THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

SEVENTH ANNUAL REPORT

OF

THE COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

FOR THE

Year ended 30th June, 1933.

Presented pursuant to Statute 16th November, 1933; ordered to be printed, 22nd November, 1933.

[*Cost of Paper*:—Preparation, not given; 840 copies; approximate cost of printing and publishing, £95.]

Printed and Published for the GOVERNMENT of the COMMONWEALTH of AUSTRALIA by L. F. JOHNSTON, Commonwealth Government Printer, Canberra.

No. 195.—F.4433—PRICE 3s. 8d.

CONTENTS.

CONTENTS—*continued.*

COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

SEVENTH ANNUAL REPORT FOR YEAR ENDED 30TH JUNE, 1933.

I. INTRODUCTION.

1. *Financial Provision for Research.*—The year 1932–33 was a period of considerable anxiety in the affairs of the Council owing to the national financial position and the necessity for economy. As a result, however, of a close scrutiny of all items of expenditure and of increased support from other than governmental sources, the Council was able to effect economies in such a way as to provide for all the investigations in progress to be continued, though it was often impracticable to develop the work on lines which were desirable, or to give effect to many requests which were received for investigation of new and important problems.

In this connexion it is desired strongly to emphasize the fact that any organization such as the Council, whose task is to conduct scientific industrial research, must necessarily suffer severe handicaps if uncertainty is to prevail as to its financial position. While such a statement may be true to some extent of almost any form of national activity, it is particularly applicable in the case of scientific research, for which continuity of planned effort and, therefore, of financial policy is essential if efficiency and economy are to be attained.

For the latter purpose, it is necessary not only that definite programmes of work should be laid down and followed, but also that skilled investigators specially trained in particular branches of science shall be employed over a series of years. If the Council is unexpectedly to be faced at any time with the necessity of a substantial reduction in expenditure, it does not mean merely that it is impracticable for its work to be planned over a series of years as is necessary; it also means that it has to dispense with the services of men who have been specially trained for their work, and that investigations which are not completed have to be abandoned. This leads to a situation which makes it difficult to secure the services of the most highly qualified men. It tends to undermine the confidence of the staff, and it leads to waste of money already expended.

Another aspect of the matter is that the Council has been so successful in establishing confidence in its operations that no less than 40 per cent. of its expenditure—apart altogether from gratuitous services and assistance in kind, the monetary value of which alone runs to a substantial sum—is contributed from sources other than the Commonwealth Treasury, a position which is indeed unique in the history of governmentally controlled institutions, at any rate, in Australia. Hence, reductions in the funds made available from the Treasury are likely to have unfortunate repercussions with respect to the financial assistance available from other sources.

Moreover, the supposition that research work on a specific problem can necessarily be maintained in a really effective way without any increase in expenditure is quite frequently erroneous. It is often the case that an investigation conducted satisfactorily up to a certain stage may demand the employment of one or more additional investigators or assistants or the provision of additional equipment or apparatus in order to enable the work to be prosecuted effectively and to facilitate the full utilization of cumulative results of the researches.

The Council desires to draw attention to these important aspects of the incidence of financial policy, and to urge very strongly that provision be made not merely for that continuity of effort which is imperative for the effective prosecution of research work, but also for such reasonable expansion of its activities as is warranted from time to time. The Council realizes fully the urgent need for economy, but in view of the close relation of its work to the welfare of Australia's primary industries, of the great economic value of the results already obtained from its researches, and of the many pressing demands made on it to undertake investigations of important and urgent problems, it submits that the people of Australia cannot afford to lag behind in the national efforts which are now being made in all civilized countries for the application of science to industry.

As already stated a very substantial part of the Council's expenditure is met from contributions derived from various sources other than the Commonwealth Treasury. Particulars of these contributions, amounting for the year 1932–33 to no less than £56,672, are given in Section XIII. of this report. It is important to observe that some of those investigations which are of the greatest economic importance and urgency are in fact being financed wholly from these contributory sources. For example, in connexion with the development of Northern Australia there is perhaps no matter of greater importance than the beef cattle industry. The development of that industry in Northern Australia is being studied by the Council from three different angles. Firstly, there is the question of the control of certain serious animal diseases which levy a very large annual toll on the industry. These problems are being investigated at the Council's Animal Health Research Station near Townsville which is financed entirely from contributed sources. Secondly, there is the problem of developing an export trade in chilled beef. This is being investigated at the laboratories and experimental cold stores provided by the Queensland Meat Industry Board, and again the whole of the expenditure for this work, with the exception of the salaries of the officers, is paid from contributions. Lastly, there is the cross breeding work with Zebu cattle, the object of which is the development of a new type of cattle which will thrive under the pastoral conditions of Northern Australia, which will be to some extent resistant to diseases and pests, and which it is hoped will thus aid materially in the development of the northern parts of Australia. This work is being paid for entirely by the owners of certain pastoral properties.

Whilst it is only appropriate that the industries concerned generally should bear a part of the cost of scientific investigations conducted in their interests, the Council may reasonably expect to be provided by the Commonwealth Government with funds to enable it to bear at least a reasonable part of the expenditure incurred in the investigation of problems which are of outstanding importance to the economic welfare and development of Australia. The Council attributes its success in obtaining funds from outside sources mainly to the fact that it has now come to be generally recognized that the Council has under its Act a large measure of freedom from the control to which ordinary Government Administrative Departments are necessarily subject.

The basic task of the Council is to conduct scientific industrial research, and for reasons stated in its previous annual reports the Council has concentrated its attention on the solution mainly of problems affecting agricultural and pastoral industries. The objection has sometimes been taken that research on these problems is not now all-important because it tends to stimulate production at a time of large surpluses which cannot be absorbed in the world's markets. Any such argument is manifestly illogical even assuming that reduced production is desirable. If it were necessary deliberately to curtail production, the method of effecting the curtailment would be of fundamental importance. Reduction by inefficient methods or by the ravages of pests or diseases might remove the surplus, but they could not do so in the long run to the profit of the farmer or the community generally. In the aggregate, profits cannot be secured by the sacrifice of efficiency. Reductions would have to be made in a manner that would not increase the costs of production. All industrial progress and improvement in the efficiency of production must rest ultimately on the application of scientific knowledge and on the progress of research. In fact, it is in times of national stress and industrial depression that the need for scientific investigation and for the application of the knowledge gained thereby is all the more urgent.

This view has recently been stressed by the Secretary of State for Agriculture in the United States of America who has stated that research is not merely the biggest job of his Department, but is the foundation of all its other jobs. Experience in America has shown that agricultural research is one of the greatest sources of private and national wealth. Its benefits do not go exclusively to any group, but become diffused throughout the community.

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

3. *Need for Co-ordination in Agricultural Research.*—In 1927 the Council convened an Agricultural Conference at which representatives of all the State Departments of Agriculture were present. The object of the Conference was to discuss with representatives of the Council

the place which the latter could most effectively occupy in scientific research work into problems affecting the pastoral and agricultural industries of Australia. It was realized that the entry of a Commonwealth organization into agricultural research work might lead to overlapping, unnecessary duplication of effort, and possibly friction unless thoroughly satisfactory relations were established with the State Departments concerned.

As a result of the Conference, the relative fields of the Commonwealth and State organizations were defined in general terms, and time has shown that the understanding arrived at was adequate to secure harmonious and effective co-operation between them. It was recognized that there would be occasions when differences of opinion might arise and when efficiency in collaboration might demand further discussion. In order to meet this, a Standing Committee on Agriculture was established, its personnel including the permanent heads of the six State Departments of Agriculture and representatives of the Council. It was arranged that, if possible, the Standing Committee should meet twice each year, once on the occasion and at the place of the annual Conference of State Ministers of Agriculture, and again about six months later. Owing mainly to the need for economy in expenditure on travelling, only one meeting of the Standing Committee was held during the year 1932–33, viz., in May, 1933.

At the meetings of the Standing Committee, it has been the practice of the Council's representatives to place very fully before their State colleagues their plans for work in all Divisions relating to agriculture using the word broadly. Criticism has been invited and given, particularly from the point of view of possible trespass by the Council into fields already occupied by the States. The result has been decidedly satisfactory as is evident in the existing relations and in the numerous co-operative arrangements between the bodies concerned.

It was, however, hoped by the Council at the time when the Standing Committee was established that its members would use the meetings for free discussion of research work on pastoral and agricultural problems, irrespective of activities of the Council itself. To some extent this has occurred, but it may well be doubted whether full advantage has been taken of the opportunity thus offered to confer on matters of common interest connected with research work, to combine in work on problems belonging to more States than one, and to ensure that each State is kept fully acquainted with the aims and activities of every other State. In the opinion of the Council it is very desirable that the Standing Committee on Agriculture should specifically be charged with the duty of watching pastoral and agricultural research work under all governmental auspices in Australia with a view to increasing its efficiency and reducing its cost by encouraging co-operation and united effort and avoiding all needless overlapping.

In order to facilitate the development of such a state of affairs, and to enable research workers in Australia to be cognisant of the investigations which are in progress on pastoral and agricultural problems throughout the Commonwealth, the Council compiled and published in 1927 a Register of Agricultural Research in Progress in Australia. A supplement to the Register was issued in 1929, and a revised issue bringing the whole of the information up to date will be published shortly.

4. *Imperial Co-operation in Research.*—The Council has learnt with very much regret that the Empire Marketing Board is to cease to exist after the end of September, 1933. The work which the Board has done in the way of linking together and co-ordinating scientific research work on agricultural problems throughout the Empire has been of outstanding importance and value, not so much by reason of the financial assistance which the Board has given to research institutions in different parts of the Empire (though that assistance has been of outstanding benefit to Australia), but rather on account of the successful manner in which the Board has brought such institutions into close touch with one another, and has enabled them to work together as members of a team. There can be no question that very great success has attended the Board's efforts, and that the associations which have been fostered by its aid have revented much expensive overlapping and have saved quite large sums of money which might ve been spent by particular organizations had they not been made sufficiently familiar with activities of others. From this point of view the fact that the Board is shortly to go out of ence is regarded with regret, and the question of how these particular activities may best ntinued becomes of much importance.

The Imperial Committee on Economic Consultation and Co-operation, 1933, has ended that the question of the research activities which should in future be carried out tively should be considered at a conference to be summoned as early as possible g partly of the administrative and scientific heads of national research organizations, ly of such other persons as the several Governments may select. The Committee hat there are difficulties in the way of the meeting of such a conference in the immediate d it accordingly recommended that the Executive Council of the Imperial Agricultural

Bureaux should be invited by the Governments of the Empire to consider immediately the question of the research activities which should, in its opinion, be conducted on a co-operative basis, and to prepare a report for presentation to the conference referred to above. If it is not possible for that conference to meet within a brief period of the completion of the report, it is recommended that it should be presented direct to the Governments of the Empire.

Whilst, therefore, as already stated, the fact that the Empire Marketing Board is to go out of existence is regarded with disquietude, it is recognized that probably the best method of reducing the consequent disadvantages to Empire agricultural research is that which has been recommended by the Imperial Committee on Economic Consultation and Co-operation. It should be mentioned that that Committee has also recommended that the Executive Council of the Imperial Agricultural Bureaux should be entrusted with the supervision of :—

(*a*) The administration and financial control of the eight Imperial Agricultural Bureaux.

(*b*) The administration and finances of the Imperial Institute of Entomology and the Imperial Mycological Institute, and

(*c*) Such research activities in the United Kingdom as the participating Governments may agree should in future be conducted on a co-operative basis.

II. GENERAL STATEMENT OF WORK AND ORGANIZATION.

1. *Main Divisions and Sections of the Council's Work.*—In regard to the major sections of the Council's work, 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. R. J. Tillyard, M.A., D.Sc., F.R.S., &c. (Chief).

(iii) The Division of Animal Nutrition—Sir Charles Martin, C.M.G., M.B., D.Sc., LL.D., F.R.S., &c. (Chief).

(iv) The Division of Animal Health—Dr. J. A. Gilruth, D.V.Sc. (Acting Chief).

(v) The Division of Soil Research—Professor J. A. Prescott, D.Sc. (Chief).

(vi) The Division of Forests Products—Mr. I. H. Boas, M.Sc. (Chief).

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

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

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

In last year's report an account was given of the more important achievements of the Council in the solution of various problems, and an attempt was made to assess the economic value of these results in those cases in which such an assessment was practicable. It is not intended to repeat that account in this report. For present purposes it will suffice to state that the monetary value of the results obtained exceeds by many times the total expenditure of the Council, and that whilst it is not possible to record the complete solution during the year 1932–33 of any of the more important problems on which the Council is engaged, notable progress was made through that year in all the sections of work.

2. *Division of Plant Industry.*—The Division of Plant Industry has its laboratories and experimental plant houses at Black Mountain, Canberra, Federal Capital Territory. At the rear of the plant houses 10 acres of land have been laid out for the purpose of experimental plo and a small experimental orchard has recently been established on a further area of about acre. At Duntroon, six miles distant, 100 acres have been provided for field experiments. the north of the Black Mountain plots is an area of, approximately, 17 acres, which is pl eventually to become an arboretum and botanic garden. For the purpose of testing new introductions suitable for tropical areas, provision for experimental plots has been mad grounds of the Council's Animal Health Research Station near Townsville. La accommodation for investigations on certain fruit problems has been provided at Hoba University of Tasmania. The general nature of the investigations which the Division Industry is conducting is as follows :—

(i) *Fruit Investigations.*—During the year 1932, approximately 7,000,000 bushel were harvested, and of these about 4,500,000 bushels were exported. In view of th

importance of the export apple industry, the fruit problems which are being investigated are concerned chiefly with this crop, although work is also being prosecuted on vine fruits, pines, plums, &c., and citrus.

One of the first problems to be tackled was bitter pit in apples, causing a loss of £100,000 per annum, and, fortunately, by the practical application of the results of research, that problem can now be regarded as solved. Efforts are now being concentrated on other orchard and storage problems, such as water-core, drought-spot, &c., in Tasmania, and also on methods of packing. Bruising is a fertile cause of loss on the overseas market, and in conjunction with the Division of Forest Products, investigations have been conducted on different types of cases in order to determine the most suitable for the reduction or practical elimination of case bruising.

Another problem is due to the fact that the export surplus of apples fluctuates heavily in alternate years. To ascertain the fundamental reasons for this and to attempt to correct them are the purposes of a series of fruit bud studies at present in progress in co-operation with State Departments of Agriculture. Eventually the bud studies will be co-ordinated with manurial, pruning and other treatments and with stock and scion studies in order to bring about a more even distribution of crop. Similar investigations with respect to alternate cropping of Valencia oranges are being conducted in co-operation with the Council's Citricultural Research Station at Griffith. In addition, sultana investigations are in progress in conjunction with the Viticultural Research Station at Merbein.

(ii) *Wheat Investigations.*—Since wheat is the most widely cultivated crop in Australia, and since the average yields in this country are relatively low, attention is being directed by the Division of Plant Industry to the solution of various problems affecting this crop, such as resistance to drought and disease, yield and quality. The aim is to reduce losses, to increase yield and to improve quality so that the cost of production may be reduced, and the producer may be enabled to compete more efficiently in the world's markets.

(*a*) *Diseases.*—Foot rots or root rots caused by at least five different soil-inhabiting fungi, cause loss of about £700,000 per annum, based on wheat at 3s. 4d. per bushel. These rots are being studied in order to ascertain the vital facts about the fungi themselves and their effects on all strains and varieties of wheat, so that, if possible, types of wheat resistant to root rots may be found or developed. Another wheat disease, investigation of which has similarly the ultimate object of the development of resistant types, is flag smut. This also is a soil inhabitor, and is the cause of an annual loss of about £400,000.

(*b*) *Drought Resistance.*—Where seasons may be or usually are rather dry, the possibility of wheat as an economic crop is determined by its drought resistance. Work is in progress which is expected to lead to the determination of those factors which make certain wheats more drought resistant than others.

(*c*) *Yield and Quality.*—In 1931, Australia produced 212,000,000 bushels from 18,000,000 acres with an average of 11.66 bushels per acre. An increase in yield of one bushel per acre would mean another 18,000,000 bushels, which at 3s. per bushel totals £2,700,000, and at 4s. per bushel some £3,600,000. An increase of 1d. per bushel due to better quality would mean nearly £1,000,000 increased return. Investigations are, therefore, in progress for the purpose of determining the factors which influence yield and quality. A genealogical chart has been prepared and published for the purpose of aiding investigators in determining those wheats which are the most desirable for cross-breeding purposes.

(iii) *Plant Introductions.*—Practically every crop grown in Australia has been introduced, and there is still a strong probability that varieties or strains may be brought in, which will be an improvement on those already grown; especially is this the case with pasture plants. Consequently some 40 different countries are represented by the seeds, which are being systematically introduced and tested under quarantine conditions until it is established that they are quite free from pests and are likely to be useful. Some of these are grown at Canberra, others at Gatton, Townsville and Mareeba in Queensland. The State Departments of Agriculture co-operate by carrying out field tests on selected introductions.

(iv) *Agrostology.*—The Division of Plant Industry has now been able to make an effective beginning in the investigation of grassland problems. The importance of this work was emphasized as a result of the visit to Australia in 1931–32 of Mr. W. Davies, M.Sc., Empire Grassland Investigator of the Welsh Plant Breeding Station, Aberystwyth. Mr. Davies's visit was a result of action taken initially by the Australian Dairy Council, and was made possible by a grant from the Empire Marketing Board. His report has been published by the Council as Pamphlet No. 39. In it, Mr. Davies pointed out that about 60 per cent. of the total value of Australia's exports is derived directly from her grasslands, and that pasture improvement

is both fundamental to, and an essential part of, Australia's national development. It is now well recognized that the selection of suitable strains of grasses and the adoption of modern plant breeding methods are of the greatest importance in connexion with pasture plants just as they have been proved to be with wheat and other crops.

One of the first steps to be taken towards the improvement of pastures is the collection of information as to the distribution of grasses, and for this purpose a grassland (and forage plant) map of Australia is being prepared by the Division of Plant Industry. Studies are also being made of certain introduced grasses, of Kangaroo grass, and of selected improved strains of certain other grasses.

(v) *Tomato Investigations.*—The studies on spotted wilt of tomatoes have been continued on a co-operative basis between the Council and the Waite Agricultural Research Institute, South Australia. A large number of commercial varieties of tomatoes have been tested, and have been shown to be susceptible to spotted wilt attack. This makes cross breeding for resistance a difficult if not impracticable task. One variety which showed a partial resistance is being used for crossing with commercial varieties. Work is also in progress on spraying and dusting experiments, on the studies of the virus in the plant, and on large-scale seedling inoculation.

(vi) *Tobacco Investigations.*—The tobacco investigations are being carried out under the control of the Australian Tobacco Investigation financed by means of certain special grants, which have been allocated by the British Australasian Tobacco Co., and the Commonwealth Government. The investigations are, however, so closely allied to the work of the Division of Plant Industry that reference is made to them in the report of that Division. Progress has been made in the studies on downy mildew of tobacco (blue mould). Satisfactory control of the leaf spot disease which is so serious in North Queensland has been obtained at Mareeba. The influence of climatic factors and several other problems affecting cultivation of tobacco in Australia are also being investigated.

(vii) *Miscellaneous.*—Investigations are also in progress on a number of minor problems such, for example, as (*a*) the pea root-rot which occurs in Tasmania, (*b*) the disease of pine trees, known as " needle fusion " which is causing such serious losses in plantations in South Australia, Tasmania and New South Wales, particularly in the coastal districts, and (*c*) the deterioration of painted surfaces due to the action of sooty moulds, particularly in areas of high humidity and temperature.

3. *Division of Economic Entomology.*—This Division also has its central laboratories in Canberra. In addition to the laboratory building there are four large insectaries and one small one where investigations are carried out under quarantine conditions. Two of these insectaries are used chiefly for experiments in connexion with insects introduced from other countries for the control and eradication of noxious weeds. The others are fitted up for research work on insect pests of animals, particularly the sheep blowfly. Most of the problems which the Division is investigating are of a highly complex nature, and a great deal of fundamental work must necessarily be done before results of economic value can be expected. Many insect enemies of noxious weeds and of insect pests of animals have been introduced by the Division, but before they can be released from quarantine very careful investigations have to be conducted in order to ascertain beyond doubt that they will not attack any plants or animals of economic value and to ensure that generations of the insects have been bred free from hyper-parasites. The main lines of work of the Division are divided into the following sections :—

(i) *Control of Noxious Weeds.*—This section is endeavouring to bring about the control and eradication of certain serious weed pests by the introduction, acclimatization and liberation of insect enemies which attack them in other countries. Efforts are being concentrated on St. John's wort, which is so serious a pest in certain districts of southern and south-eastern Australia ; on Noogoora burr, which is spreading at an alarming rate in certain parts of Queensland ; ragwort, which covers large areas in the southern States ; and bracken fern, which is so widespread in many parts of southern Australia. The section is working in co-operation with the " Parasite Zoo " at Farnham Royal, England, where an officer of the Council is located and is engaged mainly upon the problem of insect enemies of St. John's wort. Another officer has his headquarters at Manhattan, Kansas, United States of America, where he is engaged mainly on insect enemies of Noogoora burr. Though it is desirable that the staff of men who are engaged on this work should be strengthened, the financial position has prevented the appointment of any additional officer.

Consignments of seven species of insects attacking St. John's wort have been received from abroad, and a number of some of them have already been liberated in the districts where the weed is a pest. Owing to unfavorable climatic conditions and loss by predatory insects, great difficulty is being experienced in establishing insect enemies of noxious weeds in the open,

despite the continued attempts which have been made. It should be observed, however, that even in the case of *Cactoblastis cactorum* which has caused such spectacular destruction of prickly pear, in many districts, the insect was not successfully established for two or three years after the first liberation.

In 1933, liberations were made in Queensland of a seedfly which attacks Noogoora burr, but it is yet too early to state whether the fly has become established or whether it is likely to prove effective in destroying the plant. Supplies of another species of insect attacking Noogoora burr have been received from America, and investigations on it are now being conducted at Canberra under quarantine conditions. Similarly insects attacking bracken fern and ragwort are also being investigated.

(ii) *Buffalo-fly Pest.*—During the year 1930–31 public attention was directed to the menace of the buffalo-fly pest to the cattle herds of Australia. The spread and control of this pest had been enquired into by the former Advisory Council of Science and Industry as far back as 1919, but owing mainly to lack of funds it was not possible to initiate experimental work on the problem until about three years ago. It is not, of course, a function of the Council to control the pest by quarantine measures, &c., but the Council is investigating the problem with a view to control by insect parasites and predators. For that purpose, investigations were conducted for two years in the Netherlands Indies, from which country the fly was originally brought to Australia and where it is not a serious pest. A reasonable explanation of that fact might be that the fly was controlled in the Netherlands Indies by some parasite or predator which was not present in Australia. Certain parasites were discovered in the Netherlands Indies and the most effective of them (or crosses from them) have been introduced into the Commonwealth and have been liberated in northern Australia, north-western Queensland and the north-western parts of Western Australia.

(iii) *Sheep Blowfly Pest.*—The control of the sheep blowfly pest in Australia is perhaps one of the most difficult and complex entomological problems ever tackled. It involves slow and laborious investigations, and where many highly qualified workers have failed in the past it cannot be expected that early spectacular results will follow the investigations which the Council is conducting. Although, therefore, progress must unavoidably be slow, very definite advances have been made, particularly in fundamental work on the problem. For example, accurate knowledge has now been obtained regarding the habits of the various species of blowfly which attack sheep and of the conditions which favour susceptibility to attack and the reasons therefor. During 1932–33 considerable progress was made in investigations on trapping the flies. A moderately large-scale trapping experiment is in progress at "Therribri", New South Wales, and arrangements have recently been made for a similar experiment at "Cranmore Park", Walebing, in Western Australia. Experiments on jetting, carcase destruction and the application of curatives and dressings are also being conducted. A Joint Blowfly Committee representative of the Council and the New South Wales Department of Agriculture has been created for the purpose of co-ordinating the investigations of the Council and of that Department. A comprehensive report summarizing existing knowledge of the problem has been published.

(iv) *Field, Crop and Pasture Pests.*—Work is proceeding on the clover springtail (lucerne flea) in Western Australia. and on the underground grass grub in Tasmania. The former investigations resulted in the discovery of a predatory mite which in some localities has already reduced the infestation by clover springtail to negligible proportions. Experiments are being made to establish the mite also in South Australia, Victoria and Tasmania, where the springtail is a pest.

Similarly with respect to the underground grass grub which causes such serious damage to pastures, particularly in Tasmania, a parasite has been discovered in New Zealand which destroys a grub closely related to the Australian species. A number of these parasites have been released in Victoria.

(v) *Termite (White Ant) Pest.*—Progress has been made in the fundamental work on technique, both in the laboratory and in the field, to such an extent that it is now practicable to proceed effectively with tests on the resistance of timber and other materials to attack by termites. Field experiments are being conducted, and a satisfactory method of arresting damage to buildings by termites in the Northern Territory has been demonstrated. Work is being carried on in co-operation with the Division of Forest Products.

(vi) *Bee Diseases.*—In co-operation with the Victorian Apiarists' Association, investigations are being conducted on a nutritional disease of bees known as "disappearing trick", due to deficiency of pollen. It has been found as a result of laboratory investigations that certain proteins, such as casein, dried egg albumen and yeast, are efficient substitutes for pollen. In

order to test the value of the results on a practical scale, supplies of casein were sent to apiarists in certain districts in which minor pollen shortages occurred in New South Wales in 1932–33. The results of the field experiments were not, however, striking.

(vii) *Apple Thrips.*—Investigations on the control of apple thrips and associated species are being conducted with headquarters at Adelaide under a co-operative scheme between the Council, the Waite Agricultural Research Institute, the Thrips Investigation League and certain of the State Departments of Agriculture. The investigation was made possible as a result of funds collected by the Thrips Investigation League. The problem is being attacked mainly along three main lines, viz. :—(*a*) fluctuations in numbers of thrips in relation to meteorological factors ; (*b*) the efficiency of insecticides ; and (*c*) the biology of the more important species of thrips particularly with reference to overwintering. Arrangements have been completed for carrying out control experiments with insecticides in orchards in selected districts.

(ix) *Other Investigations.*—Investigations on pine chermes, an insect which is proving to be a serious pest of Australian plantations of pines, are being continued. Two promising predatory enemies of the pest have been shipped from England, and have been liberated in pine plantations in the Federal Capital Territory and New South Wales.

In order to control the destruction caused to tomatoes and other crops in Tasmania by the greenhouse whitefly, consignments of parasites have been obtained from England, and attempts are being made to establish them. Similarly with regard to the oak-scale, parasites have been obtained from New Zealand and liberated at Hobart and Launceston.

Investigations have been commenced with the object of determining whether a serious disease in cattle in northern Australia, known as anaplasmosis, is transmitted by any insect other than the cattle-tick. The existence in Australian cattle herds of the organism responsible for this disease has recently been demonstrated by the Council's Division of Animal Health, and it is, of course, important in connexion with control measures to ascertain definitely whether the disease can be transmitted by biting flies as well as by the cattle-tick. The work is being carried out in the quarantine insectary at Canberra, in which complete control of the experimental insects can be obtained.

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

At the McMaster Laboratory, the work is organized into three main divisions, viz. :—

(*a*) Bacteriological investigations.
(*b*) Parasitological investigations, and
(*c*) Field trials.

For a time the work was seriously handicapped by the absence of a suitable area whereon experimental work on sheep under natural conditions could be conducted. Through the co-operation of Mr. F. D. McMaster, the donor of the Laboratory, an area of over 300 acres about 20 miles distant from Sydney has been secured.

In the pathological investigations, considerable progress has been made in the work on caseous lymphadenitis or cheesy glands of sheep, a disease which causes severe losses in the mutton export trade of Australia. The work on this problem at the McMaster Laboratory is being directed mainly at the determination of a diagnostic test and of the method by which the organism is transmitted. Examinations of the bacteria found in cases of footrot of sheep are being conducted with the object of ascertaining the actual organism responsible for the disease. A great deal of important work has been carried out in connexion with internal parasites of sheep, and in some cases preventive measures have been devised and have already been put into operation. Field trials are being conducted in Central Queensland, on the highlands of New South Wales and in Tasmania, the owners of the properties co-operating with the scientific staff through the provision of land, stock, conveniences and general supervision. Field trials have clearly demonstrated the importance of adequate nutrition in increasing the resistance of sheep to parasitological infestation, and in leading to increased wool and mutton production. It has also been shown that there is no deterioration of the value of the wool from sheep run on improved pastures.

The Animal Health Research Station near Townsville is engaged in the investigation of problems affecting cattle in North Australia. The station was handed over to the Council by the Queensland Government at the end of 1931, and the funds for the additions to the station and its equipment, as well as for its maintenance, are provided equally by the Queensland Government and Queensland cattle station-owners on the one hand, and the Empire Marketing Board on the other. Work is being concentrated on the three most important problems, viz. :—

(*a*) Ticks and tick fever.
(*b*) Pleuro-pneumonia, and
(*c*) Peg leg disease.

Prior to the date when the investigations on ticks and tick fever were commenced by the Council, it was generally accepted that tick fever or redwater in Australia was due to the invasion of the red blood cells of cattle by a single parasite. Control of the disease as well as official and private practice concerning its prevention and treatment was accordingly centred round this conception of a single casual organism, though it was found that frequently redwater did not respond to treatment or to immunizing procedures based on that belief. An explanation of the position has been given as a result of the Council's investigations which have disclosed the presence in Queensland cattle of at least four distinct tick fever organisms.

As regards contagious pleuro-pneumonia, an exhaustive study has been made of the causal organism, and a new culture medium has been evolved. Great improvements have been effected in the complement fixation test for diagnosing the disease, so that it should soon be possible to detect even " carriers " which are perfectly healthy, but which are responsible for outbreaks of pleuro-pneumonia. Investigations are also being conducted with a view to devising improved methods of vaccination against pleuro-pneumonia. It is hoped to overcome disadvantages of present methods by the production of a desiccated virus.

Investigations on peg leg disease indicated that the trouble is due to a deficiency of phosphorus. Certain owners of affected properties in the Charters Towers district have contributed to a fund for the purpose of establishing a field station where experiments on a large scale can be carried out. These field experiments are now in progress, and it is hoped before long to obtain definite evidence as to the means by which the disease can be prevented.

Investigations on caseous lymphadenitis are being conducted in South Australia and Victoria, as well as in New South Wales. Field tests are being carried out in order to ascertain whether the disease is spread from discharging abscesses to healthy sheep by flies. Numerous experiments have been carried out, with negative results, for the purpose of determining whether the disease can be transmitted through the faeces or the dust from shearing sheds and counting-out pens of properties known to be badly infected. In South Australia, other experiments with soil from areas where sheep are in the habit of camping have demonstrated that the soil of such camps may be heavily contaminated. Arrangements have been made at a property in South Australia where the flock is badly infected and where the shearing shed and the counting-out pens cannot be implicated as an important factor, for experiments to be carried out with the object of eliminating the disease from the flock by segregating affected animals and breeding and maintaining clean lambs. Experiments with vaccines are being continued, the evidence from the field work having been very encouraging:

Work on entero-toxaemia of sheep (braxy-like disease and pulpy kidney of lambs) has been continued in Western Australia and Tasmania in co-operation with the State Departments of Agriculture. A satisfactory method of controlling the disease in certain cases by vaccination has been devised. The confirmation of the hypothesis that pulpy kidney of lambs and entero-toxaemia of sheep are pathologically identical is of great scientific interest as well as of practical importance.

In the last annual report, reference was made to the publication by the Council of a pamphlet furnishing information regarding the crossing of British breeds of cattle with Zebu or Brahman cattle, a practice extensively pursued in the hot coastal areas of the United States of America bordering on the Gulf of Mexico, in which areas conditions are generally similar to the northern coastal belt of Australia. Following the publication of the pamphlet, the owners of certain large northern Queensland properties agreed to find the necessary funds for the purchase of a number of pure-bred Zebu cattle to be distributed amongst their various properties and utilized for the purpose of a large experiment on cross breeding with different breeds of British cattle according to a scheme to be laid down by the Council's officers. As a result, nineteen animals were secured and have been brought to Australia. When they are released from quarantine they will be sent to different properties in northern Queensland, and cross breeding experiments will be commenced in accordance with a definite scheme prepared by the Council's geneticist and carried out under his general direction. Briefly the experiment will have for

its object the development and fixation on scientific principles of a new type of cattle which will thrive better than the present British breeds under the difficult pastoral conditions of northern Australia and will be to some extent resistant to diseases and pests, and which will thus prove to be a valuable aid in the development of the northern parts of the Commonwealth.

The Council has supported the action of a number of breeders of pure-bred dairy cattle in the creation of an Australian Dairy Cattle Research Association, the main object of which is to provide means to enable investigations to be undertaken into contagious abortion and contagious mastitis (or mammitis). Certain funds have already been contributed, and co-operative arrangements have been made between the Research Association and the New South Wales Department of Agriculture for an investigation into contagious abortion to be conducted at the Veterinary Research Institute at Glenfield. It is proposed that work on contagious mammitis shall be centred in Victoria, but the requisite money for the work has not yet been provided.

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

The excessive wool production which has been brought about by years of selective breeding of the Merino, opens up problems in animal nutrition entirely different from those encountered in fattening bullocks and pigs or in investigating the conditions for maximum milk production in cows. Wool consists of keratin, a protein which differs from those in the animal's food in the high proportion of sulphur which enters into its composition. If, as would appear not unlikely from present knowledge of sulphur metabolism in other animals, sulphur necessary for the growth of wool must be supplied as cystine, wool production will make special demand for protein containing this amino-acid. Whether the economy of the sheep can use sulphur supplied in other forms than as cystine can be determined only by experiment. On account of its importance, attention is being devoted by the Division to this question, and as a result of the fundamental investigations which have been, and are being, conducted definite advance had been made in many directions in our knowledge of the sulphur metabolism of sheep.

It is not anticipated that researches in nutrition will do very much to improve the position for the owner of country with good soil and abundant rainfall. Over the bulk of Australia's pastoral country, however, optimum conditions for sheep raising do not by any means prevail, and sheep suffer from a measure of either general or protein starvation during some portion of the year.

Another factor which limits the productivity of many parts of Australia where sheep are grazed is the shortage of certain minerals in the soil. This deficiency is reflected in the pasture plants, and the animals suffer accordingly in growth and fertility. For example, it is well known that the pastures in very extensive areas of Australia do not contain sufficient phosphorus for the well-being of the sheep fed on them. Special attention is, therefore, being given by the Division to the problem of phorphorus metabolism in sheep, and to the manner in which the deficiency can most economically be overcome, whether by giving the animals access to phosphatic licks, by top dressing the pastures with phosphatic fertilizers or in some other manner. Progress in work of this nature involving careful quantitative experiments on the metabolism of the animals under various conditions must inevitably be slow, but in the opinion of the Council it is the sound method to pursue for it is only knowledge of fundamental facts which can lead to the understanding of the influence of a diet upon growth, fertility and wool production and thus to the elucidation of many problems with which the pastoralist is faced.

Increased knowledge of the nutrition of the sheep will not compensate for deficient rainfall, but will indicate how animals can be maintained over periods of drought with the least deterioration of wool quality and production and at a minimum cost. In this connexion further progress has been made in the investigations which the Division is carrying on under the Australian Pastoral Research Trust–Empire Marketing Board scheme. The object of this work is to determine the best and most economical methods for the supplementary hand-feeding of sheep during drought.

