing have been completed. Following on this, an investigation of the carrying capacity, live-weight increase and wool yield of merino sheep grazed continuously but in rotation on seeded pastures, as compared with natural pastures, has been commenced, together with the study of the changes in chemical composition of the pastures throughout the year.

The interaction of available phosphorus and nitrogen supply in relation to botanical composition, growth, and chemical composition of grass-legume associations is being investigated under field conditions, and under controlled conditions in the pot culture houses.

The microbiological problem of nitrogen fixation in pasture legumes is being investigated from the viewpoint of rhizobial strain and associated growth of grasses, in co-operation with the Soils Division.

Field investigations carried out at numerous centres in the winter rainfall region have shown the importance of *Phalaris tuberosa*, perennial rye-grass, Wimmera rye-grass, lucerne and subterranean clover as a basis for pasture improvement in areas of moderate rainfall.

Strain investigations, coupled with the isolation and breeding of drought resistant and persistent pasture types of *Phalaris tuberosa*, perennial rye-grass, lucerne, and subterranean clover, are in progress.

Problems of pasture establishment, compounding of seeds mixtures, influence of cover crops, the intra-competition factor in mixed pastures, are under investigation.

Problems of pasture management have been confined to the determination of the length of the time interval between successive grazings on the carrying capacity of an established irrigated pasture, and the effect of nitrogen and phosphorus, singly and in combination, on the grazing value of mixed pastures of rye-grass and subterranean clover, and *Phalaris tuberosa* and subterranean clover.

Physiological investigations have centred round the drift with age of the potassium and calcium content of grasses, and the physiological basis of the drift, and the study of the effects of nitrogen and phosphorus on plant growth. In the latter investigation attention is being directed especially towards the interpretation of the effects in terms of the fundamental metabolism of the plant. Further study is also being made of the mechanism of the interaction of nitrogen and phosphorus in metabolism. The investigation of the influence of the phosphorus supply on the transpiration ratio has been completed.

VII. SOIL INVESTIGATIONS.

1. *General.*—The Division of Soils has its headquarters at the Waite Agricultural Research Institute about four miles from Adelaide, and is housed there in the Darling Laboratory and part of the Melrose Laboratory. A considerable part of the Division's work is, of course,

conducted in the field. As the production of wealth in Australia's pastoral, agricultural and horticultural industries is dependent ultimately on the soil, the investigations of the Division of Soils, aiming at accurate knowledge which will permit of intelligent and economic methods of soil management, treatment and improvement, are obviously matters which, in the interests of those great industries, cannot be neglected without serious consequences.

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

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

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

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

In addition to benefiting the settler by furnishing him with authoritative advice as to methods necessary to increase production, the Division has already been able to afford valuable assistance with respect to new settlement projects. During the year, surveys conducted in the Curlwaa and Coomealla areas near Wentworth, New South Wales, have formed a basis for the planning of drainage schemes and for the further development of these areas following upon the readjustment of settlers' holdings.

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

During the past year field surveys have proceeded in the following localities—Coomealla, New South Wales, Merbein, Victoria, and Burnie, Tasmania.

The main concern of the Murray River settlements is the control of applied irrigation water and as this is plainly related closely to the character of the soil, the crop requirements and the movement of added water can be satisfactorily studied only after a full examination of the soil types has been made. It is hoped that these surveys will show their practical value in the near future as a means of interpreting and applying results of irrigation experiments such as those at present being carried out under the direction of the Merbein Research Station on the Berri and Cobdogla areas and by the Research Branch of the Water Conservation and Irrigation Commission of New South Wales.

The soil survey begun at Griffith (Murrumbidgee Irrigation Areas, New South Wales) in September, 1933, was continued. The Chemist's Branch, New South Wales Department of Agriculture, is associated with the analytical work. The survey has not yet been completed.

In Tasmania, further systematic examinations were made of soils in recognized apple-growing centres in Tasmania, the chemical work being carried out in a laboratory of the University of Tasmania. Acknowledgment is made of the valuable co-operation afforded by the Horticultural Section of the Department of Agriculture. It is hoped that such questions as the relation of tree growth to soil, the suitability of certain apple varieties to definite soil types, and the possibility of relating physiological disturbances in apples to soil conditions will be cleared up. In regard to the last point analyses have been made of representative soil samples from the experimental plots established by the Division of Plant Industry. Probable correlations between the potash content of the soils and the vigour of the fruit trees has been established.

At the request of the Tasmanian Department of Agriculture, investigations have been initiated into the character of the red basaltic soils characteristic of the most fertile regions of the north coast of Tasmania. As in the case of the apple soils, 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 is, therefore, being devoted to the lime status of these soils.

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 February, 1935, the main sampling of the area surveyed was carried out and the laboratory examination of the soils begun. These samples were subsequently supplemented by a considerable number from areas of related country at Northcliffe and Redmond. 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 is being devoted to the search for traces of heavy metals in these soils.

In connexion with the soils of the Murray River horticultural areas in South Australia and in New South Wales, special attention is now being devoted to the chemical characteristics of the soils, previous emphasis having been on the physical side.

During the earlier part of the year, the Chief of the Division, while on study leave, attended conferences of the International Society of Soil Science at Versailles and visited agricultural research institutes in Britain, Belgium, France, Germany and Russia.

Activities in soil bacteriology have been renewed by placing this section of the work on a permanent basis. For the present, attention is being given to a survey of the nodule organisms as affecting subterranean clover and lucerne, both important crops in southern Australia. This work is in a preliminary stage and will form the major project for the new year in this department.

In association with the Division, activities in the Department of Agricultural Chemistry in the University of Adelaide have related chiefly to a systematic study of the red brown earths of South Australia, amongst the most fertile of the wheat soils of Australia.

The most important projects during the coming year will include the completion of the field surveys in the Murrumbidgee areas and a continuation of the work already begun in the Mildura district.

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.

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 utilising 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.

(i) *Agricultural Drainage.*—There is general agreement that free water in the sub-soil is the chief factor in soil wastage, and observations of a wide range show a close association between free sub-soil water and loss of soil fertility. Large-scale efforts are now being made to obviate this loss by agricultural drainage and a closer approximation to the minimum efficient application of irrigation water.

The results of the investigations have shown clearly that economy in water distribution is accompanied by preservation of the capital value of the lands, thus representing a double saving. It has also been shown that the wastage of land, when brought about by existing free water in the

sub-soil, can be checked by the installation of adequate agricultural drains. These established facts are being utilised by irrigation authorities as evidenced by the following constructional works :—

(*a*) A comprehensive system of drainage mains to permit the drainage of affected areas is in course of construction in the Mildura district at a cost of approximately £330,000.

(*b*) The possibility of the construction of community drainage mains in the settlements of Nyah and Woorinen (Victoria) and Barmera (South Australia) is now being considered.

(*c*) A new system of draining deep seated free water by means of wells 18 to 20 feet deep, from which the outfall is to 6-in. bores constructed down to a previous strata at depths of 100 to 140 feet has been successfully adopted in twelve areas in the Waikerie district in South Australia. This system is of special interest in that tile drains are proving unnecessary, the free water going direct to the wells for distances up to four and five chains.

(ii) *Irrigation Method.*—The results of investigations dealing with the method of irrigation are also now being utilised, 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 decreased costs in each irrigation service, and greater preservation of soil fertility, their importance cannot be too highly stressed. A prolonged period, between the irrigations of the individual, results from long periods for the community. 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.

(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 eighteen 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.

(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 utilised 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 Irrigation authorities.

(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. These constants include "field capacity," "wilting point," "moisture equivalent" and "sticky point," "mechanical analysis" and "apparent specific gravity," &c. The development of laboratory technique and statistical analysis of the figures obtained represents a type of investigation involving some years of work. Data of this description have now been obtained on nine sites, representing six major soil types.

(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 three years. The data disclose that the translocation of salt, and the preservation and improvement of soil fertility, bears a close relation to the method of irrigation, the quantity of water applied, and to agricultural drainage.

The ultimate purpose of the investigation is to ascertain the possibilities of preserving or increasing the fertility of potentially salty soils to which irrigation water is regularly applied. Although continuance for a number of years is desirable, the results to date have consistently disclosed a marked relation of the methods of irrigation and agricultural drainage to the fertility of these soil types.

(iv) *Agricultural Drainage.*—A survey of the fluctuations of free sub-soil 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.

4. *Viticultural Problems.*—The investigation of viticultural problems are 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. Results of this work are obtained relatively quickly, and interim reports are available on which modification of grower's practices may be based. Pruning, cincturing, the balance of fruiting wood, regularity of yield, and reconstitution of old and damaged vines, are embraced in this work.

5. *Fruit Processing.*—The present position of this work is that field trials have been completed, and on the results of these trials, recommendations in relation to the processing and packing of dried fruits have been made. The work covers field processing (dipping and drying), including ingredients of the dip ; moisture content and colour in relation to transport and storage ; and the control of dried fruit pests. Material improvements have been effected in these important phases of the industry.

Since the last report there have been two important developments. The measurements 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 the extensive use of this fumigant on a commercial scale initiated. In processing, the investigation now includes laboratory and field examination with a view of obtaining more definite data in respect to the chemical composition and changes of the ingredients used in processing, and of the fruit itself.

6. *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 are represented, comprise the following :—

Drainage Committee, Mildura district.
Interstate Fruit Processing Committee.
Nyah-Woorinen District Enquiry 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.

7. *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.*—Satisfactory progress has been made in the investigations at this Station, which is financed partly by the Water Conservation and Irrigation Commission of New South Wales. Further financial support has now been provided under the Commonwealth Government's five-year programme for citrus preservation experiments. This assistance, together with the co-operation of the Griffith Producers' Co-operative Society and local growers, has enabled the Research Station to continue the Griffith section of the cold storage investigations on a much wider scale.

The Station's plantings now comprise 28 acres of oranges used mainly for long-term experiments in green manuring, fertiliser requirements and various cultural practices. An additional area is now being prepared for a long-term investigation on the water requirements of citrus. The following account summarizes the results of the above investigations and of the work being carried out in irrigation, frost and other problems.

2. *Green Manuring.*—The beneficial effects of winter green manures on citrus, shown by the Station's experiments, have had considerable practical value, and green manuring is now usual on irrigated orchards in the areas.

Investigations are in progress to ascertain the more fundamental causes for the effect of green manures. In this connexion the first stage of an investigation into the nitrate conditions of green manured soil has been completed. As a result of frequent soil sampling over a period of two years it has been shown that the greatest concentration of nitrates is found in the lower depths of the soil (from 30 to 120 cm.) and that nitrates in the surface soil (from 0 to 30 cm.) do not begin to increase until November. In the lower layers the greatest concentration throughout the year occurs in the clean cultivated plots, but in the surface layers there is a greater concentration in the summer after ploughing-in a winter legume.

The differences in the soil nitrate level in the clean cultivated and green manured plots cannot explain the differences noted in the growth of the trees, and the possibility of the trees benefiting from nitrogen fixed during the growth of the legume, is not being overlooked. Further investigations are proceeding along these lines.

3. *Fertilizer Experiments.*—The fertilizer requirements 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.*—In co-operation with the Division of Plant Industry, considerable progress has been made in the investigation into the objectionable alternate cropping habit of Valencia oranges. On the irrigated areas this variety bears alternately heavy and light crops, thereby creating marketing problems and adversely affecting fruit quality. In light crop years the fruit is over large and coarse, and in heavy crop years it tends to be undersized. The investigation is proceeding along the lines of thinning and fertilizer treatment, and the progress of the work to date has been published in the Council's quarterly Journal.

In general, it has been shown that the earlier the thinning the more effective it is, but even thinning as late as August has a small beneficial effect on the setting of the next crop. In heavy crop years the best results for obtaining a good setting the following year have been given by thinning the fruit in January, and this is recommended as a practical method of overcoming the difficulty. Further investigation is proceeding on the effect of thinning on the size of the fruit remaining on the tree and the application of nitrogenous fertilizer at critical periods.

5. *Cold Storage of Citrus Fruits.*—Extensive cold storage experiments with oranges are being carried out by the Station as part of the general programme of citrus preservation being undertaken by the Council. The Station's investigations deal mainly with the effect of orchard environmental factors on the keeping quality of the fruit.

The keeping qualities of oranges varies from farm to farm and it is important to determine the relative influence of the large number of orchard factors concerned. The factors studied deal

with the strain of orange, cultural and soil moisture conditions, time of picking, method of handling, &c. The investigation also aims at determining good storage qualities from an examination of the fruit itself.

6. *Frost.*—Certain aspects of the frost problem in the Murrumbidgee irrigation areas are being investigated, and trials made of new methods developed overseas.

7. *Irrigation Investigations.*—The control of water in irrigation is a major problem on the Murrumbidgee and most other irrigation areas. Parts of these districts have gone out of profitable production because of the damage caused by excess water and attendant salt accumulation. In some cases there has been a reactionary tendency to use insufficient water, with serious effect on the growth and yield of trees.

At the Research Station experiments are proceeding which aim to elucidate the relationships between irrigation practices and soil moisture movement and distribution. Those dealing with the hydraulic principles of spray or sprinkler irrigation were completed during the year, and the results have been published. The spray method of irrigation is valuable under certain conditions where surface flow methods of irrigation are difficult or impracticable. Under present conditions, however, furrow, forder and similar methods must be used on most farms, and investigations on these are being continued.

In this work, the percolation characteristics of various soil types on the Murrumbidgee areas are being studied, together with an investigation of irrigation methods under varying conditions of soil, slope, head of water and distance of flow. In connexion with furrow irrigation, the effect of soil tilth and furrow shape and size are also being investigated.

During the 1934–35 season a large number of furrow tests were carried out on an area of approximately uniform soil type made available by the New South Wales Department of Agriculture. Difficulties of technique in measuring flows in furrows were overcome by the use of brass orifice plates in standardized submerged orifice flumes, and the desired accuracy for these experiments is now easily obtained. The experiments corroborated the formula for percolation rates recently stated by Kostiakof. The results are being mathematically treated and promise to yield a general relationship covering soil type, slope, head of water, &c. This work will be later correlated with the soil survey now being carried out by the Division of Soils on the Murrumbidgee irrigation areas.

The determination of the water requirements of citrus—of obvious importance in irrigation work—has not been made under Australian conditions. A new field is now being planted with citrus which is designed for a long-term investigation of this kind.

IX. FOREST PRODUCTS INVESTIGATIONS.

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

The Commonwealth Bureau of Forestry has the field of sylvicultural research under its care, and the line of demarcation between its work and that of the Division has been more or less arbitrarily fixed at the felled tree. From that point through every stage into its conversion into timber and articles of use there is enormous waste, and one of the most important functions of the Division is the study of methods to prevent or reduce this waste. Temporary accommodation has been provided for the Division at 314 Albert-street, East Melbourne, but permanent laboratories are to be erected at South Melbourne during the coming year.

The work is divided into two main sections—

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

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

The greater part of the energies of the Division, in its first few years, is being devoted to the above work, because it is recognized that there is an enormous amount of information in existence,

which, if properly applied, can be of the greatest value to all forms of timber industries. This practical application of existing knowledge, it is held, should take precedence over the accumulation of new information.

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

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

A feature of the year has been the extent to which sawmillers, timber merchants, manufacturers of wood products, in fact all branches of the timber industry have shown a readiness to co-operate with the Division. The value of close contact with the practical man cannot be over-estimated and the viewpoint of the Division in this respect is aptly given in an extract from a lecture by the Director of Building Research, England—

" The more contact one has with the practical man the more one appreciates his knowledge and his outlook, and the more one is convinced that only by very effective co-operation between him and the scientific worker is any progress likely in any reasonable time."

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

(i) *Telegraph Poles and Railway Sleepers.*—Two new service tests of poles were commenced during the year, one in New South Wales at two test sites and one in South Australia. In the former test, six pole-using authorities are co-operating, and 310 poles of three eucalypt species are involved. In the latter test, *Pinus radiata* poles were treated with creosote, in co-operation with the Postmaster-General's Department.

A Pamphlet, No. 55: *The Selection, Preservation, Distribution and Identification of Australian Pole Timbers* has been published in order to supply the long felt want of information on all aspects of pole supply and utilization.

Further tests of the oxyacetylene scouring and charring process for the treatment of partly decayed poles were carried out and modifications in procedure were recommended. It was demonstrated that where the recommended procedure was properly carried out, a high degree of sterilization was obtained. The results have been recorded in Pamphlet No. 57: *Tests of the Efficacy of the Oxyacetylene Scouring and Charring Process for Sterilizing Partly Decayed Poles.*

The treatment and installation of a large number of *P. radiata* railway and tramway sleepers have already been recorded.

(ii) *Fence Posts.*—A further inspection of the fence posts in Western Australia, after five years' exposure, has confirmed the results recorded last year. The posts treated with creosote plus oil and zinc chloride plus arsenic are all sound. A test of *Eucalyptus macrorrhyncha* and *E. stuartiana* treated posts has been commenced at Benalla, Victoria, and posts of *E. maculata*, *E. pilularis* and *E. grandis* are at present being seasoned prior to treatment for a test at Uffington State Forest, New South Wales.

Round log sections of *Araucaria cunninghamii*, *Eugenia gustavioides* and *Tarrietia argyrodendron* var. *peralata* from Queensland were successfully treated with creosote by the open tank process for house blocks.

(iii) *Marine Piling.*—Pile sections of *E. pilularis*, *E. saligna* and *Tristania conferta* were treated with creosote in 1932 and forwarded to Queensland for service tests. The creosoted specimens at one station (low salinity) have been badly attacked or destroyed by *Nausitora*, while two of the creosoted specimens at the other station (high salinity) are sound, and one has slight attack by *Teredo* and *Sphæroma*. All these specimens were treated with a low grade oil. A further series of similar test specimens treated with high grade oil has been installed.

(iv) *Preservatives.*—A method for the determination of fluorine in fluoride treated wood has been developed, depending on low temperature ashing in the presence of calcium acetate distillation with perchloric acid and titration with standard thorium nitrate, using sodium alizarin sulphonate as an indicator. The method is satisfactory for relatively large amounts of fluorides (greater than 0.1 per cent. in the treated wood). Samples of fluarised sleepers, &c., have been analyzed for arsenic, and similar determinations of the sodium fluoride content are now in progress.

(v) *Investigation of Lyctus (Powder Post Beetle.)*—It is now obvious that the problem of Lyctus is the problem of the occurrence of starch in sapwood and that frequently in commercial

practice starch-free sapwood is rejected because of lack of appreciation of this. A survey of starch in Victorian timbers has, therefore, been carried out during the year. It is interesting to note that although *E. regnans*, the most important Victorian timber, is reputed to be susceptible to attack, no properly authenticated case of attack has yet been found, nor has starch sufficient for attack yet been detected in commercial timber of this species. The survey is being continued on a more extensive scale in Victoria, and is being extended to Tasmanian and Queensland timbers.