Farmers engaged in sheep raising on the coastal areas of many parts of southern Australia are faced with a problem, or a series of problems, of great economic importance. "Coast disease" occurs in wide areas extending from King Island in Bass Strait to the west coast of Western Australia. The area concerned covers several thousands of square miles and consists of land which is highly calcareous. The soils are not well supplied with plant foods, but having an assured and sufficient rainfall they produce a useful amount of herbage. Although stock can

be fattened on this calcareous country during spring and early summer, they become debilitated and die when kept on it for more than a few months, but if removed to the " ironstone " heath country which is adjacent, but which is much poorer, the animals recover their health, though from scarcity of food they become in poor condition. The Division of Animal Nutrition is giving special attention to this " coast disease " problem ; its importance lies largely in the fact that it affects a very extensive area of country having an assured rainfall of upwards of 20 inches.

Work has been continued at the field stations which were established in co-operation with several owners of sheep stations. During the year 1932–33 the experiments at " Meteor Downs," Central Queensland, have been completed. These experiments were designed to show the results of supplementary feeding of proteins, particularly blood meal, which proved to be pre-eminent in increasing the yield of wool. At " Niawanda," western Victoria, experiments have been conducted on the effect of top dressing pastures with sulphur and rock phosphate, and have shown that the response to top dressing is not due to the direct manurial effect of sulphur, but to the steady production of available soluble phosphate in the soil through the action of sulphuric acid formed by slow oxidation of the sulphur, with consequent stimulation of the leguminous plants present. At the field station at " Hawk's Nest," Kangaroo Island, South Australia, experiments are being conducted mainly in connexion with " coast disease," and results of much interest and value have already been obtained. At " Wambanumba," New South Wales, the study of the effects of top dressing natural pastures with sulphur and rock phosphate is being continued.

6. *Division of Soils.*—The Division of Soils has its head-quarters at the Waite Agricultural Research Institute about 4 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 general objective of the soil investigations is, therefore, to determine the precise nature of the various soil types in different areas and regions, in order to ascertain the most suitable purposes for which such areas and regions can be used, and the most effective methods of treatment necessary to enable them to reach the highest economical level of production.

The work of the Division has been confined largely to investigations of the soils of the irrigation settlements with the main objects, firstly, of advising settlers as to the methods to be adopted in order to make their areas more productive, and to minimize the serious troubles with which many of them are faced, and secondly, to make investigations of the soils of virgin areas with a view to future settlement and development, and thus to avoid costly mistakes similar to those which have been made in the past.

Since the beginning of the work in 1927, nearly 1,300 square miles have been surveyed. During the year 1932–33 work was conducted principally in the irrigation areas at Berri and Barmera in South Australia, at apple orchards at Huonville and in other districts in Tasmania, and at Gingin, Western Australia. During the year a report on the work carried out in the irrigation settlements near Swan Hill, Victoria, was published. The survey has been completed of an area of over 300 square miles of virgin country representative of 10,800 square miles of the so-called desert country in South Australia and Victoria, stretching from the Coorong to the 142nd meridian, and bounded in the north by the Pinnaroo–Ouyen belt of mallee, and in the south by the grazing areas of the western Wimmera of Victoria and the south-east of South Australia. The results have shown that parts of this area are worthy of experimental investigation from a crop production point of view. During the forthcoming year intensive work will be undertaken in the Murrumbidgee irrigation area of New South Wales, and it is anticipated that the survey of the whole of the Murray River settlements will be completed within two years.

As a result of the Division's work, settlers in the districts surveyed have been furnished with authoritative advice on soil problems. Settlers are now becoming conversant with the various soil types occurring in their areas, and are able to apply the knowledge obtained from the work of the Division to the solution of their soil problems. The results of the survey are also proving to be of substantial value to the authorities controlling the various settlements in the solution of difficulties relating to such matters as drainage schemes, salt troubles, seepage and rising water tables.

7. *Viticultural Research Station.*—The Council's Viticultural Research Station is situated at Merbein in the Mildura district of Victoria ; it is equipped with a laboratory and is planted with vines for the production of dried fruits for experimental purposes. The problems under investigation at the Station include the study of the distribution of irrigation water on soil types already defined by soil surveys, the study of the movement of salts in the soil, irrigation problems, fruit processing, control of dried fruit pests, and physiological studies of the vine.

As a result of the work of the Station, the methods of processing dried fruits have been completely altered, and the standards for dried fruits have been raised to a point at which the prices realized in the world's market compare favorably with those of similar products of other countries. Dried fruit pests, formerly a cause of considerable depreciation, and in some cases of practically total loss, are now controlled to the extent that nearly the whole of the crop has been sold at satisfactory prices for a number of years even when surplus production has necessitated a carry-over for periods of up to six and eight months.

At the present time, work at the Station is being directed mainly to improvements in irrigation practices. A definite frequency of irrigation based on the requirements of the crops matured has been introduced in the majority of the Murray River settlements. This is being followed by the examination of irrigation practices in order to institute methods under which the capital value of the land is preserved without loss of irrigation efficiency, and with a substantial decrease in the cost of irrigation. The importance of work of this nature may be illustrated by reference to the Red Cliffs settlement adjacent to Mildura. This settlement comprises 11,000 acres in which there are now practically no unoccupied holdings. A preservation of the fertility of the land not hitherto attained in community irrigation settlements has been maintained, and has been accompanied by a decrease of no less than 50 per cent. in the community period for irrigation, together with an increase in production.

The work is being extended at the request, and with the co-operation, of the State authorities concerned, to other settlements along the Murray with the objects of arresting soil wastage resulting from the over-use of irrigation water and of decreasing distribution costs. The present position is that the main causes of deterioration of irrigation soils having been determined, security is gradually being brought about by introducing sound irrigation practices amongst the settlers.

8. *Citricultural Research Station.*—These investigations are conducted at the Commonwealth Research Station in the Murrumbidgee Irrigation Areas at Griffith, New South Wales, where experimental areas are managed as a citrus grove. Experiments on green manuring, fertilizers, and the efficacy of different methods of irrigation are being conducted. The work at the Station is carried out in co-operation with the Water Conservation and Irrigation Commission of New South Wales, and extensive studies of the factors involved in water-logging are in progress.

The experiments conducted at the Station have shown that mature citrus trees respond to nitrogenous fertilizers, and the results thus obtained have entirely altered the outlook with regard to the use of such fertilizers, and have led to the increasingly large use of sulphate of ammonia. Green manurial experiments have shown that the cultivation of tick beans effected an increase of no less than 33 per cent. in the yields of oranges. The effect of this treatment is, moreover, cumulative as the fertility of the soil is gradually being increased.

In past years, the accumulation of salt in the soil has caused losses running to very large sums of money. Work of the Station in connexion with soil moisture has demonstrated the danger of faulty irrigation, and has shown how losses can be avoided and how partly salted land can be reclaimed without resource to expensive tile drains. Already a very great improvement in irrigation methods is manifest, and the monetary value of the savings thus effected is of a large order.

A study of frost conditions in the area has shown that unduly severe frosts in Northern Lake View and at Yenda were occasioned by the presence of uncleared Mallee scrub, and that the severity could be reduced by the removal of the scrub. It has thus been possible greatly to ameliorate conditions of established farms at Yenda. Moreover, an area of some 4,000 acres at Northern Lake View on which large sums of money have been expended, has been practically reclaimed for horticultural purposes.

9. *Division of Forest Products.*—This Division was established in 1929 to undertake research into the utilization of all forms of the products of the forest, of which timber is naturally 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 when they are to be converted into timber for use. There is, however, the closest co-operation between these State Services and the Division.

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

The work is divided into two main sections—

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

(*a*) Trade Circulars issued free to all sections of timber users.
(*b*) A Monthly News Bulletin 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.
(*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, 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, and (vi) Wood Chemistry.

(i) *Preservation.*—The main work of this section is in developing methods of treatment to protect Australian hardwoods against attack of termites (white ants), other insects and decay, and a large experimental programme is in operation.

A preservation plant has been installed and this is capable of treating timber up to 13 inches diameter by 9 feet in length. The equipment consists of an impregnating cylinder with compressed air supply for providing treating pressures up to 250 lb. per square inch, storage and working tanks for storing, mixing and heating impregnating solutions, and a vacuum pump for special treatments. There is also provision for open tank treatment. Tests on the pressure treatment of some of the less durable Australian timbers have given considerable promise for their future utilization as sleepers, posts, poles, &c.

A chemical laboratory is attached to the plant, where investigations can be made of the suitability of different preservatives, the development of new preservatives, and the testing of these against organisms of decay. Studies of decay in timber, its cause and prevention, borer attack, and allied insect problems are in progress, and close co-operation on the important problem of termites (white ants) is maintained with the Council's Division of Economic Entomology. Tests of various methods for the preservation of telegraph and telephone poles and cross-arms, railway sleepers, fence posts and piles are being conducted and have already given valuable results. The ultimate method of test is by exposure *in situ*, and some years must elapse before final results can be obtained. A considerable amount of work has been done in this connexion on creosotes, crude oil and water-soluble preservatives. A comprehensive investigation on the prevention of attack by the wood-borer (*Lyctus brunneus*) has been commenced.

Many of the large timber-using public utilities are consulting this section continuously. In addition, advice is given to individuals who have problems in the field of timber preservation.

(ii) *Seasoning.*—Many calls have been made on the work of the seasoning section as sawmillers and timber users now realize that correct seasoning is the basis of prosperity in the industry. Had Australian timbers been properly seasoned in the past they would not to-day have had to meet such severe and unwarranted competition from imported timbers. The prejudices created by green timber die very hard. The Division, in conjunction with Sawmillers' Associations, individual millers, State Forest Services, and others is doing much to remove these prejudices.

In experimental kilns the Division makes a study of schedules for drying various timbers. Owners of commercial kilns have also helped in this connexion and have generously permitted the use of their plants for large-scale trials. A large number of individuals have sought assistance in solving their timber drying problems, and in many cases the troubles have been, or are being, overcome.

Working plans and specifications for kilns are provided by the Division. No less than 28 installations of kilns have been erected according to plans supplied by the Division, and many others on plans approved by it. Definite schedules for the seasoning of a number of the more important timbers have already been completed. Furthermore, kiln operators are trained in proper methods of kiln control. Seasoning classes have been held, and a number of operators have been trained in the laboratories. A correspondence course of instruction in seasoning has been started. Work is also in progress on cold-air seasoning, methods of stacking, and handling and reconditioning.

(iii) *Utilization.*—The work in this section has been directed mainly to the elucidation of certain broad problems requiring field research, such as grading studies of timbers. A great deal of work has also been done in response to inquiries received from sawmillers, timber-merchants and wood-using industries for information both as to the most suitable Australian timbers for a wide variety of purposes and as to the best uses to which available timbers can be put. Inquiries are constantly being received for advice as to the class of timber to be used for specific purposes. The Division has a collection of Australian timbers and, in many cases, has been successful in demonstrating that selected woods can replace those being imported. An investigation into the causes and prevention of wood-taint in butter has been concluded, and trial shipments of cases treated with an anti-taint spray have been sent overseas with satisfactory results. The results of an investigation on the manufacture of fibre-boards from certain Australian eucalypts have been published. A toughness machine and a well equipped wood-working plant have been installed as part of the equipment.

The Division is co-operating with the Standards Association of Australia in the important work of preparing standards for Australian timbers. Proposed grading rules for Western Australian timbers have already been published, and similar rules for flooring and for linings and weatherboards will be ready for publication at an early date. As a result of a comprehensive investigation into the question of apple cases, definite information has been obtained and must now replace the variable opinions of general observers. A standard specification for creosote for wood preservation has been issued and is being generally adopted. Steps have been taken to overcome the confusion arising from the use of the same common name for a number of different timbers or of a number of names for the same timber and from the frequent changes made in the specific names of trees. This work of standardization is of much importance and value to Australia's timber industries.

(iv) *Wood Structure.*—In this section, a study of the structure of timbers is being made to facilitate true identification, which is often at present difficult or impossible. Further, attention is given to the influence of structure of timber on its general behaviour, such as in seasoning. Structure has a very direct and practical bearing on the solution of many problems in utilization.

Satisfactory progress has been made in the studies of density, shrinkage, methods of distinction between sapwood and truewood and of miscellaneous problems. All this work is essentially of practical importance. One example may be given, viz., in connexion with the structure of compression wood. An Australian company was entering into the large-scale manufacture of blind-rollers made from hoop and bunya pines. A very large number of the rollers were found to be bent. The firm submitted the matter to the Forest Products Division, and as a result of microscopic examination it was found that the bent rollers were made of "compression" wood, i.e., timber grown on that side of a tree which is ordinarily subject to compression by the action of winds. The trouble could thus be overcome in a very simple way, viz., by the selection of logs free from compression wood.

(v) *Timber Mechanics.*—The range of work awaiting attention in this section covers a very wide field, but in view of the limited staff and funds available, efforts have been concentrated on problems of immediate and pressing industrial significance. Several of these investigations have already been completed, with highly useful results. In particular, reference should be made to the work on cases and containers. Practically no previous scientific work has been carried out in Australia on container design though, from the experience of other countries, it is apparent that a vast improvement is capable of being made in the containers used in Australia with immediate and substantial benefits to industry.

Laboratory tests on dried fruit boxes have been completed, and the best position for the wires has been determined. Experimental shipments have been made, but reports are at present incomplete. Tests with canned fruit boxes showed that their strength could be considerably increased by increasing the number of nails. The relative resistance to rough handling of various types of butter boxes has been determined, and investigations on banana boxes are in progress. One of the principal factors affecting the efficiency of containers is the holding power of nails. A thorough series of tests on this problem has been conducted, and the results will be published. Toughness tests have revealed information of much value in connexion with the utilization of Australian timber for such purposes as tool-handles, sporting goods, &c. Special studies were conducted on the utilization of timbers for axe-handles and for broom and rake handles. In the former, particular attention had to be given to shock resistance, in the latter, to static bending. Many requests for advice have been received and dealt with (so far as information is available) regarding the mechanical properties of Australian timbers. Experimental work in this respect has been concentrated mainly on two of the more commercially important species, karri and *Pinus radiata*.

(vi) *Wood Chemistry.*—The chemist also has an important part to play in the study of timber problems. This is obvious when one thinks of the large industries based on the use of wood waste in the manufacture of paper, artificial silk, fibre boards, lacquers, &c.

Moreover, the oils, resins, gums, &c., which form an important part of forest products all need study to develop their uses. For want of knowledge, many of those are at present waste materials. The microscopist must also call in the chemist to assist in identifying many of our timbers, owing to the fact that a large number have such similarity of structure that chemical means are necessary for their differentiation.

A great part of the work of this section has been devoted to the study of identification of wood by chemical means, and success has been attained in the distinction between certain of the coloured eucalypt timbers in that way. Special attention has been given to methods for the determination of lignin in wood, and of the constituents of wood ash, both matters of considerable importance in connexion with identification problems. Investigations have been made of the barks of Australian hardwoods in connexion with their possible commercial use, and on a number of miscellaneous problems in regard to which inquiries were received.

10. *Section of Food Preservation and Transport.*—In the last Annual Report of the Council it was pointed out that, owing to lack of funds and difficulty in obtaining the services of properly trained investigators, the Council had not been able to develop this branch of its work to the extent which its importance deserves, but that a small section of Food Preservation and Transport had been created to undertake a limited programme of work on—

(*a*) Meat problems.
(*b*) Non-tropical fruits.
(*c*) The maturation and transport of bananas.
(*d*) Engineering and transport investigations.

In view of its outstanding economic importance, work on meat problems has been concentrated on the chilling of beef. It is well known that in Great Britain, which is the largest meat importing country of the world, chilled beef ordinarily fetches a higher price than frozen beef, but by reason of the length of the voyage to England, Australia has been forced to export frozen beef. Since it is probable that much of the northern grazing areas of Australia cannot be used for purposes other than cattle raising, the importance of discovering a method of treatment and transport whereby beef can be exported in a chilled condition is obvious.

The causes of deterioration of chilled beef as a result of the action of bacteria and moulds have been definitely determined, and the work has shown that the reduction of initial contamination to low values during the dressing, handling and chilling of the meat is of great importance. As a result of the first series of experiments conducted by the Council at its laboratories at the Queensland Meat Industry Board's abattoir near Brisbane, it was demonstrated that by proper attention to those matters and by employing " air-conditioning ", that is, the control of temperature, humidity and air movements, the limits of the safe storage of Queensland chilled beef is approximately 48 days. Since this is shorter than the probable average period for which beef would have to be held from slaughter to marketing in Great Britain, investigations were then initiated on the use of a concentration of carbon dioxide in the storage atmosphere. The experiments so far conducted indicate that this method will permit of a safe export trade in chilled beef to be established from Australia, provided that the results can be economically transferred into commercial practice.

As there are possibilities in developing a large trade in the export of bacon-type pig carcasses preliminary investigations have been conducted with a view to defining the limits of storage of frozen carcasses of pork.

Progress has been made by the Council's Citrus Preservation Committee in its work on the preservation and transport of oranges. It has been shown that Valencia oranges can be held in storage for a period sufficiently long to enable them to be exported to England, but the investigations on Navel oranges are so far inconclusive. It appears that the problem is of considerable complexity, and that the keeping qualities of the fruit are bound up with fruit storage factors such as climate, soil, maturity and variety and size of the fruit. The Committee has prepared a comprehensive statement on the whole matter, and it is hoped that funds will be secured to enable the whole problem to be attacked in the way in which its importance deserves. In the meantime, experiments have been conducted on sweating, i.e., the exposure of the fruit to relatively high temperatures for short periods of time with a view to the control of mould growth, and thereby increasing the possible duration of storage. Respiration studies have also been carried out. The Griffith Co-operative Packing Co. is co-operating in storage experiments with fruit grown in the Murrumbidgee Irrigation Areas, and picked at different stages of maturity.

In co-operation with the Victorian Department of Agriculture, the experiments at the Victorian Government Cool Stores on non-tropical fruits have been continued. It has been shown that Williams pears if stored at 30° F. for a period of up to four months will ripen normally at 65° F., but at lower temperatures of ripening the condition of the fruit tends to be unsatisfactory. The importance of pre-cooling and of careful control of transport temperature is shown by the facts that holding the fruit for two days at 65° F. is equivalent in its effects to one months' storage at 30° F., and that carriage at 37° F., a temperature frequently obtained in some parts of a ship's hold, reduces the storage life to such an extent as to make successful transport almost impossible.

Valuable results have been obtained from experiments with Jonathan apples with respect to such matters as the influence of maturity at time of picking and the effect of the size of the fruit on the storage life, &c. Chemical analyses of apples have been carried out with a view to establishing precise maturity standards.

Investigations on the gas storage of peaches in atmospheres having different concentrations of carbon dioxide have been conducted, and it has been shown that gas storage peaches take eight days to ripen at 65° F., whilst comparable air stored fruit takes only two days. This result is of much practical importance, as the adoption of gas storage will permit of a greater margin of safety in marketing the fruit.

Notable progress has been made in the study of squirter in bananas, a disease which is common in fruit ripened in Sydney or Melbourne during the late winter and spring months, and which was for long considered to be of the nature of physiological breakdown. It has now been demonstrated that the main causal agent is a mould, and an hypothesis has been developed to account for the somwehat unusual incidence of the disease, The investigations have now been extended to plantations in New South Wales and Queensland with the object of devising preventative measures. The methods devised as a result of the Council's investigations on the ripening of bananas have now been adopted by the trade on a large scale. Work is still in progress on various aspects of the handling, transport and ripening of bananas.

11. *Commonwealth Prickly Pear Board.*—The position regarding the entomological control of prickly pear continues to be most satisfactory. Except in a few districts the great bulk of primary pear has now been destroyed throughout the whole area of infestation. The investigations are under the control of the Commonwealth Prickly Pear Board, which works in close co-operation with the Queensland Prickly Pear Land Commission and the New South Wales Department of Agriculture. Over the greater part of the area in which destruction has been effected re-growth and seedlings appear from time to time and sometimes make considerable headway before they are overtaken and destroyed by the insects. This is accounted for by the fact that after the destruction of the primary pear there is heavy mortality among the insects caused by starvation. The insects, however, soon increase in numbers and overtake the re-growth. There are some hard types of resistant pear, generally in forest country, which are slow to succumb to the attacks of *Cactoblastis cactorum* and other insects, but these are also going down before the ravages of the insects. A new strain of cochineal (*Dactylopius confusus*) which attacks tiger pear (*Opuntia aurantiaca*) has been introduced, and supplies will be distributed in the field at an early date. Investigations are proceeding with other insects with a view to finding means of destroying tree pear (*Opuntia tomentosa*). The Queensland Prickly Pear Land Commission has within the last two years opened for permanent settlement over 8,000,000 acres of land previously infected by prickly pear. The great bulk of this land has been settled and is now in course of development.

12. *Radio Research Board.*—The funds for the investigations of this Board are provided partly by the Postmaster-General's Department and partly by the Council. The work of the Board has already furnished valuable information on which the future development and improvements in present practices of broadcasting and other radio services of Australia may be based. For instance, it has been responsible for some valuable results concerning the distribution of field strengths at various distances from Australian broadcasting stations. Maps showing the distribution of such field strengths round "A class" stations in Sydney, Melbourne and Hobart have been completed. In consequence the various factors of importance in the design and situation of stations, e.g., the absorbing effect of a rugged terrain and wooded hills, have been demonstrated. While much attention has been given to the field strength distribution when the transmitter operates on waves within the broadcast band, some time has also been given to the behaviour of somewhat longer waves from the fading point of view. This field strength survey work has been linked up with more fundamental studies of fading and the peculiarities of the Kennelly-Heaviside Layer and the Appleton Layer in the southern hemisphere. Incidentally as one result, confirmation of an important hypothesis concerning the transmission of radio waves through space has been obtained. The Board is now concentrating on this fundamental work mainly from the point of view of fading, the effect of different designs of aerials, &c.

The study of atmospherics has formed another part of the Board's investigations; much information regarding the nature of atmospherics affecting radio reception in Australia has been obtained, and the main sources and the frequency of their occurrence have been determined. In this way the amount of interference to be expected in any part of Australia on any particular wave length can be determined with considerable accuracy. Another practical application that has been demonstrated during the investigations has been the value of the methods for weather forecasting. It has been demonstrated, for instance, that the paths of oncoming low pressure areas or cyclones, which very largely govern weather conditions in Australia, can be traced and can be picked up while passing over the Indian Ocean and the Australian Bight before they actually reach the continent itself and thus become more directly measurable by barometric methods.

13. *Miscellaneous.*—The Council has continued to maintain intimate contact with developments in other countries in the production of liquid fuels from coal. In 1932, arrangements were made for the return to Australia of an officer trained under the Science and Industry Endowment Fund, and subsequently employed by the British Fuel Research Board at its Research Station at Greenwich. The services of this officer have been made available, and he has furnished reports and advice on a number of fuel research problems and on claims for the treatment of fuels in Australia. In May, 1933, the officer was again sent abroad in order particularly to arrange for hydrogenation trials and cracking tests to be carried out on shale oil from Newnes, New South Wales.

The investigations on the mineral content of gold-bearing ores have been continued with satisfactory results. Surveys made in various districts have indicated the existence of promising lodes worthy of further prospecting by bores, shafts and crosscuts.

The Australian Tobacco Investigation is under the control of a Committee on which the Council is represented. The scientific investigations are being conducted by the Council's Division of Plant Industry.

The Standards Association of Australia for which the Council provides the means of liaison with the Commonwealth Government continued to accomplish much useful work during the year 1932–33. Several codes of definite value to industry have been complete, and a number of new standard specifications have been issued, and draft specifications have been circulated for public critical review prior to publication.

Throughout the course of a year the Council receives many hundreds of requests for scientific information and advice on matters concerning the primary and secondary industries of the Commonwealth. There is no doubt that in this field the Council has met a definite want, and has indirectly been responsible for many improvements in industrial practices.

III. PLANT INVESTIGATIONS.

1. *General.*—The year 1932–33 was the first during which the Division of Plant Industry had full opportunity to utilize the land provided for experimental plots at Duntroon and, although the presence of black oats constituted a problem, the various plots were satisfactorily laid down. The area is especially suitable for grass and wheat investigations and in the former a series of pasture swards is now possible. To facilitate the irrigation of grass nursery-plots a small pumping plant with a set of tanks has been installed.

At Black Mountain an area of one acre was cleared and a small experimental orchard for the furtherance of fruit investigations (growth, bud, &c.) was laid out. In addition a certain amount of incidental planting has been done with a view to beautifying the area, notably by planting kurrajongs across the front of the barn and oaks and cypress alongside the main road

by the experimental plots. The Department of the Interior planted ornamental trees and shrubs and laid down lawns about the immediate environs of the laboratories with the result that there is, even at this early stage, evidence of the fact that surroundings will be in keeping with the buildings. The Council expresses its appreciation of the work of the Department in this connexion.

For the furtherance of testing introduced plants which are considered possible for use in more tropical areas of the north, a small area has been made available by the Division of Animal Health at its Research Station, near Townsville.

In connexion with apple investigations Mr. W. M. Carne (with Mr. D. Martin, B.Sc., as assistant) has been transferred to Hobart. Laboratory accommodation has been made available by the courtesy of the authorities of the University of Tasmania and the work is proceeding in close co-operation with the Department of Agriculture.

2. *Fruit Investigations.*—These comprise the work in Tasmania on the possibility of reducing wastage of apples in cool stores and physiological problems in the orchard as related to orchard and storage diseases; the work in conjunction with the Division of Forest Products on case and pack; the growth and bud studies of apple, pear, peach, &c., in co-operation with the Victorian Department of Agriculture; a study of alternate cropping in Valencia oranges in conjunction with the Citricultural Research Station at Griffith; and sultana investigations in conjunction with the Viticultural Research Station at Merbein.

(i) *Wastage in Cool Stores.*—From information received this wastage occurs every season, but to a varying degree; 1928–29 and 1931–32 were particularly bad years. Since October, 1932, the main long-storage varieties have been affected severely. Fortunately experience gained in England enabled Mr. Carne to diagnose the main trouble as low temperature breakdown. Varieties such as Sturmer and French Crab were severely affected, others such as Democrat developed deep scald, the two diseases being related to storage at temperatures too low for safety. The Department of Agriculture arranged for the construction of a small experimental chamber in the Huonville Cool Store to be maintained at a temperature of 38°F. Space was also made available in the commercial chambers without charge. Both the experimental and commercial chambers came into operation on 1st March, 1933. The commercial chambers for apples are battery cooled and held at from 32° to 34°F. The spcial chamber has a capacity of about 250 cases and is cooled by roof grids and provided with drip trays. It has proved very efficient, the temperature varying very little from 38°F.

The varieties stored comprise—(*a*) export varieties which are not stored to any extent locally, namely, C.O.P., Cleopatra and Jonathan, (*b*) varieties normally held in store locally as well as exported—Sturmer, Crab, Scarlet, Delicious and Democrat. The former are to be held ten weeks in store, and then three weeks at room temperature, and the latter in store until about October, 1933. Already the effect of temperature has been most marked in the early pickings of C.O.P. a variety known to be highly susceptible to low temperature breakdown in England and New Zealand. No doubt now exists as to the correctness of the identification of low temperature breakdown. At least two storage temperatures should be provided for apples according to variety. There is also a strong probability that much of the so-called over-ripeness of certain varieties in the overseas markets may be due to low storage temperatures.

(ii) *Physiological Diseases in the Orchard and in Storage.*—The picking tests initiated at Huonville in 1928–29 for bitter-pit and breakdown studies have been continued with modifications. There being no meteorological data available at Huonville, maximum and minimum thermometers, wet and dry bulb, hair hygrograph, rain gauges and cup anemometers were installed. Soil tests are being made by Mr. C. G. Stephens of the Division of Soils Research. It is expected that the tests will be completed early in August.

Observations concerning field occurrence of stippen, internal cork, &c., have been made mainly in the Huonville area. Much of this area will be embraced in a soil survey started by the Division of Soils, and it is hoped to carry out a continuous survey of orchard susceptibility in order to test the correlation between susceptibility and soil type, &c. There appears to be a definite association of the troubles with soil type and drainage conditions.

Reasoning from experience in Western Australia and other countries, it appears likely that root injury plays an important part in these diseases in Tasmania. With this in view, 50 Cleopatra trees on seedling stock and 50 on Northern Spy stock were planted in August, 1932, in the Department of Agriculture nursery at Kettering. Some are being taken up monthly to gain information of the typical root growth and the seasonal cycle of root and top growth to enable abnormalities to be recognized in the orchards under observation. Regular growth measurements have been made and the soil temperature recorded. It is also proposed to use some of these trees to test methods of altering the normal date of bud burst. Laboratory

investigations have been mainly exploratory and aiming at a knowledge of the changing physiology of the fruit in its development. Samples of several varieties have been taken at regular intervals, and of each picking for storage. The tests being tried are :—(*a*) Ground colour, (*b*) Iodine reaction, (*c*) Acidity of juice, (*d*) Refractive index of juice, and (*e*) Electrical conductivity of tissues.

It may be stated shortly that it has been demonstrated beyond doubt that an apple is not a physiological unit, but consists of zones physiologically distinct. The greater differences between zones in certain varieties may be fundamentally allied to susceptibility to certain disorders and the reverse in other varieties, and any examination which omits the outer tissues and the core, as is the general practice on chemical examinations, may give very misleading results.

(iii) *Apple-case Tests.*—The tests conducted under a Special Committee of the Australian Standards Association, were initiated in 1932 and completed in 1933. The results showed that a dump-shaped case with internal measurements of 18 inches x 9 inches x 14½ inches, built of seasoned timber and to definite specifications has the necessary capacity to give a minimum of 41½ lb. net contents, even with the variety Jonathan. Further, it provides more efficient protection to its contents than any case at present in use.

(iv) *Growth and Bud Studies.*—Field observations and growth measurements have been made by the Victorian and South Australian Departments of Agriculture, by Mr. W. M. Carne in Tasmania and by Mr. C. Barnard in the Federal Capital Territory. Material for the determination of the first differentiation of fruit buds was collected and forwarded to Canberra for the necessary microscopic determination. A joint publication giving the results of the first year's work has been issued by the Council and the Victorian Department in the latter's Journal.

(v) *Investigations in Irrigation Areas.*—In connexion with alternate cropping of Valencia oranges in the Murrumbidgee Irrigation Areas, New South Wales, the programme included thinning and manurial trials. The final analysis for two seasons is expected to be made after the harvest of August–October, 1933.

The work at Merbein, Victoria, has included topping experiments on the vines of three areas, studies of starch accumulation and bud development, growth records of the shoots upon which bud development is studied and the tracing of the differentiation of buds and their subsequent development through the season. Topping experiments have given promising results, but at least one further season's work is required. An account of the differentiation and development of the buds is ready for publication.

3. *Wheat Investigations.*—The programme of wheat investigations includes studies of flag smut, root-rots, drought resistance, and yield.

(i) *Flag Smut.*—In continuation of the flag smut studies a range of both resistant and susceptible early and late maturing varieties were inoculated and fortnightly plantings were made over a period of twelve weeks. There was a close parallel between rainfall and infection in the early part of the period. Examination of material bears out the view that the degree and type of infection is constant for each variety, susceptible varieties showing not only a high percentage of plants infected, but a high percentage of tillers for each plant, the reverse holding for resistant varieties. Experiments conducted in the glasshouse tend to show that growth rate of the host is an important determining factor in infection and in symptom manifestation. Tests so far indicate that there is only one strain of the smut organism in Australia.

With a view to determining the mode of inheritance of resistance to flag smut, tests have continued, and it is indicated from experience gained that breeders are not likely to obtain results by testing before the F_3 generation. Segregation for reaction to the flag smut organism occurs, but the genetic factors for resistance may differ with variety.

(ii) *Root-rots.*—During the season isolations of root-rotting organisms were made from 378 fields in the Riverina, Mallee and Wimmera and from specimens collected by State Departments of Agriculture. The results showed that one or more of the organisms may be found in practically any district in those areas.

Tests for disease resistance were carried on, and of 813 varieties 20 showed some tolerance to *Helminthosporium sativum*, of 849 varieties none showed resistance to *Ophiobolus graminus*, and of 987 varieties 40 were apparently resistant to *Fusarium culmorum*. Preliminary pathogenicity tests involving the four organisms causing root-rots indicate that *O. graminis* and *F. culmorum* are relatively the most and *Wojnowicia graminis* the least pathogenic. Isolations from grasses show that they may be hosts or carriers of root-rotting organisms, for *F. culmorum* was obtained from nine, *O. graminis* from one, and *W. graminis* from two.

A result of great significance has been obtained by Mr. Geach with respect to the combined action of the flag smut organism (*Urocystis tritici*) and a root-rot organism (*Fusarium culmorum*) in that root and foot-rot is increased and accentuated when flag smut is present. The disease has been obtained in field plots resulting in deaths of seedlings at low temperatures when normally *F. culmorum* alone would have little effect because its optimum temperature range for disease production is from 64° to 77° F. The joint effect of other organisms is being investigated.

(iii) *Drought Resistance.*—The testing of certain varieties by subjecting them to controlled drought conditions and analysing the results in order to determine the value of a variety in withstanding drought is in progress. In order to ascertain the underlying facts which enable some varieties to withstand drought and to measure the capacity of a plant to do so, experiments are in hand dealing with wilting and transpiration, pH, viscosity, "bound water," exosmosis, and catalase activity. Present indications point to catalase activity of the leaves as being one indicator of relative drought resistance.

(iv) *Yield.*—One of the most important but most involved problems is that which has for its aim the determination of the factors which affect yield apart from such as the incidence of disease, insect pests, drought, water-logging and mineral deficiency. Some of these are under investigation, such as time of flowering and maturity, size of embryo and grain, effect of pre-treatment of grain, growth rate, tiller relationships, correlation of characters like possession of awns, length of straw, &c., and environmental factors such as spacing, date of planting, &c. As is well known most of these demand long-dated experimentation but some present results may be quoted.

With Baroota Wonder no correlation was found between date of flowering and yield, but there was between weight of seed grain and yield. Correlation has been found between the size of the embryo scar (used as a measure of the size of the embryo itself) and early growth. There was evidence that for Yandilla King at Duntroon closer spacing gave greater yield than wider spacing, but for Early Bird no significant difference in yield resulted from modified spacing. In a cross between Waratah and Garnet correlation between awnedness and high yield was demonstrated. Further work is in progress with respect to the origin of grass clumps in crosses.

In order to determine the effect of environmental factors such as rainfall, temperature, &c., on yield, 54 varieties were tested during 1932 at Duntroon. It is hoped that a co-operative attack on this problem, with a number of standard varieties, may be arranged between State Departments of Agriculture and the Division of Plant Industry.

(v) *Genealogical Chart.*—A list and genealogical chart of important Australian wheats showing pedigrees has been prepared by Mr. J. R. A. McMillan and issed as Bulletin No. 72.

4. *Plant Introduction.*—In a brief report little can be said to give a complete picture of the work or of results, but the following data will give some idea of the work. During the year, 1,760 wheats, 48 grasses, 35 legumes and 12 fibre plants were introduced for trial, making the total to date some 4,500. At Duntroon, 3,115 wheats, 61 oats and 159 barleys were tested in rows and the results are now being catalogued. Grasses and other pasture plants were tested in 648 rows at Black Mountain and in 224 rows and 357 plots at Duntroon. Of the plots, some of which are single grass, single legume, mixed grass, and mixed grass and legume, 63 are being subjected to differential mowing and grazing and a further 55 will be so treated next season. The testing of sub-tropical and tropical pasture plants and soil improvers is in progress at Gatton, Townsville and Mareeba. To date, 667 lots of seed, mainly of grasses, legumes and cereals, have been distributed for further testing in the several States of the Commonwealth. In exchange with 22 of the countries supplying seed 550 lots of seed of Australian plants have been sent out and, in addition, 160 lots of seed of plants introduced from other countries. An introduction which has attracted attention is that of pyrethrum (*Chrysanthemum cinerariaefolium*) which yielded well in the plots in its second year, though the third year is usually the first productive year in Europe and Japan.

5. *Agrostology.*—The programme of agrostological investigations at present covers the preparation of a grassland map of Australia, studies of selected introduced grasses, study of "kangaroo" grass and the selection of improved strains of certain grasses.

Information for use in the preparation of a grassland map of Australia has been gathered from libraries, rural school teachers, and individuals and has been supplied by Departments of Agriculture, Forestry and Lands. It is now in process of compilation and translation to the map.

Twelve selected grasses are being subjected to study for such determinations as conditions of seed and germination, rate of growth, root growth, tilling, water requirement, drought resistance, seed formation and capacity for self-establishment. Some interesting results are already available, e.g., seed of *Eragrostis virescens* will germinate only in light, seed of *Agropyron* spp. must be left until ready to drop off or it will not germinate, and seed of *Ehrharta erecta*

must fall naturally from the plant for satisfactory germination. A promising method of determining the relative drought resisting capacity of grasses has been evolved; it will be the subject of a publication in the near future.

Seedlings of kangaroo grass (*Themeda australis* Stapf) from Queensland, New South Wales and the Federal Capital Territory, are being grown at Duntroon with a view to ascertaining whether strains exist and to study their growth in detail.

Phalaris stenoptera, *P. coerulescens* and *Danthonia semi-annularis* are being worked with for the purpose of producing improved strains suitable for the Southern Tablelands. An agronomic problem under investigation is that of ascertaining the stage at which seed of *Phalaris* sp. could be harvested to avoid loss by shattering. In December, 1932, the best date was from the 18th to 21st days when the seed was " nearly ripe " to " apparently ripe ".

6. *Tomato Investigations.*—The studies on spotted wilt of tomato have been continued on a co-operative basis between the Council and the Waite Agricultural Research Institute. Reviewing the work of the last five seasons, 56 commercial varieties of tomato have been tested and all shown to be susceptible to spotted wilt attack, thus making cross breeding for resistance difficult. Early Dwarf Red showed a partial tolerance and is being used for crossing with Marglobe, Sensation and other good commercial varieties. Work is also in progress on (*a*) spraying and dusting experiments with a view to reducing losses of young plants before fruiting and the amount of blotchy fruit from older plants; (*b*) studies of the virus in the plant and in extracted sap; and (*c*) large-scale seedling inoculation so that it may be used on testing hybrid generations in large numbers.

7. *Tobacco Investigations.*—While by reason of the allocation of special grants by the British-Australasian Tobacco Company and the Commonwealth Government the work on tobacco problems comes under the Australian Tobacco Investigation Committee it is so closely allied to the Divisional programme that a brief account is included here.

Following the studies on downy mildew of tobacco (blue mould), a Bulletin (No. 65) was published by the Council during the year 1932–33, and a Pamphlet (No. 1) by the Australian Tobacco Investigation Committee. These publications dealt with the importance of using disease-free seed, of completely removing all tobacco plants from the field and vicinity after harvest and of destroying wild tobacco in the vicinity of seed beds. Further work is in progress concerning spraying and the regulation of temperature and humidity of seed beds.

As reported last year a leaf-spot disease was found to be serious in North Queensland and efforts were concentrated on arriving at control measures. Evidence shows that this disease may be carried on tobacco debris with the seed, on debris in the soil and on plants left over in the tobacco fields. In the seedbed, satisfactory control was obtained at Mareeba during the season by spraying with 2–2–40 Bordeaux mixture and in the field by early and thorough priming. A pamphlet giving the present findings is in the course of preparation for publication.

Last year the greatly increased yield resulting from the extension of planting necessitated the issue of a general publication dealing with the factors affecting quality. With this in mind, a Bulletin (No. 3) covering questions of climate, soil, cultivation, curing and grading was published by the Australian Tobacco Investigation Committee. The importance of considering climatic factors in tobacco culture was made evident during the past season by the occurrence of frosts in Victoria, of heavy rains in the early part of the season in Queensland from Sarina to Mareeba, and of dry conditions early in the season from Rockhampton to Brisbane. The result is a reduction of the total yield to about half of last year's and of a reduction in quality of the crop so affected.

8. *Pea Disease.*—Experiments concerning the pea root-rot which occurs in Tasmania have shown that the disease may attack plants when only 2 inches high if grown in soil in which root-rot has been present for five or six crops. Host range tests show that vetches, sweet peas and garden peas, are susceptible to root-rot, while subterranean clover, New Zealand white clover and Canadian wonder beans are not susceptible. Other species are being tried. Grey peas are being grown in infested soil with a view to ascertaining whether any are resistant and other varieties of peas are being tried in Tasmania.

9. *Pine Diseases.*—During the past two years a disease of pines known as needle fusion has attracted attention in South Australia, Tasmania and New South Wales plantations. The disease is more severe in coastal plantations where 20 per cent. of the older trees are often found affected. Present views tend to the theory that the disease is infectious, and it is evidently more prevalent in pines struggling against adverse conditions than in those growing vigorously. Many microscopic examinations have been made, but no organism has been found associated with the disease. Attempts to produce the disease by grafting, by transmission by insects, and from seed are in progress. Plans are under consideration whereby several blocks of young pines suitable for experimental work will be used to test the effectiveness of eradicating diseased trees.

10. *Fungal Discolouration of Paint.*—In areas of high humidity and temperature it is frequently found that painted surfaces rapidly deteriorate and become darkened by sooty moulds. Especially is this noticeable with light coloured painted surfaces. The discolouration is either superficial and removable by washing or is persistent. In the latter case the organism has been able to grow on the paint owing to the deterioration of the latter by the action of intense sunlight under conditions of high temperature and humidity. Control measures, if any, are, therefore, expected to involve questions of pigment and vehicle with the object of obtaining a more resistant surface.

11. *Biometrical Work.*—Miss F. E. Allan's work on biometrics comes under two categories, viz., that in connexion with the investigations of the Council itself and that concerning problems of research workers elsewhere. In the former, data were examined and reported on which had been obtained from yield studies, flag smut infection tests, drought resistance tests, root-rot of wheat investigations, and tomato spotted wilt investigations, and a scheme was drawn up whereby it was planned to gather and examine data on wheat growth characteristics and resultant yield in relation to environment in certain wheat areas.

As regards problems of other research workers, advice was given with respect to the planning of banana borer control studies. Methods of interpreting data have been discussed with officers of various Departments, an analysis of the data concerning milling qualities of wheats has been undertaken, and reports finalized on the records supplied by the Infantile Paralysis Committee (published in the Australian Medical Journal) and by Gatton College with reference to pig-breeding trials.

12. *Miscellaneous.*—A number of other matters, not included under the above headings, received attention during the year. The collections of specimens of plants, fungi and diseases were added to and further records of the occurrence of diseases were made. A report on the cultural requirements, harvesting, retting, &c., of flax was prepared and submitted with a report on the economics of the flax industry by the Director of the Development Branch of the Prime Minister's Department. A report on seed testing technique is in process of final revision. Determinations of a number of weeds and other plants were made incidentally to the regular work.

IV. ENTOMOLOGICAL INVESTIGATIONS.

1. *General.*—The progress made in the investigations of the Division of Economic Entomology during the past year has been considerable and very satisfactory in spite of the fact that no result of outstanding economic importance was achieved. It must be realized that the basis of ascertained fundamental facts upon which the economic entomologist has to work is probably less than that available to a worker in any other applied science. It is consequently necessary for him to spend much of his time on fundamental work in the earlier stages of an investigation, and he often has to develop an entirely new technique instead of merely following a recognized procedure. Great progress has been made in the discovery of the fundamental facts of the Division's problems and in the development of suitable technique for the investigation of the economic aspects of the problems. The progressive trend of the work towards economic results is clear, but the process is necessarily rather slow. Special mention may be made of the numerous natural enemies which have been introduced to combat noxious weeds and insect pests. While certain of these show signs of promise, it is as yet impossible to say whether any one of them is definitely satisfactory or definitely useless. This is in keeping with the usual progress of biological control work. For example, many years after the commencement of work on the prickly pear, and after large numbers of natural enemies had been introduced, there were no clear signs of success ; but the success and importance of the work is now beyond question.

2. *Entomological Control of Noxious Weeds.*—The work of this section has been continued by Mr. G. A. Currie as Senior Entomologist, Mr. S. Garthside at Farnham Royal, England, and Mr. S. G. Kelly at Manhattan, Kansas.

(i) *St. John's Wort (Hypericum perforatum).*—During the year further consignments of *Chrysomela varians*, *C. brunsvicensis* and *C. hyperici* were received from the Farnham Royal Laboratory (Great Britain). In the field all stages of *C. varians* could be found on the Tawonga road near Bright in November, 1932, surviving from the previous season. At all other places the beetles liberated appeared to have died out. In a continued attempt to establish the species in Australia, about 10,000 adults of *C. varians* received from England have been liberated in Victoria at various elevations in the St. John's Wort areas. Large numbers of *C. hyperici* have been bred in the insectary and they are at present laying eggs freely. In addition to the above, consignments of the following insects were sent to Australia from the Farnham Royal Laboratory, after extensive tests had been made to make

sure that they will not attack plants of economic importance :—*Anaitis* spp., *Lathronympha hypericana*, *Depressaria hypericella*, and *Aphis chloris*. Large numbers of *Anaitis* spp. were bred in the insectary at Canberra and were tested on about 30 economic plants. None of these plants were attacked.

(ii) *Noogoora Burr* (*Xanthium pungens*).—Over a 1,000 seed-flies, *Euaresta aequalis*, were liberated in Queensland in 1933, and State entomologists report that the flies were seen mating and ovipositing on the green leaves in the field. Mr. S. G. Kelly has sent from America burrs infested with *Euaresta aequalis* and dry stems of *Xanthium* containing *Cylindrocopterus adspersus*. He has also tested the following insects on economic plants at the Kansas State Agricultural College, Manhattan :—*Cylindrocopterus adspersus*, *Hippopsis lemniscata*, *Ataxia hubbardi*, *Baris callida*, *Baris xanthii*, and *Dectis spinosus*.

(iii) *Ragwort* (*Senecio jacobaea*).—About 200 eggs of the cinnabar moth, *Tyria jacobaeae*, were placed out in ragwort in Gippsland in November. Arrangements for a large supply of eggs from New Zealand broke down owing to the unexpected scarcity of the moths in the districts where they were to have been collected. Puparia of the ragwort seed-fly, *Pegohylemsia seneciella*, were received from the Cawthron Institute in January, 1933. No flies were obtained until after the flowering of the ragwort was over for the year. The bulk of the puparia have been placed in a refrigerator in an effort to obtain emergence at the flowering time of the ragwort.

(iv) *Bracken Fern.*—Mr. S. G. Kelly is attempting to establish the moth *Papaipema pterisii* on an experimental plot of bracken at Manhattan, Kansas.

3. *The Buffalo-fly Pest* (*Lyperosia exigua*).—Professor Handschin left for Switzerland and Mr. G. L. Windred returned to Canberra in July, 1932, so Mr. T. G. Campbell has been the only officer in the field during the greater part of the year. The breeding and liberating of various races of *Spalangia sundaica* and *S. orientalis* was continued, approximately 5,000 parasites being liberated in the vicinity of Burnside Station, North Australia. Two consignments of parasites have been sent to Derby, Western Australia, and the Districy Veterinary Officer reports that they have arrived in good condition. Liberations, totalling approximately 1,500 parasites, were also made by Mr. Campbell in north-west Queensland. Arrangements are in hand for liberations at Marraki and Katherine, North Australia, and in north-west Queensland. A pure strain of *S. orientalis* has been supplied to Mr. H. J. Willings for his genetical studies.

Mr. Campbell has continued his study of the biology of *Lyperosia* and *Spalangia*. Mr. Windred has investigated the biometrics of species of *Spalangia*, and has completed the papers recording his investigations of the biology of *Lyperosia* in the Netherlands Indies.

4. *The Sheep Blowfly Pest*—(i) *Studies of the Flies.*—Nineteen species of blowflies have been recorded as attacking sheep in Australia. Of these *Lucilia cuprina* is the most important in the eastern States, and experiments in insectaries have shown that this species attacks sheep much more readily than the closely related species *L. sericata*. Available information suggests that *Calliphora australis* is the most important species in Western Australia. Experiments and observations indicated that *Chrysomyia rufifacies*, which attacks sheep with particular severity, normally attacks sheep in the field after they have been attacked by other species, but primary striking of sheep by *Ch. rufifacies* has now been observed under insectary conditions.

Large pure cultures of *Lucilia sericata* and *L. cuprina*, started from the eggs of single flies respectively 37 and 20 months previously, are still vigorous and were drawn upon extensively for experimental purposes. A white-eyed mutant of *L. cuprina* appeared in the cultures and the eye colour was proved by Dr. M. J. Mackerras to be a unit recessive character which is not sex-linked. Miss M. Fuller has maintained a pure culture of *Ch. rufifacies* in vigorous condition for 30 generations, and Dr. M. J. Mackerras has shown that this species can be maintained in sterile culture. Thus neither living larvae nor bacteria are essential to its diet, though it thrives better when they are present. Miss M. Fuller has completed the third year's record of the relative seasonal prevalence of the more important blowflies.

Dr. A. J. Nicholson conducted a quantitative investigation of the influence of temperature on the activities of *Lucilia sericata*, *L. cuprina*, *Chrysomyia rufifacies* and *Calliphora stygia*. He found that the relation between activity and temperature was very different when the flies were subjected to constant temperatures from that occurring when they were subjected to progressively rising temperatures, that the closely related species *L. cuprina* and *L. sericata* exhibited markedly distinct reactions to temperature, that the temperature reactions of the four species correspond to their known seasonal and geographical distribution, and that *L. cuprina* is probably better adapted than the other species to warm, humid, cloudy conditions such as exist when sheep are most susceptible.

Dr. M. J. Mackerras proved that carrion free from maggots becomes strongly acid, that maggots thrive best in an alkaline medium, and that, when present in sufficient numbers, they themselves cause the carrion to become alkaline. Most samples of wool are nearly neutral in reaction, but a number of samples from highly susceptible areas have been found to be strongly alkaline, and it is clear that the action of ammonifying and other bacteria, which renders the fleece alkaline, influences the susceptibility of sheep to strike.

(ii) *The Problem of Susceptibility.*—Dr. M. J. Mackerras and Mr. M. R. Freney analysed wool samples from struck and unstruck sheep which had all been subjected to a dense population of blowflies. They found that susceptibility is associated with fleece that is easily wetted and with fleece in which the water soluble fraction is relatively high, but it appears that the water soluble fraction is not itself responsible for susceptibility. By means of a very delicate and specific serological method Dr. I. M. Mackerras has shown that all strikes, and many susceptible areas before being struck, contain soluble (serum) protein.

Mr. M. R. Freney and Dr. M. J. Mackerras have shown that the products of keratin hydrolysis are attractive to blowflies and provide food for their maggots. Dr. M. J. Mackerras has therefore studied the organisms which are capable of hydrolysing keratin and has developed a special technique for this work. Many species of bacteria have proved to be capable of breaking down wool fibre, but no one species is consistently present in struck areas. Incidentally, " tenderness " in wool is sometimes caused by bacteria.

Dr. M. J. Mackerras and Mr. C. R. Mulhearn have shown that maggots hatching from the egg irritate the skin of sheep and cause the production of serous exudate, which has been shown to be an adequate food for the full growth of the larvæ. It has also been shown that food for the larvæ before the production of serous exudate is provided by (*a*) moistened exudate, whether recent or old, (*b*) moist faeces in certain cases, and (*c*) products of bacterial hydrolysis of wool fibre. Mr. C. R. Mulhearn has shown that maggots produce a more widespread though shallower lesion on slack woolled sheep than they do on a sheep carrying a dense fleece.

(iii) *Carcase Disposal.*—Miss M. Fuller has studied a number of methods of carcass disposal. Burial was found to be quite useless, but various methods of treatment with poison were fairly satisfactory, provided the poison was applied early and very thoroughly.

(iv) *Trapping.*—A large scale trapping experiment is in progress at "Therribri," New South Wales. Two similar areas, each containing 900 carefully selected similar sheep, are being compared, one area being intensively trapped while the other is left untrapped. In the past season fewer sheep were struck in the trapped area than in the untrapped area, but it is not yet certain that this is really significant. The areas and sheep were made available by Mr. A. S. Austin and Mr. K. M. Austin. Arrangements have been made for a somewhat similar experiment to be carried out in Western Australia, suitable areas and sheep being made available by Mr. E. H. B. Lefroy.

Miss M. Fuller tested various proprietary traps. With the exception of the " Mutooroo " trap they were all found unsatisfactory. Mr. G. L. Windred carried out field experiments with " West Australian " traps with the object of finding how best to treat the baits with sodium sulphide. He obtained best results with 80 grammes crude sodium sulphide to 1,000 grammes liver and 3 litres water, this bait being effective for about three weeks. He also found that the best catches were obtained when the bait was allowed to become very putrid before adding the sodium sulphide.

Dr. A. J. Nicholson continued the development of a suitable technique for the accurate testing of traps and baits. He found that the great irregularities obtained with similar traps and baits are mainly due to the influence of wind, and that this may be overcome by placing the compared traps on the periphery of a slowly rotating circular table. Considerable progress was made in the construction of satisfactory test-traps and in the development of standard baits.

(v) *Dressings.*—Mr. C. R. Mulhearn has tested a number of dressings on experimental strikes in the insectary. None of these dressings proved fully satisfactory, though two of them showed some promise.

(vi) *The Blowfly Report.*—A publication giving a general account of the present knowledge of the blowfly problem, edited by Dr. R. J. Tillyard and Dr. H. R. Seddon, was prepared under the direction of the Joint Blowfly Committee by officers of this Division in co-operation with the Veterinary Branch and the Entomological Branch of the New South Wales Department of Agriculture. (Pamphlet No. 37.)

5. *Orchard and Fruit Pests—Thrips.*—Investigations on the thrips problem are being conducted under a co-operative arrangement between the Council, the Waite Agricultural Research Institute, the University of Adelaide, the Thrips Investigation League and certain of the State Departments of Agriculture. The investigations are concerned with the apple thrips (*T. imaginis*) and associated species, particularly with reference to orchard and bush fruits; they are under the direction of Dr. J. Davidson, Head of the Department of Entomology at the Waite Institute.

Certain aspects of the problem are being studied at the Waite Institute. Mr. J. W. Evans has made continuous systematic records of the numbers of *T. imaginis* and associated species in the blossom of various plants throughout the year; these have been correlated with meteorological data and show the significance of weather in relation to the occurrence of thrips in plague numbers. These studies are being continued, as they may enable the degree of infestation which may be expected in the spring in any year to be predicted in advance. Laboratory studies on the effect of temperature and moisture at various stages of development of certain species of thrips are being made in order to elucidate the effect of weather on these insects.

The insecticide aspect of control is being studied. A number of preliminary tests have been made with various substances, and Mr. W. H. Wheeler has been appointed as chemist to assist in this work. It has been shown that pyrethrum is a promising insecticide; when mixed with sulphur 1 : 10 it makes an efficient dust. Mr. Wheeler is examining various methods whereby pyrethrum and other substances may be incorporated in suitable dusts and sprays; these will be tested in orchards in the spring.

Mr. H. G. Andrewartha, assisted by Miss H. V. Steele, is studying the problem in Victoria. Through the courtesy and helpful co-operation of the University of Melbourne, this unit has been given laboratory accommodation and other facilities at the School of Agriculture. Mr. Andrewartha is studying the fluctuations in numbers of *T. imaginis* and associated species in relation to climatic conditions in Victoria, particularly with reference to their numbers in autumn and spring and method of overwintering. Arrangements have been completed for carrying out control experiments with insecticides, in orchards in selected districts. Miss Steele is studying certain aspects of the biology of the more important species of thrips, particularly with reference to overwintering; a concise account of the species of blossom-inhabiting thrips of economic importance is being prepared.

6. *Bee Research*—(i) *Deficiency Disease in Bees.*—Further work on possible substitutes for pollen was carried out by Mr. G. A. Currie during the year. In checking the previous year's results it was found that casein, Trufood skim milk, dried egg albumen, edestin, and yeast could each, when fed alone, stimulate the brood food glands to activity. Minor pollen shortages occurred in the field in New South Wales, and supplies of casein were sent to two reliable apiarists, but the results were not striking.

(ii) *Inspection of Apiaries.*—Mr. G. A. Currie was appointed inspector under the Apiaries Ordinance Act for the Federal Capital Territory, and spent much time in inspection work during the active season of the bees. No cases of foul brood were seen in the Territory, wax moth being the only serious pest.

(iii) *Galling of Eucalyptus Buds.*—The prevalence of galling in the buds of certain eucalyptus was brought to the notice of the Division by the Apiarists' Association of Victoria. Mr. G. A. Currie finds that many insects are concerned in this galling and that many species of trees are attacked, e.g., *Eucalyptus macrorrhyncha*, *E. maculata*, *E. dealbata*, *E. odorata*, and *E. rostrata*. He has discovered that an interesting association exists between a nematode worm and the larvæ of a fly common in the galls. The Forestry Department of New South Wales is also interested in this problem on account of the galling of the buds of *E. maculata*, a valuable timber tree.

7. *Field Crop and Pasture Pests.*—(i) *Clover Springtail and Red-legged Earth Mite.*—Mr. H. Womersley has continued his work on the lucerne flea or clover springtail (*Sminthurus viridis*) and on the red-legged earth-mite (*Halotydaeus destructor*) in Western Australia. He found from an examination of the experimental plots of lucernes, clovers and grasses at the State Farm at Denmark that although all lucernes, and most clovers and grasses were severely affected by these two pests, the perennial strain of red clover, known as Montgomery Red, was practically untouched and in excellent condition. He also observed that the predatory mite, *Biscirus lapidarius*, occupied a decidedly larger area at Waroona, where it was first found, than it did last season. This mite was also found in several other localities in the south-west, and in all of these the clover springtail has been reduced to negligible proportions. The mite was artificially introduced into several new localities, but it is as yet too early to report on the effect of these introductions. Arrangements are being made to continue work with this promising mite, in spite of the fact that Mr. Womersley has now left the service of the Council in order to take up his new post at the South Australian Museum.

(ii) *Underground Grass Grub* (*Oncopera*).—Mr. A. L. Tonnoir spent three months in Nelson, New Zealand, studying the parasites of *Porina*, a genus of moths closely related to *Oncopera*. He obtained much information about the two most common species of *Protohystricia* and found that these parasites can successfully attack the larvae of *Oncopera* so long as the skin of the host remains soft enough to allow penetration. About 300 adult flies were despatched to Australia. A large percentage of these reached Moe, Victoria, alive, and were released there by Mr. Gooding

Many *Protohystricia* puparia were submitted to cold treatment with the object of delaying the emergence of the flies sufficiently to allow them to attack the Tasmanian species of *Oncopera*. The experiment was not successful, but further work with a modified method of cold treatment is contemplated. A morphological study of the early stages of the parasites and a taxonomic study of the adults have been made.

(iii) *Grasshopper Problem.*—The identity of the early stages of two further species has been established. Ten species can now be recognized at any instar.

8. *Termite (White Ant) Problem.*—(i) *Investigations in Northern Territory.*—In co-operation with the Northern Agency Ltd., Mr. G. F. Hill investigated the damage to buildings, trees, &c., causes by *Mastotermes* in Darwin. As a result of these investigations further damage to the Meat Works buildings has been arrested and a satisfactory method of destroying *Mastotermes* in buildings and trees has been demonstrated.

(ii) *Field Experiments.*—Field tests of the resistance of the following materials are still in progress:—(*a*) untreated Australian commercial timbers, (*b*) impregnated timber of *P. ponderosa* (part of international termite exposure test), (*c*) samples of *Pinus radiata* and *Eucalyptus regnans* impregnated with crude oil by brush treatment, (*d*) "Xylamon" treated timbers, (*e*) impregnated "Tentest", (*f*) flourised karri cross arms, (*g*) impregnated "black boy", (*h*) untreated Canadian timbers, (*i*) "Wolman" treated samples, and (*j*) telephone cable casing. In addition tests are being made of soil poisoning around fence posts, and on the effects of the spacing of timber samples in tests.

(iii) *Destruction of Commercial Forest Trees.*—An investigation of the mode of entry of *Porotermes adamsoni* into living ash trees was begun in the Federal Capital Territory in February. The tests then begun were completed in May and the results, although inconclusive, will be of great value in continuing this work next summer.

(iv) *The Development of Standard Laboratory Colonies.*—Dr. F. G. Holdaway, assisted by Mr. T. Greaves, has made great progress with the development of standard colonies of *Eutermes exitiosus*. He has succeeded in maintaining colonies, consisting of about 5,000 individuals each, in a healthy condition and with a comparatively low mortality. The colonies are maintained in screw-topped jars in an artificially warmed room. When the technique of handling and maintaining standard colonies has been perfected, as is likely to happen soon, we will possess a powerful new method which will enable us to test the resistance of timber and other materials with much greater rapidity than has hitherto been possible.

(v) *Technique and Field Testing.*—Observations made by Dr. Holdaway indicate that the distribution of attack on samples in the vicinity of mounds is influenced by the "territory" inhabited by the termites from individual mounds and by the distribution of food in the "territory". It also appears that the temperature of mound habitats influences the intensity of attack. Further work on these points will probably lead to an improvement of the technique of field testing.

(vi) *The Physical Ecology of Termites.*—Laboratory studies are in progress on the temperatures preferred by *Eutermes exitiosus*, and field observations have been begun on the temperature relations of *Eutermes* in the mound.

9. *Pine Chermes.*—From a detailed survey of several plantations near Canberra and examination of many other plantations Mr. A. L. Tonnoir has found that *Pinus radiata* begins to be susceptible to *Chermes* attack from the third to fourth years, is most susceptible in the sixth and seventh years, and afterwards throws off the pest in a remarkable way. He has begun a series of experiments with the object of finding suitable sprays and dips. A few puparia of *Leucopis obscura* were recovered on some twigs on which this insect had been liberated in May, 1932, but it is doubtful if this natural enemy has yet been established. During the year several consignments of *Leucopis obscura* and *Lipoleucopis praecos* were sent here by Mr. Garthside from England. There was a considerable mortality in transit, but the remaining flies were liberated in pine plantations in the Federal Capital Territory, and in New South Wales. Arrangements have been made for Mr. Garthside to send further consignments of these insects and also consignments of other natural enemies of *Chermes*.

10. *Greenhouse White-fly (Trialeurodes vaporariorum).*—A first consignment of the tests of the white-fly parasitised by *Encarsia formosa* was received from England in January and taken to Tasmania by Dr. R. J. Tillyard. This consignment was not successful and arrangements have been made for other consignments to be sent in various ways with the object of finding a satisfactory method of transport.

11. *Oak Scale (Asterolecanium variolosum).*—Mr. A. L. Tonnoir despatched 4,000 scales parasitized by *Habrolepis dalmanni* from New Zealand. The parasites were liberated at Hobart and Launceston, Tasmania, but it is as yet too early to say whether they have become successfully established.

12. *Anaplasmosis.*—By arrangement with the Division of Animal Health investigations have been begun by the Blowfly Section on the transmission of this serious disease of cattle, which has been found to occur in Queensland. Virulent blood was received from Dr. J. Legg, Townsville, and the infection has been established in calves, which are kept in the quarantine insectary. The stable fly, *Stomoxys calcitrans*, has been allowed to feed on these calves and on healthy calves in a separate insectary. There has not yet been time to show whether the disease is or is not transmitted by this fly.

13. *Natural Enemies sent Overseas.*—(i) *New Zealand.*—The Forest Entomologist at Nelson, New Zealand, has reported that many moths have emerged from the cocoons of *Stathmopoda melanchra* sent by Mr. A. L. Tonnoir in April, 1932, and that a complete generation has been obtained since. There is a good prospect that this natural enemy of the Eriococcus scale will be established within a few years. Cocoons of *Meteorus* sp., an Ichneumonid parasite of *Paropsis*, have been forwarded to Nelson.

(ii) *South Africa.*—A report has been received that *Anaphoidea nitens*, an egg-parasite of the eucalyptus weevil (*Gonypterus*), has become established in districts of higher rainfall in South Africa. Parasites of this species were sent to South Africa by this Division, and also by Mr. F. G. Tooke, of the South African Department of Agriculture. Arrangements are being made to send further consignments of egg-parasites of *Gonypterus* and also natural enemies of *Phoracantha*, an Australian wood-boring beetle which has become a serious pest in South Africa.

(iii) *Solomon Islands.*—A consignment of races of *Spalangia sundaica* and *S. orientalis* is being prepared to send to the British Solomon Island Protectorate where *Lyperosia exigua* has become a serious pest in recent years.

14. *Systematic Entomology.*—(i) *Museum.*—Owing to the resignations of Miss W. P. Kent-Hughes and Miss L. F. Graham, work under this heading has had to be greatly reduced. These workers left their special groups, respectively the Coleoptera and Hymenoptera, in very good condition and the identified material they left has already proved of great use to the Division. Before leaving, Miss Graham paid special attention to the genus *Spalangia*, which contains important parasites of the buffalo fly. The most important accession to the collection during the year is the Sloane bequest, comprising many thousands of Australian and exotic Carabidae. Mr. A. L. Tonnoir presented to the Museum a collection of 109 Australian Dolichopodidae, including 39 types and 60 paratypes. Dr. Turner has now received the full complement of the cabinets supplied by the Council, and has already set out in them about half his collection of moths, which he is presenting to the Museum. Many specimens were identified for various institutions in Australia and Europe.

(ii) *Termite Systematics.*—Mr. G. F. Hill has completed for publication papers on the genera *Rhinotermes*, *Porotermes*, *Calotermes*, and *Hamitermes*. He is now giving attention to the largest genus of all, *Eutermes*, and to the economically important genus *Coptotermes*. With the completion of this work it will be possible to prepare distribution maps of all the known Australian species. Mr. Hill has also identified large numbers of termites for various institutions and private people.

(iii) *Blowfly Systematics.*—Miss M. Fuller worked out the life-history of the anomalous carrion frequenting fly *Sciadocera rufomaculata* and, in collaboration with Mr. A. L. Tonnoir, has shown that it belongs to the family Phoridae. She has also shown that the larvae of the blowfly *Onesia accepta* are parasitic on earthworms, and has worked out the complete life-history of this species.

15. *Advisory Work.*—From time to time advice has been given on many entomological problems, for example the treatment of termite infested buildings, the control of ants and " white grubs " in lawns, and the control of ants, cockroaches and " silverfish " in houses in the Federal Capital Territory, and on the attack of trees of economic importance by termites in Papua and Thursday Island.

V. ANIMAL HEALTH INVESTIGATIONS.

1. *Animal Health Research Station, Oonoonba, Townsville.*—Although the Station was formally transferred by the Queensland Agricultural Department to the Council in September, 1931, because of the necessity for extensive alterations to the premises, and the installation of a complete equipment, much of which had to be secured from abroad, active research work could not commence until six months later, and even then some time had to elapse before the staff, under Dr. A. W. Turner, who had been appointed Officer in Charge, could be accommodated. Already very material additions have been made to our knowledge of the diseases affecting the cattle of northern Queensland.

(i) *Tick Fever or Redwater.*—This disease has been estimated by the Cattle Tick Commission to have cost Queensland £7,000,000. Before the present investigations were commenced, tick fever or " redwater " in Australia was considered in official and academic circles to be due solely to the invasion of the red blood cells by the protozoan parasite, *Piroplasma bigeminum* originally discovered by Smith and Kilborn in 1893 as the cause of Texas fever or redwater in America. Control, as well as official and private practice concerning prevention and treatment, has been centred round this conception of a single causal organism, amenable to treatment, relatively easy to immunize against and invariably carried by the cattle tick alone. Yet, it had to be admitted that frequently redwater did not respond to treatment or to immunizing procedures, and that at times serious losses followed attempts at immunizing cattle. The position was so far from satisfactory that the inclusion of tick-borne disease as a subject of further research was obviously imperative.

An explanation of the past anomalies is now given by the work of Dr. J. Legg, who, following his visit to Onderstepoort, South Africa, has determined the presence in Queensland cattle of at least three distinct tick fever organisms, viz., *Piroplasma bigeminum*, *Theileria mutans*, *Anaplasma marginale* and more recently a *Babesiella*. The last two are more important than the officially recognized *Piroplasma bigeminum*, and there seems little doubt that their previous unrecognized presence has been the cause of a great deal of the dissatisfaction concerning redwater immunization. A preliminary report concerning the occurrence of anaplasmosis has been published as Pamphlet No. 38, while those investigations concerning babesiellosis are now forming the subject of a report which will be published shortly.

(ii) *Pleuro-pneumonia-Contagiosa Bovum.*—This disease has been the cause of colossal losses in Australia since its introduction in 1858. At the present time its control imposes a heavy burden upon the pastoral industry, and its existence in Queensland causes frequent prohibition of export cattle to other uninfected States and at all times necessitates the imposition of drastic regulations.

An exhaustive study has been made of the causal organism, and a new culture medium has been evolved that has considerably facilitated this work. A small infected herd of cattle has been established under conditions of isolation at the Research Station so that a continual supply of material for study is available. Mr. A. D. Campbell has greatly improved the test for diagnosing the disease by examination of the blood of the infected animal, and it is anticipated that " carriers " apparently perfectly healthy may be detected with certainty. These are the animals, of course, that are responsible for peak outbreaks of pleuro-pneumonia. It is hoped that arrangements will be made for the application of this test on a small field scale for the purpose of demonstrating its value in areas where adequate control is possible.

The present method of vaccination against pleuro-pneumonia consists in the inoculation of animals at the tip of the tail by infective material. Tests on the real value of this method of inoculation at Oonoonba have shown that, while some immunity is certainly produced, yet this immunity is not absolute ; and occasionally animals may contract the disease in a relatively mild form, thereafter becoming " carriers ". Work is proceeding on the use of methods possibly better than the present. Until such a method is found, however, natural virus is in great demand.

(iii) *Peg Leg Disease.*—Surveys of two of the most affected areas, viz., Charters Towers and Cloncurry districts, have been made by the Field Officer, Mr. R. B. Kelley, who has collected a large number of specimens for laboratory examination and has made a number of very important observations.

Analyses of soils, pastures, and rumen contents indicate that the main cause of peg leg is a deficiency of phosphorus in the soil. This work will, however, have to be considerably extended before definite conclusions can be drawn. It may be stated, however, that the hypothesis of phosphorus deficiency has been supported by clinical, post mortem and laboratory examinations.

In order to test out this hypothesis a small field station has been established on the property of Mr. A. Black of " Helenslee," who has devoted considerable time, energy and expense towards assisting in the investigation. A peg leg fund has been contributed voluntarily by the owners of many of the affected properties in the Charters Towers district. At the present moment there is a herd of 52 animals under experiment, divided into four groups of thirteen each, one of which is a control group. A second group receives every two days dicalcic phosphate by mouth, a third group has access every alternate day to disodium phosphate dissolved in the drinking water, and the fourth group, known as a free-choice group, is given the opportunity of taking voluntarily dicalcic phosphate, limonite (a natural iron ore), meat meal, sea salt and a natural edible earth consisting of a mixture of calcium and magnesium carbonates. Every fortnight the animals are weighed, and it is hoped that at the end of this year there will be indications whether the administration of phosphorus in the form of soluble sodium phosphate is sufficient to prevent the occurrence of peg leg, or whether calcium and phosphorus are both necessary as in dicalcic phosphate, or whether some other mineral is also lacking.