3. *Timber Seasoning.*—The work carried out followed essentially the same main lines as in previous years, being divided as follows: (1) Trade Contact, (2) Laboratory Work, (3) Educational Work.

Under the first of these divisions, visits were made to a number of plants in order to give advice or to assist in the early stages of operation of new kiln installations, and a considerable amount of time was spent in interviewing members of the trade at the laboratory and in replying to inquiries received by post. A very pleasing feature of the trade contact work was a marked increase in kiln seasoning, especially in Queensland.

Laboratory work consisted mostly of the development of suitable schedules for kiln-seasoning various Australian timbers, but some important work in relation to the design of seasoning kilns was carried out, as also were some promising preliminary tests of a method of veneer-drying not hitherto known in Australia.

Educational work continued along the four lines previously established, namely, the publication of Trade Circulars, the giving of lectures and practical demonstrations at the laboratory, the carrying out of a correspondence course for kiln operators, and the training of kiln-operators at the laboratory.

(i) *Kiln-drying Schedules.*—Work under this project formed the main part of the laboratory work for the year. The number of laboratory kilns has been increased to five. In spite of this, it has not been possible to keep pace with demands by the trade for information regarding kiln schedules. Laboratory tests prior to commercial tests in the kilns of the Queensland Forest Service have figured prominently in the year's work.

(ii) *Kiln Design and Construction.*—Observations and tests were made on kilns at eleven commercial plants during the year. The Division is continuing to advocate the cross shaft internal fan type of kiln for general purposes.

Two features introduced during the year were a double stack kiln and a concrete arched roof in place of the usual wooden roof. Both innovations proved successful.

(iii) *Kiln Aerodynamics.*—The special kiln designed for this work was brought into service and a number of preliminary investigations were carried out. Unfortunately, this work had to be postponed because of staff shortages and because the kiln was required for schedule work.

4. *Utilization.*—(i) *Standardization and Grading Rules.*—The Division has continued to be closely associated with the timber activities of the Standards Association of Australia. Further attention has been given to grading rules for floorings, linings, weatherboards and plywoods, and to the standardization of window sashes and frames, doors, mouldings and joinery stock. Terms and definitions used in timber grading have been reviewed to reduce discrepancies between English and Australian standard terms, and as a result of collaboration between the British Standards Institution and the Standards Association of Australia, a large measure of agreement has been secured. Specifications for wooden paving blocks which are acceptable to all interests have been drawn up.

The confusion in botanical and common names of Australian timbers has continued to be a source of worry, but it is hoped that at the International Botanical Congress in Amsterdam in September, 1935, action will be taken which will improve the botanical position. The Senior Wood Anatomist of the Division is a delegate to the conference and strong representations are being made for the conservation of specific names of long standing.

Lists of recommended common names for important timbers have been drawn up, and the Timber Sectional Committee has approved of the circulation of these amongst the State Sub-committees on timber with a view to securing agreement throughout the Commonwealth as far as the better known species are concerned.

It will be possible to place the grading of Australian timbers, both for local and export trade, on a far more satisfactory basis when extensive field studies at present in progress have been completed in all States. A three year programme has been drawn up, and field grading studies were commenced during the past year in Victoria. The output from sixteen sawmills representative of the main forest districts of the State were studied in order to show the frequency of occurrence of various defects and proportionate yields of sawn timber conforming to suggested

grades. Inquiries were also pursued among the main consuming industries to find where the demand for the various quality classes exists and to investigate how these industries are being served by present grading practices.

A grading study of sleepers was commenced in two districts, and this is being continued. Towards the close of the year, grading studies on *P. radiata* were further advanced at Bundaleer, where the oldest available plantation in South Australia is being felled for timber. The present and possible future uses of *P. radiata* were the subjects of inquiries conducted in South Australian industries.

(ii) *The Utilization of New South Wales Timbers.*—Officers of the Division attended a number of conferences called by the Minister for Forests in New South Wales (the Hon. R. S. Vincent) with the object of improving the utilization of New South Wales timbers. It became apparent that an outstanding requirement was the provision of modern kiln plant for the carrying out of kiln drying tests on a commercial scale. As a result of the conferences, amending legislation was enacted to widen the powers of the Forestry Commission, to permit the erection and suitable operation of a battery of commercial kiln units. The possibility of using New South Wales hardwoods in smaller sizes because of their high strength properties was also investigated and reduced sizes for these timbers without loss of efficiency were decided upon for use in Government buildings.

(iii) *General.*—The number and range of inquiries dealing with timber utilization is steadily increasing. One noteworthy feature is the demand for data on logging and milling. Concurrently with the field grading studies, production-time studies were made at the majority of mills visited. Althougn, at first, analysis of the data collected had to be deferred in favour of the more urgent grading work, arrangements have now been made to permit this analysis to proceed, although at a comparatively slow rate.

5. *Wood Structure.*—(i) *Wood Anatomy.*—During the latter half of 1934, the work of this Section was mainly confined to the completion of the necessary information prior to the publication of Bulletin No. 90 dealing with the general properties, macroscopic and certain microscopic features of 100 commercial Australian timbers, other than Eucalypts.

Information was also compiled regarding the general properties, wood structure, identification and durability of the 24 important pole timbers of Australia. Methods and keys for identification were prepared. This information, together with that on preservatives and methods of preservation has since been published in Pamphlet No. 55 *The Selection, Preservation, Distribution, and Identification of Australian Pole Timbers.*

Examination of all available Australian specimens is now being carried out by natural orders, and the following additional orders have received attention: Monimiaceae and Verbenaceae.

(ii) *Basic Density.*—Basic density determinations (oven dry weight and volume when soaked) have been carried out throughout a considerable number of trees of *E. diversicolor, E. astringens, E. regnans* and *Tarrietia argyrodendron* var. *peralata.* In all cases, an increase in basic density was noted from pith to sapwood, with a fall again through the sapwood.

6. *Timber Mechanics.*—During the year, the volume of testing work was increased considerably and the number of individual tests, over 8,000 (exclusive of moisture content determinations), was 35 per cent. higher than the previous year.

(i) *Standard Mechanical Tests on Australian Timbers.*—The results of the earlier tests on karri (*E. diversicolor*) were given in the previous report. During the past year, the results of the tests on the green material were analysed in detail. There was a considerable variation in the mechanical properties with distance from the pith, the strongest, hardest and stiffest wood occurring in the true wood near the sapwood. The influence of height in the tree on the mechanical properties was not marked, although there was some tendency for the wood from near the butt to be less tough, weaker, but harder than that from higher up in the tree. The influence of density on the various strength properties was investigated by statistical methods. Although the correlation between density and the various strength properties is fairly high for a pored wood (the correlation co-efficients were all about 0.6), it is not sufficiently high to allow the strength of a given piece of karri to be estimated from its density with any degree of accuracy, although, of course, any particular light pieces are likely to be low in strength.

Analysis of the tests on the bearing strength of karri at varying angles to the grain showed that the Hankinson formula fits the results remarkably well. Since this formula was derived for north American species and has been shown to fit closely the results of tests carried out in England and Russia, its general adoption in preference to the Howe formula is recommended. A short series of tests were carried out to determine the strength-moisture curves for the toughness, bending strength and hardness of karri. These showed that there is little variation in toughness with changes in moisture content, maximum toughness occurring near the fibre-saturation point. The

modulus of rupture and hardness, on the other hand, increased greatly with reductions in moisture content, the curve being logarithmic below about 26 per cent. moisture content. The material that was set aside for air-drying has not yet dried down to the required moisture content (12 per cent.) Karri is a slow-drying species and it is not expected that the timber will be ready for test until the end of next summer.

The mechanical tests on both green and dry *Pinus radiata* have been completed, and the average results computed, but a detailed analysis has not yet been made. One of the most striking features of the tests was the great change in mechanical properties of this species on drying. The air-dry wood was about 100 per cent. stronger statically but very much more brittle than the green wood, the toughness when dry being only about 60 per cent. of that when green. Comparison with New Zealand tests showed that when green, the South Australian grown timber is almost identical in its mechanical properties with that grown in New Zealand, but when dry, the South Australian wood is much stronger than the New Zealand. Arrangements have been made for a further supply of this species to be obtained from a 50-year-old plantation at Bundaleer, South Australia.

Tests on the green material from fifteen logs (twelve trees) of mallet, *E. astringens*, were completed during the year and a report prepared. The results indicated that mallet is superior to spotted gum (*E. maculata*) for handles, &c., but the conclusions must be treated with caution until the tests on the dry material are completed. This species is being extensively propagated in Western Australia because of its valuable tanning bark. Tests were made on five trees of mountain hickory (*Acacia penninervis*) from New South Wales. The tests on the green material were completed, and indicated that the wood is very tough and should be superior to spotted gum for handles, &c. This conclusion, however, is liable to modification when the air-dry tests are made.

A very extensive series of tests is being made on cypress pine (*Callitris glauca*) and 55 logs from eighteen trees were selected so as to be representative of the species in Queensland. Approximately half of this material is being used for tests on small clear specimens in order to determine the intrinsic mechanical properties of the wood ; the remainder was cut into scantling sizes and will be tested as cut from the saw. The defects in each piece will be carefully noted before test and in this way the influence of defects on the strength will be determined, thus enabling rational structural grading rules and working stresses to be drawn up. The tests on the small clear specimens of green material are not quite finished, and the results have not been computed, but it appears as if the static strength of this species is very high for a conifer.

The tests on the air-dry reconditioned and non-reconditioned immature *E. regnans* have been completed. The detailed analysis of the results has not yet been made, but preliminary investigation has shown that there was no significant difference in the strength of the reconditioned and non-reconditioned specimens. Eleven logs from six representative trees of red tulip oak have been converted into specimens but the tests have not yet commenced.

(ii) *Minor Tests on Australian Species.*—In order to obtain some information on the more important mechanical properties of Australian timbers, samples are cut from all properly identified specimens received at the laboratory. These samples are tested for toughness, hardness and bending strength when dried to about 12 per cent. moisture content. During the year, tests were made on 1,400 specimens representing 150 different species.

(iii) *Boxes.*—During the year, testing work on the design of boxes and crates was confined to several series of tests on boxes submitted by commercial firms, no very extensive series of tests having been made. It is probable, however, that the results of these short tests will be of even more immediate benefit to industry than the more fundamental studies, as the firms interested have in every case applied the results of the tests to commercial practice with beneficial results.

(iv) *Steam Bending.*—Work on this project was initiated during the year. A suitable machine for research in bending has been developed by the English Forest Products Research Laboratory at Princes Risborough. Details of the machine were obtained by courtesy of the English Laboratory, and a similar machine was constructed locally, several alterations being made to the original design. No systematic research work has yet been carried out, but trials have shown the machine to work very satisfactorily.

7. *Wood Chemistry.*—The work of this Section included a continuation of the studies on identification of wood by chemical means and on the lignin determination. Towards the end of the year, an examination of existing methods of pulp analysis was made in connexion with the investigations into the fundamentals of paper making from eucalypt woods, which were inaugurated during the year.

Work on the use of simple chemical tests for the identification of 37 important coloured Eucalypts was completed, and the results published as Pamphlet No. 53 *The Identification of Wood by Chemical Means* : Part 2—*Alkalinity of Ash and Some Simple Chemical Tests for the*

Identification of the Coloured Woods of the Genus Eucalyptus. Alkalinity of the ash gave fair separation into four groups and three additional tests were developed for further sub-division. The examination of 40 light coloured Eucalypts is proceeding.

A further publication was Pamphlet No. 51 *The Chemistry of Australian Timbers: Part 4—A Study of the Lignin Determination II.*, in which it was shown that lignin values, following pre-treatment with hot N/8 sodium hydroxide, although low, were nearer the true values than those obtained by pre-treatment with alcohol-benzene and hot water. A method of recovering some of the lignin dissolved by the alkali by precipitation with acetic acid was described. Further investigation has not shown a way of overcoming with some timbers the precipitation of non-lignin substances along with the lignin in the alkali-acetic acid method. On the other hand, it has been found that extended treatment with hot water and mild hydrolysis with sulphuric acid both remove material which on present evidence should be regarded as lignin.

In connexion with the occurrence of " brittle heart ", adjacent samples of karri truewood and brittle heart were examined. These when compared with tests of young timber indicated a loss of lignin in the " brittle heart ", and this would be consistent with the action of a lignin destroying fungus.

The possibility of interference by tannins in the pentosan determination, as suggested by some recent Russian investigations, has been examined. The results indicated that the presence of tannins in the woods examined was without influence on the pentosan values obtained.

A study of the distribution and nature of the non-volatile ether extractives in *Pinus radiata* has been completed. There seemed to be no definite relationship between the yield of extractives from a whole log section and the age of these young trees, or the presence of heart wood. The results obtained indicated the need for the examination of a much larger numbe- of trees, including studies in relation to seasonal variation and changes in the extractives during storage.

The original method adopted for the determination of arsenic in wood has been modified somewhat to reduce the time taken for an analysis. Recoveries of 97-98 per cent. have been obtained. An account of the procedure finally adopted will shortly be published.

8. *Timber Physics.*—The work of this, the youngest Section of the Division, has developed during the year, and is now spread over seven projects, although shrinkage has continued to receive most attention. Comprehensive studies of various factors which may affect shrinkage have been carried out on very thin sections from a number of different timbers. The use of such sections eliminates the variable factor of collapse. Investigations have included the effect on shrinkage of (*a*) size of sample, (*b*) previous air-drying, (*c*) thickness of sample, (*d*) moisture gradients in sample during drying, (*e*) temperature at which sample is oven-dried after air-drying, (*f*) keeping samples green over water in a closed vessel, and (*g*) keeping samples green in water. Further work on the effect of subjecting green sections to various temperatures is in hand.

A method of determining fundamental shrinkages has been adopted tentatively and tests have been carried out on some fifty species. The results so obtained have been compared with the results from the standard 4″ x 1″ x 1″ shrinkage tests and show a fairly close agreement with the figures obtained for the 4″ x 1″ x 1″ samples after reconditioning. The discrepancies are such as would result from drying stresses and the varying angles of the growth rings in the larger samples. Fundamental shrinkage figures have been obtained for a second fifty species, but the 4″ x 1″ x 1″ shrinkage tests of these have not yet been completed. A series of tests to determine the variation of shrinkage throughout six trees of red tulip oak has been carried out. In these, both 4″ x 1″ x 1″ samples and thin sections have been used.

Longitudinal shrinkage tests on 48 species have been completed and a further 50 species are under examination. The collection of shrinkage figures from samples used for kiln schedule work by the Seasoning Section has been continued during the year, and a considerable amount of information has been obtained in this way.

Interest in the Blinker electrical moisture meter as a commercial instrument has been maintained and the Australian manufacturer reports that the total number sold for use in Australia is now 103, of which 45 are sorting instruments. Correction figures have been determined for a further 42 species at moisture contents of 10, 15 and 20 per cent. To facilitate this work, two new conditioning boxes have been placed in use and one of the old ones rebuilt. Material has been prepared from nearly 40 additional species, and is now being conditioned prior to testing. To facilitate the checking of electrical moisture meters, a series of standard resistances has been prepared corresponding to the various moisture contents. The higher resistances have been made from mixtures of alcohol and xylol and the lower resistance built up from carborundum

elements. The special electrodes for testing veneer have been calibrated and two sets of these are now in commercial use. Temperature corrections to permit testing sample boards, hot from the kiln, have been determined.

Fibre-saturation points obtained from shrinkage curves, have been listed for 58 Australian species. For one species, red tulip oak, the variation throughout the tree has been considered. Investigations of the effect of medullary rays and of extractives on the fibre-saturation point are being made. A series of tests to develop details of methods of determining drying stresses and moisture distribution has been completed. Indirect methods have been adopted for determining green and air dry densities using basic density and the green moisture content for the former and basic density and volumetric shrinkage (calculated) for the latter. The method has been checked with the direct method and has been used to obtain figures for 54 species, and to study the variation in density throughout six trees of red tulip oak.

X. COLD STORAGE INVESTIGATIONS.

1. *General.*—Early in the period under review, the Council brought to the notice of the Commonwealth Government the urgent need of adequate funds for a more intensive attack on the problems of the wastage in citrus fruit exported from Australia. As the result of these representations, a sum of £10,000, to be utilized over a period of five years, was made available. At a meeting held in Sydney in February, 1935, which included representatives of the Council and of the Departments of Agriculture of New South Wales, Victoria and South Australia, a comprehensive scheme of investigations on the storage of Navel and Common oranges was adopted, and immediately put into operation. The appointment by the Council of a citrus preservation research officer has materially aided the co-ordination of the investigations which are necessarily conducted at a number of different centres.

It is of interest to record that the activities of the Section of Food Preservation and Transport, which are distributed in various laboratories in three States, are rendered possible only by the generous co-operation of many organizations which have provided not only laboratory accommodation but also, in several cases, substantial funds. Negotiations are in progress, however, for securing central laboratories in Sydney for housing various branches of the Council's food preservation investigations. Such provision will undoubtedly facilitate the organization of the work and will ultimately result in considerable saving of money.

Fruitful co-operation with many widely scattered organizations has continued throughout the year. An intensive study of the diseases of storage and ripening of bananas has continued through funds provided by the Commonwealth Banana Committee. These have enabled the Council to second an officer to the Queensland Department of Agriculture and Stock and to provide a research grant for a member of the Botany Department, University of Melbourne. Through funds provided by the Sydney Metropolitan Meat Industry Commissioner, Mr. F. Wright of the School of Agriculture, University of Sydney, is co-operating with the Section in certain microbiological investigations at the Homebush Abattoir. More recently, Mr. Wright has undertaken for the Section the considerable task of classification of the various types of bacteria responsible for the spoilage of chilled beef. The Queensland Meat Industry Board has continued to provide and maintain laboratories for meat investigations as well as giving a substantial contribution towards the cost of salaries. Since the majority of the problems being studied concern the export of perishable foodstuffs to Great Britain, co-operation with the British Food Investigation Board is essential, particularly in regard to problems of oversea transport and the nature of the various forms of wastage apparent on arrival of the foodstuffs in Great Britain. During the past year, a still better understanding with the British organization has been achieved. Through the Section's liaison officer in London, several research schemes which the Council and Board are jointly working have been arranged. Exchange of information with similar organizations in South Africa and New Zealand has taken place. These Dominions and Australia have many common problems of food preservation and transport, and it may be possible ultimately to effect a joint attack on several outstanding problems of mutual interest in overseas transport through the co-ordinating efforts of the British Food Investigation Board. Administrative difficulties, arising mainly from the vast distances separating the interested parties, have still to be overcome before a joint attack is feasible.