(iv) *Other Investigations.*—Lack of time or facilities has prevented the active prosecution of other investigations. Some progress has, however, been made in work on black leg of calves, walkabout disease in horses, potability of bore and well waters, onchocerciasis (worm nodules) and internal parasites.

2. *McMaster Laboratory.*—Under the general direction of Dr. I. Clunies Ross, the research work has progressed satisfactorily. For a time the work was handicapped, particularly that in connexion with parasitological investigations, by the absence of an area whereon experimental work on sheep, kept under natural conditions, could be conducted. However, last year, through the kind co-operation of Mr. F. D. McMaster, the donor of the Laboratory, an area of over 300 acres only 20 miles distant from Sydney was secured. This has been subdivided into ten experimental paddocks, each watered from the Sydney main water supply. A description of the area appeared in the Council's Journal (Vol. 6, No. 3, August, 1933).

3. *Pastoral Research Trust.*—The valuable contributions made by the Australian Pastoral Research Trust Ltd. and supplemented by equal grants from the Empire Marketing Board have been continued during the past year. In order to enable the Trust to be in more intimate touch with its supporters, arrangements were made whereby Mr. N. P. Graham, B.V.Sc., was seconded from the Division to that body as its special Veterinary Field Officer. Mr. Graham's head-quarters continue to be the McMaster Laboratory and his services are always available to the Division when not otherwise engaged on his special duties. The arrangement has proved satisfactory for both parties.

4. *Entero-toxaemia of Sheep—(Braxy-like Disease of Western Australia and Pulpy Kidney of Lambs).*—Further work has been done by Dr. H. W. Bennetts in Western Australia and by Mr. D. T. Oxer in Tasmania. An informative article regarding the benefits of vaccination, &c., by Dr. Bennetts has been published in the Council's Journal (Vol. 6, No. 2, May, 1933). Mr. Oxer's researches on the disease in lambs (pulpy kidney) has been published as Pamphlet No. 35. It is unlikely that vaccination of lambs, save in certain stud flocks, where by reason of the nutritional conditions the incidence is apt to be high, will become a routine procedure. In general, attention to preventive measures in flocks will prove satisfactory.

Dr. Bennetts has demonstrated that the vaccine is tolerated by lambs only fourteen days old, so that in certain stud flocks, the lambs of which have been found in the past liable to pulpy kidney disease, it may be practicable to employ this preventive measure. Further work is in progress with the object of determining the duration of the immunity conferred by the routine inoculations practised so extensively in Western Australia with Bennetts' vaccine. There is considerable evidence that a naturally acquired immunity occurs in flocks and this aspect is also being investigated. The fact that whereas pulpy kidney (entero-toxaemia) is of comparatively common occurrence in the lambs of many flocks in different parts of Australia, as well as in other countries, whereas the entero-toxaemia of adult sheep due to the same organism appears to be rare, save in certain parts such as Western Australia, supports the theory of a naturally acquired immunity as the explanation of the latter phenomenon.

5. *Black Disease.*—It is interesting to note that the value of the Turner vaccine, as an adjunct to other prophylactic measures, is now recognized by the Veterinary Branch of the New South Wales Department of Agriculture. Official vaccination continues to be practised in the States of Victoria and Tasmania with successful results.

Experimental laboratory work by Mr. D. Murnane has shown that a very marked loss of pathogenicity in the causal organism (*B. oedematiens*) occurs when cultures are frequently transplanted into artificial media. Prior to ultimate loss, a striking feature is the waxing and the waning of pathogenicity, which is not recovered by animal inoculations. This phenomenon caused some apprehension until fresh strains of the bacillus were secured from sheep outbreaks.

6. *Enzootic Ataxia in Lambs or so-called Gingin Disease (Western Australia).*—A full report of incidence, symptoms and pathological changes, prepared by Dr. Bennetts, was published in the Australian Veterinary Journal (June, 1933). Recent reports show that a disease, which appears to be identical, occurs in South Africa, as well as in parts of Great Britain and in Peru (where it was first studied), and it is understood an affection of lambs on Kangaroo Island, being investigated by the Division of Animal Nutrition, is similar, if not identical, in nature. The cause remains obscure but, for the current season, a series of experiments in Western Australia has been planned which it is hoped may throw some further light on the malady. Meanwhile, it has been demonstrated that the provision of salt and of phosphate licks to the ewes, before and after lambing, has no preventive effect.

7. *Footrot in Sheep.*—As the season was not propitious for the development of this disease, work has largely been in abeyance. Experiments with various organisms, which have been isolated and cultivated artifically, both at the Veterinary Research Institute, Melbourne, by

Mr. Murnane, and at the McMaster Laboratory, Sydney, by Messrs. Carne and Beveridge, are being continued, so far with no very definite results. Several outbreaks of footrot in dairy cattle in Victoria have been investigated by Mr. Murnane, and the cattle disease appears to be closely related to the infection of sheep.

A special report will appear in the November, 1933, issue of the Council's Journal in regard to these experiments and observations.

Mr. Carne's work, in which he is assisted by Mr. W. I. B. Beveridge, is proceeding in close association with that of Mr. Murnane, and is directly concerned with the conditions which predispose to the infection in the field, as well as a thorough study of the pathological changes which occur in the affected feet, and the bacteria associated therewith, particularly the *B. necrophorus*, claimed by American investigators to be the specific cause of footrot, a claim not confirmed by the work of the Division.

8. *Haematuria in Cattle.*—A paper by Dr. L. Bull, Mr. C. G. Dickinson and Mr. A. T. Dann, has been published as Pamphlet No. 33. Valuable scientific data have been secured, but the actual cause of the bladder lesions, which lead to the appearance of blood in the urine of cattle on certain properties, as demonstrated in each State with the exception of Western Australia, remains obscure. Certain top-dressing experiments are in progress on two farms in the Mt. Gambier district of South Australia. These have been arranged with the co-operation of the State Stock Department and the owners, and it is hoped they may throw some light on the perplexing etiology.

An extensive area in Victoria has recently been found to be very seriously affected, so much so that several farmers have had to relinquish dairying. A preliminary soil survey of this area has been made by Mr. J. S. Hosking, of the Council's Division of Soils, the results of which and of his analyses are awaited with interest.

9. *Caseous Lymphadenitis.*—An experiment is under way at "Wambrook", through the courtesy of the Australian Estates and Mortgage Company, to test, under natural conditions, the liability of the disease being spread from discharging abscesses to healthy sheep by flies infecting fresh wounds. Numerous experiments have been carried out with dust from counting-out pens of properties known to be badly affected with the disease. Guinea pigs, which are peculiarly susceptible to minute doses of pus and of culture, have been used. Wounds have been made where they could not be licked or otherwise readily interfered with, and the dust has been applied thereto. In one of the experiments a large number of guinea pigs were so wounded and exposed to continuous dust infection in a counting-out pen (assumed to be in all probability badly infected, because of the large percentage of affected sheep in the flock) for several hours, the dust being kept continuously disturbed. These experiments have been conducted in Adelaide, Melbourne and Sydney by our officers and were outlined by Dr. L. Bull, of Adelaide. In no case did any guinea pig so treated become infected with the disease, caseous lympadenitis. Brief reports were published in the Council's Journal (Vol. 6, No. 2, May, 1933).

While in Victoria experiments with soil from sheep areas, whereon sheep are in the habit of camping on three properties known to be badly infected, have been negative, in South Australia, Dr. Bull and Mr. Dickinson have demonstrated that the soil of such camps may be heavily contaminated. Opportunity has been afforded to study the conditions on one property where the stud flock is badly infected, and where the shearing shed and implements cannot possibly be implicated as the important factor. Arrangements have been made with the owner of this property, who had virtually decided to cease sheep breeding, for Dr. Bull and Mr. Dickinson to carry out an extensive series of experiments and observations, the intention being, if possible, to eliminate the disease from the flock by selecting clean animals, keeping them clean by segregating affected animals, and endeavouring to obtain and maintain clean lambs from them. This has necessitated some extra subdivision of paddocks and implies the treatment of camping grounds, vaccination of lambs, regular manual examination of the glands of all clean sheep, the careful observation of all affected sheep, the cleaning up of paddocks from sharp objects liable to cause wounds, the testing of soils at frequent intervals, &c. &c. An important article on experimental and natural infection by Dr. Bull and Mr. Dickinson appeared in the June issue of the Australian Veterinary Journal, reprints of which are available. As, however, it is rather too technical for the ordinary reader, a shorter article in more popular language, and adding any further information available, will be published later in the Council's quarterly Journal.

10. *Pregnancy Paralysis or Parturient (Twin Lamb) Disease of Ewes.*—The experiments conducted at the special farm near Launceston, under Mr. Oxer, gave negative results. A short account will be published shortly. Unfortunately, the bodily conditions, which were attempted to be produced by artificial feeding, were not attained. Arrangements have been made, however, with the Director of Agriculture of Victoria for a series of experiments to be carried out at Werribee

State Farm next season. It is hoped the results will prove of value, especially as the pasturage conditions there can be made to approximate more closely those occurring naturally and which appear to be intimately associated with the appearance of the disease.

11. *Internal Parasite Investigations.*—A valuable paper elucidating the life history of the common lung worm of sheep (*Dictyocaulus*) by Dr. Kauzal was published in the Australian Veterinary Journal (February, 1933).

(i) *Factors affecting Resistance to Haemonchus (Large Stomach Worm) Infestation.*—Some interesting experimental work by Dr. I. Clunies Ross and Mr. H. McL. Gordon (Walter and Eliza Hall Research Scholar), working at the McMaster Laboratory, has shown that age resistence, or resistance acquired from previous infestations, may be broken down by very adverse nutritional conditions. An account was published in the Australian Veterinary Journal (June, 1933).

(ii) *Hookworm of Sheep.*—The occurrence in Australia was first recorded in 1932 by Mr. H. McL. Gordon. The parasite has been proved to be a most important one in other countries, inducing serious losses. It has been demonstrated to be present in at least five Pasture Protection Board districts in New South Wales, though in one district only two sheep were found affected, each with a single worm. A survey of its extent and distribution is in progress by Dr. G. Kauzal and Mr. N. P. Graham. It is being conducted by routine examinations at the Sydney Abattoir and the Auburn Meatworks, as well as in the field and at country slaughter houses, as occasion permits. A progress report appeared in the Council's Journal (Vol. 6, No. 3, August, 1933). The indications are that so far the infestation is not widespread.

(iii) "*Gundowringa*" (*New South Wales*) *Experiments.*—These experiments, which were conducted with the valuable assistance of Mr. C. E. Prell, and through his generosity in providing land and sheep, as well as other material assistance, have been concluded. The results are extremely valuable, particularly as indicating the importance of proper nutrition in the prevention of serious parasitic invasion. A special report was published in the Council's Journal (Vol. 6, No. 3, February, 1933).

(iv) "*Meteor Downs*" (*Queensland*) *Experiments.*—Certain experiments were conducted last year at "Meteor Downs" in Queensland, and the results were published in the Council's Journal (Vol. 6, No. 3, August, 1933). Owing to last season having been unfavorable for the development of parastic infestation, experimental work on "Meteor Downs" is being continued for another year.

(v) "*Frodsley*" (*Tasmania*) *Experiments.*—A full report appeared in the Council's Journal (Vol. 6, No. 3, August, 1933), regarding last year's experiments and the results obtained. The assistance of Mr. Keith Brodribb, the owner of the property, was of the greatest value.

Notwithstanding the apparent futility of drenching sheep affected with the internal parasites existing at "Gundowringa" and "Frodsley", judging by comparison of body weights, there is some evidence that an improvement was reflected in the quality of the wool produced. Whether this was equal, however, to the cost of medicines and time expended is doubtful, when one is dealing with the special kinds of infestation encountered. In any case, further observations are required before it can be fully accepted that the medicinal treatment, while not resulting in any increase in body weight over those untreated, does result in an improvement of wool quality, assuming sheep are adequately fed. The question of periodical medicinal treatment for parasitic infestation is receiving attention.

12. *Other Investigations in Western Australia.*—Although the investigation of braxy-like disease in sheep, concerning which Dr. Bennetts was originally seconded to the Council by the Department of Agriculture of Western Australia, has been satisfactorily completed, so far as the determination of the specific cause and general means of prevention, which include the application of a special vaccine, is concerned, it has been arranged that the Council shall continue its co-operation with the Western Australian Government in respect to general research on animal health and disease. During the current year this will embrace continuation of the investigations into enzootic ataxia of lambs; botulism in sheep, cattle and horses; and the etiology of the unthriftiness in young sheep. Unthriftiness in Merino lambs and weaners is experienced over considerable areas, and in consequence difficulty is experienced in rearing them. Preliminary investigations indicate that this is associated with a very early and heavy infestation with *Ostertagia* sp. and *Trichostrongylus* sp., in the stomach and in the small intestines, hitherto overlooked because of their relatively small size. Dr. Clunies Ross, the Division's Veterinary Parasitologist, will visit the West shortly and assist in the investigation.

Botulism in sheep, associated with depraved appetite and manifested by the ingestion of rabbit carrion, is common in certain districts of Western Australia at certain seasons. The *Bacillus parabotulinus* has been isolated from such carrion on badly affected properties. A preliminary report by Dr. Bennetts appeared in the Council's Journal (Vol. 6, No. 3, August,

1933), in which the term sarcophagia is used to designate the flesh-chewing habit, differentiating it from osteophagia, the bone-chewing habit. In most cases botulism in domesticated animals is associated with one or the other of these abnormal tastes which in turn are caused by the lack of essential minerals, notably phosphorus in the diet.

Extensive experiments are being arranged and these will be conducted by Dr. Bennetts in conjunction with Dr. Underwood of the Western Australian Department of Agriculture.

Although the Division has assisted only in an advisory capacity in the investigations on Denmark disease in dairy herds, it is gratifying to record that Mr. J. F. Filmer, B.V.Sc., of the Veterinary Division of the Western Australian Department of Agriculture has pursued his investigations with very satisfactory results. He has determined that the disease is definitely of a nature similar to that known as " Bush Sickness " in New Zealand, deemed to be due to a deficiency of iron in the soil and herbage. While it may be prevented by the administration of certain compounds of iron, and affected animals may even recover under treatment, Mr. Filmer's researches indicate that other factors may be of great importance.

13. *Contagious Bovine Mastitis* (*Mammitis*).—As a preliminary to an intensive investigation into this disease, which entails a huge monetary loss annually to the dairying industry of Australia, in common with the industry in most parts of the world, the preparation of a bibliography, containing a précis of the scientific work done in other countries by different investigators, has been prepared by Mr. H. R. Carne, of the Sydney University Veterinary School, in conjunction with Mr. E. Munch-Petersen, M.Sc., Assistant Bacteriologist in the Division of Animal Health. Such a compilation is necessary for the proper consideration of a plan of research, and it will be made available not only to Australian investigators, who it is hoped will be secured and remunerated from funds provided through the Australian Dairy Cattle Research Association, but to investigators in other countries with whom it is necessary ours should maintain close touch.

14. *Poison Plants.*—The northern ironwood (*Erythrophloeum*) has been tested at the Melbourne Laboratory and proved highly toxic for both the horse and the sheep, thus confirming previous observations, so far as the latter is concerned. It is common knowledge, however, that animals reared in ironwood country refuse to partake of the tempting looking leaves even when forcibly starved.

Ragwort (*Senecio jacobaea*) is common in certain parts of Gippsland and is known to produce serious liver changes, followed by death in horses, cattle and sheep in New Zealand, in cattle in Nova Scotia, and in horses in Britain, while other species of the genus have proved pathogenic in Africa and the United States of America. No cases had, however, been encountered in Australia until 1932, when a number of cases, which on clinical and post-mortem examination proved suspicious, occurred. Subsequent feeding experiments at the University Veterinary Research Institute by Mr. Murnane confirmed the diagnosis.

15. *Arthritis in Lambs.*—Outbreaks of a specific type of arthritis occur frequently in Victoria and doubtless also in other States. The infection causes marked lameness and a varying degree of swelling of the affected joints, but is usually not fatal. Affected animals, however, frequently fail to thrive and permanent deformity is not uncommon.

A recent outbreak was investigated by Mr. Murnane. The causal organism which has been isolated and identified appears to be morphologically and culturally identical with the bacillus of swine erysipelas, though clinically no association between the two diseases has been demonstrated. Experimental intravenous inoculation and infection of surface wounds in lambs with cultures of this organism have given positive results. This organism has been described as the causal agent of a similar type of arthritis in lambs by workers in America, England, New Zealand and New South Wales.

Arrangements have been made to obtain strains of this organism from each of the countries mentioned for comparison with the Australian strain. Preliminary work has indicated that a vaccine may prove to be effective as a preventive. It will be tested on a large scale on affected properties.

16. *Rabbit Mortality in North-west New South Wales.*—In 1932 the Pastures Protection Board of the Bourke district submitted reports to the Council regarding a disease of rabbits which, observed first in the far west of the State, had gradually extended eastward. It was considered possible that a determination of the cause, which was certainly not associated with lack of feed, might assist in the mitigation of the rabbit pest.

Accordingly, it was arranged for a preliminary investigation to be made by the Chief of the Division. Unfortunately before he could reach the district, on most properties the mortality had ceased with the advent of rains and the consequent growth of young grass. Nevertheless, on one large station a few cases were found sufficiently soon after death for a satisfactory

post-mortem examination. From these it was determined (*a*) that the animals were almost always in good condition, (*b*) that there were few, if any, symptoms exhibited prior to death, which occurred fairly suddenly without previous struggling, (*c*) that no internal parasites were present, (*d*) that the blood contained no infective agent determinable either by microscopical examination or by blood inoculation into healthy animals, and (*e*) that putrefaction set in much sooner after death than occurred under the same circumstances in rabbits killed by violence (shooting). The general post-mortem appearance of the cadavers, particularly the heart and the kidney, approximated that seen in sheep and lambs dead of entero-toxaemia, and this was confirmed by subsequent microscopical examination of tissues. Facilities did not exist, however, for securing and transmitting to the laboratory intestinal contents for experimental work thereon, though arrangements were made for their collection later on, should the mortality recur. So far the disease seems to have disappeared. Should it recur, every effort will be made to ensure a full investigation, although it is not anticipated the disease could be utilized as a practical means of reducing the extent of the rabbit plague, but in the study of entero-toxaemia generally it may be of importance. It may be noted that inquiries did not lead one to suspect that entero-toxaemia of sheep, as studied by Bennetts and by Oxer, exists on the properties in question, but as they are all of low-carrying capacity (from a sheep to 10 or even 14 acres) the evidence available as to the cause of any losses is not at all conclusive.

17. *Mouse Plague.*—An investigation into a mortality of mice, so numerous in wheat stacks in Victoria in 1932, was made by Mr. D. Murnane. The extremely high mortality and the sudden disappearance of mice when the plague had reached its height (but while there was still an abundance of food) led to the consideration of at least two possible causes (*a*) the effect of the onset of cold and wet weather, and (*b*) the outbreak of a specific infectious disease. In the event of the latter being responsible, it seemed likely that the nature of the disease could be established and the causal organism isolated, and that it might be possible to assist in the control of future plagues by the deliberate dissemination of such disease throughout the mouse infested stacks.

It was found that the mortality was due partly to the onset of cold nights and partly to suffocation in the burrows by overcrowding due to cold. Burrows which normally harbour two to three mice were found packed tightly by upwards of twenty animals, those towards the entrance pushing and crowding inwards so forcibly that the animals in the blind end of the burrow were suffocated. Again, deaths were due to favus ("honeycomb ringworm") which attacks the head in the region of the eyes and mouth to such an extent that the animals are rendered blind or unable to open the jaws, and they eventually die.

Finally, an infectious disease was found to be prevalent, the lesions of which were multiple nodules in the liver. The causal organism was isolated and cultured. It proved to be highly pathogenic for mice.

After a somewhat extensive examination of the organism it has been determined to be *B. enteriditis* Gaertner, one of the food-poisoning organisms of the Salmonella group (the so-called ptomaine poisoning germs) affecting man. This is unfortunate, as it obviously precludes its use in efforts to minimize the mouse plague.

18. *Zebu Cattle Cross-breeding Experiments.*—In 1933 the Council issued a special report prepared by Mr. R. B. Kelley as Pamphlet No. 27 on "Zebu (Brahman) Cross Cattle and their Possibilities in Northern Australia". Mr. Kelley's observations and inquiries indicated that the admixture of Zebu blood with British blood resulted in a type of cattle more resistant to ticks and other skin pests and also to the blood diseases attendant thereon than pure British breeds. The cross breds are able to withstand the heat better than British cattle, and they can subsist on a poorer quality of herbage. They tolerate the heat of the sun better and consequently do not tend to camp together in shady places in the day, a habit that helps to increase tick infestation. The skin of even white-haired Zebus is pigmented, particularly that covering the back and the sides; it is distinctly greasy to the feel; and the hair is much shorter than that of British cattle; all of which are useful in tropical climates as heat resistant factors.

Following the publication of the Council's pamphlet the owners of certain large North Queensland properties requested the Council to arrange for Mr. Kelley to pay another visit to the United States of America in order to select a number of pure bred Zebu male and female cattle to be distributed amongst their various properties and their utilization in a large experiment with different breeds of British cattle according to a scheme to be laid down by Mr. Kelley and to be conducted under his general supervision, particularly in the matters of mating and culling. This was agreed to by the Council, the station-owners bearing the cost of purchase, transport, &c.

As a result of these arrangements, nineteen animals have now been brought to Australia, eighteen of them being pure bred and one a cross-bred bull representing the sixth generation, and containing three-eighths Zebu and five-eighths Shorthorn blood. Briefly the experimental work has for its aim the evolution and fixation on scientific principles of a new type of cattle which it is hoped will prove a valuable aid in the development of the great coastal regions of Northern Australia.

VI. ANIMAL NUTRITION INVESTIGATIONS.

1. *General.*—In the report for 1931–32 the attention of the Council was drawn to the necessity for the co-operation of the agrostologist and soil chemist with the physiologist for the solution of many of the problems of sheep raising and wool production which the Division was attempting. At that time, an agrostologist had just been added to the staff of the Division of Animal Nutrition and a welcome measure of help from the Division of Soils during the year was proving very valuable. Since then, the advantages of the services of a skilled agrostologist have become more apparent in the interpretation of the Division's experiments at some of its field-stations.

During the year the Division has enjoyed an increasing amount of help from the Waite Agricultural Research Institute. To Professor Prescott it is indebted for arrangements whereby a thorough soil survey has been made of the area of Kangaroo Island where its experiments are being carried on; to Professor Richardson for placing the facilities at the Waite Agricultural Research Institute at the disposal of its agrostologist to carry out pot-culture experiments on soils from "Wambanumba", Young, New South Wales; and to Mr. Trumble for friendly co-operation in making similar experiments with soils from Kangaroo Island where the Division is investigating the cause of "Coast Disease".

As will be explained a little later in this report, farmers engaged in sheep raising on the littoral of many parts of southern Australia are beset with troubles. Some of these are directly, others, perhaps, indirectly, due to qualitative deficiencies in the herbage; for one of them a nutritional defect does not appear to be responsible. "Coast Disease" occurs in areas scattered from King Island in Bass Strait to the west coast of Western Australia. The area affected is computed to be thousands of square miles. Although the soils in these parts are not well supplied with plant foods, having an assured and sufficient rainfall they produce a useful amount of herbage. If the precise nature of their defects were understood the way to counteract them would be indicated but to what extent the remedy would be economically practicable will depend on local conditions. How be it, Australia cannot afford to neglect to explore the possibilities of territory with an assured rainfall of upwards of 20 inches.

During the year the experiments at the field station at "Meteor Downs", central Queensland, have been completed and those at "Niawanda", western Victoria, have been reduced in scope. The Division now has but two field stations in operation, one at "Wambanumba", New South Wales, and the other at "Hawk's Nest", Kangaroo Island.

The work which has been carried out at the various field stations, with the co-operation of pastoralists, has been of great value to the Division and has yielded useful information, although not always of the kind which the experiments were planned to elicit. Recent experience of these large-scale observations at field stations at a distance from the central laboratories indicates that they have their usefulness but are not suitable for establishing principles. There are too many variables out of control. Whenever feasible, principles can better be sought for by experiments in the laboratory at Adelaide and at the small experimental station at the Waite Agricultural Research Institute. At both places facilities now exist for experimenting with small numbers of animals under rigidly controlled conditions. The proper functions of observations at field stations are (1) to give greater definition to problems suggested by pastoral experience, and (2) to find out how principles discovered in the laboratory and research station can be applied to practice.

At the close of the year, the Chief of the Division, Sir Charles Martin, resigned in order that he might return to England. He included the following passages in his final report:—

In this, my final report to the Council, I wish to say how much we as a Division owe to our propinquity to the University of Adelaide. Of the material benefits to the Division of the close association existing between it and the University, the Council is well aware. I would stress, however, the spiritual benefits of this association. The advantage to an institution, the ultimate object of which is the application of science to industry, of close communion with the staffs of the scientific departments of a university can hardly be over-estimated.

Lastly, it is my pleasant duty to record my gratitude to Mr. Marston, principal research officer, and my other colleagues in the Division for their loyalty and forbearance. I found a fine scientific spirit amongst them. I have, and I hope they have, enjoyed our work together. I relinquish the Chieftainship of the Division with many regrets but with complete confidence that it will justify its formation by its usefulness and soon be recognized throughout the world as one of the important centres of scientific research in Australia.

2. *Individual Investigations at the Laboratories of the Division.*—(i) *Sulphur Metabolism in Sheep.*—(*a*) *Estimation of Cystine and Cysteine in Grasses and Other Fodder Plants.*—During the year work upon the methods of estimating cystine and cysteine, referred to in the last report, has been continued. Investigations of the phospho-18-tungstic acid colorimetric methods have been published in The Biochemical Journal, Vol. 26 (1932) under the title " The Application of Phospho-18-Tungstic Acid (Folin's Reagent) to the Colormetric Determination of Cysteine, Cystine and Related Substances ". In last year's report it was indicated that attempts to improve Sullivan's method of estimating cystine had not been entirely successful. Since then, however, material improvements have been effected and a modification found which can be used, under prescribed conditions, with a fair guarantee as to the accuracy of the result obtained. An article dealing with the modified method will appear shortly in The Biochemical Journal under the title " Sullivan's Reaction for the Quantitative Estimation of Cysteine and Cystine ".

Having arrived at reasonably accurate methods for estimating cystine and cysteine the efficacy of the usual methods for breaking down the proteins and getting the cystine and cysteine in them into solution was critically examined. Acid hydrolysis was found to be unsuitable for complex materials such as fodders containing much carbohydrate, and the reasons why this preparatory procedure cannot be applied to fodders directly have been ascertained. These investigations will also appear directly in *The Biochemical Journal* under the title " Some Sources of Error in the Estimation of Cysteine and Cystine in Complex Materials when Acid Hydrolysis is Employed ". As a result of them, it has been found that for the estimation of cystine and cysteine in fodders it is necessary either to separate the proteins of the fodder plants prior to analysis or to apply enzymic hydrolysis to them directly. Apparently unaware of the many possibilities of error in their analytical procedures, more than one investigator has come to the conclusion that there is not enough cystine and cysteine in grass, hay, &c., to account for the cystine in the wool grown and that the sheep must possess the ability to synthesize cystine from other sulphur compounds.

A few years ago, before the methods of estimation had been improved, it was concluded that the cystine content of yeast was of the order of 3 per cent. It has recently been redetermined and the cystine calculated from the total disulphide present has been found to be of the order of 0.5 per cent., or about 1 per cent. of the yeast proteins. This result may be on the low side because the carbohydrate content of yeast is fairly high and much " humin " was formed during the preliminary acid hydrolysis. It will be impossible to fix the figure with any accuracy until either the yeast proteins are separated or a total hydrolysis of the yeast by enzymes is achieved.

In the case of grass, acid hydrolysis of the plant is quite inapplicable for reasons given above and separation of the protein is fraught with difficulty. An attempt has therefore been made to hydrolyze the protein in the grass directly with the aid of enzymes. At least 0.3 per cent. of cystine was present in the dried acetone exhausted young leaves of *Cynodon dactylon*—the common couch grass. This grass was utilized in the preliminary studies because of the ease with which it could be obtained in nearly pure growth from the bowling green in close proximity to the laboratory. The amount of cystine found represents about 1.3 per cent. of the crude protein in the grass and would, if 1 kg. of dried grass were consumed each day by the sheep, be sufficient to provide about three times the amount of cystine in the wool grown.

(*b*) *The Influence of Incubation on the Amount of Sulphydryl-Sulphur and Cystine-Sulphur in the Hen's Egg.*—It is generally regarded that cystine or cysteine is essential to the nutrition of the higher animals. This conclusion is based on experiments showing that neither the rat, nor the mouse, nor the dog can synthesize this amino-acid from sulphates, sulphur, sulphides or any of the more complex organic compounds containing sulphur which have, so far, been tried.

A further support to this conclusion is provided by some experiments at the Division during the last couple of years. The hen's egg was chosen because it is a self-contained unit, and during its development there is a mobilization of sulphur to provide the high cystine content of the gram of feathers grown. It was thought that if, as has been suggested, the wool follicles were able to synthesize cystine, the feather follicles would be likely to possess the same capacity.

From some clutches of new-laid eggs, ten pairs of equal weight were selected. The contents of one of each pair, including the egg membrane, was forthwith thrown into alcohol. The other of each pair was incubated. The chicks were hatched out in galley pots covered with mosquito netting. On emergence they were killed and, with their egg membranes and all debris of feathers &c., thrown into alcohol. After extracting with alcohol and ether, the residues of egg and of chick were hydrolysed and the total sulphydryl compounds and combined cystine and cysteine estimated by Lugg's modifications of Folin and Marenzi's and of Sullivan's methods.

A loss both of total sulphydryl compounds and of cystine to the extent of 20 per cent. was found to have occurred during incubation.

(*c*) *The Estimation of Wool Grown over Short Periods.*—The determination of the effect of any modification of nutritive conditions by experiments in the field is a lengthy business. Such experiments are liable to be rendered valueless by the vicissitudes of the Australian climate, and, even when climatic conditions are favorable, observations have to be made on large numbers of sheep to eliminate inherent individual differences in wool production. With large numbers it is not practicable to shear more than once a year.

The rate of wool growth can be estimated by means of the method outlined in a previous report, by collecting the wool grown on areas of about 150 sq. cm. situated on each shoulder. These areas, which occupy a definite anatomical position, are defined by tattooing, and represent approximately 2.5 per cent. of the total wool-bearing surface. The wool grown in ten days on such areas, when the animal is on a fixed diet, has been determined, and it has been found that the variation from time to time for individual animals is but a few per cent.

The method is now being used to ascertain the influence of feeding different materials and in different amounts upon the growth of wool, and for calculating the amount of nitrogen and sulphur stored as wool.

(*d*) *Balance Experiments on the Metabolism of Sulphur in which the Amount of Sulphur Retained in the Wool Grown is Estimated.*—In these studies on wool production the animal is confined in a metabolism cage and given a diet in such amount and of such composition that, while the production of wool fleece is sub-maximal, the requirements of energy and nitrogen of the mature animal are fulfilled and body-weight is maintained without change over lengthy periods. This basal diet, composed of a mixture of chaffed lucerne hay and oaten straw-chaff, is eaten with appetite, and when fed at a level of 1 kg. per day is completely consumed.

The 'crude protein' intake in the series of balance experiments varied somewhat with the different samples of materials fed; the observed variations in different experiments ranged between 62 and 74 gm. per day as inferred by the ingestion of between 9.86 and 10.75 gm. of nitrogen, while the daily intake of sulphur in different sets of matched periods varied between 1.380 and 1.820 gm. This amount of sulphur, had the animal capacity to use it to make cystine, would be enough to provide from 3.5 to 4.5 gm. of this amino-acid per day, or sufficient to produce from 400 to 500 per cent. more wool fleece than was grown in the observed periods.

When 1 gm. of pure crystalline laevo-cystine was added to the daily ration of a sheep receiving 1 kg. of this basal diet, the nitrogen and sulphur balances, which are indications of protein utilization, were favorably influenced, and the animal grew 16 per cent. more wool on the sample areas. A considerable increase of sulphur in the faeces was noticed in those animals receiving free cystine in the dietary indicating that the utilization of the amino-acid was comparatively small. This may be attributable to the conversion by the rumen bacteria of a large proportion of the free cystine to a form which the animal is unable to utilize.

To circumvent the possible destruction of cystine by the rumen bacteria 1 gm. of laevo-cystine in its easily soluble reduced form, cysteine, was subcutaneously injected each day for a period of ten days into the same animal while it was still being fed on the basal diet. The nitrogen and sulphur balance was this time more favorably influenced. The wool growth was increased during the period of injections to 34 per cent. above that grown on the previous basal diet, and in the subsequent three basal periods the measured increase of wool was 30 per cent., 18 per cent. and 7 per cent. above that grown on the basal. It would seem that the animal had stored sufficient of the amino-acid to effectively influence its wool production for at least 30 days after the cysteine injections were discontinued. In this experiment about 65 per cent. of the sulphur in the injected cysteine was accounted for in the extra wool, and 25 per cent. in the excreta.

Another balance experiment, in which 1 gm. of elementary sulphur was added to the basal diet indicated that sulphur fed in this form had no beneficial effect on wool production. The experiment was made as the possibility could not be neglected that sulphur, after being subjected to bacterial action in the intestinal tract of the sheep, might be compounded into some organic substance capable of replacing cystine of the dietary.

(*e*) *The Effect of Adding Sulphur to the Diet of Merino Sheep on their Wool Production.*—The result of the sulphur balance experiment described above is in accordance with observations on groups of sheep which have been carried out at the Division's experimental station at Adelaide during a period of 31 weeks. The animals were shorn and fed on a diet composed of hay and straw-chaff, molasses, some linseed oil and casein. It had previously been found that this diet was more than adequate for maintenance of mature sheep but not for optimum wool production. The sheep were divided into two groups of five, as similar as possible. All animals had the same diet, but those in one group received 2 gm. of flowers of sulphur per day as well. The weights

and well-being of the sheep were recorded. They were shorn after 223 days. The mean weights of greasy wool cut were, for those receiving sulphur 4.5 lb., the others 4.8 lb., from which 2.9 and 3.0 lb. of clean scoured wool was obtained respectively. The addition of sulphur made no difference either to the well-being of the sheep or to the wool they produced. An account of these observations has been prepared and will appear in a forthcoming number of the Journal of the Council for Scientific and Industrial Research, where the divergence between the results obtained in Australia and in South Africa is discussed.

(*f*) *Biological Assay of the Amount of Cystine—Cysteine in Fodders.*—As the chemical separation and estimation of cystine in complex organic materials such as fodders is fraught with so great difficulty, a biological means of assay is being explored. The method consists in comparing the increased growth increment of rats on a cystine-deficient diet which supervenes on the addition of a definite amount of the material to be examined with that of known amounts of l-cystine. The difficulty of supplying the " B " vitamins in a form relatively free from cystine has, however, been encountered. Yeast, which is usually employed for the purpose, while supplying the accessory food factors, added such an amount of cystine to the dietary as to reduce materially the usefulness of the rat-feeding technique for the estimation of this amino-acid. So far, fractionation of the yeast has only partially overcome the difficulty.

(*g*) *Studies on the Polypartite Nature of " B " Vitamin.*—During the course of study of cystine deficiency in rats it has been found that the diet usually employed in the study of B2 avitaminosis is deficient in cystine when the level of intake is lowered by drying the food until it contains about 5 per cent. of water. When this diet contains 20 per cent. of water much more is eaten by the animals and the intake of protein is then sufficient to supply their requirements. Rats fed on the dry diet supplemented with Jansen's B1 concentrate failed to grow and exhibited the symptoms of B2 avitaminosis with surprising regularity, while those offered the wet diet (20 per cent. moisture) grew a little and only occasionally showed any symptoms of dermatitis.

(ii) *Phosphorus Metabolism in Sheep.*—(*a*) *The Concentration and Distribution of Phosphorus in the Blood of Sheep.*—Upwards of 100 observations have been made on the concentration and distribution of phosphorus in the blood of sheep on pasture throughout the year at Glen Osmond, South Australia. About 18.5 mg. P/100 cc. blood was found to be present, of which about 4.5 mg. was inorganic, 4.7 mg. organic acid soluble and 9.2 mg. organic acid insoluble (mainly lipoid). Some observations have also been made on the phosphorus in the blood of sheep in the north-east of South Australia on saltbush (*Atriplex vesicarium*) and on spear grass (*Stipa nitida*). The values were much the same as those obtained near Adelaide except in the inorganic fraction in which 3.8 mg. P/100 cc. was recorded from sheep on good saltbush and 3.1 mg. P/100 cc. from ewes with lambs at foot on spear grass. It is reported that bone chewing occurred in this last area.

The mean values for the organic acid insoluble (lipoid) fraction varied somewhat throughout, probably bearing some relation to the fat metabolism of the animals. In contrast the inorganic phosphorus and organic acid soluble phosphorus fractions have remained fairly constant, though in each case there has been considerable variation between different individuals on the same occasion and in the inorganic fraction sometimes between the same individual on different occasions.

(*b*) *The Renal Excretion of Phosphates by the Sheep.*—It has been found that sheep on Australian pastures do not usually secrete a detectable amount of inorganic phosphates in their urine but that if the concentration in the blood is raised sufficiently, either by starvation or feeding excess in the diet, phosphates are excreted by the kidney. During starvation the rate of secretion is roughly proportional to the concentration in the blood in excess of a threshold value, though subsequently phosphate continued to be secreted at concentrations below this threshold value. Simultaneous analyses have also been made of the blood and urine of sheep in which the concentration of inorganic phosphate in the blood ranged from 2 to 9 mg. P/100 cc. consequent upon varying amounts of easily assimilable phosphorus in the diet. When the concentration of inorganic phosphate in the blood became more than 6.5 mg./100 cc., inorganic phosphate was secreted in the urine.

These experiments, which have been conducted by Mr. Rodger H. Watson, Robert Philp Scholar of the University of Queensland, who has been a scientific guest of the Division during the last eighteen months, show that there is a relatively high renal threshold for inorganic phosphate in the sheep.

(*c*) *The Secretion of Phosphorus in the Saliva of the Sheep.*—The investigations into this subject by Mr. Watson were outlined last year. Since then they have been published in The Australian Journal of Experimental Biology and Medical Science. The phosphorus of the sheep's saliva is almost entirely inorganic. Concentrations of inorganic phosphorus from <5 mg. to >100 mg. P/100 cc. saliva have been observed, but usually from 20–60 mg. P/100 cc. is present.

The concentration of inorganic phosphorus in the saliva is correlated with that in the blood. The ratio between them is found to range from 3 : 1 to 20 : 1, but most values are between 5 : 1 and 8 : 1. Computations indicate that 2.4–7.7 gm. of phosphorus are secreted in the saliva daily. This considerable secretion of phosphorus in the saliva of the sheep suggests that it serves some purpose in digestion. Notwithstanding the large amount of organic acids set free by bacterial fermentation of cellulose in the rumen, the pH of the rumen contents does not usually fall below neutrality. Mangold attributes the regulation to the appropriate addition of alkali by the saliva according to the acid formed by fermentation, but the buffer capacity of phosphate over the range of pH usually found in the rumen is such that the phosphate added simultaneously would very materially assist in the adjustment of reaction.

(*d*) *The Distribution of Calcium and Phosphorus between Blood Plasma and Erythrocytes.*—The work on calcium distribution between the plasma and the formed elements in the blood of various animals, an outline of which was given in the report of last year, has been published in *The Australian Journal of Experimental Biology and Medical Science*, Vol. XI. (1933).

(*e*) *Effect on Young Merino Sheep of a Diet Deficient in Phosphorus but containing an Adequate Amount of Digestible Proteins and those Vitamins which have been shown to be Indispensable to Ruminants.*—Much attention has of late years been directed to the ill effects of pastures which do not contain enough phosphorus, but the fact that insufficiency of proteins is generally associated with lack of phosphorus has received less consideration. For the growing, gestating or lactating wool-sheep, however, a sufficient supply of protein is at least as important and more immediately necessary.

It is common knowledge that as the plant matures the amount of phosphorus and nitrogen diminishes. Quantitative observations for individual fodder-plants have been made in South Africa, in South Australia, in Scotland and in Kenya.

The great improvement obtained in South Africa, in New South Wales, and in Kenya by giving cattle on phosphorus-deficient pastures a supplementary ration of phosphates or adding these to their food, has not been paralleled in the experience of this Division with sheep.

Experiments designed to ascertain to what extent the growth of lambs and the production of wool could be improved by allowing the animals access to phosphatic licks have been carried out by the Division for upwards of two years in two regions where the soil is unusually poor in phosphorus. In both experiments the benefit of phosphatic licks was small in comparison with the improvement which took place in similar lambs on adjoining land which had been top-dressed.

The examination of bones from parts of Australia where the soil is particularly lacking in phosphorus, has afforded information which points to the same conclusion.

It seemed, therefore, that it would be helpful to ascertain what were the effects on the growth, well-being, production of wool and skeletal development of sheep kept for a year or more on a diet containing a minimal quantity of phosphorus, but not, as far as could be arranged, deficient in other respects.

An account of the arrangement of this experiment, which was then in progress, was given in the last report of the Council. Since then, it has been completed and written up with a view to its publication in one of the Council's bulletins, but the results may be briefly summarized here.

After three months on the diet the consumption of food by the animals receiving the phosphorus-deficient diet and their growth rate fell away. The experiment was so arranged that this falling off affected only the amount of straw-chaff eaten, and throughout the fifteen months they were under observation they ate nearly the same amount of proteins and supplements as their companions on the same diet but with more phosphorus, which was given them in the form of pills of dicalcic phosphate. The latter increased 30 per cent. in weight during twelve months, the former 15 per cent. Notwithstanding the difference in weight between the groups, the stature was the same and when, later, the animals were destroyed for examination of their skeletons no difference was found in the length of the long bones. The inorganic phosphorus in the blood of the groups on the small ration of phosphorus soon fell and, at the end of the year, was between 1 and 2 mg. per 100 cc. of blood. In the group receiving an adequate amount of phosphorus it steadily rose until it reached a limit of about 7 mg. per 100 cc. of blood, the average for Divisional sheep being 4.5 mg. The calcium in the two diets was the same and the calcium in the blood of all the groups changed very little.

The average clean scoured wool grown by the lambs in 371 days was, for those receiving an adequate amount of phosphorus 2.9 kg., for those on the diet as deficient of phosphorus as could be contrived 2.87 kg., and for a similar group of lambs on pasture near Adelaide 2.99 kg. While the numbers in each of the various experimental groups was only five, these figures indicate

that deprivation of phosphorus, provided the diet is adequate in other respects, did not, during a period of one year, modify the amount of wool grown. Both groups of pen-fed sheep grew slightly finer wool than those on pasture, the average counts being 64 and 60 respectively.

The effect of phosphorus starvation on the skeleton was to produce an extreme degree of thinning and rarification of the bones and some softening of the reduced amount of bony tissue which existed. This latter was due to their being 20–30 per cent. less mineralized. In only one of the lambs was there obvious rickets, but some or other of the bones of all of them showed, on microscopical examination, the endochondral bone-formation had not been quite perfect.

(*f*) *A New Apparatus for Measuring Gaseous Metabolism.*—In continuation of the studies of animal calorimetry which have been referred to in previous reports, an apparatus has been designed and constructed by means of which the gaseous exchange of a sheep can be measured over 24 hour periods in addition to the determination of the intake of materials by the mouth and their output in the excreta. Such a piece of apparatus is required to allow a carbon balance to be struck, as well as one for nitrogen, phosphorus, sulphur or total energy.

(*g*) *The Effects following the Removal of the Thyroid Gland from Merino Sheep.*—The results of the experimental studies of the symptoms which supervene on thyroidectomy of merino sheep referred to in the last report have been published in The Australian Journal of Experimental Biology and Medical Science, Vol. X. (1932).

(*h*) *Experiments on Longevity.*—The experimental studies of the effect of various substances on the growth of senescence of white mice, which were started in 1929 by Professor Brailsford Robertson and which were explained in previous reports, have now reached completion and the manuscripts of a series of papers have been accepted for publication by The Australian Journal of Experimental Biology and Medical Science. Two of these—"The Effects of Moderate Overdosage of Vitamin D and of Vitamins A + D on the Growth Rate and Longevity of the White Mouse," and "The Influence of Injections of Thorium Oleate in Oleic Acid, and of Oleic Acid Alone, on Growth and Longevity"—have appeared during the year.

(*i*) *Haemoglobin in Healthy Sheep.*—In 1929 a series of samples of blood from Merino sheep that had been grazed on natural grasslands in the proximity of Burra, South Australia, were collected at slaughter and the haemoglobin determined by means of the Bürker method. The mean haemoglobin content of healthy sheep's blood indicated by this series of analyses was 13.6 $\pm$ .129 g. per 100 cc. of blood, with a range from 12.2 to 15.2 g. Hb per 100 cc. This mean is considerably above the usual in the Division's flock of normal healthy Merino sheep which are grazed on the excellent pastures at the Waite Agricultural Research Institute, this latter being about 10.3 g. Hb per 100 cc. of blood for sheep of approximately the same age and breeding.

The immediate practical importance of reaching a conclusion as to the range of variability of haemoglobin in the blood of healthy sheep led to the examination of a further series of blood samples drawn from sheep pastured on saltbush country in the vicinity of Waucharinga, South Australia. The individuals from which these blood samples were drawn had been grazing since birth on dry saltbush, for this district has suffered eleven years of drought. Notwithstanding, the mean haemoglobin was 11.4 gm. per 100 cc. of blood in the young sheep and 12.2 g. per 100 cc. in aged ewes with lambs at foot, and the range of the group examined was between 12.2 and 13.3 g. Hb per 100 cc.—a much higher content than that present in the flock at the Waite Agricultural Research Institute. These latter figures were obtained by Sahli's method after standardizing the instrument by the oxygen method of Van Slyke.

In animals infested by blood-sucking intestinal parasites, the severity of the symptoms depends upon the rapidity of blood regeneration. An experiment is being carried out to ascertain the capacity of the sheep to regenerate its blood by withdrawing definite amounts each day and observing the effect upon the amount of haemoglobin and number and nature of the blood corpuscles per unit volume of blood.

(*j*) *The Toxic Dose of Fluorides for Merino Sheep.*—In the report for 1930–31, reference was made to early experiments by the Division to find out how much fluorine could be ingested daily by sheep over a period of about one year. The investigation was undertaken owing to the increasing use of phosphatic licks compounded of rock phosphate. Sheep were given 14 mg. of fluorine per day in the form present in rock phosphate without apparent detriment to their health or wool production. The quantity administered was reckoned to be twice that which they would obtain by a maximum consumption of lick containing Nauru rock. Recently, however, doubt has arisen as to the accuracy of the estimations of fluorine in Nauru rock phosphate which were given to the Division. Samples analysed at the laboratories of the United States Bureau of Agriculture were found to contain 2.6 per cent. of fluorine instead of .33 to .67 per cent. as we had been led to suppose, and analyses of samples recently made by the Division have

afforded confirmation of the higher figures. In view of this, the indication in the report of 1930–31 that, provided Nauru phosphate is used for the compounding of licks, there is not any danger from fluorine poisoning may require modification.

Experiments are at present in train in which a graduated series of larger doses is administered, but as fluorine is an insidious poison the results will not be available for many months.

(*k*) *The Amount and Composition of Milk Secreted by the Australian Merino.*—There are many observations on the amount of milk produced by milking ewes and analyses of their milk, but not of the wool-sheep. How much energy and materials is transferred from the mother to her offspring in good natural conditions is a piece of fundamental information in the nutritional physiology of the animal. To fill this lacuna in knowledge, attempts are being made during the present lambing season to ascertain the total output of milk by ewes on pasture. The lamb is allowed access to its mother at intervals during the 24 hours. It is weighed on a spring balance immediately before and after each meal. The composition of the milk is being determined on samples milked from these ewes.

3. *Field-Stations*—(i) "*Niawanda*", *near Beaufort, Victoria.*—The investigations which have been taking place at this field station since 1929 were dealt with at some length in the previous report. Top-dressing pastures on this soil, which is low in sulphur and phosphorus, with a mixture of sulphur and rock phosphate was followed by improved growth of herbage and carrying capacity, but sheep pastured on the matured paddock grew no better nor produced more wool than their companions on an adjoining paddock left in its natural state. For the time being, the indirect method of assessing the effect of sulphur manuring by observations on sheep grazed on the pasture has been abandoned and recourse had to the direct one of ascertaining the effect on plant growth.

In May, 1930, twenty movable quadrats were erected on the experimental paddocks with the object of making a series of pasture cuts to determine the effect of S and P_2O_5 manuring on the total yield of herbage and the production of species groups in each cutting period. Eight quadrats were placed on the unmanured area, eight on Paddock B which had received 187 lb. per acre of rock phosphate (70 per cent.)—sulphur mixture in March, 1930, and a further dressing at 1 cwt. per acre in May, 1932, two on natural pasture treated with 1 cwt. per acre of elementary sulphur in May, 1932, and two on an area receiving triple phosphate at the same rate and on the same day.

A series of bi-monthly cuts was commenced on 27th July, 1932. Two samples, each 5 x 4 links in area, were taken within each quadrat. The quadrats were moved after the cuts were made.

The main conclusions to be had from the first year's results are :—

(*a*) The natural pasture was made up largely of native perennial grasses (mainly *Danthonia* spp.) which provide practically all the available green feed in the summer to early spring period. Annual grasses and clovers contributed some 17 per cent. of the total yield in the spring.

(*b*) Sulphur manuring had no effect on the total yield or the production of species groups.

(*c*) Rock phosphate alone did not significantly affect the growth of grass and the effect on legumes was small.

(*d*) Dressing with soluble phosphate had an immediate and pronounced effect on the yield of legumes in the first season. Clovers contributed 40 per cent. of the total yield on 26th November, 1932, on the manured area compared with 7 to 8 per cent. on the untreated. There was no apparent effect on the grass and miscellaneous species in this year.

(*e*) There was a 60 to 70 per cent. increase in total yield of green herbage on Paddock B. This figure corresponds to the increase in sheep carrying-capacity observed by the owner. Legumes contributed 46 per cent., annual grasses 15 per cent., and miscellaneous species 6 per cent of the spring yield. Miscellaneous species (largely *Erodium*) were most prominent in September. The yield of perennial grasses, although reduced to 33 per cent of the total, was not significantly less than that from the unmanured area.

(*f*) The results of the experiments at "Niawanda" are similar to those obtained on top-dressing natural pasture with superphosphate at the Waite Agricultural Research Institute. It is evident from these first year results that the observed response to top-dressing with a mixture of rock phosphate and sulphur in Paddock B was not due to the direct manurial effect of elemental sulphur but to the production of available P_2O_5 in the soil and the consequent stimulation of the leguminous elements present.

(ii) "*Meteor Downs*", *Springsure, Central Queensland.*—The experiments in 1929–30 and 1930–31 showed that a supplement of ½ oz. of protein per day in the form of blood meal resulted in a 38 per cent. increase in wool.

In 1931–32 the effect of a supplement of ½ oz. of protein in the form of yeast was compared with a similar quantity of protein in the form of casein. By the time the lambs were shorn those of both groups had attained the same average weight, but those receiving the proteins of yeast grew 17 per cent. more wool.

In the 1932–33 experiment one group of lambs was given a supplement of ⅔ oz. of protein in the form of linseed meal as long as the pasture was dry, i.e., 9th July to 8th October and 5th November to 19th November. Another group was kept in the same pasture, but without supplement.

As often happens in field experiments, owing to circumstances beyond our control, the 1932–33 experiment was not carried out as originally planned. The summer rainfall had fallen short, and in July, eleven weeks after the experiment had begun, the number of lambs in each group was reduced from 110 to 54 as it was clear that unless unexpected rain fell there would not be enough feed to carry the larger number. Also, the duration of the observations had to be curtailed. Lambing was late and as shearing in this region takes place in February, the average age of the experimental flock at shearing was only 35 weeks. These divergences do not entirely vitiate the experiment, but they seriously reduce its scale.

The statistical analysis of the data for weights of individual sheep at various ages, and their individual wool production, has not been completed. For mixed sexes, the average weight before shearing and the average production of greasy and clean wool in the respective groups was as follows :—

—	Average oz. greasy wool in 35 weeks.	Average oz. clean scour in 35 weeks.	Average weight of lambs before shearing—35 weeks.
			lb.
Pasture alone	58.6	30.5	59.5
Pasture linseed meal—2 oz.	63.0	32.6	62.7

The effect of a supplement of 2 oz. of linseed meal during the nineteen weeks in which the pasture was confined to standing straw was to increase both the live weight and the wool by about 6 per cent.

It is to be regretted that the average age at shearing differs in the investigations over four years. This was unavoidable. Each experiment is complete in itself because it has its own control, but if the experiments over the four years are to be compared it is necessary to compute the wool production for a standard period. This has been done in the results presented in tabular form below for 52 weeks by assuming that the wool grown during the first five weeks of life does not exceed the amount left on at shearing and that after five weeks the rate of growth is uniform. Neither of these assumptions is universally true, but experience indicates that their use affords a fairer basis for comparison than merely adjusting for age. The average age of the lambs when shorn was, in the experiment of 1929–30, 53 weeks ; in the experiment of 1931–32, 47 weeks, and in that of 1932–33, 35 weeks. Five weeks has been subtracted in each case giving 48, 42 and 30 respectively as the period of uniform growth. Computing the wool grown in each case on a basis of 52 weeks of age gives the figures set forth in the table.

AVERAGE WOOL PRODUCED BY 100 LAMBS OF MIXED SEXES IN ONE YEAR (CALCULATED).

—	Supplement.	Oz. Greasy Wool.	Oz. Clean Wool.	Weight at shearing (lb.).
1929–30	½ oz. protein as blood meal ..	109.0	52.8	59.5 } 53 weeks
		79.5	38.2	55.0 }
1931–32 (First 30 weeks had to be hand fed with maize owing to drought)	½ oz. protein as yeast	65.0	34.0	53.0 } 47 weeks
	½ oz. protein as casein	56.0	29.0	50.5 }
1932–33	⅔ oz. protein as linseed during nineteen weeks of the 35	95.0	49.0	62.7 } 35 weeks
		88.5	46.0	59.5 }

Calculated on the basis explained above, the increase in the wool production over a year due to the various supplements would be approximately as follows :—

2 oz. linseed meal, containing $\frac{2}{3}$ oz. protein during dry period only	6 per cent.
Improvement from 1 oz. yeast over $\frac{1}{2}$ oz. casein, both containing $\frac{1}{2}$ oz. of protein	17 per cent.
$\frac{3}{5}$ oz. blood meal, containing $\frac{1}{2}$ oz. of protein	38 per cent.

All the concentrates investigated improved the growth of the lambs, but blood meal was pre-eminent in increasing the wool clip. Added to the protein in the pasture they appear to serve equally for flesh-formation, but differ in their value as material from which to produce wool. Whether it is worth while supplementing the diet of sheep during the dry period in Central Queensland depends upon the respective prices of wool and the concentrate chosen. If the supplementary feeding is to be a commercial success the value of the concentrate must not be assessed merely upon the amount of protein it contains.

The vicissitudes of the climate of Central Queensland during the last few years and its distance from the laboratory have made field experiments at "Meteor Downs" difficult. Nevertheless, valuable information has been obtained. It is thought, however, that work at this field-station should now be suspended, and that further experiments on the value of different supplements for sheep when the pastures are reduced by long dry periods should now be carried out in an area where the climatic conditions are different, and which is, if possible, more accessible.

(iii) "*Dismal Swamp*", *near Mount Gambier, South Australia.*—Observations at this field station had been discontinued at the time the last report was penned. It was indicated, however, that it was proposed to compare the growth and wool production of Mr. Sutton's sheep when transferred to Adelaide.

Thirty ewes were mated at "Dismal Swamp" in February, 1932, and sent to Adelaide in April, 1932. They ran with the Division's breeding flock there until December, by which time their lambs were about twenty weeks old. The lambs from "Dismal Swamp" ewes did not grow as well as those from ewes of the Division's flock at "Urrbrae" (Waite Institute) raised in the same paddock. Although the "Urrbrae" male lambs were 7 per cent. lighter than those of "Dismal Swamp" blood at birth, by twenty weeks of age the former were 11 per cent. heavier. The female lambs from "Urrbrae" ewes were 10 per cent. lighter at birth and 12 per cent. heavier at twenty weeks of age. The growth rate of the lambs of "Dismal Swamp" ewes dropped at "Urrbrae" was identical with those raised on pasture manured with superphosphate at "Dismal Swamp" the previous year. It would appear, therefore, that on top-dressed pasture at "Dismal Swamp" as good growth was attained as this particular strain of Merino is capable of.

The results of the observations made at "Dismal Swamp" during 1929 and 1930 have now been collected and analysed and a succinct report of them and the conclusions to be drawn is being prepared for publication.

(iv) "*Hawk's Nest*", *Kangaroo Island, South Australia.*—Farmers having a certain type of coastal land which extends from King Island, Victoria, to the west of South Australia, and occurs again on the west coast of Western Australia, experience difficulties in raising sheep and cattle. Such land is highly calcareous, and its soil is deficient in plant foods, but, as it has a good rainfall it grows a fair amount of herbage after it is cleared of scrub and still more if cultivated. The area affected is estimated in thousands of square miles.

The general story, dating back 50 years, is that although stock might be fattened upon calcareous country during the spring and early summer, when kept upon it for more than a few months, they became debilitated and died, but if removed to much poorer "ironstone" heath country on the elevations adjoining the calcareous flats they recovered their health but became, from scarcity of food, poor.

The trouble was investigated by the Stock Department of South Australia in 1926. The veterinarians found a heavy infestation with lung worms and stomach worms in the animals they examined, and concluded that this was the cause of the trouble. In 1929, the matter was enquired into by Mr. Sim, of the Waite Agricultural Research Institute, who concluded that the primary cause of the condition was a deficiency of some mineral constituent, probably iron, in the feed available.

In 1929–30, the problem of "Coast Disease" was also attacked by the Division of Animal Nutrition. An area in Kangaroo Island was chosen for the investigation. A geological survey of the area was made by Mr. Thomas, the Division's geologist, and typical fodder plants were also analysed by him. As a result of his observations, and in view of the statement of farmers

that one of the symptoms of " Coast Disease " was brittleness of bones, the investigation of the Division was planned on the provisional assumption that " Coast Disease " was to be attributed to the small amount of phosphorus in the soil, aggravated by the high calcium content. A preliminary experiment in 1930 indicated, indeed, that lack of phosphorus was, at least, one of the causes of trouble.

In April, 1932, a thorough soil survey of the area where the Division's experiments are being conducted and of the surrounding country, and a chemical analysis of the soils, were made by Mr. Hosking, an officer of the Division of Soils. His observations showed that phosphate deficiency was apparent throughout the area, but particularly in the soils of the ironstone plateau, which is the area credited with curing " Coast Disease."

In June, 1932, a vegetation survey of the area where the experiments of the Division are being conducted was undertaken by its agrostologist. No plants known to be poisonous to stock were discovered. Observations were made on the species grazed by stock, and recorded. It is intended to gather samples of these at varying growth stages for chemical analysis. As yet no work has been done along these lines apart from the analysis of " lakeweed " from one of the areas. At present, soils obtained from " coasty " and " ironstone " areas are being studied by the method of pot culture, with the co-operation of members of the staff of the Waite Agricultural Research Institute.

A paddock of " coasty " and healthy country has been manured and sown down to subterranean clover. It is proposed to ascertain whether experimental sheep, which have become sick by grazing on the adjoining paddocks in their natural condition, will recover their health when transferred to these improved pastures, as they undoubtedly do when changed on to the so-called " ironstone " soils.

The Division's first series of experiments in 1930–32 were planned prior to the soil survey. Their object was to determine the effect of licks containing phosphorus in various forms. The results showed that lambs dropped on " coasty " paddocks and kept for upwards of one year, were free from illness and grew as well as lambs from the Division's flock at " Urrbrae " whether they had phosphatic licks or only salt lick. It appears that with light stocking there was just enough phosphorus and other nutriments available. The lambs have been maintained on the same paddocks, half with and half without access to licks containing dicalcic phosphate. The ewe lambs have been mated and are about to drop their lambs. Whether there are enough nutriments in the pasture for breeding and whether inadequacy, if it exists, can be remedied will be determined in the coming season. Records will be made of—(*a*) proportion of lambs dropped; (*b*) survival and growth of lambs; (*c*) health of dams and live weights; and (*d*) amount of wool grown by all the animals. Observations will be continued on amounts of phosphate in their blood up to next October as opportunity affords.

(*a*) *Possible Relationship of a too Exclusive Diet of " Lakeweed " (Selliera radicans) to " Coast Disease."*—On " Hawk's Nest " is a large shallow sheet of brackish water, 2,500 acres in extent, called Murray's Lagoon. Especially during the summer, sheep from the surrounding country congregate on the borders of the lagoon and subsist largely upon " lakeweed " (*Selliera radicans*), a succulent plant which grows luxuriantly there. After a few weeks, many of them shift themselves to the " ironstone " country, but if they do not they become lethargic and, if allowed to remain longer, suffer from so great muscular weakness that there is difficulty in getting them to travel. With still longer sojourn they become so ill that they have to be transported or they die. There are symptoms which are described by farmers as characteristic of " Coast Disease."

In September, 1932, the Division fenced off 25 acres of the lake margin and placed two groups of sheep upon the area in order to make a closer scrutiny of what happened. A proportion of the wethers and of the ewes and their lambs were given pills containing 1 gm. of phosphorus as $CaHPO_4$ every other day. They were weighed fortnightly and all sheep were drenched monthly with carbon tetrachloride to minimize the ravages of stomach worms. The lambs were weaned in January, 1933, and the ewes removed from the experiment. Any ewe becoming sick was removed to a small " ironstone " paddock about 1 mile away. Determinations of the inorganic phosphate in the blood of all sheep were made in the field monthly until January, 1933, and thereafter every two months.

The results to date are as follow :—The wethers, whether receiving pills of $CaHPO_4$ or not, have remained in apparently fair health but have lost in weight during their nine months' sojourn there. The dry ewes remained healthy on the shore of the lagoon for five months; they gained in condition and were growing wool well. The wet ewes became sick after two to three months and were removed from the experiment and placed on the poor " ironstone " country, where they slowly improved. On 17th May, 1933, two lambs already had shown weakness and fallen over when being driven $1\frac{1}{2}$ miles to the weighing shed.

The experimental sheep were placed on the shore of Murray's Lagoon in September, 1932. From October up to the present time the amount of inorganic phosphate in the blood of the wethers, of the lactating ewes, and of some of the lambs have been determined each month. In all cases the inorganic phosphate has been found to be considerably higher than is usual in our flock at Adelaide, indicating that they are not suffering from lack of phosphorus. In those which have been transferred to the poor ironstone ridges surrounding the lake, the inorganic phosphate in their blood has steadily diminished; at the same time they improved in health and vigour, but remained poor.

The following tentative conclusions as to the effect of a diet largely consisting of "lakeweed" may be drawn:—

(*a*) The conditions obtaining on the shore of Murray's Lagoon—where the fodder mainly eaten is "lakeweed" (*Selliera radicans*)—are adverse to the well-being and development of sheep. Growth is poor, but departure from health is not obvious for three to eight months, according to age, sex and previous history.

(*b*) Sick animals improved in strength and vitality within three weeks when changed to a paddock of "ironstone" soil. Other affected animals did not make much progress towards recovery when changed to grass growing on calcareous soil (Hosking's Type 5).

(*c*) The evidence does not show whether the unsuitability of the diet is due to the continuous consumption of something deleterious or to a deficiency.

(*d*) This malady is not due to an insufficiency of phosphate.

(*b*) *Complexity of "Coast Disease."*—So far, the investigations into "Coast Disease" have indicated that the subject is more complex than at first supposed and that the problem has not been sufficiently defined. Everything amiss with cattle or sheep in these areas is consigned by the farmer to the category of "Coast Disease", and it has become obvious that there is a variety of maladies included in the term. These include—

(1) Effects of parasitism in some localities;

(2) An enzootic ataxia, a nervous disease producing inco-ordination of movement, but called "rickets" by the farmer;

(3) A lethargy with muscular weakness affecting animals which may be in apparently good nutritive condition, proceeding to emaciation and death;

(4) Maladies due to various degrees of general and mineral starvation.

(1) is of unequal distribution, depending upon dryness of soil and husbandry. (2) occurs on certain paddocks on "ironstone" country in Kangaroo Island, as well as on the calcareous littoral. It has many resemblances to Gingin disease and a disease of sheep which occurs in Peru in the Andes, 14,000 feet above sea level, and is possibly an infectious disease or due to slow poisoning by some plant. (3) as far as known, is peculiar to the coast and is remedied by a few weeks' sojourn on the poor heath country; (4) occurs on both types of country.

Recently the Division was able to obtain cases of ataxia from Kangaroo Island, and brought three to the laboratory, where their symptoms were closely observed. After three weeks, one had recovered but in the other two the disease progressed until the animals could not rise, although they could still eat. These two were slaughtered and their nervous systems have been examined by appropriate histological methods and show extensive degeneration of nerve fibres. An emulsion of the cord of one was inoculated into the brain of a normal lamb by Dr. Bull to see whether it may, perchance, be a virus disease. The lamb was kept under observation for a month, but remained in health.

Knowledge of the nature of these various maladies must at first be gained before their causation and possible interdependence can be understood. To acquire this knowledge it is very desirable to secure the co-operation of veterinarian, agrostologist and soils chemist.

Although it will be clear, from the preceding paragraphs, that a good deal of co-operative effort has already been focussed on the problem, to ensure the continuation and extension of collaboration between investigators trained in different departments of scientific inquiry, the future direction of researches into the nature and causation of "Coast Disease" has been entrusted by the Council to a Committee composed of Dr. Gilruth and Mr. Dickinson of the Division of Animal Health, Dr. Bull, Director of the Pathological Laboratory at the Adelaide Hospital, Mr. Macindoe, representing the Stock Department of South Australia, together with Professor Prescott of the Division of Soils, and Sir Charles Martin and Mr. Marston from the Division of Animal Nutrition. This Committee has decided to continue the programme at present being carried out by the Division of Animal Nutrition, and has made arrangements for studying the enzootic ataxia upon two properties where it occurred last year. One of these properties is in

the centre of Kangaroo Island on "ironstone" country, the other on the Cretaceous soils of the littoral. The Committee also hopes to be able, with the help of the Stock Department of South Australia, to have a survey made of the incidence in South Australia of the different diseases included in the term "Coast Disease".

(v) "*Wambanumba*," *Young, New South Wales.*—The study of the effects of top-dressing natural pastures at "Wambanumba," which was referred to in 1931–32 report, was continued until the experimental animals were shorn in October, 1932. The differences in productivity of the areas treated were maintained; the growth of herbage and consequent carrying-capacity of the pasture dressed with rock phosphate + sulphur mixture was much superior to either that of the area treated with soluble phosphate and nitrogen or that of the unmanured control paddock. Furthermore, it would appear that the nutritive quality of the herbage grown on the P + S area was enhanced by the manurial treatment, for the animals grazed on it continued to maintain their superiority in body-weight and fleece production above that of similar groups on the other areas, although the stocking of the P + S area was kept considerably above that of the other areas. The number of animals grazed on all the other areas was purposely reduced so as to allow a superabundance of herbage to be continually available to the animals.

The 1931–32 wool-clip yielded the following information :—

Sheep on.	Mean Greasy Wool.	Mean Clean Scoured Wool.	Mean Yield of Clean Wool.
	Oz.	Oz.	%
P + S area	159 ± 1.48	90.2 ± .96	57
Unmanured area	143 ± 1.68	80.0 ± .91	56
P + N area	147 ± 1.62	82.0 ± .83	56

As the response to the treatment of these natural pastures with rock phosphate + sulphur mixture was far superior to that after simultaneous treatment of an adjacent area with soluble phosphate + nitrogen, it appeared that either sulphur was a limiting factor to the growth of desirable fodder species, or that, with this particular soil, the gradual addition of soluble phosphate, due to the slow decomposition of rock phosphate by the SO_4 formed, was a superior method of phosphate manuring than adding a corresponding quantity of soluble phosphates in the form of "super" at one time. The soil at "Wambanumba" is short of both phosphate and sulphur and, to discriminate between the possibilities mentioned above, experiments are being conducted this year to ascertain the effect of each constituent of the mixture applied separately.

The area which had been previously dressed with soluble phosphate and nitrogen has been divided longitudinally into two paddocks, each of 44 acres. One of these has received 118 lb. per acre of a mixture of 70 per cent. rock phosphate and 30 per cent. sulphur, while the other has been treated with an equivalent amount of rock phosphate (82 lb. per acre). The adjacent unmanured area, which acted as a control paddock in the first experiment, has, likewise, been divided into two 44-acre areas, one of which has been dressed with 35.4 lb. of sulphur per acre, an amount equivalent to that applied to the P + S area, the other being left as an untreated control. The area of 88 acres which has been dressed with rock phosphate + sulphur mixture three years previously was not further treated; the observations on the carrying-capacity and growth of lambs grazed on it will be continued for two further years so that the persistence of this manurial treatment may be gauged.

Fifty ewes with ewe lambs have been placed on each of the five areas, and their growth and wool production will be used, as previously, to indicate the effectiveness of the manurial treatments. In addition to this, the change in quality, quantity and botanical composition of the pasture which supervenes on the various manurial treatments will be measured by means of bi-monthly cuts of fenced movable quadrats distributed at random over each area. This latter investigation will be carried out by the Division's agrostologist. By the courtesy of the Director, facilities at the Waite Agricultural Research Institute have been afforded to the agrostologist of the Division to further complement the investigation by observations on the effect of the above manurial treatments when applied to "Wambanumba" soil in pots.

4. *Mineral Content of Pastures.*—A series of investigations relating to the mineral content of pastures has been carried out as a co-operative enterprize by the Empire Marketing Board, the University of Adelaide, and the Council, the work being centred at the Waite Agricultural Research Institute. The original objectives, as approved by the Empire Marketing Board,

included the composition of pastures in mineral deficient areas, the role of phosphorus in pasture production, factors affecting the water requirement of pasture plants, and the determination of the most economic methods of alleviating mineral deficiencies.

The five-year programme carried out by the co-operating parties was completed in July, 1932. A report of this work, together with a list of individual papers prepared, has been published in the Journal of the Council (Vol. 5, No. 3, August, 1932). The work was extended for a further period of twelve months pending the determination of British Government policy regarding the Empire Marketing Board. Much information of fundamental and general interest to workers associated with grassland problems in other parts of the Empire, and in particular where rainfall limits production from pastures, has been obtained. The results obtained have also acted as a stimulus to pasture research in Australia.

The investigations have shown that while the environment exerts an important influence on the mineral content of each plant species, there is a limit to the ability of plants to make use of available mineral nutrients, a limit imposed by the nature of the species itself. It has been shown that the most economic method of overcoming the mineral deficiency problem on arable land in regions of moderate rainfall is to replace the " natural " pasture with perennial species and strains adapted to the soil and climate, and to maintain their productivity by appropriate methods of pasture management. For these reasons work on pure species, strain variation within the species, and pasture management in representative regions of the winter rainfall zone have been regarded as an essential part of the mineral deficiency investigations.