2. *The Preparation and Transport of Chilled Beef.* (i) *General.*—With the export of increasing quantities of chilled beef from Australia to Great Britain, the trade may be said to have passed from the experimental to the commercial stage; shipments of 200 to 300 tons from one works are now common. From Queensland alone, 8,391 tons were exported during the year ending 30th June, 1935, while considerable quantities have also been sent from New South Wales and Western Australia (Wyndham). The majority of shipments arrived in excellent condition, but several may be regarded as partial failures. Of these, fairly precise data are available concerning four consignments, and in three instances, failure may definitely be

attributed to a lack of adherence in the meatworks to the strict conditions of preparation and chilling defined by the officers of the Section. In the fourth instance, an unsatisfactory out turn was due to an experimental attempt to carry the beef at a slightly higher temperature (30° to 30.5° F.) than is normally practised. The attempt was theoretically sound for beef of good quality, but, as this particular shipment was of rather poor quality, serious loss of bloom of the meat ensued.

While the major problems of the preparation and transport of Australian chilled beef appear to have been solved, many investigations must still be pursued with the objects of increasing our knowledge of several rather obscure changes taking place in the beef during storage and of discovering preventive measures for many minor defects still apparent. Among the more important of these investigations are studies of the nature, extent and causes of the loss of bloom so frequently occurring in commercial shipments, and the influences of varying degrees of superficial desiccation of the meat.

Close contact has been maintained with officials of the beef exporting works, and the results of the Section's investigations are thereby being rapidly applied in commercial procedure. This has been important since it has been expedient only to publish a very small amount of the results obtained. General surveys of five exporting works have been completed during the year and reports issued to the firms concerned.

(ii) *Microbiological Investigations.* (*a*) *Influence of Microbial Population of the Soil.*—In the last report, it was pointed out that in any given locality there was a good correlation between the " low temperature population " (micro-organisms capable of appreciable growth at 30°F.) of the soil and of the contamination of the chilled beef prepared in that locality. Moreover, the seasonal rhythm in the numbers and activity of the micro-organisms found on the surface of the beef was traced to a similar rhythm in the microbial population of the soil. More intensive work along these lines at one meatworks in Queensland, accompanied by a continuous record of surface soil temperatures, together with the regular examinations of soil samples from Townsville, and occasional examinations of soil from Winton (Queensland), Wyndham (Western Australia,) Aberdeen (New South Wales), Hobart (Tasmania), and Wanganui (New Zealand), have amply confirmed the previous findings that the higher the prevailing soil temperatures the lower, in general, is the contamination of the beef by " low-temperature population " micro-organisms, and the weaker their activity. While insufficient data have been collected for States other than Queensland, it seems certain that, for the latter, assuming a standard method of preparation, safe storage life of the beef, viewed from the aspect of the onset of visible microbial growth, increases with a decrease of latitude and with increases of mean surface soil temperatures beyond the optimum for " low temperature " organisms. In other words, in any given meatworks in Queensland, the safe storage life in the summer months is somewhat greater than in the winter, and, at any given time, it tends to be greater the more northerly the situation of the works.

Since the prevailing soil temperatures largely control the extent and activity of the micro-organisms constituting the initial " low temperature " population of the beef, it is important to have precise data regarding the growth rates at different temperatures of the more important of these organisms, and more particularly knowledge is required of their thermal death points under standard conditions. Preparations for extensive work on the former aspect are now being made, and investigations of the latter have been commenced.

(*b*) *The Control of Initial Contamination.*—Experimental work has commenced in order to examine the possibilities of using some form of radiation for the purposes of controlling the initial contamination on chilled beef. Exploration of portions of the electro-magnetic spectrum has shown that there are regions which are markedly bactericidal. In much of the early work a certain unreliability in results was apparent, and was obviously due to the operation of variables whose existence was not altogether apparent. Further experimental studies has led to an understanding and control of these variables to the point where results are reproducible to an unusual degree of accuracy considering the nature of the material used. Organisms spread on experimental agar plates are readily and completely killed with surprisingly small amounts of radiant energy. For equal amounts of radial energy the percentage " kill ", using meat (muscle) as a substrate, is a little less than with agar. This is readily understandable when one considers the physical nature of the respective surfaces in the two cases. For purposes of accurate quantative study it was necessary to develop a method of securing very uniform distributions of the organisms used. A description of this work and the method now employed is to appear in a forthcoming number of the Council's Journal.

(*c*) *Action of Yeasts and Achromobacter on Fat.*—During the prolonged storage of chilled beef, *Achromobacter* and yeast slime may be formed on certain areas of the fatty tissues as well as on exposed muscle. The fatty tissues so attacked acquire a rather acrid, and sometimes " stale " flavour. While the percentage of free fatty acids in the fat of such areas is considerably

higher than in adjacent relatively sterile areas (these fatty acids do not, of themselves, give rise to " off-flavours "), it has not yet been possible to detect any appreciable rancidity which might account for the " off-flavours ". It is possible that these may be due to microbial breakdown of the connective tissue surrounding the fat globules, but, in order to ascertain whether microbial attack on the glycerides is capable of producing unpalatable products, a more detailed exploration of the action of various organisms in pure culture on emulsions of beef fat are being made. Prolonged studies of the action of certain slime-producing organisms on emulsions of beef fat have definitely proved that some have a marked lipolytic action, while the effect of others is negligible.

(iii) *Cooling of Sides.*—In the last Annual Report, a statement was given of the approximate speed of cooling hot sides of beef necessary for subsequent safe storage of the quarters. Further evidence of the importance of this phase of treatment has been obtained and has stimulated more intensive analysis of the physical and biological aspects of the problem.

While it has not been possible to make a complete analysis of the physical aspect, the following tentative results are of considerable interest.

The rate of evaporation of moisture per unit surface area of a side of beef during cooling is approximately proportional to p. 1–2 where p. is the difference between the saturation vapour pressure of water at the temperature of the surface and the aqueous vapour pressure of the surrounding air. The constants have been determined for two different types of chilling chamber—forced air circulation and convective air movement types—and these appear to be characteristic of each and must ultimately be functions of air speed. In the early stages of cooling, the rate of reduction of the temperature of the surface of the side alone seems to govern the rate of evaporation of moisture. After about 12 to 16 hours the relative humidity of the air begins to exert its characteristic effect, and the " cooler " having continuous forced air circulation then maintains a higher rate of evaporation than does the " convection cooler ". During the first 16 to 24 hours of cooling, there is a rapid decrease of moisture content of exposed muscle from 74 per cent. (approx.) to values of the order of 45 to 50 per cent. ; thereafter, a slow rise of moisture content to 53 to 60 per cent. usually occurs. While the factors governing the rate of proliferation of " low-temperature " micro-organisms during the cooling of the sides now appear to be rather complex, preliminary results would seem to indicate that the rapid production and maintenance of relatively low moisture contents of exposed tissues are of primary importance in the prevention of marked proliferation during chilling of those organisms responsible for spoilage of chilled beef. The reasons for the marked superiority of chambers which effect rapid cooling and subsequent relative dryness of the surface of the sides are, therefore, becoming apparent.

(iv) *Storage.* (*a*) *Microbial Studies.*—Several storage experiments of quarters of beef were completed during the year.

A further comparison of the storage life of quarters stored in 10 per cent. CO2 and in air at 29½°F. was made during the period when the activity of the contaminating organisms is usually the most apparent (late winter). The mean generation time for achromobacteria on muscle stored in 10 per cent. CO_2 was approximately three times as great as that for air stored muscle, but the bacteria on the CO_2 stored muscle had not entered their phase of most active growth when the experiment terminated (49 days' storage). From the form of the growth curves it appeared that the storage life of the muscle stored in 10 per cent. CO_2 would be approximately double that of the control in air. On the fatty tissues the generation time in CO_2 was only about 20 per cent. greater than that in air. For the wild yeasts on muscle stored in 10 per cent. CO_2 the generation time was 30 per cent. greater (approx.) than on the control in air, but, on the fat no significant difference was detected.

Comparison was also made of the storage of quarters in the usual 10 per cent. CO_2 and in 6 per cent. CO_2. For the growth of achromobacteria on muscle, a true comparison could not be made, since, for some unexplained reason, there was a marked decrease in their population between 36 and 47 days' storage in 10 per cent. CO_2. On the fatty tissues, however, the mean generation time was approximately 30 per cent. greater in 10 per cent. than in 6 per cent. CO_2. A similar marked decrease in the population of yeasts on muscle occurred between 36 and 47 days, storage in 10 per cent. CO_2. On the fat, however, there was no significant difference in the degree of inhibition produced by the two concentrations.

In another experiment, the rates of microbial proliferation on exposed muscle of similar moisture contents at 30.4°F. (slightly above the freezing point of muscle) and 29.5°F. (slightly below the freezing point) were studied. The time taken for the production of ten generations of *Achromobacter* on exposed muscle having a moisture content of 46 per cent. was 30 per cent. greater at 29.5°F. than at 30.4°F. It was shown also that, on dry muscle substrates, relatively high numbers of *Achromobacter*, e.g., 6×10^9 could be present without producing visible slime. For yeasts, the time taken for ten generations to appear on muscle with an initial moisture content of 48 per cent. was 30 per cent. greater at the lower temperature.

In conjunction with the above experiments, the exposed muscles around the aitch bone of a number of buttocks were trimmed and subjected to varying degrees of desiccation. Several areas were then inoculated with one strain of *Achromobacter*, and others with a large-celled variety of yeast (*Torula* spp.). Storage was carried out at a temperature of 30.4°F. The times for the generations of *Achromobacter* to appear on muscle of 74, 46, and 38 per cent. water contents were approximately in the ratio of 1 : 1.5 : 2. On the other hand, in the case of muscle samples inoculated with the yeast and having initial moisture contents of 75, 55 and 41 per cent., there were no differences in the time taken for ten generations to appear. In view of the important bearing of these results on the storage life of the beef, more precise studies of the rates of growth of *Achromobacter* on muscle of different water contents have recently been commenced. In spite of many experimental difficulties, considerable progress is being made.

(*b*) *Studies of Loss of Bloom.*—The storage experiments have given further confirmation of the previous findings that the rate of loss of bloom in 10 per cent. CO_2 does not differ appreciably from that of similar beef stored under the same physical conditions in air. A slight exception must, however, be stated. On any areas of quarters where very thin coverings of fatty tissue obtain, the fat frequently acquires a dull, grey colour after storage for about six weeks, and the development of this discolouration appears usually to proceed at a slightly greater rate in 10 per cent. CO_2 than in air.

More precise experiments on the nature and causes of the loss of bloom are now being planned. One of the first phases of the investigation will be the making of accurate, quantitative measurements of the colour of characteristic areas of the meat in the terms of the system of colorimetry for standard reference agreed upon by the Congress of the International Commission on Illumination in 1931. These measurements will be made both immediately post slaughter and again after a period of storage similar to that occurring during overseas transport of the beef.

(v) *Overseas Transport.*—Reasonably complete physical and biological data have been collected concerning the preparation, cooling and transport of some 17 shipments of chilled beef. In general, the results have amply substantiated the findings of semi-commercial scale experiments in this laboratory. These shipments have afforded some empirical information, on the basis of which it would appear desirable for somewhat greater mass rates of air circulation to be employed during transport. At present, there is little exact knowledge of effects on the rate of loss of weight and bloom of chilled beef of different values of circulation and relative humidity of the air in ships' cargo spaces. In order to obtain such information, experiments on a portion of certain shipments have been commenced jointly by the Section and the British Food Investigation Board. Plans are now being discussed, also, for obtaining more precise data concerning the physical conditions responsible for loss of weight of chilled beef during transport.

3. *Banana Investigations.* (i) *Investigations in Melbourne of Black-end.*—These studies have defined the chief types of " black-end " disease in ripening bananas and the causal fungi associated with them, together with the relative pathogenicity of each. The investigations have shown that the ripening rooms are not sources of infection. An account of these studies will shortly appear as one of the Council's Pamphlets.

(ii) *Black-end and Squirter Investigations in Queensland.*—In confirmation of the investigations in Melbourne, the chief cause of " black-end " was found to be attack by the fungus *Gloeosporium musarum*. The relative importance of the main causal organisms may be illustrated by the respective numbers of isolations, as follows : *Gloeosporium*, 92; *Fusarium*, 32; *Nigrospora*, 22 ; *Gloeosporium* and *Fusarium*, 8. In addition, a number of wound parasites are responsible for minor blackening.

In order to determine the prevalence of *G. musarum* in the plantation, agar plates were exposed at different positions, and microscopic and cultural examination was made of leaves, bracts and fruit. Few spores of this fungus are present in the air, a few are usually present on fruit, while the organism and its spore masses are almost invariably found growing on dead and dying leaves and bracts. It is probable that leaves provide the substratum for breeding infection, and spores find their way to the fruit by air, water, and animal agents ; infection of the cut ends of the fruit takes place, for the most part from the outer surface, at the time of division of the bunches into singles. The packing shed does not appear to be an important source of spore contamination, although mechanical spread of spores on fruit may take place during packing.

Visits made to plantations suffering from " black-end " and to those normally free from the trouble suggest that the incidence of the disease is correlated with poor cultural practices which allow weed growth and the retention of dead leaves on the plants. " Black-end " from such plantations can be attributed to :—

(*a*) Provision of a large quantity of spore inoculum on dead leaves ; (*b*) rough handling of fruit when packing ; and (*c*) poor quality, slow-selling fruit.

In the ripening room, slow ripening under humid conditions is favorable to " black-end " development. During the summer, high temperatures and, possibly, a soft-natured fruit are factors determining the large amount of " black-end " at this time.

Fumigation and treatment with liquid fungicide were investigated as control measures. For the large ranges of fungicides tested, negative or only poor control was obtained ; several giving partial control caused bad blemishes on the fruit. Three possible reasons for these unsatisfactory results are advanced—(*a*) Resistance of spores, (*b*) Failure to wet surface of fruit or remove latex from the end, and (*c*) Latent infection. The resistance of the spores has been shown to be an important factor, and investigations in connexion with wetting and latent infection are proceeding.

Investigations on the " squirter " disease are being continued. Cultures of *Nigrospora* isolated during studies on the plantations have been retained for classification as to pathogenicity. It is to be expected that measures of control checking *G. musarum* will also be effective against *Nigrospora*, the causal organism of " squirter ". In order to avoid duplication, therefore, experiments on control measures were mainly restricted to " black-end ". The most successful fungicides for the latter disease are now being used for treatment of experimental lots of fruit to study the degree of control of " squirter ".

(iii) *Investigations of Rubberiness.*—Even after the utmost care has been expended on their ripening, " rubbery " or " leathery " bananas are scarcely palatable. There is some evidence to show that temperature and soil conditions on the plantation are responsible for this defect. Extensive field experiments have, therefore, been commenced by the New South Wales Department of Agriculture, and fruit from the experimental plots is being forwarded to Melbourne for ripening and chemical examination. The latter work is being carried out on behalf of the Council in the Biochemistry School, University of Melbourne, and is under the supervision of Associate-Professor W. J. Young.

(iv) *Transport.*—A full account of these (completed) investigations has been published in the Council's Bulletin No. 91.

4. *Citrus Preservation Investigations.*—(i) *Investigations in Melbourne (in conjunction with the Victorian Department of Agriculture).*—(*a*) *Navel Oranges.*—Respiration and storage experiments were conducted with Washington Navel oranges from Merbein, Lockington, Cobram, Shepparton and Griffith. Of these, Merbein and Griffith appear to be the only districts whose fruit is worthy of consideration for export. The fruit from these districts is thin skinned, full of juice and of excellent quality. The earliest picking time for Merbein fruit is 1st June, when the fruit is green yellow, slightly acidic and of fair flavour. This fruit could be coloured and sweetened on arrival in England. A more suitable picking time would be a fortnight later, when the fruit has lost its green colour and developed good quality. All fruit should arrive in England by mid-September, and, in consequence, the latest picking date would be 15th July. The peak of respiratory activity is reached on 6th July and from this date onwards the fruit is drifting rapidly downwards towards senescence.

The fruit from Griffith could be picked somewhat earlier than 14th June, the date of the first picking, as the fruit was well advanced at this time.

The experiments carried out in 1934 confirmed the opinion that Lockington fruit matures at the same time as Merbein fruit, but its full flavour is developed at a later stage in its life-history than the Merbein fruit.

Delaying the picking time merely reduces the subsequent storage life by the length of time the fruit is allowed to remain on the tree. In consequence no advantage can be gained by cool storing fruit for local consumption, since as long, and in some instances, a longer storage life was obtained by leaving the fruit on the tree. Leaving the fruit on the tree would save cool storage and handling charges and eliminate the risk of any cool storage injuries.

The storage life was terminated in some instances by loss of flavour, and, in others, by mould attack. Examinations were made after the fruit had been out of cool store for a week under atmospheric conditions (55°F. approx.). This report merely gives a very brief indication of the general results, but it is hoped that a paper will be published in the near future giving full details of the experiments carried out during the past two years.

(*b*) *Storage of Valencia Oranges.*—Temperature and storage experiments were conducted with Valencia oranges from Lockington and Merbein. The fruit was picked at one stage of maturity and stored at 31°, 34°, 37°, 40° and 43°F. Samples were removed at definite intervals and examined after one week at atmospheric temperature. The results indicated that

temperatures below 40°F. are detrimental to the storage of Valencia oranges owing to injury through browning. This injury is not always apparent in cool store, but occurs after the removal of the fruit from store to the higher atmospheric temperature. The storage life of the fruit at 40° and 43°F. was terminated by loss of flavour, the Lockington fruit having a storage life of twelve weeks and Merbein eighteen weeks at 40° and 43°F.

(ii) *Investigations Re-organized under the Citrus Preservation Technical Advisory Committee.*—At the initial meeting of this Committee, a comprehensive plan of experiments on Navel and Common oranges from the chief centres of production in Australia was adopted. It was agreed that the work could best be concentrated in three centres—Sydney, Melbourne and Griffith. In Sydney (cold storage of the fruit is being carried out at Newcastle) fruit from the coastal and hills districts of New South Wales is being studied. In Melbourne, work is being continued on Navel oranges from several districts in Victoria and South Australia, and samples of fruit from all other experimental areas are being sent to Melbourne for studies of their respiratory activity. Precise investigations on the effects of "sweating" fruit from the coastal district of New South Wales and from the Murray Valley, South Australia, are also being carried out in Victoria. In Griffith, work will be continued on the storage of Navel oranges produced in the Murrumbidgee Irrigation Area.

In order that results from the experiments in the various centres should be comparable, uniform methods to be used in the majority of the experiments have been adopted. These relate principally to the amount of fruit to be used, dates of picking, temperature of storage, methods of classification of parasitic and non-parasitic diseases, and chemical estimations on the juice.

For all districts, large-scale experiments are being carried out to investigate the influence of maturity at the time of picking on the keeping quality of Navel and Common oranges. The investigations in Melbourne, outlined above, have indicated the great importance of this factor, but it is considered that similar data from many widely-scattered areas in other States are also required before the results may definitely be regarded as of general application. It is expected that these experiments will yield a considerable amount of information concerning the nature of the disorders to which both varieties of oranges are subject during prolonged storage.

Experiments on the effects of various degrees of sweating are also being carried out on Navel oranges from all districts except the Griffith area. A series of experiments on the washing, processing and waxing of Navel oranges from the coastal and hills districts of New South Wales has been commenced. The effects of several different types of individual paper wraps on this fruit are also being tested. Other series of investigations include (*a*) the effects of various temperatures of storage on Navel and Common oranges from the coastal and hills districts of New South Wales, and (*b*) the effects of various cultivation and irrigation practices in the groves on the keeping quality of the fruit. The latter investigations are being carried out at Griffith, where conditions are such that the experiments can be kept under strict control.

(iii) *Overseas Experimental Shipments.*—During 1934, consignments of Navel, Joppa, Mediterranean Sweet and Valencia oranges were forwarded to London on four overseas vessels, and after careful examination at that port, the British Food Investigation Board has issued a report relating to the types and extent of wastage present in each variety.

In regard to Navel oranges, the most striking feature of the results was the much greater extent of wastage in fruit from the coastal districts of New South Wales as compared with the consignments from three other districts, on the same ships. These data may not necessarily be typical and the need for land storage work on coastal fruit, as outlined above, is obvious.

The factor of locality was again apparent in the consignments of Valencias, the fruit from the coastal district of New South Wales showing considerably more wastage than that from the Griffith area in that State.

The data in regard to Common oranges are scarcely sufficient for any definite conclusions to be drawn, and, therefore, further overseas experimental consignments of the Joppa and Siletta varieties are being forwarded this year to London for careful examination.

5. *Non-tropical Fruit Investigations* (*Melbourne*) *in conjunction with Department of Agriculture of Victoria.*—(i) *Storage of Pears.*—In 1934 the effects of size, locality and maturity at picking time on the subsequent length of the storage life of Williams pears were studied at the following temperatures:—30°, 32°, 34° and 36 °F. Pears of three maturities and three

sizes were selected from Doncaster and Shepparton. Size did not influence the storage life at any temperature, and delaying the picking time merely had the effect of reducing the subsequent storage life by the length of time the fruit had been allowed to remain on the tree.

Shepparton fruit was much superior in quality to Doncaster fruit, being free from russet and of better flavour; Shepparton fruit also had a rather longer storage life. Temperature was of great importance in the storage of the fruit. The length of storage life at the four temperatures was as follows :—

—	30°.	32°.	34°.	36 °F.
				weeks.
Doncaster	12	10	8	6
Shepparton	14	12	9	7

During 1935, ripening trials were carried out at a series of temperatures, and 65 °F. was found to be the optimum ripening temperature. At higher temperatures there is full development of flavour but colour development is retarded; at lower temperatures flavour is not fully developed. A delay before ripening of four days at 50 °F., which approximates to the average temperature of the London warehouse at the time when Australian Williams pears usually arrive on the English market, has the effect of changing the state of the pear and rendering normal ripening impossible.

As last year's experiments indicated that intensity of illumination was of great importance in determining the colour of the pears, considerable attention has been given this year to carefully standardized measurements of this factor.

Storage trials at 32 °F. with other varieties of pears gave the following results :—

Variety.	Length of storage life.
Howell	4 months
Beurre Bosc	4½ months
Keiffer	5 months
Packham	5 months
Josephine	5 months
Winter Nelis	6 months
Winter Cole	6 months

In addition to these common varieties, a collection of 36 varieties from the Burnley Horticultural Gardens was stored in the hope of finding suitable varieties of good quality and long storage life, which might supersede the more common varieties. No such varieties were found.

(ii) *Experimental Consignment of Pears sent Overseas.*—Through the courtesy of the shipping companies and the officers of the Victorian Department of Agriculture, two experimental consignments of Williams pears were forwarded to London in 1934 and 1935 and examined on arrival by investigators from the Low Temperature Research Station, Cambridge. The results of the 1934 shipment confirmed the work in Australia and showed that a delayed shipment usually gave unsatisfactory results. As a result of the 1934 shipment, certain recommendations were made to the shipping companies concerned regarding temperature conditions in the ships' cargo spaces carrying pears.

Only one commercial shipment of Williams pears was sent by agents from Victoria this year, and it is pleasing to note that the fruit arrived in England in excellent condition. Although heavy supplies of Williams pears from other countries were being marketed at the same time, the best prices were obtained for the Australian fruit.

(iii) *Storage of Plums.*—In 1934, experiments showed that the general practice of picking plums in a soft mature condition could be departed from and the fruit could be picked hard and immature and subsequently ripened artificially. The results were promising but not conclusive enough to make definite recommendations regarding the overseas export of the fruit.

The experiments have been continued this year, and the results have indicated that the optimum picking time occurs at the first dawn of colour, the fruit being still hard and immature. No special ripening treatment is necessary as the fruit will develop full flavour and juice when held at 50°F. subsequent to cold storage. A rather surprising result was that plums like the October Purple and Narrabeen will develop their natural blood-red colour off the tree. Hitherto,

a change from green to yellow but not from green to red had been observed. The storage life of the various varieties at 32 °F., picked at the optimum immature stage, is as follows :—

Variety.	Length of Storage Life at 32°F.
Wickson	5 weeks.
Jefferson	5 weeks.
October Purple	6 weeks.
King Billy	6 weeks.
Ballena	6 weeks.
Satsuma	7 weeks.
Narrabeen	7 weeks.
President	7 weeks.
Lawford Gage	8 weeks.
Coe's Golden Drop	8 to 9 weeks.

There was a large increase in the number of cases of plums exported overseas this year, but the results were far from satisfactory. In most instances the fruit arrived in England in apparently excellent condition and high prices were realized. Adverse reports, however, were received from the retailer that internal browning took place within a very short time. Internal browning is merely a normal disorder, characteristic of over-stored plums. When one realizes that few agents are prepared to take the risk of exporting Williams pears which have a storage life of twelve weeks, it is obvious that much more risk is attached to the export of plums with an average storage life of only seven weeks. Moreover, this length of storage life can only be obtained at 32°F., a temperature of 34°F. giving a storage life of only half this magnitude.

(iv) *Storage of Peaches.*—Maturity experiments with peaches have indicated that the earliest picking time is just prior to full maturity, when the ground colour of the fruit is green yellow and the fruit is in a firm condition. Fruit picked at an earlier stage does not ripen with full flavour and juice. A ripening temperature of 65°F. is essential to ensure full development of flavour and juice in fruit picked prior to full maturity. The varieties studied during the year were Zerbe, Pump, Wiggans (early maturity) ; Smith's Seedlings (mid-season) ; Crawford (late season). The Zerbe and Pump varieties had a storage life at 32°F. of ten weeks ; Wiggans five weeks ; Smith's Seedling eight weeks, and Crawford twelve weeks. The results are most promising especially with the Crawford variety, and it is hoped that a small experimental shipment will be sent overseas next year. Here again temperature is of paramount importance as the storage life at 34°F. is only five weeks as compared with twelve weeks at 32°F. It must be borne in mind, however, that a constant temperature of 32°F. is not always practicable in commerce, particularly in ships' cargo spaces.

(v) *Experiments with Jonathan Apples.*—(*a*) *General.*—Maturity and storage experiments were continued with Jonathan apples from the four selected districts of Harcourt, Somerville, Red Hill and Geelong. These experiments were designed to study the influence of locality and maturity on the storage behaviour of Jonathan apples, but, at the moment, it is impossible to make a comparison between districts owing to the great disparity between individuals from one tree and between samples from apparently comparable trees. As an expression of comparison in keeping quality, it was considered that a suitable measure would be the relative times to reach 10 per cent. wastage in cool store, such wastage to include scald and breakdown. In the pear, scald and breakdown are normal disorders, which terminate the life of the fruit in store, and these disorders do not differ greatly in the time of their occurrence from year to year. One can state very definitely that the life of the Williams pear picked hard and green is twelve weeks at 32°F. In the Jonathan apple, however, the appearance of scald is very haphazard. The occurrence of scald interrupts the normal life history of the fruit and until it is eliminated it will be impossible to state, in a precise manner, the length of storage life of the Jonathan apple, and to compare the fruit from different localities.

(*b*) *Jonathan Scald.*—The general opinion is that a temperature below 36°F. is responsible for the disease of Jonathan scald. While this may be a contributory factor to its occurrence it is obviously not the cause, for even at 32°F. scald only makes its appearance in isolated samples. The experiments carried out over three years have indicated that during storage scald usually makes its appearance in June and July and does not increase in its incidence after that time. The respiration experiments have shown that at this time the apple is at its climacteric and at this stage there is a copious evolution of gases responsible for the odour of ripe apples. Humidity also appears to be an important factor.

Particular attention is being given this year to the problem of scald and the effects of temperature. Volatile products of metabolism, humidity and carbon dioxide are being studied in the hope of finding the nature and cause of this physiological disorder.

(c) *Breakdown in Jonathans.*—In other fruit-growing countries there appear to be various types of breakdown, but "internal" is the only type which has been found in Victorian grown apples. This internal type appears to be a disorder of senescence and is likely to occur in apples of a yellow ground colour at a very early stage after picking.

It is the general practice for growers to leave the fruit on the tree as late as possible in order to obtain highly coloured fruit of the "extra fancy" grade. As apples are not pre-cooled, such mature fruit begins to deteriorate in flavour very quickly after picking and the life is soon terminated by breakdown. Reports from London of the 1934 apple season indicate that Australian Jonathan apples are not arriving in England in good condition. Mature, non pre-cooled fruit must of necessity have a much shorter storage life than less mature, pre-cooled fruit. Evidence obtained would seem to indicate that the Jonathan apple should be picked when the ground colour is green yellow and such fruit pre-cooled. This fruit would tend to improve in quality in cool store and should arrive in England in excellent condition.

(d) *Temperature Trials.*—Facilities are now available for temperature trials, and Jonathan apples of two maturities from Red Hill, Harcourt and Somerville are being stored at 32°, 34°, 37° and 40°F.

(vi) *Superficial Scald in Granny Smiths.*—Superficial scald is one of the chief causes of wastage with Granny Smith apples. This disorder can usually be controlled by waxed papers or by delayed storage. The effect of delayed storage is being studied.

(vii) *Effect of Spray Residues and Washing Treatments.*—The effect of spray residues and washing treatments on the storage behaviour of several varieties of apples is again being investigated.

(viii) *Storage of Grapes.*—Maturity and storage experiments have been carried out this year with grapes from the Victorian Government Experimental Farm at Rutherglen. It is desired to thank Mr. Golding, manager of the farm, for his generous co-operation in this work. Over 100 varieties, a great many of them unknown, are grown at Rutherglen, and it is to be regretted that the possibility of exporting most of these varieties has never been investigated. The grape is probably one of the most profitable fruits to export, for overseas prices at certain times of the year are often very high. Wastage in grapes is due to dehiscence of the berries and to mould attack. The experiments have indicated that dehiscence is merely a disorder of senescence, and mould attack can be largely controlled by careful handling in the orchard and in the packing shed. No methods yet known, however, can control its occurrence after the storage life of the grape has terminated. Particular attention has been given to the handling of the fruit in the orchard. The usual procedure is to place the fruit in baskets after picking, and this method causes a great deal of injury to the berries. The method employed in these experiments has been to suspend the bunches from nails on a long stick, which is carried on the shoulders of two pickers to the packing shed. Such fruit, wrapped in sulphite paper and packed in the standard grape case, has arrived in Melbourne in excellent condition. Some of the varieties were picked just prior to full maturity, and this fruit gave much better storage results than that of a later maturity. The varieties studied were Gordo, Purple Cornichon, Red May, Maravacca, Red Prince, Red Malaga, Waltham Cross, Oeillade, White Crystal, Red Haneport, Malvoisie, Gianette and Olivette de Vendemien. Most of these varieties were still in excellent condition after three months' storage at 32°F., but from the point of view of appearance and quality the most suitable varieties for export appear to be the Gordo, Waltham Cross, Red Malaga, and Gianette. The results are promising and warrant further intensive investigations.

(ix) *Experimental Consignment Overseas of Passion-fruit Pulp.*—At the request of certain Melbourne firms interested in the export of passion fruit, samples of pulp with and without seeds were prepared by mixing quantities of juice and sugar. Samples were forwarded to the Victorian Agent-General by the Victorian Department of Agriculture. Passion-fruit is being used extensively for flavouring, but London reports indicate that there is no demand for pulp with seeds. The sample received fairly favorable comment, but it is thought that a superior product could be obtained by using smaller quantities of sugar with the addition of a trace of sulphur dioxide. Time has not permitted a more intensive study of the preparation of passion-fruit pulp and other juices.

(x) *Experiments on Gas Storage.*—Experimental work on gas storage has been continued at the Government Cool Stores, Melbourne. Concentrations of carbon dioxide from 5 to 15 per cent. have been obtained by controlled ventilation in small gas-tight containers. In each container the fruit rests on a wooden grid supported on a tray containing solid calcium chloride, which serves to prevent the fruit becoming excessively wet.

The results obtained with Smith's Seedling and Crawford peaches at 34°F. are promising. The storage life of Smith's Seedling peaches in air at 34°F. was found to be only three weeks; peaches stored longer become mealy at the post-storage temperature (65°F.) instead of

ripening normally. In 5 per cent. and 10 per cent. carbon dioxide the storage life was increased to four and six weeks respectively. The peaches stored in 10 per cent. carbon dioxide ripened to almost as good a flavour as those stored in air. The storage life in 15 per cent. carbon dioxide was four weeks; peaches stored longer developed a fermented appearance and flavour on subsequent ripening.

The storage life of Crawford peaches at 34°F. also increased in 10 per cent. carbon dioxide. The life of less mature peaches was increased to seven and one-half weeks, compared with five weeks in air, while the life of more mature peaches was increased to five and one-half weeks, compared with four and one-half weeks in air. Similar results were obtained by storage in 5 per cent. carbon dioxide. The storage life in 15 per cent. carbon dioxide was only four weeks. Crawford peaches which were over-stored developed tissue breakdown and a fermented flavour at ripening temperatures.

"Gas"-stored peaches ripened more slowly than air-stored. Air-stored Smith's Seedling peaches were fully ripe in four days, while the "gas"-stored peaches took six days to ripen. Similarly, the ripening period of Crawford peaches was extended from five to seven days.

Experiments on the "gas" storage of President and Golden Drop plums at 34° F. have given definitely unfavorable results. With both varieties the storage life in 5, 10 or 15 per cent. carbon dioxide is less than in air. Concentrations of carbon dioxide as low as 5 per cent. hasten the development of internal browning. Internal browning first made its appearance after about the same length of storage independently of the maturity of the fruit at picking, but it became more severe in the less mature plums.

The presence of carbon dioxide during the storage of grapes has no influence on the development of the dropping of the berries. After removal, a slight fermented flavour developed in grapes stored in 10 per cent. carbon dioxide, and a very definite "off" flavour developed in grapes stored in 15 per cent. carbon dioxide. Carbon dioxide appears to check the growth of mould slightly, but such a control was of no importance, since serious mould development only occurred after the storage life was terminated.

A preliminary experiment on the "gas" storage of passion-fruit at 45°F. was carried out. Concentrations of carbon dioxide from 5 to 15 per cent. appeared to reduce the wastage to an approximately equal extent. As passion-fruit appears to be very sensitive to wilting, it is likely that the effect was due rather to the higher humidity obtained in the "gas" storage containers than to the presence of carbon dioxide. Further investigations are required on the effect of both humidity and "gas" storage on passion-fruit.

A similar experiment on the "gas" storage of Navel oranges is in progress.

(xi) *Effect of Humidity and Carbon Dioxide on Development of Soft Scald and Breakdown in Jonathan Apples.*—Jonathan apples of two pickings are being stored at 32°F. and 37°F. in air, and in 2, 5, and 10 per cent. carbon dioxide, these concentrations being obtained by reduced ventilation. The air-stored apples are kept in desiccators, through which air of two different humidities is being drawn. The dry air is drawn over solid calcium chloride, and the moist air is saturated by bubbling through water. Two different humidities are also being maintained in the storage atmospheres containing 10 per cent. of carbon dioxide.

The experiment at 31°F. has not indicated so far that carbon dioxide has any influence on the development of soft scald, but high humidity very definitely increases its development.

6. *Chemical Investigations on Fruit at the Biochemistry Department, University of Melbourne.*—During 1933 and 1934 a considerable number of chemical analysis of Jonathan apples, Williams pears, and Washington Navel oranges have been made at picking and during storage. These data have been examined further, and this work is being continued together with analysis of Smith's Seedling peaches and President plums.

The chemical data appear to be of value more as a measure of quality than of the stage of senescence of the fruit. The term quality is used to denote the development of a satisfactory texture and flavour. In apples, the initial development of quality appears to be related to the stage of senescence, but this is not generally true for other fruits. The final loss of quality in storage is more definitely related to the stage of senescence. Commercially, the term maturity is used to cover both quality and the stage of senescence, but it seems better to use the term maturity only in relation to the stage of senescence.

Evidence has been obtained that the ratio of cane sugar to acid is related to the maturity of Jonathan apples at picking. Starch and acid in apples at picking correlate very definitely with each other, but neither are related to the maturity. No correlation has been obtained between the chemical composition at picking and the liability to soft scald and breakdown in storage.

During the picking period of Williams pears, cane sugar has been found to increase from 0.2 to 1.0 per cent. No determinations of acid have been made during the picking period.

The analyses of Washington Navel oranges obtained in 1933 and 1934 indicate a fairly close relation between quality and the acid titration of the juice. The relation between quality and the ratios Brix reading ; acid, total sugar ; acid, or cane sugar ; acid of the juice was certainly no better, probably because the greater variations in acid titration predominated over other variations. Generally, oranges with an acid titration above 22 ml. were sour, and those with an acid titration between 22 ml. and 15 ml. were palatable. The main exceptions were obtained with sour oranges which became sweet after a few days at a high temperature, but whose acid titration scarcely changed during this treatment. During the present season, analyses have been made of oranges having a high acid titration but nevertheless palatable. When the juice of such oranges is boiled, however, the flavour is practically destroyed, and the boiled juice has a sour taste. The view now held is that oranges with an acid titration more than about 22 ml. are sour, unless considerable orange flavour is present to mask the acidity.

The total sugar content in the peel of oranges at picking has been determined. The sugar content of the peel of fruit on the tree passes through a maximum at about the time of the climacteric in respiration. Oranges picked green generally have only from 6 to 8 per cent. of sugar in their peel, while oranges picked fully coloured have over 9 per cent. The peel of oranges picked green does not gain in sugar content during subsequent colouring.

Tests with different methods of extracting the juice from oranges have shown that the amount of juice extracted depends almost entirely on the shape of cone used. Provided the most efficient type of cone is used, as much juice is obtained by hand pressure as by using an electrically operated extractor. As the former method involves a minimum aeration of the juice, its specific gravity reaches equilibrium within 10 minutes of extraction.