Considerable progress has been made in the production of strains of *Phalaris tuberosa* and perennial rye grass adapted to areas of moderate rainfall, and in determining the conditions for the establishment and management of permanent pastures in the winter rainfall regions of Australia.

Physiological studies are in progress of the external and internal factors governing the intake of mineral ions, and the part played by these ions in regulating metabolism, growth and development of the plant. A special study has been made of the fundamental nature of the parts played by nitrogen and phosphorus in determining growth rate and water requirement, and of the inter-relationships between these two elements in the plant. Twenty-one papers dealing with various phases of the investigations have been published.

VII.—SOIL INVESTIGATIONS.

1. *General.*—The Division of Soils is located in the Melrose and Darling Laboratories of the Waite Agricultural Research Institute under a co-operative agreement with the University of Adelaide. The main objects of the Council's soils investigations are 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 regarding 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.

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.

Recent examples of this have included a soil survey of the bed of Lake Albert at the mouth of the Murray, where conditions for successful development were proved to be unfavorable, and a survey of portion of the " ninety mile desert " of sandhill and heath country near the Victorian-South Australian border west of Bordertown, where the nature of the soil problems associated with more intensive exploitation have been accurately defined.

2. *Soil Surveys.*—The work of the Division has been directed primarily to investigations of the more closely settled and more valuable lands, namely, the irrigation settlements. The task of surveying is divided into convenient units, each capable of being covered by a field party in the course of six months or less.

With each survey unit a chemical group is usually associated, and working agreements to this end have been concluded with the Director of the State Chemical Laboratory in Victoria and with the Chief Chemist of the New South Wales Department of Agriculture. The co-operation of the Victorian chemists in connexion with work in the Victorian settlements during the year is warmly acknowledged.

The completion of these surveys in the irrigation areas may be considered to be a settled policy of the Division, but attention has also been directed to surveys of a more extensive character in non-irrigated areas. Since the beginning of this work in 1927 the total areas surveyed have been :—

	Square Miles.
River Murray settlements	87
Murrumbidgee areas (heavy soils only)	150
Tasmania—King Island (reconnaissance survey)	425
Other areas	40
South Australia—Non-irrigated areas	457
Bed of Lake Albert	54
Western Australia—Gingin area	23
Total	1,236

It is anticipated that more intensive work in the Murrumbidgee areas will be undertaken during the year 1933–1934.

It will be seen that all States except Queensland and the Northern Territory have received some degree of attention from field parties of the Division.

During the year under review field work was conducted principally in the following localities :—

	Acres.
Irrigation areas at Berri and Barmera, South Australia ..	13,600
Apple orchards at Huonville, Tasmania	1,500
Frodsley Estate, Tasmania	5,000
Christmas Hills and Brickmakers, Smithton, Tasmania ..	15,400
Gingin, Western Australia	14,700

During the year the report on the work carried out in the irrigation settlements near Swan Hill, Victoria, was published as Bulletin 73 of the Council; five new soil types were defined and named; the Tatchera sand, the Tatchera sandy loam, the Tyntynder sand, the Vinifera loam and the Nyah clay loam. Messrs. Marshall and Penman have described four further types, the Murrabit clay, the Benjeroop clay, the Bungunyah clay and the Koraleigh sandy loam associated with alluvial flats in the Swan Hill district.

The laboratory work associated with the survey of the Hundreds of Laffer and Willalooka mentioned in the last report has been completed and a report prepared for publication under the editorship of Mr. J. K. Taylor. This area of 310 square miles of virgin country is representative of 10,800 square miles of so-called "desert" country or "sandhills with heath" in South Australia and Victoria, stretching from the Coorong to the 142nd meridian and bounded on the north by the Pinnaroo-Ouyen belt of mallee and on the south by the grazing areas of the western Wimmera and of the south-east of South Australia. Three very distinct soil types in this country have been named :—the Laffer sand, the Willalooka sand and the Monkoora sand. With these types are associated extensive areas of sand ridge country and swamp formation as well as other minor types. The soils are all characterized by an exceedingly low content of phosphate in the neighbourhood of 0.005 per cent. acid soluble P_2O_5. In the past, only very extensive exploitation of this country has been practicable and the surveys afford a rational basis for future development. The Laffer sand is the type most suitable for immediate attention while the Willalooka sand is probably worthy of experimental investigation from a crop production point of view.

In the irrigation areas attention has been concentrated on the group of settlements centred round Berri and Barmera in South Australia. To the end of the year 13,600 acres had been surveyed and twelve soil types recognized of which four were new major types and three of minor occurrence. The laboratory work has been begun, while the field investigations and mapping are expected to be completed in July, 1933.

In the Murrumbidgee irrigation areas, Mr. H. N. England has been seconded to the Water Conservation and Irrigation Commission for work on water-logging problems under the direction of Mr. F. K. Watson. Laboratory work on soils of the area has been carried out by Mr. A. Howard, who has concentrated his attention on certain aspects of the study of the heavy rice soils and on the rate of nitrification in the permanent citrus orchard of the Griffith Research Station devoted to the investigation of effects of green manuring.

The formal soil survey of these areas will in future be directed from head-quarters at the Waite Institute with the co-operation of the Chemists' Branch of the New South Wales Department of Agriculture.

The results of investigations carried out by Mr. C. G. Stephens into soil conditions controlling the establishment and growth of exotic conifers, notably *Pinus radiata*, in Tasmania have been published in the Council's Journal; a marked degree of correlation between degree of soil acidity and poorness of growth has been established. The programme of work in Tasmania has included soil surveys in the Huonville district, as part of a general reconnaissance of the apple-growing soils of the State; a survey of the soil conditions of the Frodsley estate near Fingal and a survey for the Forests Department of areas near Smithton—notably some 24 square miles in the Christmas Hills district. Information is rapidly being accumulated to enable a general soil map of Tasmania to be constructed, as well as an understanding of the lime status of the more important of the soil types.

Mr. J. S. Hosking has continued his studies on soils associated with pastoral problems. A very complete report on the soils of the "Hawk's Nest" field station has been prepared for the Division of Animal Nutrition. A field examination has been made of the Gingin area of Western Australia associated with an ataxia of lambs and laboratory work on these soils is in progress. A report preparatory to investigations into soils of the Denmark district of the same State has been prepared. In this work the co-operation of the Western Australian Department of Agriculture is to be warmly acknowledged and it is hoped that more active co-operation will be possible in the near future.

Professor Prescott and Mr. C. S. Piper of the University staff have completed an examination of representative soils from the mallee areas of South Australia. The samples examined included a number collected by the State Lands Department in the course of classification as well as special type samples collected by the Division. In all, 328 samples were examined from 148 sites; nineteen complete profiles were also examined for the most important characteristic data.

Miss P. M. Rountree has completed her studies on the bacteriological oxidation of sulphur in the Renmark clay loam. An organism of the *Thiobacillus* group, which appears to be widely distributed in South Australia, has been isolated. Under favorable moisture conditions (60–70 per cent. saturation) the organism oxidizes sulphur extremely rapidly, a change in the soil reaction from pH 8.4 to pH 4.5 having been noted in twelve days. Field plots to test the effect of sulphur under natural conditions have been laid down in irrigated vineyards at Berri, South Australia and Merbein, Victoria.

Mr. H. G. Poole resigned in November, 1932, to continue his chemical studies at University College, London. Prior to leaving he carried out the bulk of the laboratory work on the soils of the Willalooka-Laffer survey and completed an examination of representative Australian soils from the point of view of the single values known as moisture equivalent and sticky point. Both these values are of importance in soil moisture studies and in soil survey work as rapid estimates of texture. Professor Prescott and Mr. Poole have prepared for publication a paper on the correlations between mechanical analyses and these two single values. The body of data on which these correlations are based has been deposited with the Imperial Bureau of Soil Science.

Mr. A. Walkley has been appointed to the vacancy created by Mr. Poole's resignation.

VIII.—IRRIGATION SETTLEMENT INVESTIGATIONS.

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

1. *General.*—The major investigations undertaken at this Station are associated with problems arising from the irrigation of the land and the treatment of the vine and its product. At the request of the dried fruit industry, administrative work, in initiating improvements in routine practices, is also undertaken in cases where the results of the investigations show the need for alterations in existing conditions. The general nature of the work of the Station has changed in recent years. Previously, relatively short-dated investigations dealing with such questions as the processing of the fruit, storage and transport in relation to entomological pests,

and the treatment of vineyard pests, were considered of greatest urgency. These investigations have now reached the stage where recommendations to producers have been made and improvement in production and processing practices brought about. The present trend of work is towards long-dated investigations of major problems which have confronted the dried fruits industry since its establishment many years ago. These include the method of irrigation as affecting the continued productivity of the land; the incidence of injurious salts as related to soil type and irrigation practice; agricultural drainage; the periodicity of irrigation in relation to the soil vine group; and an examination of pruning and manuring practices in relation to the nutrition of the vine.

2. *Irrigation Problems*—(i) *Method of Irrigation.*—The inquiry into methods of application is of primary importance, since it has been established that there is an intimate relation between the continued productivity of the land and the quantity of irrigation water applied. Investigations disclose a general tendency to apply irrigation water too copiously, with the result that portions of the irrigated settlements are becoming wholly or partially unproductive. It has been found practicable to determine, by a study of "penetration" profiles, the minimum efficient quantity of irrigation water; and the investigations have now reached the stage where service trials are in progress on selected sites representing major soil types.

(ii) *Periodicity of Irrigation.*—A study of soil moisture changes during the inter-irrigation period is being continued and extended to include the determination of the effective penetration of soil moisture, seasonal "loss of moisture" curves, and the quantities of, and the periods for, irrigation water necessary to maintain satisfactory conditions for plant growth.

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

(iv) *Agricultural Drainage.*—The investigation of this problem is in the preliminary stages, being limited chiefly to a survey of existing conditions. An examination of the subsoil on selected sites in the Mildura district (Victoria) and the Berri, Barmera and Waikerie districts (South Australia) has shown that free water in excessive quantities exists over wide tracts. The work for the immediate future will consist of an examination of drainage methods to remove the free soil water, and of the extent to which relief may be secured by a modification of irrigation practices.

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

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

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

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

(ii) *Investigation in the Nyah-Woorinen District.*—The staff of the Merbein Station co-operate with the local " Research Committee " in investigations of local problems. A report of two years' work has recently been submitted and provision made for continuation. The investigations are carried out conjointly by Mr. F. Penman, Department of Agriculture, Victoria, and the staff of the Merbein Station.

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

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

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

In reference to production, the rate of improvement in yield may be considered satisfactory, with further advancement probable. The 1933 harvest was a record for average acreage yield throughout Australia, and may be ascribed to a favorable season together with the more general adoption of improved practices.

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

It may now be said that the transition stage has been reached, when settlers are changing from the wasteful and damaging methods associated with the over-use of water to a nearer approach to the minimum efficient quantities

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

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

The recent marked increase in citrus production, combined with prevailing low prices, has emphasized the value of the Station in meeting difficulties in production and marketing, and in reducing production costs generally. The establishment of the Station in 1924 was opportune in that it coincided with a marked increase in citrus growing in Australia. During the nine-year period since the Station's establishment the average annual output of the industry has increased by nearly 50 per cent. and the annual value of its production now approximates £2,000,000. The Murrumbidgee Irrigation Area is now the chief district in the Commonwealth for the production of Navel oranges.

As indicated in previous reports, the work of the Station includes a comprehensive study of green manuring, fertilizer applications, soil moisture conditions and various cultural practices on an irrigated area of about 28 acres of oranges. Certain features of this work extended to other farms on the area, where studies under varying soil and tree conditions are of value. More recently, greater attention has been paid to fundamental problems, such as climatic influence on plant growth, methods of irrigation, and cool storage of fruit, and this work will be of valuable application to the horticultural industry generally.

2. *Green Manuring.*—Green manurial experiments extending over eight years have shown that tick beans have effected the striking increase of 33 per cent. in the yields of oranges. The cultivation of this winter legume has now become a standard practice on citrus groves in the district, and increased annual returns to the grower must amount to several thousands of pounds sterling. Owing to the local demand for tick bean seed, tests are being conducted to determine the practicability of raising seed locally and thus reducing the cost to the grower. Green manurial investigations have been extended to test out other winter crops, which may be either cheaper or more easily grown than tick beans. To obtain information of a more fundamental nature regarding green manurial treatment, weekly determinations of the fluctuations in soil nitrates in treated and non-treated plots have been commenced.

3. *Fertilizer Experiments.*—The extensive fertilizer experiments carried out at the Research Station are important, in that they show that no commercial advantage is derived from the use of artificial fertilizers on young trees grown under the soil conditions typical of the Station. Experiments conducted on mature groves, however, indicate that older trees show a marked response to nitrogenous fertilizers.

4. *Alternate Cropping of Valencia Oranges.*—The objectionable alternate cropping habit of Valencia oranges, characterized by a troublesome over-production in one year followed by a scanty crop in the next, is being investigated in co-operation with the Division of Plant Industry. Tests of more intensive remedial measures, suggested by preliminary work last year, are in progress.

5. *Cool Storage of Citrus Fruits.*—The expansion of the citrus industry, previously referred to, has demanded greater attention to export marketing problems, particularly cool storage. The great bulk of Australia's citrus exports are derived from the Griffith district, and the Research Station is, therefore, in a particularly favorable position to study many important features associated with export marketing problems. Extensive cold storage tests with oranges are being carried out by the Station on behalf of the Citrus Preservation Committee, the activities of which are described in another part of this report. In this work very useful assistance is being received from the Griffith Producers Co-operative Company Ltd., which has made available cold storage facilities.

6. *Soil Problems.*—Co-operation with the Division of Soils has been maintained as in former years. Work on soil moisture relationships, which was outlined in last year's report, has received more detailed treatment in a Bulletin by Mr. E. S. West, to be issued in the near future. This work has been extended, and two new soil columns for water table, salt studies, &c., are being constructed.

7. *Methods of Irrigation.*—Much of the earlier work of the Station on the root distribution of citrus and other plants, and optimum soil moisture conditions for their growth, has been of great value as a guide for the proper watering of orchards. The potential danger of great damage to orchards by excessive salt accumulation, seepage, water-logging, &c., due mostly to faulty application of irrigation water, is ever present on most irrigation areas, and unless active precautionary steps are taken, it becomes more serious as the settlement proceeds. As a result of previous work at the Research Station, however, the importance of care in applying irrigation water is now generally recognized, and the serious losses occasioned by the dying out of orchards have been greatly reduced. The earlier work of the Station on soil moisture conditions has been particularly valuable in this connexion. The Station is now concentrating on investigations to determine the best methods of irrigating soils under varying conditions of texture and slope. Prelininary work has indicated that in addition to obtaining an improvement on present rule of thumb methods of irrigating, a useful guide in laying out new irrigation areas will be available.

IX. FOREST PRODUCTS INVESTIGATIONS.

1. *General.*—Though none of the major investigations of the Division of Forest Products were brought to completion during the year 1932–33, all the main lines of work progressed satisfactorily, and in many directions it was found practicable to utilize the results obtained for the benefit of various sections of the timber industry. The field of influence of the Division has continued to extend rapidly, not only within the Commonwealth, but also beyond its borders. In addition to regular and close co-operation with timber research institutions in the Empire

and the United States of America, contacts have now been established with workers in Holland, Germany, Soviet Russia, the Argentine Republic, Japan and China. Several of the Division's publications have been reprinted in foreign timber journals, and the Division has now established for itself a recognized place among the forest products research institutions of the world.

During the year 1932–33, in addition to numerous requests for advice received from correspondents, officers of the Division attended to over 1,000 personal inquiries made either by visitors to the laboratories or to officers of the Division when on visits of inspection to mills and factories. In the course of this work a great deal of valuable information has been collected, indexed on cards and made available to the staff by means of a well-designed system of records.

In the course of the year seven trade circulars and three pamphlets were published and six articles were contributed by the Division to the Council's quarterly Journal. The demand for trade circulars has increased steadily. First issues of 2,500 have been exhausted and later issues of 4,000 proved inadequate. For future numbers 6,000 copies will be printed. Many of these circulars are reprinted in trade journals. The Monthly News Bulletin issued by the Division has proved to be very popular and has brought many country firms into touch with the Division's operations. The Bulletin is circulated to foresters, timber merchants and sawmillers and to about 160 newspapers and trade journals which generally reprint part or all of the articles.

Lectures and publicity addresses to sawmillers' associations and other bodies have been given in New South Wales, Victoria, Queensland and Tasmania, and three addresses by members of the staff have been broadcast. A series of lectures on forest products research was given to 70 forestry officers in connexion with a " refresher " course arranged by the Forests Commission of Victoria.

2. *Wood Preservation.*—Owing to the demands of industry the work of the Section of Wood Preservation under Mr. J. E. Cummins has increased substantially. Provision was made in the annual programme for no less than 26 projects. Work has been carried out on 21 of them, and it has been found necessary to add six further projects. The number of inquiries and interviews increased to 222 for the year. The Section works in close co-operation with the Postmaster-General's Department, the Victorian Electricity Commission, the Forest Services of the six States, the Railways and Public Works Departments, the Western Australian State Saw Mills and a number of private companies.

In connexion with the preservation of timber a large amount of work has been done on Australian commercial creosotes, and a tentative standard specification has been issued (Pamphlet No. 24). The use of creosote as a preservative has received wide recognition by various Governmental or private bodies. The Postmaster-General's Department and certain of the State Government Departments have adopted it as a standard treatment for posts and poles, and recently tenders were called for 200,000 gallons of creosote to be supplied in accordance with a specification issued by the Division. The Postmaster-General's Department has installed open-tank treatment plants at Sydney and Adelaide, and contemplates installing others. The Victorian Electricity Commission has also installed a plant for creosote treatment of bed and stay logs.

The field tests of various methods of treating cross-arms, sleepers, fence posts and poles are proceeding satisfactorily. The tests of cross-arms of powellized, fluarized and untreated karri (*Euc. diversicolor*) and untreated stringybark (*Euc. obliqua*) have been in progress for three and a half years at Belgrave (Victoria) and for three years at Canberra. Some of the untreated pieces have been destroyed and others attacked. This test will give very definite information in the course of the next few years. Inspections have been made of 3,000 fluarized karri sleepers installed in Western Australia in 1929. Though a number of the controls were showing decay, all of the treated sleepers were sound. Inspection of fence posts showed that already definite results are becoming evident. The creosote oil, and zinc chloride plus white arsenic treatments are entirely satisfactory. Sodium fluoride plus white arsenic treatment is satisfactory in the drier districts, but not in the higher rainfall areas. Posts treated in other ways are all showing signs of both termite and rot attack, while the untreated controls are deteriorating rapidly.

A comprehensive set of tests of methods of treating poles of *Euc. obliqua* has been initiated at two places in Victoria, one where termite attack is bad and one where rot is prevalent. Piles of *Euc. pilularis*, *Euc. saligna* and *Tristania conferta* have been treated with creosote and placed in the Brisbane River where teredo and other marine organisms are active. After less than one year the controls are badly attacked, but none of the treated piles show any damage.

An investigation into the durability of Australian timbers against termites is being carried out in co-operation with the Division of Economic Entomology. Further field tests have been postponed pending the completion of investigations into a satisfactory method of technique. These investigations are nearing completion, and by the use of standard termite colonies in jars it will be possible to get rapid results of a directly comparable nature.

Further progress has been made in the investigations on both pressure and open-tank methods for the preservation of Australian timbers. A beginning has been made in a comprehensive plan of work on the relationship between infestation by the powder post borer (*Lyctus brunneus*) and the condition of the timber.

3. *Timber Seasoning.*—The adoption by saw-millers of kiln seasoning continued to expand during the year 1932–33. There are now in Australia no fewer than 82 kiln installations with a total of 202 kilns. Of the former number, 28 installations have been erected on plans prepared by officers of the Section (of which Mr. C. S. Elliot is in charge) and many others on plans approved by them. The favorable position has now been reached at which there is practically no kiln installation erected without the advice of the Section. Many installations of inferior design or of extravagant cost, erected in past years, have failed, and this seriously delayed the development of kiln drying in Australia. By numerous visits to timber yards, lectures to merchants and millers in every State, newspaper articles, trade circulars, and, above all, by the successful operation of kilns designed by the Division's officers, the Australian timber industry is now convinced of the importance of kiln drying.

The treatment of " collapsed " timber is perhaps of greater significance than any other phase of seasoning in so far as some of the most important Australian timbers are concerned, and although reconditioning of timbers prone to collapse is now becoming the general practice there are many problems in this connexion still awaiting solution. For example, it is frequently found that some boards do not recondition well. Further, the time taken in large plants is much longer than in the experimental plant. The optimum point at which to recondition has yet to be determined. The effects of different drying methods on collapse are not properly understood. All these and allied problems are being attacked experimentally, and the results checked in the commercial kilns of the Victorian Forests Commission at Newport, Melbourne.

Kiln drying schedules have been worked out for a number of timbers, and the results will be published at an early date. Small scale tests have been completed on the possibility of expediting the preliminary air-drying of timber during the winter months by the use of fans to promote a definite circulation through the air-seasoning stacks. The results are to be tried out on a full-size scale.

There have been considerable developments in the use of the " Blinker " electrical moisture meter, and this instrument is now in common use by the timber trade. Two trial shipments of kiln-dried flooring were sent to England, and with the co-operation of the Forest Products Research Laboratory at Princes Risborough were examined for change in moisture content during the voyage. Only one report has so far been received, and this indicates that very little change occurs. The Section continues to co-operate with the Vancouver branch of the Canadian Forest Products Laboratory in similar shipments from Canada to Australia.

4. *Utilization.*—During the year 1932–33 the work of the Utilization Section under Mr. R. F. Turnbull was devoted particularly to the investigation of broad problems requiring field research. A great deal of time was devoted to the important matter of timber standards. A valuable development in the direction of establishing definite grading rules was made by a co-operative field study of such rules for Western Australian timbers. This work took six months and necessitated the detailed examination of 35,000 pieces of timber and the analysis of the observations. The study has shown how important it is to supplement " round-table " grading rules by field studies. The former are likely to lead to such serious errors that the rules could not be applied in practice. The results have been published in the Council's Pamphlet No. 41. The rules finally prepared suggest a much more satisfactory basis for supply than any others, and it is anticipated that they will form the foundation on which uniform standards of quality will be maintained. After numerous conferences, grading rules for flooring, lining and weatherboards have been drawn up in all the States and have been subjected to critical examination. Most of the differences of opinion have already been removed, and it is anticipated that agreement will be attained and the results published at an early date.

A second season's work on the standardization of apple cases has been carried out by the Section in co-operation with Mr. W. M. Carne of the Division of Plant Industry. This involved the examination of 307 cases of Jonathan apples for bruising due to methods of packing and the mechanical hazards of handling. The work entailed the examination of 32,500 apples. The results have been embodied in a report which will be published shortly. Very interesting and valuable information has been obtained and will replace the variable opinions of general observers. The main results demonstrate that the Australian dump case, if properly constructed, is a better protection against bruising than the Canadian standard design, and also that a moderately loose pack causes less bruising than a tight pack.

Studies have been made of a number of problems referred by timber-using industries. Among the diverse inquiries received are those for timber suitable for the manufacture of baseball bats, benches, bent-work, bobbins, bottle stoppers, cotton reels, cricket bats, croquet mallets, handles, pianos, tennis racquets, skis, tobacco pipes and veneers. The converse problem of finding uses for certain species available in commercial quantities has been met. For this purpose a store of specialty timbers is being collected.

An investigation into the causes and prevention of wood taint in butter was completed in 1932. Three trial shipments of cases treated with an anti-taint spray were sent overseas, and the reports received have established the success of the method of treatment under export conditions.

The results of investigations into the manufacture of fibre boards have been published in the Council's Pamphlet No. 36.

5. *Wood Structure.*—Owing to the large number of inquiries received for the identification of timbers, the greater part of the experimental work of this Section, of which Mr. H. E. Dadswell is in charge, was devoted during 1932–33 to the recording of the necessary information and the development of identification keys. A considerable amount of work has been done on the density of timbers, and results have been obtained for 80 different species of Eucalypts. The variation in density throughout the tree has been examined in two trees of *Euc. gigantea*, one from Tasmania, the other from New South Wales. The results show that there is little variation in the basic density of sound truewood.

Shrinkage studies have been carried out for the purpose of developing rapid and accurate methods for the determination of radial and tangential shrinkage.

One of the most important investigations of the Section is that concerned with the identification of Eucalypt timbers. Following the publication of the results obtained for 33 species representing the more important coloured woods of the genus *Eucalyptus*, attention has been devoted to the study of the characteristics of 41 different species representing the more important pale coloured timbers of the same genus. Tentative keys for the identification of these various timbers have been developed, and will be published at an early date. A considerable amount of work has also been done on the identification of timbers of various species of non-Eucalypts belonging to the natural order of Myrtaceae, and on over 180 species of other commercial timbers.

Further investigations into the variation of wood structure throughout a tree have been commenced. Eighty samples have been taken from a tree of *Euc. gigantea* at different positions both as regards height in the tree and location (i.e., from sap and heart). An examination of young Eucalypts from South Africa has shown that variation in climatic and soil conditions have no great effect in altering the structure of the wood.

Progress has been made in the survey of information regarding Australian timbers, the object of the survey being to compile and publish all authentic data available concerning species of commercial importance. Information for a number of species of Eucalypts has been prepared and collected with respect to botanical name and authority, common names, description of tree, range and distribution, general description and properties of timber, seasoning properties, durability, ease of penetration of preservatives used, strength properties, chemical composition and wood structure. This information will be published at an early date. Methods have been investigated for distinguishing between sapwood and truewood in numerous Australian timbers. It is often most difficult to detect visually the presence of sapwood which owing to its susceptibility to the attack of fungi and wood borers is a major defect in timber used for such purposes as flooring, linings, cabinet making, handles, &c. Promising results have been obtained by means of an impregnation test by which the sapwood was detected very easily in most cases owing to its complete penetration with liquids, while the truewood showed little or no penetration. These experiments are being continued with the object of developing, if possible, a simple field test for distinguishing the sapwood.

6. *Timber Mechanics.*—During the year 1932–33 several investigations which produced highly informative results were completed by this Section which is under the charge of Mr. I. Langlands. The lack of knowledge concerning the mechanical properties of Australian woods has again been brought into prominence by the difficulty experienced in recommending suitable substitutes for the overseas timbers for purposes of determining whether mechanical properties are of importance. In a number of cases the only information available was that obtained by carrying out tests on one or two samples of timber considered to be suitable substitutes; very little reliance can be placed on tests of this nature and they are even liable to be definitely misleading.

A great deal of work has been done on the testing of boxes and crates in regard to which there is such immense scope for improvements and economies in Australia. An additional series of tests of dried fruit boxes was carried out during the year for the purpose of determining the best position for the wires. The tests showed that the optimum position is from 2 inches to 2½ inches from the ends. Arrangements were made for large-scale tests to be conducted consisting of four shipments each of 40 boxes nailed in accordance with existing practice, and 40 boxes nailed according to the schedule recommended by the Division to be shipped at intervals throughout the year from each of three packing sheds, thus making a total of 960 boxes. The inspections in Melbourne indicated that very little damage occurs to the box prior to loading on the ship. Reports of inspection in England by representatives of the English Forest Products Research Laboratory, the Department of Commerce, and the Shipping Agents are not yet available. A series of tests was carried out for the purpose of improving the resistance of rough handling of the two-dozen canned fruit box, and to investigate the effect of such factors as species of timber, method of cutting shooks, &c. The tests showed that, from the point of view of strength, boxes made from hemlock can be improved considerably by increasing the number of nails, and that the kiln dried, redried hardwood box is capable of withstanding more rough handling than the hemlock box. Another series of tests was carried out for the purpose of determining the relative resistance to rough handling of various types of wire-bound butter boxes. The tests were also carried out on boxes used for packing soap and various other commodities.

One of the principal factors affecting the serviceability of containers is the holding power of the nails, and many attempts have been made in different parts of the world to develop high holding power nails. In Australia, a large variety of special nails is available, but little is known of their relative efficiency, and no independent comprehensive tests have previously been carried out. It was, therefore, decided to make a thorough study of the problem, and during the year an intensive series of tests was carried out to determine the relative efficiency of the various special nails on the Australian market. Tests were carried out on the static holding power and also on the work required completely to pull the nails under a sudden blow. In static holding power the rusted nails proved to be the best, twisted nails coming second, the twisted nail made from square wire being superior to that from grooved wire. In impact holding power, the twisted nails held the best (the nail from square wire being outstanding), the rusted nail coming next. An interesting point brought out was that a certain type of barbed nail widely used in the industry has no advantages over the plain nail. Cement-coated nails on the whole showed no improvement over plain nails.

A considerable amount of attention has been given to investigations on the toughness of certain of the Eucalypts, particularly those species likely to be useful for such purposes as tool handles, sporting goods, &c. The tests were carried out in accordance with the International standard methods so that the results are directly comparable with those of Great Britain and the United States of America. In addition to routine tests for toughness, hardness, &c., a thorough investigation was made of the variation in the toughness of green air-dried and air-dried reconditioned specimens from throughout the length and width of a tree of *Euc. gigantea* from Tasmania. The result showed that the toughness of the green timber increased considerably with the height of the tree, but that the toughness of the air dried material reached a maximum at the 54 feet level after which it fell off to some extent. Toughness tests were also carried out on willow from Tasmania, and showed that in one year the material from the butt was over 200 per cent. tougher than that from the 23 feet level. Tests on wire wood (*Acradenia franklinii*) showed that this wood is very tough being equal to good quality hickory in that respect. Wire wood is the only Australian timber tested which approaches hickory in shock resistance, and if sufficient supplies are available it should prove an efficient substitute for hickory, especially for comparatively small articles such as first-class hammer handles. A number of tests have also been carried out on timber for axe handles, and handles for brooms and rakes.

Systematic tests in accordance with the international standard method are being carried out on the mechanical properties of karri (*Euc. diversicolor*) which is one of the most important of Australian species, and has a big export market. Material has been obtained from five trees which were selected as being representative of the species. From two of the trees material for standard tests has been collected from throughout the length of the trees, whilst in another tree sufficient material for toughness testing was collected. In this way the variation of properties throughout the tree will be determined, and the effect of such factors as rate of growth, density, colour, &c., will be studied.

At the request of the South Australian Woods and Forests Department, arrangements have been made to carry out standard tests on *Pinus radiata*, mainly for the purpose of determining the relation between mechanical properties and the age of the tree.

7. *Wood Chemistry.*—The work in this Section of which Mr. W. E. Cohen is in charge is directed to a study of the chemistry of Australian timbers. This involves the collection of an enormous amount of data from many samples on each of hundreds of species. The work is likely

to be of considerable importance as chemical methods of utilizing wood become extended in Australia. The manufacture of paper, artificial silk, lacquer, &c., must some time be established here, and the data now being collected will prove of great value. During the year 1932–33 the greater part of the Section's time was devoted to a study of identification of wood by chemical means.

Studies on the identification of wood by qualitative chemical tests have been carried out for the purpose of investigating the possibility of using the chemical reactions of the various extractives in woods to aid their identification. The investigation was confined to groups of coloured Eucalypt woods which were otherwise not easy to distinguish, and also to the woods of bunya pine (*Araucaria bidwilli*) and hoop pine (*Araucaria cunninghamii*). As a result of this study definite differences between the aqueous extracts of bunya pine and hoop pine have been developed. Another test which in most cases will separate the alcoholic extracts of these woods has also been obtained. A note describing the tests was published in the Council's quarterly Journal for May, 1933. A study of the coloured Eucalypt woods has also revealed satisfactory methods for distinguishing groups of these woods.

Results of investigations on methods of determining the lignin content of woods were published in the Council's Pamphlet 22, and have in some measure been responsible for modifications in the original Madison procedure for the determination of lignin in wood. Further investigations on this matter are being conducted.

A considerable amount of preliminary work was done in connexion with the determination of the constitution of wood ash. Microchemical methods for detecting and estimating the various elements were obtained from a survey of available literature, and the technique was studied and developed in such a way that the work can now be proceeded with at any time without delay. A preliminary qualitative examination of the ashes of the five more important ironbarks and of two associated grey gums was made in order to obtain some idea of the diagnostic value of such a study. It was, however, concluded that the separation of these particular woods on a quantitative basis was rather doubtful.

X. COLD STORAGE INVESTIGATIONS.

1. *General.*—During the year 1932–33 there was a steady expansion both in the number and scope of the investigations into problems relating to the handling, transport and storage of perishable food-stuffs. While the investigations so far undertaken are intended chiefly to effect improvements in the storage and transport of fruit and meat exported from the Commonwealth, nevertheless, the Council's policy in the sphere of food preservation by no means excludes investigations in connexion with food-stuffs intended for local consumption. Indeed, the Council has carried out extensive investigations, eminently successful in their results, on the handling and maturation of Australian Cavendish bananas. In the last annual report, an extensive programme of desirable investigations was outlined, but, owing largely to limited funds and to the lack of suitably trained investigators, experimental work on the more urgent problems only has been possible during the current year.

Several investigations have again been rendered possible by the financial aid and co-operation afforded by various public bodies interested in the storage and transport of foodstuffs. An outstanding instance of this valuable co-operation was the provision of the Food Preservation Research Laboratory at the Brisbane Abattoir, which has been erected, equipped and maintained through the courtesy of the Queensland Meat Industry Board, and was officially opened by the Minister in charge of the Council, Senator the Honorable A. J. McLachlan, on 26th July, 1932.

Further investigations designed to improve the conditions of transport of bananas from Queensland and northern New South Wales to Sydney and Melbourne have again been rendered possible by the co-operation of interests so widespread as the Railways Departments of New South Wales, Victoria and Queensland, the Committee of Direction of Fruit Marketing, the Banana Industry Protection Board of the Queensland Department of Agriculture and Stock, and the New South Wales Department of Agriculture.

During the year, the Commonwealth Government appointed a Commonwealth Banana Committee to administer, in the interests of the Australian banana industry, the funds available from the duty on Fiji bananas. With the aid of a grant from these funds, the Council has been able to undertake a more intensive study than would otherwise have been possible of the incidence of, and preventive measures for, " squirter " and " black-end ", two diseases causing considerable wastage in ripened bananas, and also of certain aspects of handling and maturation.

The organization of the work of the Section of Food Preservation and Transport on the storage of non-tropical fruits has again been materially aided by the work of the Victorian Advisory Committee on Fruit Storage Investigations and the Citrus Preservation Committee. In Queensland, the Council has again had the assistance of its Food Preservation Research Committee in defining the programme of investigations relating to meat and tropical fruits.

Several changes and additions to the Section's staff have been made during the present year. Dr. F. E. Huelin, one of the trainees appointed under the auspices of the Science and Industry Endowment Fund, returned to Australia in November last, after having spent two years at the Low Temperature Research Station, Cambridge. Dr. Huelin is now located at the Biochemistry Department of the Melbourne University where he is investigating, under the direction of Associate-Professor W. J. Young, the chemical changes taking place in various fruits during storage. The re-organization of the banana maturation and transport investigations has enabled the Council to re-appoint as an investigator Mr. E. W. Hicks, who had been seconded for a period of thirteen months to the Committee of Direction of Fruit Marketing to take charge of the banana ripening operations at its Sydney branch. To enable further work to be carried out on preventive measures for " squirter " and " black-end " in bananas, a research grant has been given to Miss S. Hoette, of the Botany Department, University of Melbourne. Both the investigators are located in laboratories of the University of Queensland, Brisbane, the facilities having been generously made available by the University authorities. On the occasion of a private visit to England, the Section's engineer, Mr. N. E. Holmes, was asked to undertake several extensive inquiries relating chiefly to the overseas transport of perishable foodstuffs. Through the courtesy of the Director of the British Food Investigation Board, Mr. Holmes is located at the Low Temperature Research Station, Cambridge, where he is working in close co-operation with the officers of the Board.