Interesting curves have been obtained by plotting the changes in the ratio of cane sugar to acid during storage of pears and oranges. Points of inflexion were obtained, which corresponded approximately with the end of the storage life.

7. *Liaison Work in England.*—The closer co-operation with the British Food Investigation Board, obtained largely through the Council maintaining an officer in London, has fully merited the continuance of the liaison work. Briefly, the objects of the liaison work itself are as follow :—

(*a*) To keep the Section of Food Preservation and Transport informed of the results of work in progress in the laboratories in England.

(*b*) To keep the British Food Investigation Board informed of the Section's work.

(*c*) With the advice of officers of the Food Investigation Board and from experience gained from the examinations of cargoes of perishable foodstuffs, to make suggestions concerning further experiments in transport. In some cases, suggestions are made concerning laboratory and field work in Australia in relation to the foodstuff concerned.

(*d*) To facilitate shipboard experiments by maintaining contact with the shipowners and keeping them informed of the results and objects of these experiments. This policy is pursued through the Food Investigation Board.

(*e*) To co-operate with the officers of the Commonwealth and States responsible for the inspections of shipments of perishable foodstuffs. The aim is to determine what are the major problems in the transport of foodstuffs and also how far the results of scientific research work are being applied with success in such transport.

Mainly in conjunction with the Food Investigation Board, the liaison officer has been responsible for the examination of many different types of experimental shipments and for the collection of physical data regarding them. These have included some twenty shipments of chilled beef, five of oranges, and two of pears. The reports furnished by the officer himself, or jointly with the Food Investigation Board have been of considerable value in checking the results of storage experiments in Australia, in indicating the main forms of deterioration, and in suggesting desirable investigations to be carried out in Australia.

XI. OTHER INVESTIGATIONS.

1. *Commonwealth Prickly Pear Board.*—Seasonal conditions were again favorable to *Cactoblastis cactorum* ; the winter of 1934 was particularly mild, and although the summer months, January to March, were hot and dry, no heat waves occurred to cause serious mortality among the pupæ and moths.

The control of prickly pear throughout Queensland and the greater portion of New South Wales continues to give entire satisfaction. During the year, *Cactoblastis* attacked in force the remaining large areas of vigorous re-growth, that had persisted for three years, in the Wandoan-Taroom and south-western districts in Queensland, and the north-western districts of New South Wales ; great destruction has been accomplished in these sections, and the good work is being continued by a heavy population of the larvae. In the case of heavily-scattered seedling pear

which has sprung up on improved country, mainly in south-west Queensland and adjacent districts in New South Wales, very effective destruction has been brought about in many instances, while in other areas the infestation of *Cactoblastis* is such that eventual control is assured.

In the Hunter River District of New South Wales, *Cactoblastis* has made steady progress in reducing the density of this large tract of resistant yellow pear. It has not, however, effected much destruction in the similar type of prickly pear among the timbered hills of the Bingara-Inverell district, but as the timber is being destroyed on larger areas of this country, the improvement in the succulence of the prickly pear will assist materially towards its destruction by *Cactoblastis*.

The reclamation, for pastoral and agricultural purposes, of former dense prickly pear land, made available by the activities of *Cactoblastis*, has been further advanced, not only in Queensland, but in New South Wales by the throwing open for settlement of the Mungle Scrub country between Moree and Boggabilla. The dry period experienced from January to June has assisted settlers by permitting the more ready killing and burning of the timber. During the year, developmental work has been very pronounced in such large belts of pear country as the Wandoan-Taroom and Moonie River districts in Queensland.

With reference to the pest pears of lesser importance, the Board has introduced from South America for the tiger-pear (*Opuntia aurantiaca*), the caterpillar *Tucumania* ; this insect is now being reared in considerable numbers. Another introduction from the Argentine has been the caterpillar *Cactoblastis bucyrus*, which is being bred with the object of attacking the tree-pear, *O. tomentosa*. In Mexico, another enemy of tree-pears, the beetle, *Lagochirus funestus*, is receiving special attention.

The Board's officers have gathered considerable information concerning the insect enemies of galvanized burr (*Bassia Birchii*) and related plants in Queensland and New South Wales. On behalf of the Council, liberations and cage rearing experiments have been conducted with the Noogoora burr seed-fly (*Euaresta aequalis*). An officer of the Board has been despatched to America to carry out a survey of insect enemies of Noogoora burr and other species of *Xanthium*.

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 work on fading, which in its turn involves extensive studies of the ionosphere, is centred at the University of Sydney. During the past year, new methods of attack have been developed and considerable advances in technique have been effected—in particular, the adaptation of the cathode ray tube to most of the methods of investigation being followed. This adaptation had had the advantage of rendering most of the work independent of the rather cumbersome and delicate Einthoven galvanometers. Advantage was also taken of the co-operation of Dr. O. O. Pulley, Walter and Eliza Hall Fellow in the University of Sydney, in order to bring into operation the pulse method of ionospheric investigation. It is anticipated that the application of this method to some of the problems under investigation will greatly facilitate the interpretation of the results in cases where more than one down-coming wave is being received. Automatic height-recording by the pulse method has now been in operation for some weeks, and measurements of the ionization densities in the various layers of the ionosphere have also been made by this method. Promising results have been obtained in the control of the fading of wireless telegraphic signals following the adoption of a method depending on the suppression of the carrier-wave. Experiments have been made in Melbourne and Perth, and operating at distances, respectively, of 700 and 3,300 kilometers from the transmitter in Sydney, it has been found that a considerable improvement in constancy of signal can be obtained with the suppressed carrier modulation. The application of this system of fading control to telephonic circuits is very much complicated by the presence of the undesired control modulation. Theoretical considerations, however, point to at least one way of effecting this desired result.

The Board's work on atmospherics is centred at the University of Melbourne. During the last year, the data of the Toowoomba expedition were analyzed with the following results *inter alia*. The previous finding that the mean peak power radiated by lightning flashes in the frequency band between 10 and 1,000 Kc/s is sensibly the same for all thunderstorms was confirmed. The previously determined law of distribution of individual intensities of atmospherics from a particular source about the mean has been confirmed on observations on 100 Kc/s and extended to 1,000 Kc/s. The observations also gave results of meteorological significance in various directions. For example, a study of the general meteorological conditions associated with the source of atmospherics (which are due to lightning flashes) located by the radio observations showed that the proportion of sources due to heat appears to increase from practically nil south of latitude

40°S. to nearly 100 per cent. north of 15°S. In the region below 30°S., continuity of a source can often be traced for several days as it moves from the Australian Bight through the south-east of South Australia, Victoria, and into the Tasman Sea.

During the year, results obtained by the Board were published in the Council's Bulletins 87, 88, and 89, and also in a number of articles which appeared in various technical journals.

3. *Mineragraphic Investigations.*—The rehabilitation of the gold-mining industry involves, *inter alia*, the development of the utmost efficiency in the method of extraction of valuable minerals from complex ores. Every ore body has its own special problems which can be more clearly defined and more directly attacked when information is available concerning the precise mineral content of the deposits. Ordinary assays of a complex ore are not enough. What is of great importance is a determination of the precise minerals in the ore, the size of the individual crystals, their associations and relationships to each other, because milling and ore dressing procedure are based primarily on the characteristics of the ore treated. Observations of the relation of the individual minerals to each other are also frequently of considerable importance to the mining geologist, giving him information as to the genesis of the deposit and thus leading to suggestions for the better development of the mine.

Mineragraphic investigations are concerned with ascertaining full information regarding mineral associations in complex ores. Many valuable minerals occur in opaque particles of microscopic size which cannot be identified by ordinary petrographic methods. They may only be observed by the microscopical examinations 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. 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.

The mineragraphic investigations were commenced in 1927, and the gradually increasing demands for work since that time have led to the appointment of Dr. A. B. Edwards, B.Sc., Ph.D., as assistant to Dr. Stillwell. Dr. Edwards commenced duty on 15th October, 1934.

During the past year, auriferous ores from Wadnaminga and Bird-in-Hand Mine in South Australia, and Tennant's Creek in Northern Territory have been examined for the South Australian section of ore-dressing investigations. An examination of the flotation concentrates from Moonta, prior to investigations directed towards an improvement in grade, indicated that approximately one-seventh of the concentrate consisted of gangue minerals, and that the remainder consisted of 88.5 per cent. chalcopyrite, 3.5 per cent. covellite, and 8.0 per cent. pyrite.

Ore specimens from the Triton Mine, Western Australia, consist of a quartz carbonate biotite schist impregnated with sulphides and gold. A number of minute particles of free gold, the largest being 0.016 mm. x 0.014 mm. were observed in sections embedded both in gangue and pyrite. One-eighth of the number of observed particles were embedded in pyrite. Ore from Jimblebar, Western Australia, consists of altered greenstone densely impregnated with pyrite and lesser amounts of magnetite, and contains gold particles, 0.025 mm. in width, embedded in gangue minerals, while other particles both larger and smaller are included in pyrite or interstitial between pyrite crystals. The size of these gold particles indicates that their recovery would be less difficult than those observed in a specimenof auriferous pyrite from the Golden Oxide claim in in Upper Mitta Valley in Victoria. Here the average of half a dozen particles in 0.003 mm. width and a considerable percentage of the gold would not be freed from pyrite even by grinding to a size of 200 mesh.

The examination of two specimens of auriferous antimonial ore from the Moonlight lease at Wiluna was undertaken to determine the relationship of the gold stibnite. Some specimens containing stibnite were reported to be barren while other, apparently similar specimens, were rich in gold. Observations showed that stibnite crystallized later than the quartz, and the gold content of a specimen was primarily dependent on the gold particles embedded in the quartz. Where stibnite has invaded quartz with included particles of gold, thin flakes of gold may be found on the walls of the stibnite veins, and occasionally gold particles may be surrounded by stibnite. When no gold appears in the quartz, the invading stibnite is also free of gold.

An interesting and important determination during the past year was the observation of the auriferous telluride mineral, nagyagite, in a specimen from the Loloma Gold Mines, Tavua, Fiji. Nagyagite is a complete mineral containing lead, antimony, sulphur, tellurim, and from 5 to 12 per cent. gold, and its occurrence in quartz associated with an andesitic breccia has considerably increased the speculative interest attached to the development of the new gold-field in Fiji. Nagyagite is a rare and comparatively unimportant telluride on the Kalgoorlie gold-field, but it may prove otherwise under the widely different conditions at Tavua.

Following upon microscopical examinations of mine dust from Broken Hill during the preceding year, two lungs from deceased miners affected with silicosis were received from Broken Hill. One of the miners had been exclusively employed at Broken Hill and the determination of the mineral particles in these lungs was carried out by Dr. Edwards in order to obtain evidence of the dangerous constituents of the Broken Hill dust. Recent researches by Dr. W. R. Jones of London on the mineral content of silicotic lungs have directed the attention of the mining industry to the mineral sericite as a dangerous constituent of mine dust. Dr. Edwards who, prior to his present appointment, had spent some time with Dr. Jones in London, employed the methods devised by Dr. Jones. The lung tissues are dissolved and slimed with concentrated nitric acid, and the residue, containing the mineral particles, is filtered off and ignited. The petrological examination and chemical analysis of the mineral residue revealed that the bulk of the mineral fibres in the residues is sericite. In addition, quartz and rhodonite are present, together with subordinate amounts of fluorite, rutile, biotite and sillimanite. A petrological examination was also made of a series of samples of Broken Hill mine dust collected under special conditions at half-hourly intervals after firing, indicating that a gradual increase in the proportionate amount of suspended sericite up to three hours after firing is possible.

The investigations have been facilitated by a contribution by a number of mining corporations through the Australasian Institute of Mining and Metallurgy. The University of Melbourne has also assisted by granting the 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 deposits now unworked could be brought into profitable production provided that adequate technical assistance was made available towards the solution of the metallurgical problems involved.

In planning 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. It has been decided to intensify the mineragraphic investigations on which Dr. Stillwell was formerly the sole investigator engaged, and also to carry out a programme of ore dressing research, confining it for the time being to gold-bearing ores. In addition to ores especially chosen for examination, it is open for leaseholders to submit samples of ore for testing. In the latter cases, details of the ore bodies are required in order that the Council may be assured that the ore exists in tonnages sufficient to warrant the investigations.

The work is being 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. The Council's grant has been used in part to purchase extra equipment for each of these laboratories. In addition, each has been provided with the services of an investigator appointed by the Council to assist the regular officers. The scope of the testing laboratories will thus be considerably extended.

The ore dressing investigations are being directed by the Mining Advisory Committee, of which three leading Australian mining engineers (Messrs. G. C. Klug*, W. E. Wainwright and H. St.J. Somerset) are members.

In addition, three Local Sub-committees, representative of the University or the School of Mines accommodating the work, the Chamber of Mines, the State Department of Mines and the Australasian Institute of Mining and Metallurgy have been established to help the laboratories at which the work is centred. The personnel of all these Committees is given in the Appendix to this report.

Up to date, reports have been furnished on gold bearing materials from the following localities :—Berri Leads (Victoria), Mt. Freda (Queensland), Wadnaminga (South Australia), the Bird-in-Hand G.M. (South Australia), the Hercules G.M. (Northern Territory), the Trafalgar G.M. (Western Australia), the Shenton Extended G.M. (Western Australia), the Lady Miller G.M. (Western Australia), the Leonora Central G.M. (Western Australia), Kalgoorlie (Western Australia) Kundip (Western Australia), Dart River (Victoria), the O.K.G.M. (Western Australia), the Lake Austin Eureka G.M. (Western Australia), Randells (Western Australia), the Santa Claus G.M. (Western Australia), Norseman, Menzies, and Southern Cross (Western Australia), and the Hill 50 G.M. (Western Australia).

5. *Standards Association of Australia.*—The Standards Association of Australia for which the Council is the means of liaison with the Commonwealth Government, again reports a year of

* Mr. Klug left Australia on a visit to Europe and died whilst abroad early in July, 1935. Before he left Australia it was arranged that Mr. C. C. Freeman would act as his deputy on the Committee.

effective work. Under the Commonwealth Government's policy of progressive restoration of financial support, the Association received a further slight increase in the grant for the year 1934–35, which made possible the appointment of a technical assistant. Though the staff is not yet up to its previous strength nor adequate for meeting the many demands for new work, this appointment has made it possible to commence work on three important new activities and to expedite work in a number of other directions. Co-operation with the British and Dominion Standards Association has been well maintained, a particularly large number of new British Specifications, averaging about four per week, having been received and reviewed as to their suitability for Australian requirements. The Association has collaborated with the Standing Committee on Agriculture in exploring the prospects of usefully applying standardization to products used by the primary industries and to the grading of primary products.

6. *Fuel Problems.*—Mr. L. J. Rogers, Commonwealth Fuel Adviser, who is attached to the staff of the Council, was engaged throughout the year in further investigation into the refining of Newnes shale oil, on behalf of the Governments of the Commonwealth and New South Wales.

In accordance with recommendations contained in the report of the Newnes Investigation Committee, a sample of crude oil has been cracked to petrol in the United States under Mr. Rogers' supervision. The crude petrol has been refined at the University of Michigan, and 40 gallons of the finished product have been returned to Australia. Dynamometer tests, and road trials for hill climbing and petrol consumption, are now being conducted in Sydney for the purpose of demonstrating to possible purchasers of the shale spirit that it is a satisfactory product meeting the requirements of the local market. The trials are being carried out by the National Roads and Motorists' Association, and Mr. Rogers is observing them on behalf of the Newnes Investigation Committee.

Further information has been acquired on the chemical treatment of the crude spirit, and on the blending of shale oil residuum to the specifications of Navy fuel oil.

Mr. Rogers has discussed the results of his recent investigations with officials of Scottish Oils Ltd., who have been inquiring into the exploitation of the Newnes-Capertee field on behalf of the Anglo-Persian Oil Company. In the course of his visit abroad, Mr. Rogers has become acquainted with recent progress in fuel technology, including developments in the hydrogenation of coal in England.

With the assistance from the Commonwealth Government, the Tasmanian Department of Mines has carried out research work, on an experimental scale, on the preparation of bitumen from Latrobe shale. From a technical point of view, the results of these preliminary investigations are encouraging.

7. *Fisheries Investigations.*—In 1909 the Commonwealth Government initiated an investigation of occurrences of demersal or " bottom-dwelling " fish in Australian waters. The steam trawler " F.I.S. Endeavour " was built in Australia for the exploration which ended tragically with the loss of the vessel and all hands in 1914.

The investigation established the existence of two large trawlable areas giving promise of profitable commercial fishing. One of the areas extended southwards within the 100 fathom line from a point near Port Stephens on the New South Wales coast to a point east of Flinders Island in Bass Strait. This area is now the basis of a large trawling fleet operating from Sydney. The other area extends for several hundreds of miles within the 100 fathom line of the Great Australian Bight. The commercial development of this area has been retarded by its being located far from large consuming centres.

With the loss of the investigation vessel and the outbreak of war this valuable exploratory work ceased. However, interest in the potential value of Australia's marine resources did not flag, and, in July, 1929, a national fisheries conference of representatives of the Commonwealth and State Governments, and of others interested in the development of the fisheries, met at Sydney and unanimously resolved :—" That this Conference bring before the attention of the Commonwealth Government the great national advantages to be derived from a fuller utilization of Australia's fisheries resources and urge, as an essential means to their development, the setting up by the Federal Government of an organization and equipment for the scientific, statistical and practical investigation of the fisheries aiming at their commercial development."

In September, 1932, by direction of the Minister (Senator the Hon. A. J. McLachlan), a report on the development of the fishing industry was prepared jointly by the Development Branch of the Prime Minister's Department and the Council for Scientific and Industrial Research. This report also recommended that the Commonwealth Government undertake an investigation of Australia's marine resources with a view to their commercial development. This investigation, it was stressed, would not in any way involve the regulation and control of the fisheries which are constitutionally within the functions of the States.

In October, 1933, the Commonwealth Government decided to engage in a programme of fishery investigation and research under the following main heads :—

(i) To procure a vessel specially designed for exploration of pelagic or surface-swimming fish, but which could also carry out certain investigations of demersal or bottom-dwelling species.

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

(iii) To undertake tests to determine the best methods of curing and preserving fish, especially the more common varieties.

(iv) To undertake, in co-operation with State authorities, a study of the systems of distribution of fish in each State with a view to the improvement of existing transport and marketing facilities.

The carrying out of the programme of investigation was entrusted to the Director of Development of the Development Branch, Prime Minister's Department. Subsequently, in January, 1935, control of the investigation was vested in a Committee representing the Council for Scientific and Industrial Research and the Development Branch, but this in turn was changed by Cabinet's decision on the 29th July, 1935, that general responsibility for oversight of fisheries investigation work be placed directly upon the Council for Scientific and Industrial Research and that Mr. S. Fowler, Fisheries Officer of the Development Branch, be seconded to the Council. Professor W. J. Dakin, of the Department of Zoology, University of Sydney, has been appointed as Adviser to the Council in connexion with marine biological research.

Funds were assured for the programme of work by Cabinet's deciding on 29th May, 1935, that a sum of £20,000 be provided in 1935–36 and £15,000 per annum for the ensuing four years for fisheries research and investigation.

Estimates for the construction of the research vessel are being prepared by Australian shipbuilders and consideration is being given to work on other phases of the fishing industry.

8. *Biometrical Work.*—In the development of the work of the Council, the use of biometrical methods for planning and analysing experiments has become accepted as an essential part of the programme. With increased experimentation the demands for biometrical assistance have been proportionately increased. Moreover, as new statistical methods are being continually developed, it seems advisable in some instances to review and reorganize experiments planned according to older systems. Particularly is this so with field experiments. The new development of complex experimentation where a number of different interacting factors may be tested in the one trial, by a system in which the less important treatment differences are confounded with differences due to soil heteorogeneity, makes possible a great variety of tests and comparisons that otherwise could not have been attempted.

In the Division of Plant Industry, biometrical work has been done in connexion with problems relating to genetics, physiology, pathology and noxious weeds. Significance tests have been performed on results of experiments conducted by the Blowfly Section of the Division of Economic Entomology, and on data relating to the thrips problem. Statistical discussions have taken place on the planning of experiments and questions of analysis, with members of both Divisions.

A visit was paid by the biometrician to the Commonwealth Research Station at Merbein for the purpose of discussing the new methods of field experimentation, and consideration was given also to the analysis of experiments already carried out with vines, and of investigations into soil conditions.

The analysis of results of field trials conducted by the New South Wales Department of Agriculture has been undertaken and commenced.

Many inquiries of a biometrical nature from workers in other research organizations have been answered throughout the year.

XII. MISCELLANEOUS.

1. *Publications of the Council.*—The following is a complete list of the publications issued by the Council up to the 30th June, 1935, since its inception in 1926. The numbering of the Bulletins and Pamphlets is a continuation of the previous issues of the former Institute of Science and Industry.

A. Bulletins.

1927—

No. 30—An Investigation of the Bunchy-top Disease in the Banana ; by C. J. P. Magee, B.Sc. Agr.

No. 31—Newsprint—Preliminary Experiments on the Grinding of Immature Eucalypts for Mechanical Pulp and the Possibilities of Manufacturing Newsprint in Australia ; by L. R. Benjamin.

No. 32—A Survey of the Tanning Materials of Australia ; by D. Coghill.
No. 33—The Possibilities of Power Alcohol and Certain Other Fuels in Australia ; by G. A. Cook, M.Sc., B.M.E.

1928—
No. 34.—The Biological Control of Prickly Pear in Australia ; by A. P. Dodd.
No. 35.—Kraft Pulp and Paper from *Pinus insignis* ; by L. R. Benjamin, J. L. Somerville, B.Sc., R. B. Jeffreys, B.Sc., and W. E. Cohen, B.Sc.

1929—
No. 36.—Kimberley Horse Disease ; by D. Murnane, B.V.Sc., and A. J. Ewart, D.Sc., Ph.D., F.R.S.
No. 37.—Paper-pulp and Cellulose from the Eucalypts by the Sulphite Process ; by L. R. Benjamin and J. L. Somerville, B.Sc.
No. 38.—The Chemical Composition of Wool ; by H. R. Marston.
No. 39.—The Utilization of Sulphur with especial Reference to Wool Production ; by H. R. Marston and T. Brailsford Robertson, Ph.D., D.Sc.
No. 40.—Observations on the Hydatid Parasite ; by I. Clunies Ross, D.V.Sc.
No. 41.—Bitter Pit of Apples in Australia ; by W. M. Carne, F.L.S., H. A. Pittman, B.Sc.Agr., and H. G. Elliot, Dip.Agr.
No. 42.—A Soil Survey of Block E (Renmark) and Ral Ral (Chaffey) Irrigation Areas ; by J. K. Taylor, B.A., M.Sc., and H. N. England, B.Sc.
No. 43.—The Bionomics of Fasciola Hepatica ; by I. Clunies Ross, D.V.Sc., and A. C. McKay, B.V.Sc.

1930—
No. 44.—Investigations on " Spotted Wilt " of Tomatoes ; by Geoffrey Samuel, M.Sc., J. G. Bald, B.Agr.Sc., and H. A. Pittman, B.Sc.Agr.
No. 45.—A Soil Survey of the Woorinen Settlement, Swan Hill Irrigation District, Victoria, by J. K. Taylor, B.A., M.Sc., and F. Penman, M.Sc.
No. 46.—Black Disease (Infectious Necrotic Hepatitis) of Sheep in Australia ; by A. W. Turner, D.V.Sc.

1931—
No. 47.—Radio Research Board : Report No. 1.—
(1) Corrections to Field Strength Measurements with Loop Antennae ; by W. G. Baker, B.Sc., B.E., and L. G. H. Huxley, M.A., D.Phil.
(2) A Radio Field Strength Survey within 100 miles of Sydney ; by W. G. Baker, B.Sc., B.E., and O. O. Pulley, B.Sc., B.E.
No. 48.—The Experimental Error of the Yield from Small Plots of " Natural " Pasture ; by J. Griffiths Davies, B.Sc., Ph.D.
No. 49.—Factors Affecting the Mineral Content of Pastures ; by A. E. V. Richardson, M.A., D.Sc., H. C. Trumble, M.Ag.Sc., and R. E. Shapter, A.A.C.I.
No. 50.—The Poisonous Action of Ingested Saponins ; by A. J. Ewart, D.Sc., Ph.D., F.L.S., F.R.S.
No. 51.—A Soil Survey of the Swamps of the Lower Murray River ; by J. K. Taylor, B.A., M.Sc., and H. G. Poole, M.Sc.
No. 52.—The Soils of Australia in relation to Vegetation and Climate ; by J. A. Prescott, M.Sc.
No. 53.—The Flying Fox (*Pteropus*) in Australia ; by F. N. Ratcliffe, B.A.
No. 54.—Investigations on " Spotted Wilt " of Tomatoes—II. ; by J. G. Bald, B.Agr.Sc., and G. Samuel, M.Sc.
No. 55.—The Basal (Standard) Metabolism of Australian Merino Sheep ; by E. W. Lines, B.Sc., and A. W. Peirce, B.Sc.

1932—
No. 56.—A Soil Survey of Blocks, A, B, C, D and F, Renmark Irrigation District, South Australia ; by T. J. Marshall, B.Sc.Agr., and P. D. Hooper.
No. 57.—Infectious Entero-toxæmia (the so-called Braxy-like Disease) of Sheep in Western Australia ; by H. W. Bennetts, D.V.Sc.
No. 58.—The Life Cycle of Stephanurus dentatus Deising, 1839 : The Kidney Worm of Pigs, with observations on its Economic Importance in Australia and Suggestions for its Control ; by I. Clunies Ross, D.V.Sc., and G. Kauzal, D.V.Sc.
No. 59.—Radio Research Board : Report No. 2.—
(1) The State of Polarization of Skywaves ; by A. L. Green, M.Sc.
(2) Height Measurements of the Heaviside Layer in the Early Morning ; by A. L. Green, M.Sc.

No. 60.—Radio Research Board: Report No. 3.—(1) The Influence of the Earth's Magnetic Field on the Polarization of Skywaves; by W. G. Baker, B.E., B.Sc., and A. L. Green, M.Sc.

No. 61.—Studies in the Supplementary Feeding of Merino Sheep for Wool Production—I. The Effect of a Supplementary Ration of Blood Meal on the Growth Rate and Wool Production of Merino Sheep on Central Queensland Pastures; by Hedley R. Marston.

No. 62.—A Soil Survey of the Cadell Irrigation Area and New Era, South Australia; by T. J. Marshall, B.Sc.Agr., and N. J. King, A.A.C.I.

No. 63.—Radio Research Board: Report No. 4.—

(1) A Preliminary Investigation of Fading in New South Wales; by A. L. Green, M.Sc., and W. G. Baker, B.E., B.Sc.

(2) Studies of Fading in Victoria: A Preliminary Study of Fading Medium Wave Lengths at Short Distances; by R. O. Cherry, M.Sc., and D. F. Martyn, Ph.D., A.R.C.Sc.

No. 64.—The Ripening and Transport of Bananas in Australia; by W. J. Young, D.Sc., L. S. Bagster, D.Sc., E. W. Hicks, B.A., B.Sc., and F. E. Huelin, B.Sc.

No. 65.—Downy Mildew (Blue Mould) of Tobacco in Australia; by H. R. Angell, B.Agr.Sc., Ph.D., and A. V. Hill, B.Agr.Sc.

No. 66.—The Influence of Growth Stage and Frequency of Cutting on the Yield and Composition of a Perennial Grass—*Phalaris tuberosa*; by A. E. V. Richardson, M.A., D.Sc., H. C. Trumble, M.Agr.Sc., and R. E. Shapter, A.A.C.I.

No. 67.—Methods for the Identification of the Coloured Woods of the Genus *Eucalyptus*; by H. E. Dadswell, M.Sc., and Maisie Burnell, B.Sc.

No. 68.—Radio Research Board: Report No. 5.—Atmospherics in Australia—(1) by G. H. Munro, M.Sc., A.M.I.E.E., and L. H. G. Huxley, M.A., D.Phil.

No. 69.—An Investigation of the Taxonomic and Agricultural Characters of the Danthonia Group; by A. B. Cashmore, B.Sc.

No. 70.—A Soil Survey of King Island; by C. G. Stephens, M.Sc., and J. S. Hosking, B.Sc.

No. 71.—Investigations on Irrigated Pastures—

(1) The Yield and Botanical Composition of an Irrigated Permanent Pasture under Various Systems of Pasture Management; by A. E. V. Richardson, M.A., D.Sc.

(2) The Chemical Composition of Irrigated Pastures at Wood's Point, South Australia; by H. P. C. Gallus, B.Sc.

1933—

No. 72.—Varieties of Wheat in Australia. A Catalogue with Pedigree or Source, and a Genealogical Chart showing the Relationships of the more important Varieties; by J. R. A. McMillan, M.Sc.

No. 73.—A Soil Survey of the Nyah, Tresco, Tresco West, Kangaroo Lake (Victoria) and Goodnight (New South Wales) Settlements, by J. K. Taylor, B.A., M.Sc., F. Penman, M.Sc., T. J. Marshall, B.Sc.Agr., and G. W. Leeper, M.Sc.

No. 74.—Observations on Soil Moisture and Water Tables in an Irrigated Soil at Griffith, New South Wales; by Eric S. West, B.Sc., M.S.

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

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

1934—

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

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

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

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

No. 81.—A Comparative Study of *Lolium perenne* and *Phalaris tuberosa* at Varying Stages of Growth; by A. B. Cashmore, B.Sc.

No. 82.—The Insect Inhabitants of Carrion: A Study in Animal Ecology; by Mary E. Fuller, B.Sc.

No. 83.—Natural Pastures: Their Response to Superphosphate; by J. Griffiths Davies, B.Sc., Ph.D., A. E. Scott, M.Sc., and K. M. Fraser, M.Agr.Sc.

No. 84.—The Basal (Standard) Metabolism of the Australian Merino Sheep—II; by A. W. Peirce, B.Sc.

No. 85.—Studies on the Phosphorus Requirements of Sheep—II. The Effect of Supplying Phosphatic Supplements to Growing Lambs Depastured on Phosphorus Deficient Country; by H. R. Marston, E. W. Lines, B.Sc., T. J. Marshall, B.Agr.Sc., and J. S. Hosking, M.Sc.

1935—

No. 86.—A Soil Survey of the Berri, Cobdogla, Kingston and Moorook Irrigation Areas, and of the Lyrup Village District, South Australia; by T. J. Marshall, M.Agr.Sc., and P. D. Hooper.

No. 87.—Radio Research Board: Report No. 6—

(1) On the Rotation of the Plane of Polarization of Long Radio Waves; by A. L. Green, M.Sc., Ph.D., and Geoffrey Builder, Ph. D.

(2) A Field Intensity Set; by A. L. Green, M.Sc., Ph.D., and H. B. Wood, B.Sc., B.E.

No. 88.—Radio Research Board: Report No. 7.—

(1) The Propagation of Medium Radio Waves in the Ionosphere; by D. F. Martyn, Ph.D., A.R.C.Sc., F.Inst. P.

(2) The Characterictics of Downcoming Radio Waves; by D. F. Martyn, Ph.D., A.R.C.Sc., F.Inst.P., and A. L. Green, M.Sc., Ph.D.

(3) The Influence of Electric Waves on the Ionosphere; by V. A. Bailey, M.A., D.Phil., and D. F. Martyn, Ph.D., A.R.C.Sc., F.Inst.P.

(4) Long Distance Observations of Radio Waves of Medium Frequencies; by D. F. Martyn, Ph.D., A.R.C.Sc., F.Inst.P., R. O. Cherry, M.Sc., F.Inst.P., and A. L. Green, M.Sc., Ph.D., F.Inst.P.

No. 89.—Radio Research Board: Report No. 8—

(1) Simultaneous Observations of Atmospherics with Cathode ray Direction-finders at Toowoomba and Canberra; by G. H. Munro, M.Sc., A.M.I.E.E., H. C. Webster, M.Sc., Ph.D., and A. J. Higgs, B.Sc.

(2) Atmospheric Interference with Reception; by W. J. Wark, M.Sc.

No. 90.—The Identification of the Principal Commercial Timbers Other than Eucalyptus; by H. E. Dadswell, M.Sc., and Audrey M. Eckersley, M.Sc.

B. Pamphlets.

1927—

No. 4.—The Bionomics of *Symnthurus viridis* Linn. or the South Australian Lucerne Flea; by F. G. Holdaway, M.Sc.

1928—

No. 5.—Liver Fluke Disease in Australia—Its Treatment and Prevention; by I. Clunies Ross, B.V.Sc.

No. 6.—Standard Methods of Drying Sultana Grapes in Australia; by A. V. Lyon, M.Agr.Sc.

No. 7.—The Export of Oranges; by W. Ranger and W. J. Young, D.Sc.

No. 8.—Methods for the Examination of Soils; by J. A. Prescott, M.Sc., and C. S. Piper, B.Sc.

No. 9.—A Forest Products Laboratory for Australia; by A. J. Gibson, F.C.H., F.L.S., F.Z.S.

1929—

No. 10.—The Health and Nutrition of Animals, Reports by Sir Arnold Theiler, K.C.M.G., D.Sc., and J. B. Orr, D.S.O., M.C., M.A., M.D., D.Sc.

No. 11.—The Tasmanian Grass Grub ; by G. F. Hill.
No. 12.—The Cattle Tick Pest; Report by Cattle Tick Dip Committee.
No. 13.—The Mechanical Analysis of Soils ; by C. S. Piper, B.Sc., and H. G. Poole, M.Sc.
No. 14.—The Work of the Division of Economic Botany for the year 1928–29 ; by B. T. Dickson, B.A., Ph.D.
No. 15.—The Work of the Division of Economic Entomology for the year 1928–29 ; by R. J. Tillyard, Sc.D., D.Sc., F.R.S.
No. 16.—The work of the Division of Animal Nutrition for the year 1928–29 ; by T. Brailsford Robertson, Ph.D., D.Sc.

1930—
No. 17.—The Mineral Content of Pastures—Progress Report on Co-operative Investigations at the Waite Agricultural Research Institute.

1931—
No. 18.—The Influence of Frequency of Cutting on the Value of "Natural" Pastures in Southern Australia ; by J. Griffiths Davies, B.Sc., Ph.D., and A. H. Sim, B.Sc., B.Agr.Sc.
No. 19.—Black Disease ; by A. W. Turner, D.V.Sc.
No. 20.—The Identification of Wood by Chemical Means—Part I. ; by H. E. Dadswell, M.Sc.
No. 21.—The Density of Australian Timbers—A Preliminary Study ; by H. E. Dadswell, M.Sc.
No. 22.—The Chemistry of Australian Timbers—Part I : A Study of the Lignin Determination ; by W. E. Cohen, B.Sc., and H. E. Dadswell, M.Sc.
No. 23.—Refrigeration Applied to the Preservation and Transport of Australian Foodstuffs. A Survey and a Scheme for Research ; by J. R. Vickery, Ph.D.

1932—
No. 24.—The Preservative Treatment of Fence Posts (with particular reference to Western Australia) ; by J. E. Cummins, M.Sc.
No. 25.—Termites (White Ants) in South-eastern Australia. A Simple Method of Identification ; by G. F. Hill.
No. 26.—The Irrigation of Horticultural Community Settlements. Notes for the Guidance of Advisory Boards in Murray Valley Settlements ; by A. V. Lyon, M.Agr.Sc.
No. 27.—Zebu (Brahman) Cross Cattle and their Possibilities in North Australia ; by R. B. Kelley, B.V.Sc.
No. 28.—The Pig Industry : Report on Conditions in Great Britain and America, with Suggestions Applicable to Australia ; by R. B. Kelley, B.V.Sc.
No. 29.—The Possibility of the Entomological Control of St. John's Wort in Australia—Progress Report ; by G. A. Currie, B.Sc., B.Agr.Sc., and S. Garthside, M.Sc.
No. 30.—The Bionomics and Economic Importance of *Thrips imaginis* Bagnall, with special Reference to its Effect on Apple Production in Australia ; by J. W. Evans, M.A.
No. 31.—A Preliminary Report on Investigations on the Buffalo Fly (*Lyperosia exigua* de Meij.) and its Parasites in Java and Northern Australia ; by Professor E. Handschin.
No. 32.—The Chemistry of Australian Timbers, Part 2—The Chemical Composition of the Woods of the Ironbark Group ; by W. E. Cohen, B.Sc., A. L. Baldock, B.Sc., and A. G. Charles.
No. 33.—Enzootic Haematuria (Haematuria Vesicalis) of Cattle in South Australia ; by L. B. Bull, D.V.Sc., C. G. Dickinson, B.V.Sc., and A. T. Dann, M.Sc.
No. 34.—The Collembola—Symphypleona of Australia : A Preliminary Account ; by E. Womersley, A.L.S., F.E.S.
No. 35.—"Pulpy Kidney in Lambs"—
(1) "Pulpy Kidney" or Acute Infectious Entero-toxaemia of Sucking Lambs due to *B. ovitoxicus* (Bennetts) ; by D. T. Oxer, B.V.Sc.
(2) "Pulpy Kidney" : A Post-mortem Change in Experimental Infectious Entero-toxaemia ; by H. W. Bennetts, D.V.Sc.
No. 36.—Fibre Boards. Their Uses and the Possibilities of their Manufacture in Australia ; by R. F. Turnbull, B.E.

1933—

No. 37.—The Sheep Blowfly Problem in Australia. Report No. 1; by the Joint Blowfly Committee.