Associate-Professor W. J. Young has continued to act as the Council's Adviser in matters of food preservation, and, in particular, has devoted considerable time to the direct supervision of the investigations on non-tropical fruits in Melbourne.

2. *Meat Investigations.*—(i) *The Storage of Chilled Beef.*—Great Britain still remains by far the greatest meat importing country, and the satisfaction of that market must continue to be the chief concern of Australian meat exporters. Lamb, mutton and pork are still exported in the frozen condition by all countries, and, in this trade, therefore, Australia is under no serious disadvantage in her competition for a share in the British imports. On the other hand, however, the standard method of marketing beef in Great Britain is in the chilled condition, and by reason of the distance from British markets, Australia has been forced to export frozen beef, which is becoming more and more difficult to sell. Since the cattle industry of Queensland and Northern Australia exports more than 50 per cent. of its production, which represents about 95 per cent. of Australia's exports of beef, and since it seems doubtful whether much of these northern grazing areas can be utilized for any other purpose than the raising of cattle, the importance of discovering a method of treatment and transport whereby beef can be safely exported in the chilled condition from Queensland and Northern Australia to Great Britain is apparent.

For countries regularly engaged in a chilled beef trade with Great Britain, the duration of the voyages seldom exceeds 25 days, but, from Queensland and Northern Australia, the exporters would probably have to contend with a voyage of 45 to 50 days' duration which would be equivalent to a period of 52 to 58 days from slaughter to marketing of the beef.

In view of these facts, extensive experiments have been undertaken at the Council's laboratories at the Brisbane Abattoir in order to discover the methods by which beef should be treated prior to shipment and to define the optimum conditions required during overseas transport to enable it regularly to be placed on the British markets without appreciable deterioration.

The initial experiments served to define the chief causes of wastage in chilled beef stored for prolonged periods. While the large and small scale tests from which this knowledge has been gained have so far been restricted to one meat works, the results of a preliminary microbiological survey of several other Queensland works would seem to indicate that the causes of wastage are likely to be similar in most meat works in that State. The chief source of deterioration has invariably been the rapid multiplication of certain bacteria, chiefly, *Achromobacter* (unnamed species), and to some extent, *Pseudomonas* (unnamed species), on the exposed muscle and connective tissue. Certain moulds, for example, *Penicillium expansum* and *Sporotrichum carnis*, have at times caused some deterioration, but the extent of the initial infection of these moulds and the subsequent rates of growth during storage of the meat have seldom been sufficiently great to cause much more than a poorer appearance ; in few cases did the growth of the hyphae become sufficiently great to cause " hairiness ". On the other hand, when the growth of *Achromobacter* and *Pseudomonas* became apparent as relatively large nodules and slime on exposed muscle and connective tissue, a permanent sour taint was acquired by the affected

tissues, and this off-flavour was frequently acquired by the surrounding fat. During storage, the relative rates of growth of the bacteria and moulds were dependent to a large extent on the rates of evaporation of moisture from the surfaces of the meat, and probably to some extent on the relative humidity of the surrounding atmosphere. In general, the greater the rate of evaporation, the slower was the rate of growth of the bacteria relative to the growth of the moulds.

In storage experiments, prolonged even to 60 days, rancidity of the fat could not be detected by the usual chemical methods, and any off-flavours acquired by the fat during storage probably arose from the attack by bacteria and moulds on the connective tissue covering the fat.

Since wastage was caused by attack of certain bacteria, and, to a lesser extent, of moulds, the extent of the deterioration of the chilled beef after a given period of storage would obviously be dependent both on the number of micro-organisms capable of growth at low temperatures being deposited on the meat during the initial operations of dressing, handling and chilling, and also on the rates of growth of these " low-temperature " organisms during storage. An extensive examination has therefore been carried out of the likely sources of contamination, such as the air of the slaughter floor and chilling rooms, and the water, brushes and cloths employed during the dressing of the beef. From the large number of different types of bacteria and moulds so found, the characteristics and rates of growth of those capable of appreciable proliferation at low temperatures have been studied. As the result of such studies, it is hoped that it will be possible soon to elaborate a modified technique to be adhered to during the dressing, handling and chilling of the beef, in order that the initial contamination of the superficial tissues by micro-organisms may be reduced to relatively low values, and the prospects of safer storage thereby enchanced.

In the initial experiments, methods of storage, for convenience described as " air conditioning ", were studied wherein, at a constant temperature usually about 30°F., the relative humidity and the rate of air flow were adjusted to desired values. It was believed that such methods would prove relatively easy of application in ships' holds.

By these methods of storage, it was desired so to adjust the extent of the superficial desiccation of the beef that the rates of growth of the micro-organisms would be restricted to low values, and the duration of storage without deterioration would be sufficient to permit of its safe carriage to British markets. Since the extent of the superficial desiccation of a quarter of beef varies greatly at different points, it was impossible to predict accurately the effect of a given set of storage conditions on the extent of the attack by bacteria and moulds and, in addition, the extent of the initial infection by micro-organisms would naturally vary greatly in different experiments. It was realized, therefore, that the optimum conditions of storage could be obtained only by successive " trial and error " experiments.

Storage trials, usually with twelve quarters of beef, have been carried out wherein the extent of the rate of evaporation of moisture from the beef has been adjusted so that losses of weight of the quarters per 44 days of storage have varied from 2.2 per cent. to 5.3 per cent. To these losses there must be added about 1.2 per cent. for the loss of weight during the initial reduction of temperature of the meat from the temperature of the animal (about 100 degrees F.) to that of storage (about 30 degrees F.). The loss of " bloom " of the meat is, in some measure, proportional to the extent of the total loss of weight from slaughter to the completion of storage, and it was found that if such losses exceeded approximately 5.5 per cent.—the maximum allowable depends largely on the quality of the carcase—the consequent loss of " bloom " seriously affected the market value of the beef. A strict standard has been formulated defining the amount of deterioration permitted in the hind and forequarters without appreciably affecting their market value. Bearing in mind the limitation on the loss of weight, as the result of four experiments the tentative conclusion has been reached that, employing " air conditioning " methods of storage, the limit of the safe storage of Queensland chilled beef, calculated from the time of slaughter, is approximately 48 days, and this period can be attained only when the degree of infection by " low temperature type " micro-organisms at the commencement of storage is extremely low.

It must not be assumed that it is never possible to maintain chilled beef in an edible condition by methods of " air conditioning " for a period greater than 48 days. This may frequently be possible, though the amount of beef escaping deterioration will probably be less than that laid down in the standard. Then, again, the period of storage may reasonably be exceeded safely for beef from meat works giving a very low initial infection of " low-temperature type " bacteria, particularly strains of *Achromobacter*.

Since the probable duration of safe storage, using " air conditioning " methods, is somewhat below what seems likely to be the average period of holding Queensland beef from slaughter to marketing in Great Britain, it was essential to investigate the possibilities of other methods of preservation. The second method investigated was the use of small percentages

of carbon dioxide in the storage atmosphere. This method, first suggested by Killifer in America, had given promising results when tested on a laboratory scale at the Low Temperature Research Station, Cambridge. While insufficient work has been possible to enable definite conclusions to be quoted, it would appear that when constant concentrations of carbon dioxide, of the order of 12 per cent., are employed for a period of storage of 55 days, almost complete control is obtained of the growth of moulds commonly found in Queensland meat works, while, for the "low-temperature type" bacteria, the rate of growth of *Pseudomonas* is extremely slow in such concentrations of carbon dioxide, and the rate of growth of various strains of *Achromobacter* is appreciably reduced when compared with their growth rates in air at similar temperatures and relative humidities. If the initial infection by *Achromobacter* can be kept reasonably low, it appears likely that the use of carbon dioxide in the storage environment of ships' holds carrying chilled beef may provide sufficient restriction of microbial growth to permit a safe trade in chilled beef to be established between Queensland and Great Britain. Before such a trade can be commenced, however, the problem of rendering the holds of overseas ships "gas-tight" must be solved.

(ii) *The Storage of "Bacon-type" Pig Carcases.*—Experiments to define the limits of the storage in the frozen condition of "bacon-type" pig carcasses from various localities were commenced during the year. Owing to the necessity of concentrating the efforts of the small staff on the more urgent problem of the storage of chilled beef, it has been impossible, however, to carry out more than preliminary work, such as the most reliable methods of sampling and analysis of the fats.

3. *Problems of the Storage and Transport of Non-tropical Fruits.*—These experiments have again been carried out at the laboratories shared by the Council and the Victorian Department of Agriculture at the Victorian Government Cool Stores, and also at the Biochemistry Department, University of Melbourne. Some experiments on Navel and Valencia Late oranges have been undertaken directly by the Council's Citrus Preservation Committee, but part of its programme was deputed to be carried out under the direction of the Advisory Committee on Fruit Cool Storage Investigations. During the year, the Citrus Preservation Committee reviewed the results of work on the preservation of citrus fruit extending over four seasons, and, as a result, formulated a report which has been published in the Journal of the Council.

At the outset it may be mentioned that it is the intention of the investigators to study the influence of pre-storage factors such as climate, soil, maturity and size of the fruit at the time of picking on the subsequent life of the fruit in cold store, and to correlate, if possible, the changes which invariably take place in cold store during the metabolic drift of the fruit towards senescence with the respiratory activity and chemical composition of the fruit. Special attention will be directed towards the measurement of respiration, for it is felt that any changes which take place will be reflected in the curve rate of respiration plotted against time.

The object of this work is to determine for every variety of fruit the optimum storage temperature and the maximum length of time the fruit can be stored at this temperature and still remain of good quality under marketable conditions for at least fourteen days after its removal from cold store.

(i) *Experiments on the Storage and Ripening of Williams Pears.*—It is not generally recognized that Williams pears will not ripen in cold store, but require a relatively high temperature for normal ripening to take place. Pears were stored at 37 degrees F. and 30 degrees F. immediately after picking, and samples were removed at fortnightly intervals to three ripening cabinets maintained at the respective temperatures of 45 degrees, 55 degrees and 65 degrees F. The pears did not ripen normally at 45 degrees, but remained hard and devoid of flavour, and then finally scalded. The pears ripened at 55 degrees, but without the full development of flavour, aroma and lusciousness which characterized those ripened at 65 degrees F.

It was found that pears stored at 40 degrees F. for periods up to four months ripened normally at the optimum ripening temperature of 65 degrees F., but with increasing storage at 30 degrees F., a definite series of changes which characterize abnormal ripening occurred after removal to 65 degrees F. The first lot removed after four months' storage at 30 degrees F. ripened at 65 degrees F. without full development of flavour and lusciousness. Succeeding lots were characterized by mealiness of flesh, core collapse and finally scald.

The results at 37 degrees F. were strictly analogous to those at 30 degrees F., except that the maximum length of time to which a pear could be stored and then ripened normally at 65 degrees F. was only seven and a half weeks as compared with four months at 30 degrees F.

From these results it appears that abnormal ripening is not an obscure phenomenon but really represents the physiological state of the fruit when optimum conditions for ripening do not obtain. Hitherto, the origin of physiological diseases associated with abnormal ripening has been rather obscure.

In order to correlate the changes taking place in ripening with the metabolic drift of the fruit towards senescence, the respiratory activity of the fruit at 30 degrees and 37 degrees F. was determined. It was observed that changes in colour were associated with increased production of carbon dioxide, and that the rate of carbon dioxide attained its maximum just prior to the appearance of scald, and then fell rapidly to the extinction point. At this point the fruit had completely scalded, and scald may therefore be regarded as the physiological state of the fruit in the last stages of its senescence when all respiratory processes have ceased.

The results further serve to emphasize the importance of temperature in the storage and transport of Williams pears, for at 37 degrees the peak of carbon dioxide production was reached at the beginning of April, and at 30 degrees three months later.

How essential are pre-cooling and a carefully controlled transport temperature for the successful overseas transport of Williams pears may be gathered from the fact that holding the fruit for two days at 65 degree F. is equivalent to one month's storage at 30 degrees F., and carriage at 37 degrees, a temperature frequently obtained in some parts of the ship's hold, reduces the length of storage life to such an extent as to make successful transport almost impossible.

The most important practical point in connexion with the changes taking place in store is that, correlated with the metabolic drift of the fruit towards senescence, there is a distinct series of colour changes from green to deep yellow, through the stages of dull green, green yellow, pale yellow. The disappearance of green marks the end of the commercial storage life of the fruit, for it fails to ripen at any temperature when the green colour has disappeared.

(ii) *Storage Experiments with Jonathan Apples.*—Storage experiments were conducted with Jonathan apples in order to determine—

(1) The chance variability in cold storage properties of the fruit from tree to tree and the variability of the fruit carried on different portions of the same tree. From these results it was hoped that the number of fruits which constitute a reliable sample of a tree crop and the replication required could be determined.

(2) The influence of locality, size and maturity of the fruit at the time of picking and of radial water-core on the subsequent life of the fruit in cold store as determined by the onset of breakdown.

(*a*) *Sampling Test.*—Samples of 30 ($2\frac{1}{2}$ to $2\frac{3}{4}$ inches) apples of comparable maturity, obtained from each of 50 trees, were held at 35 degrees F. and examined frequently for breakdown. In some cases, however, none of the 30 fruits, comprising a tree sample, had broken down at the time the experiment was concluded, and consequently no relative figure indicative of the behaviour of the fruit from each tree could be obtained. The absence of such definite figures prevented proper statistical examination of the results and in future experiments of this nature each sample will be held until a definite percentage of breakdown occurs.

The test has indicated considerable variation in respect to the incidence of breakdown between individual tree samples, for, at the conclusion, the percentage of breakdown per individual sample varied from nil to 60 per cent. Taking individual trees, there was no significant difference in storage behaviour of apples borne on new spurs, old spurs or laterals nor between apples borne on limbs facing different points of the compass.

(*b*) *Effect of District on Storage Life.*—Comparable samples of fruit of two maturities and one size were selected from six trees from the districts of Somerville, Harcourt, Geelong and Red Hill. From the results, it appeared that the district factor was of importance, but the variation in the storage behaviour of individuals of each district was of greater significance than the variation between the groups from the various selected districts.

(*c*) *The Influence of Maturity on the Storage Life.*—From each of six trees from the districts mentioned above, two pickings of apples were made in which the ground colour of the first pick corresponded to dull green yellow and that of the second pick to chalcedony yellow. Although the average figures for six trees indicated a higher percentage of breakdown in the second pick in each of the four districts, an examination of individual tree records cast doubt upon such a conclusion. It is highly desirable to repeat this experiment with the same trees for a number of years in order to determine whether the behaviour of individuals is the same from season to season.

Experiments have shown that there is a definite correlation between the size of the fruit and the percentage of breakdown.

(*d*) *The Effect of Radial Water-core on Storage Life.*—Breakdown associated with radial water-core was noted separately throughout the experiments, but there was no definite relation between the amounts of breakdown with or without radial water-core in any case.

(iii) *Experiments with Navel Oranges.*—Experiments embracing sweating, respiration and storage studies have been conducted with Navel oranges, for the Citrus Preservation Committee.

(*a*) *Sweating Experiments.*—A study of the effect of sweating, i.e., exposure of the fruit to high temperatures for short periods of time, on the control of mould growth and on the subsequent life of the fruit in cold store was made during the 1932 Navel season.

In a room specially constructed for the purpose, where temperature and humidity could be accurately controlled, the fruit was subjected to the following sweating treatments :—

(i) 90 degrees F. for three days at 94 per cent. humidity.
(ii) 90 degrees F. for three days at 50 per cent. humidity.
(iii) 84 degrees F. for four days at 94 per cent. humidity.
(iv) 84 degrees F. for four days at 50 per cent. humidity.
(v) 78 degrees F. for five days at 50 per cent. humidity.

The results were not very conclusive and did not agree with the findings of previous workers, for in no case was mould growth on fruit previously inoculated with *Penicillium digitatum* controlled by any of the above treatments. It must be recorded, however, that the experimental fruit was very mature, and it is probable that the efficacy of the treatment is largely bound up with maturity. It is hoped that experiments with less mature fruit will be carried out during the 1933 citrus season.

It was observed that temperatures above 78 degrees rendered the flavour of the fruit somewhat flat, but exposure of the fruit to 78 degrees for five days had no appreciable effect on the flavour or on the subsequent length of storage life of the fruit at 42 degrees F.

(*b*) *Respiration and Storage Studies.*—With a view to determining the optimum storage temperature and the length of storage life of Navel oranges, a series of respiration and storage experiments were carried out at 36 degrees, 42 degrees and 78 degrees F., the last temperature being selected as one approximating to the probable optimum sweating temperature for citrus fruits. The length of storage life was four weeks at 36 degrees, twenty weeks at 42 degrees and five weeks at 78 degrees F. These results clearly emphasize the importance of temperature, and serve to indicate that low temperatures may be more detrimental than high temperatures in the storage and transport of citrus fruits. Moreover, in these experiments the fruit was fairly mature, having already passed its climacteric at the time of picking, and less mature fruit should have a much longer storage life at 42 degrees F. than has hitherto been realized.

Collapse was only observed in fruit stored at 36 degrees F. which might serve to indicate that this obscure physiological disease is no more than low temperature breakdown.

(*c*) *Experiments carried out by the Citrus Preservation Committee.*—(1) *Navel Oranges.*—Experiments carried out during the early part of the year showed that Navels kept better at 45 degrees F. than at 38 degrees. This was shown not to be due to any accumulation of carbon dioxide, but the exact conditions have not yet been ascertained, and further experiments are proposed.

(2) *Valencias.*—Preliminary washing with salicyl anilide, which has been found useful in controlling mould in other foods, was not found to have any such effect with these oranges. Spraying with paraffin was found definitely to prevent skin-browning, and the oranges so treated retained their flavour after long storage much better than untreated fruit.

During the year experiments have been commenced in conjunction with the Griffith Co-operative Packing Co. and the Commonwealth Citrus Station at Griffith on the storage of citrus fruits picked at different stages of maturity. The Griffith Co-operative Co. has fitted up a cold store with refrigeration coils and thermo-regulators, so that a constant temperature can be maintained. The fruit will be tested from time to time for its acid content, sugar, and other constituents. A parallel experiment is being done in Melbourne with oranges from a Victorian district. In addition, an experiment on maturity at picking of lemons is also in progress at Griffith.

(iv) *Passion Fruit.*—An experiment was carried out on passion fruit grown on a plantation in the Mornington Peninsula. The fruit was of very poor quality, small and unripe and sour, and contained very little juice, while the quantity obtainable was too small to do more than a limited number of treatments.

The following were tried :—

(1) Washing with 5 per cent. borax at 110 degrees F.
(2) Washing with 2.5 per cent. sodium bicarbonate at 110 degrees.
(3) Washing with sodium hypochlorite at ordinary temperature.

In each case comparison was also made with fruit wrapped in sulphite tissue and with unwrapped fruit, and with fruit sprayed with paraffin. The fruit was stored at 44 degrees F.

Wastage, due to breakdown and mould, commenced after about four weeks' storage, and most of the fruit had collapsed after eight weeks. None of the treated fruit showed any advantage over the untreated fruit, but the wrapped fruit generally showed less mould, collapse and crinkling than the unwrapped.

(v) *Gas Storage of Peaches.*—Gas storage or control of the composition of the storage atmosphere has proved very effective in England in delaying senescence and extending the storage life of several varieties of apples.

In Australia the method had not been exploited, but it was felt that its application would find more ready use in the storage and transport of soft fruits than with apples. The method was applied this year in the storage of peaches. It was only possible, with the apparatus available, to carry out small scale experiments and to use two atmospheres, viz., 10 per cent. CO_2 + 11 per cent. O_2 and 5 per cent CO_2 + 16 per cent. O_2. Control fruit was stored at the same temperature, and samples of this and gas stored fruit which had been stored at 34 degrees F. removed at weekly intervals to a ripening temperature of 65 degrees.

After one month's storage at 34 degrees, the control fruit failed to ripen normally at 65 degrees developing mealiness and other physiological diseases. Fruit from both artificial atmospheres ripened normally at 65 degrees after eight weeks' gas storage, but after nine weeks' gas storage abnormal ripening with mealiness, &c., developed on removal from the atmospheres to 65 degrees F. One outstanding result was the retardation in subsequent ripening which gas storage produced, for gas-stored fruit took eight days to ripen at 65 degrees whilst comparable air-stored fruit took only two days. This result is of paramount importance, as it allows a great margin of safety in marketing such fruit. The prevailing temperature in England when peaches would arrive would not exceed 45 degrees F., and the time to ripen at this temperature would be approximately eighteen days. The total length of storage life, including time taken to ripen, would be at least eleven weeks. It is not improbable that a higher concentration of carbon dioxide could be used with safety and with less mature fruit the length of storage life would probably exceed the above time.

(vi) *Chemical Studies on Stored Fruit.*—(*a*) *Apples.*—Chemical analysis of Jonathan apples at picking has been carried out with the view to establishing more precise maturity standards. Estimations of the contents of reducing sugars, sucrose, acid and nitrogen have been performed on apples picked at intervals of three weeks from two localities in Victoria and each picking corresponded approximately to a different colour standard. This work will need to be continued over several seasons.

(*b*) *Pears.*—Chemical changes in Williams pears during storage at a temperature of 34 degrees F. and ripening at 65 degrees F. have been investigated. During storage the pears became yellow and the hardness, as measured by the pressure test, decreased. The concentration of acetaldehyde and alcohol increased, while the total and reducing sugars remained practically constant. At the limit of the commercial storage life of the pears, the concentrations of acetaldehyde and alcohol were approximately 0.001 per cent. and 0.01 per cent. respectively. During ripening at 65 degrees F. core breakdown ensued when the alcohol content was about 0.1 per cent. During the progress of normal ripening, the percentage of sucrose increased from 0.7 to 1.8.

4. *Investigations on the Handling, Transport and Maturation of Bananas.*—(*i*) *" Squirter " Disease.*—Notable progress has been achieved in the study of the development of " squirter " in bananas. This disease, so common in fruit ripened in Sydney and Melbourne during the late winter and spring months, has long been considered a physiological breakdown rather than being microbial in origin. Investigations carried out, however, by Associate-Professor Ethel McLennan and Miss Hoette of the Botany Department, University of Melbourne, and assisted materially by Associate-Professor W. J. Young, have demonstrated conclusively that a hitherto undescribed mould of the *Nigrospora* type is the main causal agent. The investigators have proposed the name *Nigrospora Musae* for this mould. From studies of its characteristics of growth, an hypothesis has been developed to account for the somewhat unusual nature of the incidence of the disease.

In May, 1933, the studies were extended to include the incidence of *Nigrospora Musae* in various plantations in Queensland and New South Wales, and to devise appropriate preventive measures for " squirter ".

(ii) *Keeping Qualities of Bananas removed from the Ripening Rooms at Various Stages.*—Experiments are being carried out in which fruit is removed from the ripening rooms at various stages to different atmospheric conditions, in order to determine accurately the best time of removal of the fruit from the ripening rooms at different seasons and for different trade conditions.

(iii) *Chilling.*—In the southern markets during the winter, the colour of the ripened fruit is almost invariably dull, and ripening is often very slow. These troubles have sometimes been attributed to cold conditions during transport, but observations on plantations and in the Brisbane market support the view that they are largely due to plantation conditions. The dullness in the colour of the fruit became apparent in bananas ripened in Brisbane at the same time this year as it began to appear in the southern cities. Also the characteristic " chilled " colour has been frequently observed in green fruit still hanging on the plant in the plantations. Further information on this point will be obtained in conjunction with some of the later tests in connexion with " squirter ".

(iv) *Packing Tests.*—In packing bananas, standard cases are used, but in practice the size of the bulge varies greatly. Experiments are being planned in conjunction with the Division of Forest Products, to determine, if possible, the effect of using various degrees of bulge on the amount of bruising which takes place firstly in packing, and secondly, after packing due to handling such as would be experienced during transport.

(v) *Bunch Ripening Tests.*—Considerable trouble has been experienced in the commercial handling of bananas on the bunch because of the tendency of the fruit to drop from the bunch when ripe. Experiments are being carried out in order to discover whether this tendency can be reduced by varying the ripening conditions. Variations of temperature, humidity and coal gas concentration are being tested, but difficulty has been experienced in obtaining uniform samples of fruit, and no definite conclusions can be drawn at this stage.

(vi) *Ripening of Bananas in Hands.*—It has been thought that " finger dropping " would be almost as serious with fruit ripened in hands as with fruit ripened on the bunch. However, definite evidence has been obtained indicating that this trouble should be much rarer in bananas ripened in hands than in bananas ripened on the bunch, under normal ripening conditions, and probably " finger dropping " would never be a source of trouble commercially with fruit packed in hands. However, more tests will be necessary before a definite statement can be made.

(vii) *Transport Investigations.*—Studies of the transport of bananas from Queensland and Northern New South Wales to the southern cities were resumed in July, 1932. The tests have confirmed the previous conclusions of Mr. R. A. Holloway and Mr. O. Barr of the New South Wales Government Railways that, during the winter and spring months, the present methods of transport of the fruit are satisfactory. The results of work during the summer months, however, have indicated the necessity for some change in the methods of transportation by rail, particularly through New South Wales, during the hotter months. The data obtained suggest that mechanically ventilated trucks may alleviate the troubles now experienced. It is proposed therefore, to co-operate with the New South Wales Government Railways in the re-fitting of a B.L.V. truck to forced air circulation, and to carry out tests in it during the coming hot season.

Comparisons have also been made of the " open " and " closed " methods of stacking of cases of bananas in the New South Wales fruit trucks during the summer months. The work so far carried out indicates that the temperature conditions attained in the bulk of the fruit do not differ materially when either " open " or " closed " stacking is employed.

XI. OTHER INVESTIGATIONS.

1. *Commonwealth Prickly Pear Board.*—The destruction of prickly pear by *Cactoblastis cactorum* has continued to progress most satisfactorily. During the year 1932–33, the primary or original pear collapsed over extensive areas, mainly in outlying districts away from the chief rail and road arteries. The former dense pear territory in Queensland has been reduced in almost all districts to limited areas of resistant pear, usually partially damaged, and to secondary growth of varying degrees of height and density. In New South Wales, the position is very similar in the North-west and Pilliga State Forests sections; there is, however, one extensive belt of primary pear on hilly country in the Inverell-Bingara district where the original pear, which is of a yellow resistant type, still flourishes.

In the Hunter River district of New South Wales, the definite increase of *Cactoblastis*, which was noted in the previous season after years of poor results, has been more than maintained. Excellent destructive work is now apparent in many localities, and although the total destruction does not represent a large proportion of the infested area, definite progress has been made.

Regrowth, springing from the underground butts and the partially destroyed lower joints after the initial collapse of the primary pear, remains a feature of the situation in many districts. However, in many extensive areas where this secondary wave of infestation was most vigorous and the insect population was scattered, *Cactoblastis* has made a very rapid recovery, and the position is now satisfactory. In central Queensland, regrowth has not assumed dense proportions

except over limited areas ; hence, the eradication of *O. inermis* and *O. stricta* has been virtually accomplished over extensive tracts of country. Owing to the capacity of *Cactoblastis* to rehabilitate itself after temporary setbacks, it has not been found necessary to redistribute this insect in regrowth.

Since *Cactoblastis* is so widely and generally established, distribution during the year has been restricted to relatively small supplies liberated in a few special areas. 11,138,000 eggs and 1,850,000 eggs were supplied from the field stations for liberation in New South Wales and Queensland respectively.

The process of the occupancy of prickly pear land rendered available for settlement by biological control has made rapid progress in Queensland. 2,238,303 acres have been re-selected for mixed farming operations and 3,430,266 acres for grazing purposes, all under developmental conditions. Road making, ring-barking and clearing of useless timbers and fencing have assumed considerable importance. New settlers' homes continue to arise, and dairying and the growing of crops are being successfully pursued.

Cochineal is gradually thinning out the extensive scrubs of dense tree pear, *O. tomentosa*, in central Queensland.

Investigations in the United States have been continued with insects of potential importance for the control of regrowth. This work has resulted in the establishment in Australia of a second species of cochineal, *Dactylopius confusus*, on the spiny pest pear, *O. stricta*. In South America, two officers of the Board have been engaged in the study of insect enemies of the tiger pear, *O. aurantiaca*, and its allies. A strain of the cochineal, *D. confusus*, has been forwarded to Australia, where it is being reared successfully on *O. aurantiaca*, a plant that has hitherto resisted the attack of all species and strains of cochineal.

The Board's staff in Australia has devoted special attention to (*a*) the breeding of certain prickly pear insects, viz., *Moneilema* and *Melitara* species ; (*b*) the study of resistent forms of prickly pear ; (*c*) the progress of *Cactoblastis* throughout the pear areas ; and (*d*) the investigation of native parasites and their controlling effect on *Cactoblastis*.

2. *Fuel Problems.*—In previous Annual Reports of the Council it has been pointed out that research in connexion with the production of liquid fuels from coal either by low temperature distillation, hydrogenation, &c., involves not only the provision of complicated and expensive plant, but also the employment of highly qualified officers, and that large sums of money have been expended on such researches by public and private interests in various European and American countries. The Council accordingly decided that it would be undesirable for it to undertake research work in Australia on these problems and that its appropriate policy would be closely to watch the course of developments in other countries. Close liaison was, therefore, established and has been maintained between the Council and the British Department of Scientific and Industrial Research, and the Council is thus in the fortunate position of being kept in intimate touch, through the British Fuel Research Board, with all developments in the field of liquid fuel research.

Mr. L. J. Rogers, who left Australia in 1926 as a student under the Science and Industry Endowment Fund in order to undergo a course of training in research on fuel problems, was employed by the British Fuel Research Board at its Research Station at Greenwich after the termination of his studentship until August, 1932, when he returned to Australia. After his return he was engaged for some months on enquiring into, and reporting upon, various schemes for the low-temperature distillation of Australian coals and oil shales, and then left Australia again in May, 1933, on an official visit abroad in order particularly to arrange for hydrogenation trials and cracking tests of shale oil from Newnes.

The announcement that Imperial Chemical Industries Limited had authorized the expenditure of £2,500,000 in England on a plant for the hydrogenation of 400 tons of coal per day aroused very great interest in Australia. The annual output of the plant is estimated at 30,000,000 gallons of petrol and the Company will receive from the British Government a preference of at least 4d. per gallon over foreign petrol. An article by Mr. Rogers summarizing the present state of knowledge regarding the hydrogenation of coal and oil was published in the Council's quarterly Journal (Vol. 6, No. 2, May, 1933). As regards the prospects of hydrogenation in Australia, Mr. Rogers reached the conclusion that, in spite of the low cost of brown coal in Victoria, it is probable that hydrogenated petrol could be produced more cheaply from New South Wales bituminous coal. He estimated that a plant with a capacity of converting 1,000 tons of coal a day into liquid fuel would cost about £12,000,000 in Australia and that based on comparative English figures, the production costs, including interest charges, would probably amount to 1s. 3d. per gallon of petrol.

3. *Radio Research Board.*—The original three-year arrangement regarding the financing of the Board has now expired, but the two co-operating bodies, namely, the Postmaster-General's Department and the Council, have entered into another agreement to finance the Board's work for a further period of three years as from 1st July, 1933.

The completion of the experimental transmitting equipment at the University of Sydney at the end of last year has considerably facilitated the Board's investigations on fading and the reflection of radio waves by the ionosphere. In the previous work of the Board, carried out at Jervis Bay, it was evident that under the particular conditions that applied, the chief reflecting medium concerned in the return of indirect rays to the earth was a layer at a height of about 110 kms., i.e., the Kennelly-Heaviside Layer. However, definite indications of the Appleton Layer at a height of about 250 kms. were observed. Further observations have been carried out at Liverpool, New South Wales, some twenty miles from the University transmitter. In addition, a few simultaneous observations made in Melbourne have thrown considerable light on the mechanism of interstate broadcast reception at such distances. On those nights when the check measurements at Liverpool indicated that the Kennelly-Heaviside Layer was in operation, the reception in Melbourne was comparatively steady and the photographic records of the special " frequency change " tests showed that the received signal was composed of two sky waves of approximately the same amplitude. On other nights when the Liverpool measurements showed that the upper layer was the chief reflecting agent for sky waves received at short distances, the long distance reception was irregular, variations in signal occurring very frequently ; at these times, the " frequency change " tests showed that either two or three sky waves were being received, one of them having a much longer path than the others and being of less intensity.

Attention has also been given to fading experienced with long waves (1,500 metres wavelength). When using such waves, measurements of ground wave attenuation, night-time severity of fading, and intensity of sky waves have been made in a number of representative localities in south-eastern Australia, both along the coast line and inland. In consequence, much information regarding the fading of long waves over different types of country and at different distances from the transmitter has been obtained. The results of this work have been published (*J. Inst. Eng. Aust.* Vol. 5, No. 6, June, 1933).

Some investigations have been carried out on the distribution of atmospherics that arise in Australia. The main points brought out by this work are (i) in general the annual number of sources increases towards the Equator, the topography affecting the number considerably ; (ii) the activity of sources shows a steady increase with rise in latitude ; (iii) the average duration of sources increases slightly towards the north, but the most noticeable feature is the marked difference between sea and land sources. (The average duration for land sources is six hours and the sources occur mainly between noon and 6 p.m. ; for sea sources the average is ten hours and the times of occurrence are distributed much more uniformly over day and night) ; (iv) in the north the land sources are of the tropical type and are practically confined to the summer months, while in the south they are of the cyclonic type and occur much more evenly throughout the year.

During the coming year it is proposed to transfer the Laverton direction-finder to Toowoomba, Queensland, and to carry out further work on this longer base line with the dual objects of obtaining further information regarding the atmospheric differences, and of further establishing the value of the cathode-ray direction-finder as a meteorological instrument.

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

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

During the year, Dr. Stillwell has continued the examination of Read-Rosebery ores as a supplement to a geological survey recently carried out at Rosebery by the Geological Survey of Tasmania. An interesting feature proves to be the frequent association of minute quantities of gold with disseminated particles of fahl ore among the lead and zinc minerals.

The examination of ore containing cobalt and vanadium from Mount Renus, Tasmania, indicated that the cobalt is associated with pyrite and the vanadium with a chloritic mica.

The examination of specimens of nickel ore from the Hecla adit in N.E. Dundas, Tasmania, led to the discovery of geradorffite, a rare nickel arsenic sulphide which had not been previously recorded in Australia.

The examination of ores, concentrates and tailings from Mt. Morgan, Queensland, has confirmed the belief of the staff metallurgists that losses of gold in the tailings are due to encased particles of gold and that improved recoveries will depend upon finer grinding.

Dr. Stillwell's services have also been used in connexion with surveys that have been undertaken with a view to the encouragement of gold-mining. In association with Sir Herbert Gepp, Consultant on Development to the Commonwealth, and Mr. Baragwanath, Director of the Geological Survey of Victoria, an investigation has been conducted on the possibilities of gold-mining in the Maryborough district, Victoria. In association with Sir Herbert Gepp and Mr. Nye, Government Geologist of Tasmania, investigations have been made into the gold resources of Tasmania, the dolomite deposits of Smithton and the copper nickel resources of the West Coast of Tasmania.

The investigations carried out by Dr. Stillwell have been facilitated by a subsidy of £320 contributed by a number of mining corporations through the Australasian Institute of Mining and Metallurgy. The University of Melbourne has also assisted by granting the investigator laboratory accommodation at the Geology School.