No. 38.—The Occurrence of *Anaplasma marginale* Theiler 1910 in Northern Australia; by J. Legg, D.V.Sc.

No. 39.—The Grasslands of Australia and some of their Problems. A Report upon the Dairy Pastures; by William Davies, M.Sc.

No. 40.—A Guide to the Seasoning of Australian Timbers, Part 1; by C. S. Elliot, B.Sc.

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

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

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

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

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

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

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

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

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

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

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

1934—

No. 48.—Field Observations on Weather Stain and Blowfly Strike of Sheep with Special Reference to Body Strike; by F. G. Holdaway, Ph.D., and C. R. Mulhearn, B.V.Sc.

No. 49.—Some Important Poison Plants of North Australia; compiled by the Poison Plants Committee.

No. 50.—The Design of Overhead Irrigation Systems; by E. S. West, B.Sc., M.S., and A. Howard, M.Sc.

No. 51.—The Chemistry of Australian Timbers. Part 4—A Study of the Lignin Determination II.; by W. E. Cohen, B.Sc.

1935—

No. 52.—Systematic Entomology—Contribution 1—

(1) Notes on the Genus *Hexamera* B. and B. (Dipt. Tachin.); by A. L. Tonnoir.

(2) Australian *Hamitermes* (Isoptera) with Descriptions of New Species and Hitherto Undescribed Castes; by G. F. Hill.

No. 53.—The Identification of Wood by Chemical Means. Part 2—Alkalinity of Ash and some Simple Chemical Tests for the Identification of the Coloured Woods of the Genus *Eucalyptus*; by W. E. Cohen, B.Sc.

No. 54.—Thrips Investigation: Some Common Thysanoptera in Australia; by H. Vevers Steele, B.Agr.Sc., M.S.

No. 55.—The Selection, Preservation, Distribution and Identificaton of Australian Pole Timbers; by J. E. Cummins, M.Sc., and H. E. Dadswell, M.Sc.

C. Circulars.

1927—

No. 9.—Preliminary Report on the Treatment of Redgum and Marri Kino (*Eucalyptus calophylla*) for the Preparation of Tannin Extract; by D. Coghill.

No. 10.—Report by the Meat Freezing Committee of the Australian National Research Council on the Bullot Process for the Preservation of Meat. (This series was discontinued with No. 10).

D. Trade Circulars (Division of Forest Products.)

1930—

No. 1.—Sound Practice in the Air Seasoning of Boards. (*Revised* 1935).
No. 2.—The Testing of Timber for Moisture Content. (*Revised* 1935).
No. 3.—The Growth and Structure of Wood. (*Revised* 1933).

1931—

No. 4.—The Functions of the Division of Forest Products.
No. 5.—Vacuum Kilns.
No. 6.—Wood Borers in Australia.—Part 1—Lyctus, or the Powder Post Beetle.

1932—

No. 7.—Sample Boards: Their Use in Timber Seasoning. (*Revised* 1935).
No. 8.—Identifying Australian Timbers. The Value of Structure, Composition, and Precise Names.
No. 9.—Electrical Moisture Meters: For Measuring the Moisture Content of Timber. (*Revised* 1933).
No. 10.—The Principles of Wooden Box Construction.
No. 11.—Wood Borers in Australia. Part 2—Anobium, or the Furniture Borer.
No. 12.—Combined Air and Kiln Seasoning. Handling by Means of the Christensen Truck.

1933—

No. 13.—Cross, Diagonal, and Spiral Grain in Timber.
No. 14.—Gluing Practice. Part 1—The Preparation and Use of Animal Glues.
No. 15.—Draft Terms and Definitions used in Timber Grading Rules.
No. 16.—Terms used in Timber Seasoning: Part 1.
No. 17.—Types of Timber Seasoning Kilns.
No. 18.—The Prevention of Decay in Building Foundations.

1934—

No. 19.—Gluing Practice. Part 2—Casein Glues.
No. 20.—Collapse and the Reconditioning of Collapsed Timber.
No. 21.—Drying Rooms for Furniture Stock.
No. 22.—Timber Bending.
No. 23.—The Shrinkage of Wood during Drying.
No. 24.—The "Working" of Wood.
No. 25.—Wood Borers in Australia. Part 3—Pin-hole Borers.
No. 26.—Some Terms used in the Mechanical Testing of Timber.

1935—

No. 27.—The Preservation of Timber.
No. 28.—The Chemistry of Wood.

E. Other Circulars (Section of Food Preservation and Transport.)

No. 1.—P. The Commercial Ripening of Bananas.

F. Journal of the Council for Scientific and Industrial Research.

This publication, which is issued quarterly, was commenced in 1927, the first number appearing in August of that year. It has now reached the eighth volume, the second number of this appearing in May of the year under review.

G. Annual Reports.

Nos. 1 to 9 inclusive; 1926–27 to 1934–35.

H. Miscellaneous Publications.

1930—

The Dairy Industry of the Commonwealth in relation to Possible Activities of the Council for Scientific and Industrial Research; by Professor S. M. Wadham, M.A.

Catalogue of Scientific and Technical Periodicals in the Libraries of the Commonwealth; edited by E. R. Pitt, B.A.

1934—

Catalogue of Scientific and Technical Periodicals in the Libraries of the Commonwealth Supplement 1928–1933; edited by E. R. Pitt, B.A., C. A. McCallum, B.A., and D. W. I. Cannam.

2. *Papers contributed to Scientific Journals, &c. by Officers of the Council.*—The following is a list of papers contributed by officers of the Council and published in various scientific journals, &c. up to 30th June, 1935 :—

A. Division of Plant Industry.

Allan, F. E.—The general form of the orthogonal polynomials for simple series, with proofs of their simple properties. *Proc. Roy. Soc. Edin.* 50 : 310, 1930.

Allan, F. E.—A percentile table of the relation between the true and observed correlation coefficient from a sample of 4 inch. *Proc. Cam. Phil. Soc.* 26 : 536, 1930.

Allan, F. E.—Appendix to a report of the epidemic of polyiomyelitis in New South Wales 1931–1932. The *Med. Jour.* of *Aust.* 20th year 1 : 58, 1933.

Allan, F. E. (with Wishart, J.).—A method of estimating the yield of a missing plot in field experimental work. *J. Agr. Sc.* 20 : 399, 1930.

Bald, J. G.—Statistical aspect of the production of primary lesions by plant viruses. *Nature* 135 : 996, 1935.

Bald, J. G. (with Samuel, G.)—Some factors affecting the inactivation rate of the virus of tomato spotted wilt. *Ann. Appl. Biol.* 21 : 179, 1934.

Bald, J. G. (with Davidson, J.)—Description and bionomics of *Frankiniella insularis*, Franklin (*Thrysanoptera*). *Bull. Entom. Res.* 21 : 365, 1930.

Bald, J. G. (with Davidson, J.).—Sex determination in *Frankiniella insularis* Franklin (*Thrysanoptera*). *Aust. Jour. Exp. Biol. & Med. Sci.* 8 : 139, 1931.

Bald, J. G. (with Samuel, G.).—*Thrips tabaci* as a vector of plant virus disease. *Nature* 128 : 494, 1931.

Bald, J. G. (with Samuel, G.).—Tomato spotted wilt on tobacco. *J. Dept. Agr. South Aust.* 37 : 190, 1933.

Bald, J. G. (with Samuel, G.).—On the use of the primary lesions in quantitative work with two plant viruses. *Ann. App. Biol.* 20 : 70, 1933.

Bald, J. G. (with Samuel, G. and Eardley, C. M.).—" Big bud ", a virus disease of the tomato. *Phytopathology* 23 : 641, 1933.

Barnard, C. (with Read, F. M.).—Studies of growth and fruit bud formation:—

1. A year's observation on Victorian apples. *J. Dept. Agric. Vic.* 30 : 349, 1932.
2. A year's observations on Victorian pears. *J. Dept. Agric. Vic.* 30 : 463, 1932.
3. A year's observations on Victorian plums. *J. Dept. Agric. Vic.* 31 : 37, 1933.
4. Studies of growth and fruit bud formation in the apricot and peach. *J. Dept. Agric. Vic.* 31 : 44, 1933.

Barnard, C. (with Fowler, R.).—5. Observations during two seasons on South Australian apples. *J. Dept. Agric. South Aust.* 28 : 1, 129, 1935.

Calvert, J.—An abnormal Xanthium burr. *Proc. Linn. Soc. of N.S.W.* 55 : 475, 1930.

Carne, W. M. (with Pittman, H. A. and Elliott, H. G.).—The present position of the Bitter pit problem in Australia. *Proc. 1st Imp. Hort. Conf.*, Part III. : 37, 1931.

Dickson, B. T.—Leaf spot of banana in Southern Queensland. *Q'land Agric. J.* 30 : 455, 1928.

Dickson, B. T.—Downy mildew (" blue mould ") of tobacco. Australian Tobacco Investigation, Pamp. 1, 1932.

Dickson, B. T.—The tobacco-growing industry (address before members of the Commonwealth Parliament, May 18, 1932). *Tobacco* 1 : 1 : 15, 1932.

Dickson, B. T.—Downy mildew (" blue mould ") of tobacco. *Tobacco* 1: 2 : 18, 1932.

Dickson, B. T.—The history of smoking. *Tobacco* 1 : 3 : 22, 1932. 1 : 5 : 27, 1932. 2 : 1 : 14, 1933.

Dickson, B. T. (with Marks, G. E. and Hill, A. V.).—Tobacco production in Australia. Australian Tobacco Investigation Bull. 3, 1932.

Dickson, B. T.—Review of tobacco growing areas. *Tobacco* 1 : 5 : 14, 1932.

Dickson, B. T.—Filterable viruses. *Rept. A. & N.Z.A.A.S.* 21 : 437, 1932.

Dickson, B. T.—Disease resistance in plants. *Rept. A. & N.Z.A.A.S.* 21 : 439, 1932.

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Hill, A. V.—Wildfire of tobacco. *Tobacco* 1 : 3 : 18, 1932.

Hill, A. V.—Black root rot of tobacco caused by *Thielavia basicolor*. *Tobacco* 1 : 5 : 19, 1932.

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Hill, A. V.—Frogeye disease of tobacco. Australian Tobacco Investigation Pamp. 2, 1933.

Hill, A. V.—Downy mildew of tobacco on tomato, eggplant and pepper. *J. Aust. Instit. Agric. Sc.* 1 : 81, 1935.

Jarrett, Phyllis H.—Streak—a virus disease of tomatoes. *Ann. App. Biol.* 17 : 248, 1930.

Jarrett, Phyllis H.—The role of *Thrips tabaci* Hindeman in the transmission of virus diseases of tomato. *Ann. App. Biol.* 17 : 444, 1930.

Ludbrook, W. V.—Pathogenicity and environal studies on *Verticillium hadromycosis*. *Phytopathology* 23 : 117, 1933.

McMillan, J. R. A.—The inheritance of grass clumps in wheat (Abst.) *Rept. A. & N.Z.A.A.S.* 21 : 291, 1932.

McMillan, J. R. A. (with Bryan, W. W.).—Maize varieties for the Lockyer Valley. *Q'land. Agric. J.* 41 : 174, 1934.

McTaggart, A.—Plant introduction in relation to pasture development in Australia. *Herbage Reviews* 3 : 53, 1935.

McTaggart, A.—Pasture plant introduction work of the Australian Council for Scientific and Industrial Research. *Herbage Reviews* 3 : 56, 1935.

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Paltridge, T. B. (with Osborn, T. G. B. and Wood, J. G.).—On the growth and reaction to grazing of the perennial saltbush, *Atriplex vesicarium*. An ecological study of the biotic factor. *Proc. Linn. Soc. of N.S.W.* 57 : 377, 1932.

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Thomas, L. A. (with Roach, W. A.).—Injection of fruit trees : Preliminary experiments with artificial manures. *J. Pom. & Hort. Sc.* 12 : 151, 1934.

B. Division of Economic Entomology.

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3. *Commonwealth Scientific Publications Committee.*—The following books have been issued under the aegis of this Committee which consists of representatives of the Australian National Research Council, of the Commonwealth Department of the Treasury, and of the Council for Scientific and Industrial Research :—

Meteorological Observations of the First Shackleton (Nimrod) Antarctic Expedition 1907–1909, by E. Kidson, O.B.E., D.Sc., &c., formerly of the Commonwealth Meteorological Bureau, now of the New Zealand Department of Scientific and Industrial Research.

Australian Rain Forest Trees, by W. D. Francis, Assistant Government Botanist, Queensland

4. *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 and these have been 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 from this latter category and concerning which information has been supplied during the past year :—

(i) *Agricultural and Horticultural.*—Lime sulphur spray, derris powder and pyrethrum as insecticides, locust control, stomach worm in sheep, ensilage, patent harvester, Spangenburg process, bracken control, sheep licks, rabbit fumigants, rice oil and pollard, ethyl formate as an insecticide.

(ii) *Food Preservation.*—Smoking of fish, prunes, wines, fruit juices, apple silage, citrus juices.

(iii) *Industrial Minerals, Chemicals, &c.*—Salt, alunite, sulphur, asbestos, glucose, lactose, glycerine, pine oil, cholesterol.

(iv) *Manufactures.*—Luminous paint, power alcohol from maize, silvering mirrors, cinematograph films, power alcohol from wheat, cellophane, banana by-products, butter milk potato by-products, sausage casings, collapsible tubing, cider.

(v) *Miscellaneous.*—Copra dryers, insulating materials, sun power, water divining, Woolstra, dewoolling skins, preservation of cordage, air conditioning, tintometer, catalyn, tin plating, rust-proofing, shellac as a binder in abrasives, smoke abatement, plastics for dental plates.

XIII.—FINANCIAL MATTERS AND STAFF.

1. *Finance.*—The statement of expenditure from 1st July, 1934, to 30th June, 1935, is as follows :—

	£	£	£
1. Salaries and contingencies	..	..	13,990*
2. Remuneration of Chairman and Members of Council	..	..	2,021†
3. Investigations—			
(i) Animal Problems—			
(1) Sheep diseases : footrot, black disease, preputial disease, caseous lymphadenitis, entero-toxaemia, pregnancy disease and equine navel ill ..	1,513		
Less contribution from the Australian Pastoral Research Trust	162		
		1,351	
(*b*) Parasitology	4,430		
Less contributions from the Australian Pastoral Research Trust	827		
		3,603	
(*c*) Caseous lymphadenitis (New South Wales)	..	1,439	
(*d*) Bovine haematuria and caseous lymphadenitis (South Australia) ..	..	720	
(*e*) Tick and tick fevers, pleuro-penumonia, &c.	8,092		
Less contributions from Queensland Government, Council of Agriculture, Brisbane, and the Empire Marketing Board, England	3,168		
		4,924	
(*f*) Entero-toxaemia (Braxy-like disease), Moora (Gingin) disease, Ataxia in lambs, &c. (Western Australia) ..	..	312	
(*g*) Parasitology and caseous lymphadenitis (at Noondoo, Queensland) ..	483		
Less contributions from the Australian Pastoral Company ..	405		
		78	
(*h*) Mastitis (Victoria)	321		
Less contributions from Australian Dairy Cattle Research Association ..	61		
		260	
(*i*) Zebu Cattle project	114		
Less contributions from Messrs. Winter-Irving and Alison, Queensland Stations Ltd., Messrs. Meredith Menzies & Co. Pty. Ltd. and C. W. Wright, Esq.	4		
		110	

* 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.

	£	£	£
(*j*) Genetics (New South Wales and Queensland)	..	728	
(*k*) Haematuria (Victoria)	..	49	
(*l*) Central office salaries, &c.	2,702		
		16,276	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)	..	4,000	
			12,276
(ii) Plant Problems—Division of Plant Industry—			
(*a*) Central Laboratory—			
Annual	5,187		
Capital	152		
		5,339	
(*b*) Experimental plots	..	475	
(*c*) Plant pathology	2,371		
Less contributions from Empire Marketing Board, England ..	2		
		2,369	
(*d*) Plant genetics	..	3,291	
(*e*) Plant Introduction	..	1,333	
(*f*) Agrostology	..	1,097	
(*g*) Plant physiology	..	563	
(*h*) Noxious plants	..	470	
(*i*) Fruit problems	..	1,204	
(*j*) Experimental Farm, Duntroon ..	..	463	
(*k*) Tomato wilt	..	210	
(*l*) Plant Introduction Garden, Gatton, Queensland	..	56	
(*m*) General botany	..	592	
(*n*) Apple root stocks, Stanthorpe, Queensland	468		
Less contributions from Committee of Direction of Fruit Marketing, Brisbane, Queensland	376		
		92	
(*o*) Tobacco Investigations	6,360		
Less contributions from Tobacco Trust Fund	6,360		
		..	
			17,554
(iii) Entomological Problems — Division of Economic Entomology—			
(*a*) Central laboratory	..	5,334	
(*b*) Noxious weeds	..	2,375	
(*c*) Blow-fly and buffalo-fly	..	3,585	
(*d*) Orchard and fruit pests	..	222	
(*e*) Forest insects	..	2,144	
(*f*) Oriental Peach Moth	..	206	
		13,866	
Less contributions from Empire Marketing Board, England, Australian Pastoral Research Trust and Department of Agriculture, Victoria ..	..	285	
			13,581

	£	£	£
(iv) Animal Nutrition—Division of Animal Nutrition—			
(*a*) Central laboratory	5,443		
(*b*) Waite Institute	1,906		
(*c*) Field Station, Young, New South Wales	174		
	7,523		
Less contributions from Commonwealth Bank (Rural Credits Development Fund)	3,000		
		4,523	
(*d*) Field Station, Kangaroo Island, South Australia	225		
Less contributions from the Australian Pastoral Research Trust ..	225		
		..	
(*e*) Drought feeding experiments at Waite Agricultural Research Institute, Glen Osmond, South Australia	1,134		
Less contributions from Australian Pastoral Research Trust and the Empire Marketing Board ..	289		
		845	
(*f*) Agrostological Investigations at Waite Agricultural Research Institute, Glen Osmond, South Australia	..	491	
(*g*) Survey of Coast Disease	233		
Less contribution from Department of Agriculture, South Australia and G. H. Michell & Sons Ltd. ..	61		
		172	
At Waite Institute in co-operation with Carnegie Institute and Adelaide University—			
Mineral deficiencies in pastures ..	3,363		
Less contribution from Carnegie Institute	2,188		
		1,175	
			7,206
(*v*) Horticultural Problems of the Irrigation Settlements—			
Citricultural—			
(*a*) Research Station, Griffith—			
Salaries and incidentals ..	4,092		
Capital	328		
	4,420		
Less funds provided from Station Revenue ..	415		
	4,005		
Less contributions by New South Wales Water Conservation and Irrigation Commission	1,200		
		2,805	

	£	£	£
Viticultural—			
(*b*) Research Station, Merbein—			
Salaries and incidentals ..	4,869		
Capital	606		
	5,475		
Less funds provided from Station Revenue ..	292		
	5,183		
Less contributions by Dried Fruits Control Board and Woorinen Dried Fruits Inquiry Committee ..	1,887		
		3,296	
(*c*) Ripening, processing, &c., of vine fruits, Mildura district ..	828		
Less contributions by Irymple Packing Pty. Ltd., Mildura Co-op. Fruit Co., Red Cliffs Co-op. Fruit Co. Ltd. and Aurora Packing Pty. Ltd. ..	376	452	
			6,553
(vi) Soil Problems—			
(*a*) Investigations at Waite Institute, Irrigation Areas and Tasmania—			
Salaries, &c.	5,025		
Capital	21		
		5,046	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)		2,500	
			2,546
(vii) Food Preservation and Transport—			
(*a*) Meat and fish investigations (Brisbane Abattoir)	2,451		
Less contributions by Queensland Meat Industry Board ..	250		
		2,201	
(*b*) Banana investigations (Queensland University)	1,182		
Less contribution by Commonwealth Banana Committee	1,182		
		..	
(*c*) Banana investigations (Melbourne)..	370		
Less contribution by Committee of Direction of Fruit Marketing	370		
		..	
(*d*) Non-tropical fruits (Melbourne)		1,086	
(*e*) Citrus preservation		766	
(*f*) Engineering problems		896	
(*g*) Adviser on Food Preservation		285	
		5,234	

	£	£	£
Less contributions from Commonwealth Bank (Rural Credits Development Fund)		2,000	
			3,234
(viii) Prickley 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	5,839		
Capital	461		
		6,300	
(*b*) Seasoning		1,170	
(*c*) Preservation		1,152	
(*d*) Chemistry		1,111	
(*e*) Wood Anatomy		1,079	
(*f*) Timber Mechanics		911	
(*g*) Timber Utilization		820	
(*h*) Timber Physics		564	
(*i*) Grading Studies		962	
(*j*) Queensland Timber Problems ..	175		
Less contribution by Lands Administration Board, Brisbane, Queensland ..	175		
		..	
(*k*) Oxacetylene process for treating poles	50		
Less contribution by Messrs. Allen-Liversidge Ltd. ..	50		
		..	
(*l*) Pole Tests in New South Wales ..	21		
Less contributions by Sydney Municipal Council, Newcastle Municipal Council and Department of Public Works, New South Wales	21		
		..	
(*m*) Paper Pulp	19		
Less contribution by Australian Paper Manufacturers Ltd.	19		
		..	
(*n*) Railway Sleepers	25		
Less contribution by South Australian Railways ..	25		
		..	
		14,069	
Less contribution from Commonwealth Bank (Rural Credits Development Fund)..		1,500	
			12,569

	£	£	£
(x) Mining and Metallurgy—			
(*a*) Mineragraphic Investigations ..	..	743	
Less contribution by Australasian Institute of Mining and Metallurgy ..	..	336	
			407
(xi) Radio Research—			
(*a*) Melbourne and Sydney Universities	5,011		
Less contributions by Postmaster-General's Department	3,758		
		1,253	
(*b*) Advisers on Radio Research ..	..	87	
			1,340
(xii) Library	..	..	988
(xiii) Contributions to Imperial Agricultural Bureaux, Imperial Institute of Entomology, Farnham House, Imperial College of Science and Technology, Slough, and Low Temperature Research Station, Cambridge	..	..	9,958
(xiv) Gold-Mining—			
(*a*) Mineragraphic Investigations (Melbourne University)	..	497	
(*b*) Ore Dressing (Melbourne University)	..	768	
(*c*) Ore Dressing (Adelaide School of (Mines)	..	555	
(*d*) Ore Dressing (Kalgoorlie School of Mines)	..	424	
			2,244
(xv) Miscellaneous—			
(*a*) Wood taint in butter investigations	9		
Less contributions by Australian Dairy Council ..	9		
		..	
(*b*) Bee Investigations	201		
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	201		
		..	
(*c*) Thrips Investigations	986		
Less contributions from the Thrips Investigation League	986		
		..	
(*d*) Watery Whites in Eggs Investigations	33		
Less contribution by Egg Producers' Council ..	33		
		..	
(*e*) Fisheries Investigations	43		
Less contribution by Development Branch, Prime Minister's Department ..	43		
(*f*) Various	..	259	
			259
Total of Item 3—Investigations	..	..	90,715

2. *Contributions.*—The following statement shows the receipts and disbursements during the year 1934–35 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 1933–34.	Expenditure 1934–35.
	£	£
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)	223	200
Empire Marketing Board, England (Entomological Investigations)	81	81*
Empire Marketing Board, England (Plant Industry Investigations)	222	222†
Empire Marketing Board, England (Animal Health and Animal Nutrition Investigations—Sheep Research)	15	15
Empire Marketing Board, England (Animal Health Investigations—Cattle Research)	89	89
Postmaster-General's Department (Radio Research) ..	3,755	3,758
Australian Pastoral Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,154	1,497
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	1,200	1,200
Queensland Government (Animal Health Investigations—Cattle Research)	3,988	3,079
Council of Agriculture, Brisbane (Animal Health Investigations—Cattle Research)	386	..
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	336	336
Dried Fruits Control Board (Dried Fruits Investigations) Woorinen Dried Fruits Enquiry Committee (Dried Fruits Investigations)	1,984	1,886
Australian Dairy Council (Wood Taint in Butter Investigations)	29	9
Queensland Meat Industry Board (Food Preservation Investigation)	250	250
Sir MacPherson Robertson (Entomological Investigations)	183	..
Thrips Investigation League (Thrips Investigations) ..	1,000	985
Queensland Stations Ltd. (Zebu Cattle Project) ..	31	‡31
C. W. Wright, Esq. (Zebu Cattle Project)	31	‡31
Commonwealth Banana Committee (Banana Investigations)	1,722	1,181
Revenue Fund—Griffith Research Station (Citricultural Investigations)	1,520	416
Revenue Fund—Merbein Research Station (Viticultural Investigations)	1,110	292
Messrs. Allen-Liversidge (Aust.) Ltd. (Forest Products Investigations)	100	88
Lands Administration Board, Queensland (Special Forest Products Investigations)	248	175
Committee of Direction of Fruit Marketing (Apple Root Stocks Investigations)	376	376
Tobacco Trust Fund—Prime Minister's Department (Tobacco Investigations)	15,210	6,360
Carried forward ..	53,748	40,057

* Includes £29 on account of 1933–34 expenditure. † Includes £220 on account 1933–34 expenditure. ‡ Includes £11 on account 1933–34 expenditure.

	Receipts including balances brought forward from 1933-34.		Expenditure 1934-35.
	£		£
Brought forward ..	53,748	..	40,057
Mildura Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	95	..	95*
Irymple Packing Co. (Dried Vine Fruits Investigations, Merbein)	95	..	95
Red Cliffs Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	95	..	95
Aurora Packing Co. (Dried Vine Fruits Investigations, Merbein)	95	..	95
Australian Dairy Cattle Research Association (Mastitis Investigations)	61	..	61
Australian Pastoral Co. (Animal Health Investigations, Noondoo)	405	..	405
Office of Minister of Agriculture, South Australia (Survey of Incidence of Coast Disease)	41	..	41†
Carnegie Institute (Mineral Deficiencies in Pastures Investigations)	2,188	..	2,188
Council of Advice, Rabbit Destruction Fund (Work on Rabbits)	300	..	..
Jericho Wool Committee, Jericho, Queensland (Sheep Research)	4	..	..
Michell & Sons Ltd. (Erection of Sheep Pens for Coast Disease Investigations)	25	..	25
Animal Health Research Station, Oonoonba, North Queensland (Sale of Vaccine)	85	..	..
Department of Agriculture, Victoria (Oriental Peach Moth Investigations)	206	..	206
Committee of Direction of Fruit Marketing (Banana Investigations)	370	..	370
Newcastle Municipal Council (Pole Tests in New South Wales)	25	..	
Sydney Municipal Council (Pole Tests in New South Wales)	50	..	21
Department of Public Works, New South Wales (Pole Tests in New South Wales	25	..	
Australian Paper Manufacturers Ltd. (Paper Pulp Investigations)	130	..	19
South Australian Railways (Treatment of Railway Sleepers)	120	..	25
Egg Producers' Council (Watery Whites in Eggs) ..	50	..	33
Development Branch, Prime Minister's Department (Fisheries Research)	50	..	43
Australian Investment Agency (Poison Plant Pamphlet)	10	..	10
Revenue Fund—Ore Dressings	6	..	..
Revenue Fund—Mining and Metallurgy	3	..	..
Senator C. Hardy (Forest Products Investigations) ..	11	..	..
C. H. Tutton Ltd. (Forest Products Investigations) ..	21	..	..
Stephenson & Meldrum (Forest Products Investigations)	3	..	..
Sundry Contributors (Forest Products Investigations) ..	6	..	..
	58,323	..	43,884

3. *Staff.*—The following is a list of the staff of the Council as at the 30th June, 1935. 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.

* Includes £4 on account 1933-34 expenditure. † Includes £5 on account 1933-34 expenditure.

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.
Assistant Librarian—Miss A. L. Kent.

Accounts, Staff, Stores—

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

Orders—

R. W. Constable.

Records—

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

Head Typiste—

Miss M. Polwarth.

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

2. Secretaries of State Committees.

New South Wales—

Mrs. N. Roberts, 906 Culwulla Chambers, Castlereagh-street, Sydney.

Victoria—

G. A. Cook, M.Sc., B.M.E., A.A.C.I., 314 Albert-street, East Melbourne.

Queensland—

Miss H. F. Todd, corner Ann and Edward streets, Brisbane.

South Australia—

J. Ward Walters, Division of Animal Nutrition, University of Adelaide.

Western Australia—

L. W. Phillips, M.Sc., A.A.C.I., Box K766, General Post Office, Perth.

Tasmania—

F. J. Carter, Box 631B, General Post Office, Hobart.

3. Australia House, London.

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

4. Division of Plant 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 Botanist—C. Barnard, M.Sc.
Assistant Plant Pathologist—W. L. Geach, B.Sc.
Assistant Plant Pathologist—W. V. Ludbrook, B.Agr.Sc., Ph.D.
Assistant Plant 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.
Assistant Plant Geneticist—C. S. Christian, B.Sc.Agr., M.Sc.
Junior Research Officer (Genetics)—S. G. Gray, B.Sc.Agr.
Assistant Research Officer (Genetics)—K. Loftus Hills, B.Agr.Sc.
Assistant Botanist (Agrostological Investigations)—H. K. C. Mair, B.Sc.
Assistant Physiologist—J. Calvert, M.Sc., F.L.S.
Assistant Plant Physiologist—C. G. Greenham, M.Sc.

Biometrician—Miss F. E. Allan, M.A., Dip.Ed.
Assistant Botanist (Agrostological Investigations)—T. B. Paltridge, B.Sc.
Chemist—E. H. Kipps, B.Sc.
Librarian (part-time)—Miss F. Stops, B.A.
Assistant Research Officer (Agrostology)—A. B. Cashmore, B.Sc.Agr..
Assistant Plant Pathologist—J. M. Allan, B.Agr.Sc.
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.
Research Officer (Tobacco)—G. E. Marks.
Chemist (Tobacco)—N. F. B. Hall, M.Sc.

At Stanthorpe, Queensland—

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

At University of Tasmania, Hobart—

Senior Plant Pathologist—W. M. Carne, F.L.S.
Assistant Plant Physiologist—D. Martin, B.Sc.

5. Division of Soils.

At Waite Agricultural Research Institute—

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

At University of Tasmania—

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

6. Irrigation Settlement Problems.

Commonwealth Research Station, Griffith—

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

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.

At Head Office, Melbourne—

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

At Melbourne University Veterinary Research Institute—

Veterinary Officer—D. Murnane, B.V.Sc.
Assistant Bacteriologist—E. Munch-Petersen, M.Sc., P.H.B., M.I.F., F.L.S.
Technical Assistant—Miss C. Eales, B.Sc.

At Adelaide Hospital Pathological Laboratory—

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

Townsville (North Queensland) Cattle Research Station—

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

At Department of Agriculture, Western Australia—

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

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

Officer-in-Charge—I. Clunies Ross, D.V.Sc.
Assistant Parasitologist—H. McL. Gordon, B.V.Sc. (seconded to the Graziers' Co-op. Shearing Co. of New South Wales as from 1st April, 1935.)
Technical Officer—E. Parrish.
Veterinary Field Officer—R. B. Kelley, B.V.Sc.
Field Officer—N. P. Graham, B.V.Sc. (seconded to Australian Pastoral Research Trust as from 1st October, 1932.)
Assistant Parasitologist—G. Kauzal, D.V.Sc.
Assistant Veterinary Officer—W. I. B. Beveridge, B.V.Sc.
Assistant Bacteriologist—L. W. N. Fitch, B.V.Sc.
Secretary and Statistician—Miss H. A. Newton Turner, B.Arch.

At the University of Adelaide—

Acting Chief—H. R. Marston.
Chief Assistant—J. Ward Walters.
Field Officer—E. W. Lines, B.Sc.
Chemist—R. G. Thomas, B.Sc.
Technical Officer—J. D. O. Wilson.
Biochemist—J. W. H. Lugg, D.Sc., A.I.C., A.A.C.I.
Biochemist—I. W. McDonald, B.V.Sc.
Statistical Recorder—G. W. Bussell.
Technical Officer—F. C. Farr.
Assistant Technican (Drought Feeding)—H. Munz.
Junior Research Officer—H. J. Lee, B.Sc.

At Waite Agricultural Research Institute—

Assistant Field Officer—A. W. Peirce, B.Sc.

At "Wambanumba" Field Station, Young, New South Wales—

Field Officer—R. Tout.

9. 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.

10. Division of Economic Entomology.

At Canberra—

Acting Chief—A. J. Nicholson, D.Sc.
Senior Entomologist—G. F. Hill.
Senior Systematic Entomologist—A. L. Tonnoir.
Senior Entomologist—I. M. Mackerras, B.Sc., M.B., B.Ch.
Senior Entomologist—G. A. Currie, B.Sc., B.Agr.Sc.
Entomologist (Termite Investigations)—F. G. Holdaway, M.Sc., Ph.D.
Assistant Entomologist—Miss M. Fuller, B.Sc.

Assistant Entomologist (Blowfly Investigations)—Mrs. M. J. Mackerras, M.Sc., M.B.
Biochemist—M. R. Freney, B.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.Agr.Sc.

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

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

11. Division of Forest Products.

At Head Office, Melbourne (temporarily)—
Chief—I. H. Boas, M.Sc., A.A.C.I.
Deputy Chief—S. A. Clarke, B.E., A.M.I.E. (Aust.).
Senior Chemist—W. E. Cohen, B.Sc. A.A.C.I.
Senior Seasoning Officer—C. S. Elliot, B.Sc.
Senior Preservation Officer—J. E. Cummins, B.Sc., M.S., A.A.C.I.
Assistant Preservation Officer—H. B. Wilson, B.Sc.
Senior Wood Anatomist—H. E. Dadswell, M.Sc., A.A.C.I.
Timber Testing Officer—I. Langlands, B.E.E.
Timber Physics Officer—W. L. Greenhill, B.E., Dip.Sc., M.E.
Utilization Officer—R. F. Turnbull, B.E.
Technical Officer—A. G. Charles, A.A.C.I.
Assistant Utilization Officer—F. E. Hutchinson, B.Sc.For., M.N.Z.I.F.
Assistant Utilization Officer—A. J. Thomas, Dip.For.
Assistant Seasoning Officer—R. A. Bottomley, B.Sc., A.A.C.I.
Assistant Wood Anatomist—Miss A. M. Eckersley, M.Sc.
Technical Assistant (part time)—Miss J. Ellis.
Technical Assistant (part time)—Miss J. Galbraith.
Librarian and Records Clerk—Miss I. Hulme.
Technical Officer—S. G. McNeil.
Draughtsman and Computer—B. Whitington.

12. Cold Storage Investigations.

At Brisbane Abattoir—
Officer-in-Charge—J. R. Vickery, M.Sc., Ph.D.
Assistant Biochemist—W. A. Empey, B.V.Sc.
Assistant Biochemist—W. J. Scott. B.Agr.Sc.
Investigator—A. R. Riddle, M.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 University of Queensland—
Assistant Biochemist—E. W. Hicks, B.Sc. (seconded to Committee of Direction of Fruit Marketing as from 28th August, 1934.).

At Department of Agriculture, Brisbane—
Mycologist (Banana Investigations)—R. S. Mitchell, B.Agr.Sc., Dip.Agr.

At Department of Agriculture, Sydney—
Assistant Research Officer—L. J. Lynch, B.Agr.Sc.

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

13. Radio Research.

At University of Melbourne—
Research Physicist—H. C. Webster, M.Sc., Ph.D.
Research Physicist—R. W. Boswell, B.Sc. (part time).

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., B.Sc., Ph.D.
Research Physicist—G. H. Munro, M.Sc.
Research Physicist—J. H. Piddington, B.Sc., B.E.

14. Ore Dressing Investigations.

At University of Melbourne—
Assistant Research Officer—S. S. Pullar, B.M.E.
At School of Mines, Adelaide, South Australia—
Assistant Research Officer—A. B. Beck, M.Sc.
At School of Mines, Kalgoorlie, Western Australia—
Assistant Research Officer—G. H. Payne, B.Sc.

15. Other Investigations.

Mineragraphic Investigations—
Investigator—F. L. Stillwell, D.Sc.
Assistant Research Officer—A. Edwards, Ph.D.
Thrips Investigation—
Assistant Entomologist—H. G. Andrewartha, M.Agr.Sc. (at University of Melbourne).
Assistant Entomologist—Mrs. H. G. Andrewartha, M.Sc. (at University of Melbourne).
Fisheries Investigations—
Adviser (part time)—Professor W. J. Dakin, D.Sc., F.L.S., F.Z.S.

XIV. ACKNOWLEDGMENTS.

In several sections of this report reference has been made to the valuable assistance afforded by many organizations and individuals. The Council desires to express its thanks for the help given by these bodies and persons in affording laboratory accommodation and other facilities and in many other ways. In particular, it desires to make special reference to the help given by the various State Departments, particularly those of Agriculture and by the Universities, and to the contributions either in money or in kind provided by such bodies as the Australian Pastoral Research Trust, the Australian Dairy Cattle Research Association, the Thrips Investigation League, the Australian Dried Fruits Control Board, and by many other bodies, companies and individuals. 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.

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G. LIGHTFOOT, Secretary.
3rd October, 1935.

APPENDIX.

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

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

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Professor H. A. Woodruff, M.R.C.V.S., &c.
G. S. Colman.

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W. Baragwanath.
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L. J. Weatherly, M.A.
Associate-Professor W. J. Young, D.Sc.

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