5. *Standards Association of Australia.*—The Standards Association of Australia, for which the Council is the means of liaison with the Commonwealth Government, received renewed financial support during the year 1932–33 from the Commonwealth Government, and was thereby enabled to maintain its activities. Though still compelled, owing to limitations of funds, to restrict its operations, much useful work was accomplished during the year 1932–33. Several codes that should prove of definite value to industry have been completed and others previously published have been brought up-to-date. Standard specifications have been issued and draft specifications have been circulated for public critical review prior to publication. Notwithstanding its financial difficulties, the usefulness of the Association remains unimpaired, and the Association is receiving in increasing measure the confidence of the commercial and industrial community.

XII.—MISCELLANEOUS.

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

(i) *Bulletins*—

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. G. H. Huxley, M.A., D.Phil.

No. 69.—An Investigation of the Taxonomic and Agricultural Characters of the Danthonia Group ; by A. E. 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.

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 (Vic.) and Goodnight (N.S. 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.

(ii) *Pamphlets*—

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.

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 Australia Timbers, Part 1; by C. S. Elliot, B.Sc.

(iii) *Quarterly Journal*—

Vol. 5, No. 3, August, 1932.
Vol. 5, No. 4, November, 1932.
Vol. 6, No. 1, February, 1933.
Vol. 6, No. 2, May, 1933.

(iv) *Annual Report for the year ending 30th June,* 1932.

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

2. *Catalogue of Scientific Periodicals.*—It was realized early in the year that owing to the financial depression it would be impossible from the funds at the disposal of the Council to edit and publish a supplement to the Catalogue of Scientific and Technical Periodicals in the Libraries of the Commonwealth. It was decided to ask for financial aid from various scientific associations, to the members of which the keeping of the catalogue up to date was a matter of importance. A letter was accordingly forwarded to all Australian scientific societies, universities and certain other bodies informing them that it would not be possible to bring the catalogue up to date unless they could assist financially. A good response was received and the sum of £267 was promised towards the expense of editing and printing, with the result that it was possible to complete arrangements for the work of revision to be commenced.

Owing to the kindness of the Trustees of the Melbourne Public Library, Mr. C. A. McCallum, Senior Assistant of that Library, was able to undertake the editorial work with the assistance of Mr. D. W. I. Cannan, Assistant, and under the direction of Mr. E. R. Pitt, Principal Librarian.

The number of entries received having exceeded all estimates, the task of publishing the Supplement is proving a more lengthy one than was anticipated, and it is not yet certain when it will be available for distribution.

3. *Library.*—The additions to the shelves during the year 1932–33 amounted to 275 volumes, of which 173 consisted of bound volumes of periodicals. These figures refer to the Council's head office library only. The libraries of the several Divisions of the Council have also received many additions and are becoming valuable centres of literature on specialized subjects. A particularly useful library of veterinary works, with special reference to tropical disease of animals, is being accumulated at the Townsville Animal Health Research Laboratory.

The number of periodicals, reports, bulletins, &c., received has been definitely affected by the world depression. Many scientific institutions are publishing less than in former years, while others have found it necessary to restrict their exchange mailing list. The number of publications of all sorts handled per month by the head-quarters library staff has averaged about 600 as against 725 last year. The reduction in this figure is also partly accounted for by the fact that a number of the periodicals, &c., are now forwarded direct to the Divisions.

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

4. *Bureau of Information.*—As in previous years, enquiries for information on a diversity of subjects have been received by the Bureau of Information. These have been dealt with, either personally or by letter, as fully as possible, using the resources of all the Council's libraries, and, where necessary, obtaining the required information from outside sources. A few of the subjects on which information has been sought are as follow :—

(i) *Agricultural and Horticultural.*—Tung oil cultivation, beet sugar, stinkwort control, smoke screens for frost protection, rabbit control by disease, passion-fruit cultivation, dingo baits, mint weed, value of birds to mankind, rice-growing in Australia, insect infestation of cocoa, worms in lambs, tobacco-curing, walnut culture, licorice cultivation, phosphate rock for cattle, cattle egret birds, sunflower seeds, pyrethrum, flax cultivation, fishmeal-fodder value, sheep dips, sisal hemp, pigs (McLean County Sanitation Scheme), bacteriological examination of milk, salt bush (fodder value), germination of strawberry clover, eradication of Paterson's curse.

(ii) *Food Preservation.*—Drying rabbits, fruit dehydration, whitebait canning, brine canning of beans, fruit storage and transport, fish preservation, sultana drying.

(iii) *Industrial Minerals, Chemicals, &c.*—Bentonite, manganese sulphate, grass tree gum, vegetable black, sulphonated oil, radium metallurgy, shellac (solubility of wax), tartaric acid, gypsum products, micanite milling, fulminate of mercury, dicalcium phosphate, anhydrous ammonia, ergot (pharmaceutical properties), cellulose (solubility), Huon pine oil, hydrogen sulphide, sulpho-ricinate, bauxite, diatomaceous earth, fruit pectin, grape seed oil, gold mining in New Guinea, vitamins, magnesite, Cajaput oil, rotenone from derris, nicotine sulphate.

(iv) *Manufactures.*—Cements for high temperature, boot polishes, paper from straw, coir fibre, insecticides, dry cells, porcelain electric insulators, black coal briquettes, Worcester sauce, cyanogas, citric acid, mustard pickles, tooth pastes, brass polishes, calsomines, salt licks, artificial gems, rice starch, caramel, egg pulp, egg powder, plaster of Paris, glucose, macaroni.

(v) *Miscellaneous.*—Seaweed, liquid fuels, deodorisers, cattle hides (pink colouration), oil shale, paper pulp, ethylene oxide as a fumigant, wool grease, solder extraction, Posidonia fibre, bakelite, moulding of plastics, chemical composition of orange juice, nail enamel, specifications for fire extinguisher liquid, adulteration of ghee, dried fruit (food value), starch adhesives, bulk handling of grain, dried eggs, oil press for apricot kernels, methods of working cork, reclaiming scrap non-ferrous metals, decomposition of rice hulls, anthrax from leather, seawater purification, porcelain fire bricks, glass-making, utilization of scrap steel plate, pumice, talc, and casein utilization, detinning scrap tin plate, synthetic nitrates, activated carbon, water softeners, deposits on valves of suction gas engines, eucalyptus residual oils, suction gas and diesel oil, patent motor car headlamps, moulded goods, linen and cotton thread (comparison of properties), refrigerated trucks, cotton waste, effect of heat on cotton thread, celluloid colouring, bacteriology of sausage casings, wood distillation, fire-proofing fabrics, jute substitute (patent), houseflies (colour deterrants), dyeing of woollen goods, Wood's metal, silver plating, olives (chemical composition), lanoline for lubrication, lithography.

XIII.—FINANCIAL MATTERS AND STAFF.

1. *Finance.*—The statement of expenditure from 1st July, 1932, to 30th June, 1933, is as follows :—

	£	£	£
1. Salaries and contingencies	..	..	*12,641
2. Remuneration of Chairman and Members of Council	..	..	†1,902
3. Investigations—			
(i) Animal problems—			
(*a*) Black disease, walkabout disease, foot-rot, entero-toxaemia, and preputial disease	1,455		
Less contributions from the Australian Pastoralists' Research Trust and the Empire Marketing Board, England ..	579		
		876	
(*b*) Parasitology	4,487		
Less contributions from the Australian Pastoralists' Research Trust, the Empire Marketing Board, and McGarvie Smith Institute	1,133		
		3,354	
(*c*) Caseous lymphadenitis (New South Wales)	945		
Less contributions from the Australian Pastoralists' Research Trust and the Empire Marketing Board, England.. ..	71		
		874	
(*d*) Bovine haematuria and caseous lymphadenitis (South Australia) ..	..	797	
(*e*) Tick and tick fevers, pleuro pneumonia, &c.	9,443		
Less contributions from Queensland Government, Council of Agriculture, Brisbane, and the Empire Marketing Board, England	8,939		
		504	
(*f*) Entero-toxaemia (Braxy-like disease) Moora (Gingin) disease, &c. (Western Australia)	..	523	
(*g*) Pregnancy disease in ewes and pulpy kidney in lambs	211		
Less contributions from the Australian Pastoralists' Research Trust and the Empire Marketing Board, England	211		
		..	
(*h*) Peg leg disease (Queensland) ..	142		
Less contributions from Empire Marketing Board and certain graziers of Charters Towers District	142		
		..	

* 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 clerk and typiste at Australia House; travelling expenses of head office staff, members of the Council, &c., and printing and general office expenditure.

† Provided from Consolidated Revenue Fund.

	£	£	£
(*i*) Blowfly trapping experiments (New South Wales)	71		
Less contributions from the Australian Pastoralists' Research Trust and the Empire Marketing Board, England ..	71		
		..	
(*j*) Zebu cattle project	586		
Less contributions from Messrs. Winter-Irving and Allison, Queensland, Stations Ltd., Messrs. Meredith Menzies, & Co. Pty. Ltd., and C. W. Wright, Esq.	586		
		..	
(*k*) Central office salaries, &c.	..	1,705	
		8,633	
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..	..	5,000	
			3,633
(ii) Plant Problems—Division of Plant Industry—			
(*a*) Central Laboratory— £			
Annual	4,563		
Capital 256			
Less contribution from Empire Marketing Board, England, towards erection of plant house 34			
	222		
		4,785	
(*b*) Experimental plots		502	
(*c*) Plant pathology	2,076		
Less contributions from Empire Marketing Board, England ..	369		
		1,707	
(*d*) Plant genetics	2,796		
Less contributions from Empire Marketing Board, England ..	1,200		
		1,596	
(*e*) Plant introduction	..	1,156	
(*f*) Agrostology	1,126		
Less contributions from Empire Marketing Board, England ..	975		
		151	
(*g*) Plant physiology	586		
Less contributions from Empire Marketing Board, England ..	572		
		14	
(*h*) Noxious plants	..	373	
(*i*) Fruit problems	1,192		
Less contributions from Empire Marketing Board, England ..	600		
		592	
(*j*) Experimental Farm, Duntroon ..	..	436	
(*k*) Tomato wilt	..	601	
(*l*) Plant Introduction Garden, Gatton, Queensland	..	76	
(*m*) General botany	..	392	
			12,381

	£	£	£
(iii) Entomological Problems—Division of Economic Entomology—			
(*a*) Central laboratory—		5,394	
(*b*) Noxious weeds		1,845	
(*c*) Blow-fly and buffalo-fly		4,579	
(*d*) Orchard and fruit pests		419	
(*e*) Field crop and pasture pests		245	
(*f*) Forest insects		1,598	
		14,080	
Less contributions from Empire Marketing Board, England, Australian Investment Agency Ltd. and Sir MacPherson Robertson ..		4,996	
			9,084
(iv) Animal Nutrition—Division of Animal Nutrition—			
(*a*) Central Laboratory—	6,322		
(*b*) Waite Institute	1,359		
(*c*) Field Station, Beaufort, Victoria ..	110		
(*d*) Field Station, Young, New South Wales	303		
	8,094		
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..	5,000		
		3,094	
(*e*) Field Station, Springsure, Queensland	233		
Less contributions from the Australian Pastoralists' Research Trust and the Empire Marketing Board, England	233		
		..	
(*f*) Field Station, Kangaroo Island, South Australia	321		
Less contributions from the Australian Pastoralists' Research Trust and the Empire Marketing Board, England	321		
		..	
(*g*) Drought feeding experiments at Waite Agricultural Research Institute, Glen Osmond, South Australia ..	1,408		
Less contributions from the Australian Pastoralists' Research Trust, the Empire Marketing Board, and the Commonwealth Bank (Rural Credits Development Fund) ..	1,408		
		..	
(*h*) Agrostological Investigations at Waite Agricultural Research Institute, Glen Osmond, South Australia	450		
Less contribution from the Empire Marketing Board, England	450		
		..	
At Waite Institute in co-operation with Empire Marketing Board and Adelaide University—Mineral deficiencies in pastures ..		709	
			3,803

	£	£	£
(v) Horticultural Problems of the Irrigation Settlements—			
Citricultural—			
(*a*) Research Station, Griffith—			
Salaries and incidentals	2,868		
Capital	636		
	3,504		
Less contributions by New South Wales Water Conservation and Irrigation Commission	1,200		
		2,304	
Viticultural—			
(*b*) Research Station, Merbein—			
Salaries and incidentals	3,491		
Capital	848		
	4,339		
Less contributions by Dried Fruits Control Board and Woorinen Dried Fruits Enquiry Committee ..	1,266		
		3,073*	
			5,377
(vi) Soil Problems—			
(*a*) Investigations at Waite Institute and Irrigation Areas—			
Salaries, &c.	4,082		
Capital	117		
		4,199	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)		3,000	
			1,199
(vii) Food Preservation and Transport—			
(*a*) Meat and fish investigations (Brisbane Abattoir)	1,572		
Less contribution by Queensland Meat Industry Board ..	436		
		1,136	
(*b*) Banana investigations (Queensland University)	343		
Less contribution by Commonwealth Banana Committee ..	268		
		75	
(*c*) Non-tropical Fruits (Melb.)	..	954	
(*d*) Citrus preservation	182		
Less contribution by Board of Trade	124		
		58	
(*e*) Engineering Problems	..	472	
(*f*) Adviser on Food Preservation ..	..	301	
		2,997	
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..	..	2,883	114
(viii) Prickly Pear—			
(*a*) Grant for investigations	..	4,500	
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..	..	4,500	
			..

* £643 was received from sale of produce and credited to Trust Fund receipts.

	£	£	£
(ix) Forest Products—			
(a) Central Laboratory—			
Annual	9,444		
Capital	1,578		
		11,022	
Less contributions—			
Commonwealth Bank (Rural Credits Development Fund)..	2,080		
Victorian Hardwood Coy. Pty. Ltd.	7		
Melbourne and Metropolitan Tramways Board ..	19		
Derwent Valley Paper Co. Ltd.	96		
Postmaster-General's Department	20		
Messrs. Allen-Liversidge (Aust.) Ltd.	11		
Messrs. Longoni Seggel & Co. Pty. Ltd.	3		
		2,236	
			8,786
(x) Mining and Metallurgy—			
(a) Mineragraphic Investigations ..	..	687	
Less contribution by Australasian Institute of Mining and Metallurgy	..	252	
			435
(xi) Radio Research—			
(a) Melbourne University	926		
(b) Sydney University	2,816		
(c) Adviser on Radio Research ..	106		
		3,848	
Less contributions by Postmaster-General's Department ..	..	2,886	
			962
(xii) Library	..	..	858
(xiii) Contributions to Imperial Agricultural Bureaux and to British Woollen and Worsted Association	..	..	3,125
(xiv) Miscellaneous—			
(a) Wood taint in butter investigations ..	39		
Less contributions by Australian Dairy Council	39		
		..	
(b) Bee investigations	124		
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..	124		
		..	
(c) Thrips investigations	322		
Less contributions from the Thrips Investigation League ..	114		
		208	
(d) Supplement to Catalogue of Scientific and Technical Periodicals in the Libraries of Australia	..	70	
(e) Various	..	373	
			651
Total of Item 3—Investigations ..	..	..	50,407

2. *Contributions.*—The following statement shows the receipts and disbursements during the year 1932–33 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 1931–32.	Expenditure 1932–33.
	£	£
Commonwealth Bank (Animal Health, Horticultural, Food Preservation and Transport, Prickly Pear and Forest Products Investigations)	22,383	22,383
Commonwealth Bank (Erection of Drought Feeding Building)	58	41
Commonwealth Bank (Bee Investigations)	161	124
Commonwealth Bank (Forest Products Investigations)	80	80
Empire Marketing Board, England (Erection of Plant House)	34	34
Empire Marketing Board, England (Entomological Investigations)	6,533	*5,729
Empire Marketing Board, England (Plant Industry Investigations)	4,407	†4,339
Empire Marketing Board, England (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,187	1,989
Empire Marketing Board, England (Animal Health Investigations—Cattle Research)	4,466	4,466
Postmaster-General's Department (Radio Research) ..	2,892	2,886
Australian Pastoralists Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,032	1,989
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	1,200	1,200
Queensland Government (Animal Health Investigations—Cattle Research)	4,140	4,140
Council of Agriculture, Brisbane (Animal Health Investigations—Cattle Research)	404	404
McGarvie Smith Institute (Animal Health Investigations)	8	8
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	252	252
Dried Fruits Control Board (Dried Fruits Investigations) / Woorinen Dried Fruits Enquiry Committee (Dried Fruits Investigations)	1,266	1,266
Australian Dairy Council (Wood Taint in Butter Investigations)	81	39
Australian Meat Industry Employees' Union (Food Preservation Investigations)	50	..
Board of Trade (Storage and Transport of Citrus Fruit)	124	124
Melbourne and Metropolitan Tramways Board (Forest Products Investigations)	19	19
Queensland Meat Industry Board (Food Preservation Investigations)	440	436
Contributions received through Graziers' Association of Central and North Queensland (Peg Leg Disease Investigations)	134	71
Various Contributions (printing of Supplement to Catalogue of Scientific and Technical Periodicals in Libraries of Australia)	267	..
Australian Investment Agency Ltd. (Termite Investigations), Division of Economic Entomology) ..	75	75
Sir MacPherson Robertson (Entomological Investigations)	200	14
Thrips Investigation League (Thrips Investigations) ..	150	‡150
Messrs. Winter Irving and Alison (Zebu Cattle Project)	477	146
Carried forward ..	40,309	39,185

* Includes £821 on account of 1931–32 expenditure. † Includes £173 on account of 1931–32 expenditure. ‡ Includes £36 on account of 1931–32 expenditure.

	Receipts including balances brought forward from 1931–32.		Expenditure 1932–33.
	£		£
Brought forward ..	40,309		39,185
Queensland Stations Ltd. (Zebu Cattle Project) ..	150	..	146
Meredith Menzies & Co. Pty. Ltd. (Zebu Cattle Project)	475	..	147
C. W. Wright, Esq. (Zebu Cattle Project)	475	..	147
Derwent Valley Paper Co. Ltd. (Reconditioning of Experimental Paper Machine)	96	..	96
Commonwealth Banana Committee (Banana Investigations	270	..	268
Griffith Research Station (Citricultural Investigations)	645	..	..
Postmaster-General's Department (Forest Products Investigations)	20	..	20
Messrs. Allen-Liversidge (Aust.) Ltd. Forest Products Investigations)	11	..	11
Victorian Hardwood Co. Pty. Ltd. (Forest Products Investigations)	7	..	7
Messrs. Longoni Seggel & Co. Pty. Ltd. (Forest Products Investigations).	3	..	3
	56,672	..	53,249

3. *Staff.*—The following is a list of the staff of the Council as at the 30th June, 1933. The list does not include typists, laboratory assistants and labourers, &c.

1. Head Office Staff.

Chief Executive Officer—A. C. D. Rivett, M.A., D.Sc., F.A.C.I.
Secretary—G. Lightfoot, M.A.
Assistant Secretary—G. A. Cook, M.Sc., B.M.E., A.A.C.I.
Chief Clerk and Accountant—H. P. Breen. L.I.C.A.
Library—
Librarian and Scientific Assistant—Miss E. Archer, M.Sc.
Assistant Librarian—Miss A. L. Kent.
Accounts, Staff, Stores—
M. G. Grace, L.I.C.A.
J. Derum.
D. J. Bryant.
Orders—
R. W. Constable.
Records—
P. Domec Carre.
H. T. Chadwick.
W. Gillespie.
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.

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. (Queen's Can.), Ph.D. (Cornell).
Senior Plant Pathologist—H. R. Angell, B.Sc.Agr., (McGill), M.S. (Wis.) Ph.D. (Wis.)
Senior Plant Geneticist—J. R. A. McMillan, B.Sc.Agr. (Syd.), M.S. (Cornell).
Senior Plant Introduction Officer—A. McTaggart, B.S.A. (Toronto), M.S.A. (Cornell), Ph.D. (Cornell).
Assistant Botanist—C. Barnard, M.Sc. (Syd.).
Assistant Plant Pathologist—W. L. Geach, B.Sc. (Bristol).
Junior Plant Pathologist—Miss P. H. Jarrett, M.Sc.
Junior Plant Pathologist—W. V. Ludbrook, B.Agr.Sc. (Adel.), Ph.D. (Wis.). From 1st December, 1932.
Junior Plant Introduction Officer—W. Hartley, B.A. Dip. Agr. (Cantab.).
Junior Plant Geneticist—H. F. Smith, B.Sc. (Agr.), (Edin.), M.S.A. (Cornell).
Junior Plant Geneticist—C. S. Christian, B.Sc.Agr. (Q'land). M.Sc. (Min.). From 22nd May, 1933.
Technical Assistant (Genetics)—J. A. Harris, B.Sc.Agr (resigned 2nd June, 1933).
Technical Assistant (Genetics)—K. Loftus Hills, B.Agr.Sc.
Junior Botanist (Agrostological Investigations)—H. K. C. Mair, B.Sc.
Assistant Physiologist—J. Calvert, M.Sc. (Belfast), F.L.S.
Junior Plant Physiologist—C. G. Greenham, B.Sc. From 28th September, 1932.
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)—Mrs. L. M. Willings, B.A. (resigned 10th March, 1933).
Librarian (part-time)—Miss A. Taylor, B.Sc. (commenced 27th February, 1933).

At Waite Agricultural Research Institute, South Australia—

Assistant Plant Pathologist—J. G. Bald, B.Agr.Sc.

At University of Tasmania, Hobart—

Senior Plant Pathologist—W. H. Carne, F.L.S.
Junior Plant Pathologist—D. Martin, B.Sc. From 28th December, 1932.

5. Division of Soils.

At Waite Agricultural Research Institute—

Chief—Professor J. A. Prescott, M.Sc., A.A.C.I. (part-time).
Soil Survey Officer—J. K. Taylor, M.Sc., M.Agr.Sc., B.A.
Assistant Field Officer—T. J. Marshall, B.Agr.Sc.
Assistant Chemist—H. G. Poole, M.Sc., A.A.C.I. (resigned 14th December, 1932).
Assistant Chemist—J. S. Hosking, B.Sc.
Assistant Field Officer—P. D. Hooper.

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).
Temporary Chemist—A. Howard, M.Sc.

At University of Tasmania—

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

6. Irrigation Settlement Problems.

Commonwealth Research Station, Griffith—

Liaison Officer—F. K. Watson, M.A., B.Sc., A.M.Inst.C.E. (part-time).
Officer-in-Charge—E. S. West, B.Sc., M.S.
Accountant (part-time)—D. Chalmers.
Orchard Superintendent—B. H. Martin.
Field Assistant—S. Smith-White, B.Sc.Agr. (ceased 21st December, 1932.)
Field Assistant—R. R. Pennefather, B.Agr.Sc. (commenced 15th December, 1932).
Clerical Assistant—Miss E. Beck.

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

7. Division of Animal Health.

At Head Office, Melbourne—
Acting Chief—J. A. Gilruth, D.V.Sc., M.R.C.V.S.

At Melbourne University Veterinary Research Institute—
Veterinary Officer—D. Murnane, B.V.Sc.
Technical Assistant—Miss C. Eales, B.Sc.

At Adelaide Hospital Pathological Laboratory—
Veterinary Officer—C. G. Dickinson, B.V.Sc.
Chemist—A. T. Dann, M.Sc. (to 2nd April, 1933).

Townsville (North Queensland) Cattle Research Station—
Officer-in-Charge—A. W. Turner, D.Sc., D.V.Sc.
Veterinary Officer—J. Legg, D.V.Sc., M.R.C.V.S. (seconded from the Queensland Department of Agriculture and Stock).
Veterinary Field Officer—R. B. Kelley, B.V.Sc.
Assistant Bacteriologist—A. D. Campbell, B.V.Sc.
Chemist—A. T. Dann, M.Sc. (from 3rd April, 1933).
Assistant Bacteriologist—A. T. Dick, B.Sc. (from 10th January, 1933).
Clerical Assistant—Miss E. Horne (ceased 13th March, 1933).
Clerical Assistant—Miss M. Camp (commenced 15th March, 1933).

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.
Haematologist—W. A. Carr Fraser, D.Sc., B.V.Sc.
Bacteriological Technician—E. Parrish.
Field Officer—N. P. Graham, B.V.Sc. (seconded to Australian Pastoral Research Trust as frem 1st October, 1932).
Assistant Parasitologist—G. Kauzal, D.V.Sc.
Assistant Veterinary Officer—W. I. B. Beveridge, B.V.Sc.
Assistant Bacteriologist—E. Munch-Petersen, M.Sc., (temporary).
Clerical Assistant—Miss H. A. N. Turner, B.Arch.

8. Division of Animal Nutrition.

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

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

At "Buln Gherin" Sheep Station, Beaufort, Victoria—
Field Assistant—A. R. Beggs.

At "Meteor Downs" Sheep Station, Springsure, Queensland—
Field Assistant—C. Brown.

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

9. Mineral Deficiency of Pastures Investigation.

At the Waite Agricultural Research Institute—

Agronomist—K. M. Fraser, B.Agr.Sc.
Analytical Chemist—R. E. Shapter, A.A.C.I.

10. Division of Economic Entomology.

At Canberra—

Chief—R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), F.R.S.
Senior Entomologist—A. J. Nicholson, D.Sc.
Senior Entomologist—G. F. Hill.
Senior Systematic Entomologist—A. L. Tonnoir.
Senior Entomologist—I. M. Mackerras, B.Sc., M.B., Ch.M.
Senior Entomologist—G. A. Currie, B.Sc., B.Agr.Sc.
Entomologist—(Thrips Investigations)—J. W. Evans, B.A. (at Waite Institute).
Entomologist (Termite Investigations)—F. G. Holdaway, M.Sc., Ph.D.
Junior Entomologist—H. Willings, B.A. (resigned 13th February, 1933).
Junior Entomologist—Miss M. Fuller, B.Sc.
Junior Entomologist (Blowfly Investigations)—Mrs. M. J. Mackerras, M.Sc., M B.
Junior Systematic Entomologist—Miss W. P. Kent-Hughes, M.Sc. (resigned 31st August, 1932).
Junior Systematic Entomologist—Miss L. F. Graham, B.A (resigned 10th November, 1932).
Field Assistant—T. Greaves.
Veterinary Officer (Sheep Blowfly Investigations)—C. R. Mulhearn, B.V.Sc.
Librarian (part-time)—Mrs. L. M. Willings, B.A. (resigned 10th March, 1933).
Librarian (part-time)—Miss A. Taylor, B.Sc. (commenced 27th February, 1933).

At Farnham House Laboratory, England—

Entomologist—S. Garthside, B.Sc.Agr., M.Sc.

At Buitenzorg, Java, and Northern Australia—

Investigator (Buffalo-fly)—Professor E. Handschin, (ceased 22nd September, 1933).
Junior Entomologist—G. L. Windred, B.Agr.Sc. (resigned 19th May, 1933).

In Northern Australia—

Junior Entomologist—T. G. Campbell.

In Western Australia—

Assistant Entomologist—H. Womersley, (resigned 31st December, 1932).

At State College, Manhattan, Kansas, U.S.A.—

Junior 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.(Wis.), A.A.C.I.
Senior Wood Anatomist—H. E. Dadswell, M.Sc., A.A.C.I.

At Head Office, Melbourne (temporarily)—continued.

Assistant Timber Testing Officer—I. Langlands, B.E.E.
Seasoning Officer—W. L. Greenhill, B.E., Dip.Sc.
Utilization Officer—R. F. Turnbull, B.E.
Assistant Chemist—A. G. Charles.
Assistant Chemist—A. B. Jamieson, M.Sc.
Assistant Wood Technologist—Miss M. D. Burnell, B.Sc. (resigned 12th December, 1932).
Assistant Seasoning Officer—A. J. Thomas, Dip.For.
Assistant Wood Anatomist—Miss A. M. Eckersley, M.Sc.
Technical Assistant (part time)—Miss J. Galbraith.
Librarian and Records Clerk—Miss I. Hulme.
General Assistant—S. G. McNeil.

12. Cold Storage Investigations.

At Brisbane Abattoir—

Officer-in-Charge—J. R. Vickery, M.Sc., Ph.D.
Assistant Investigator—N. E. Holmes, B.E.E.
Assistant Biochemist—W. A. Empey, B.V.Sc.
Assistant Biochemist—W. J. Scott, B.Agr.Sc.

At University of Melbourne—

Advisor 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. (Cantab.).

At University of Queensland—

Assistant Biochemist—E. W. Hicks, B.Sc.
Assistant Plant Pathologist—Miss S. Hoette, M.Sc. (temporary from 1st January, 1933).

13. Radio Research.

At University of Melbourne—

Senior Investigator—G. H. Munro, M.Sc.
Investigator—R. O. Cherry, M.Sc. (resigned 15th January, 1933).

At University of Sydney—

Senior Investigator—A. L. Green, M.Sc., A.M.I.R.E.
Investigator—D. F. Martyn, B.Sc., Ph.D.

14. Other Investigations.

Mineragraphic Investigations—

Investigator—F. L. Stillwell, D.Sc.

Wood Taint in Butter Investigations—

Investigator—W. J. Wiley, M.Sc., (returned to Department of Agriculture and Stock, Brisbane, on 31st October, 1932).

Thrips Investigation—

Entomologist—J. W. Evans, B.A. (at Waite Institute).
Assistant Entomologist—H. C. Andrewartha, B.Agr.Sc. (W.A.), M.Agr.Sc. (Melb). —(at University of Melbourne).
Assistant Entomologist—Miss H. V. Steele, M.Sc. (at University of Melbourne).
Chemist—H. V. Wheeler, B.Sc. (at Waite Institute).

XIV.—ACKNOWLEDGMENTS.

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

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

G. LIGHTFOOT, Secretary.

October, 1933.

APPENDIX.

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

COUNCIL (AS AT 30TH JUNE, 1933).

Executive.

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

Chairmen of State Committees.

Professor R. D. Watt, M.A., B.Sc. (New South Wales).
W. Russell Grimwade, B.Sc. (Victoria).
Professor H. C. Richards, D.Sc. (Queensland).
Sir Walter J. Young, K.B.E. (South Australia).
B. Perry (Western Australia).
P. E. Keam (Tasmania).

Co-opted Members.

Sir David Orme Masson, K.B.E., M.A., D.Sc., L.L.D., F.R.S.
Professor E. J. Goddard, B.A., D.Sc.
Professor H. A. Woodruff, M.R.C.V.S., &c.

STATE COMMITTEES (AS AT 30TH JUNE, 1933).

New South Wales.

Professor R. D. Watt, M.A., B.Sc. (*Chairman*).
E. C. Andrews, B.A., F.G.S.
Professor Sir Henry E. Barraclough, K.B.E., V.D., B.E., M.M.E., M.Inst.C.E., M.I.Mech.E.
Professor H. G. Chapman, M.D., B.S.
G. P. Darnell-Smith, D.Sc., F.I.C.
C. H. Hoskins.
The Hon. Sir Norman W. Kater, Kt., M.L.C., M.B., Ch.M.
F. Leverrier, K.C., B.A., B.Sc.
F. D. McMaster.
J. Nangle, O.B.E., F.R.A.S.
E. D. Ogilvie, B.A.
Professor T. G. B. Osborn, D.Sc.
Professor J. D. Stewart, M.R.C.V.S., B.V.Sc.
G. D. Ross.

Victoria.

W. Russell Grimwade, B.Sc. (*Chairman*)
Emeritus-Professor Sir David Orme Masson, K.B.E., M.A., D.Sc., LL.D., F.R.S.
Professor W. E. Agar, M.A., D.Sc., F.R.S.
W. Baragwanath.
W. F. Cuming (died May, 1933).
Sir Herbert W. Gepp, Kt., M.Aust.I.M.M., M.Am.I.M.M.
G. D. Kelly, LL.B.
Professor W. N. Kernot, B.C.E., M.Mech.E., M.Inst.C.E.
Emeritus-Professor Sir Thomas R. Lyle, M.A., D.Sc., F.R.S.
H. A. Mullett, B.Agr.Sc.
F. J. Rae, B.Agr.Sc., B.Sc.
W. E. Wainwright, A.S.A.S.M., M.Aust.I.M.M., M.Am.I.M.M.
L. J. Weatherly, M.A.
Associate-Professor W. J. Young, D.Sc.

South Australia.

Sir Walter J. Young, K.B.E. (*Chairman*).
E. H. Bakewell.
L. B. Bull, D.V.Sc.
Professor Kerr Grant, M.Sc., F.Inst.P.
W. A. Hargreaves, M.A., B.C.E., D.Sc., F.I.C.
W. J. Hill.
Professor T. H. Johnston, M.A., D.Sc.
Sir Charles J. Martin, Kt., C.M.G., M.B., D.Sc., LL.D., F.R.C.P., F.R.S.
Professor A. J. Perkins.
F. T. Perry.
Professor J. A. Prescott, D.Sc.
L. K. Ward, B.A., B.E., D.Sc.

QUEENSLAND.

Professor H. C. Richards, D.Sc. (*Chairman*).
Professor H. Alcock, M.A.
J. D. Bell.
J. C. Brunnich, F.I.C. (Died 3/7/33).
E. Graham.
J. B. Henderson, O.B.E., F.I.C.
T. L. Jones.
A. J. B. McMaster.
Professor J. K. Murray, B.A., B.Sc.Agr.
Professor T. Parnell, M.A.
Professor B. D. Steele, D.Sc., F.R.S., F.I.C.
W. L. Payne.

WESTERN AUSTRALIA.

B. Perry, (*Chairman*).
F. G. Brinsden, M.I.M.M., M.Aust.I.M.M.
Professor E. de Courcy Clarke, M.A.
J. D. Hammond.
S. L. Kessell, M.Sc., Dip.For.
E. H. B. Lefroy.
Professor G. E. Nicholls, D.Sc., A.R.C.Sc., F.L.S.
Professor A. D. Ross, M.A., D.Sc., F.R.S.E., F.Inst.P.
E. S. Simpson, D.Sc., B.E.
G. L. Sutton.
Professor H. E. Whitfield, B.A., B.E., M.I.M.M., M.I.E.Aust.
Professor N. T. M. Wilsmore, D.Sc., F.I.C., M.I.Chem.E.

TASMANIA.

P. E. Keam, (*Chairman*).
N. P. Booth, F.I.C.
Professor A. Burn, M.Sc., B.E.
H. A. Curtis, A.M.Am.I.E.E., A.M.I.E.Aust. (died May, 1933).
Professor A. L. McAulay, M.A., B.Sc., Ph.D., F.Inst.P.
D. O. Meredith, A.Inst.M.M., M.I.E.Aust., M.A.C.S.
A. K. McGaw.
F. H Peacock.
R. O. Shoobridge.
S. W. Steane.
F. E. Ward.

STANDING COMMITTEE ON AGRICULTURE (STATE MEMBERS).

Professor A. J. Perkins, Director, Department of Agriculture, South Australia (*Chairman*).
H. A. Mullett, Director, Department of Agriculture, Victoria.
E. Graham, Under-Secretary, Department of Agriculture and Stock, Queensland.
G. D. Ross, Under-Secretary, Department of Agriculture, New South Wales.
G. L. Sutton, Director, Department of Agriculture, Western Australia.
F. E. Ward, Director, Department of Agriculture, Tasmania.

COMMONWEALTH RESEARCH STATIONS, MERBEIN AND GRIFFITH—COMMITTEE OF CONTROL.

B. T. Dickson, B.A., Ph.D., Chief, Division of Plant Industry, C.S.I.R.
Professor J. A. Prescott, M.Sc., Waite Agricultural Research Institute, University of Adelaide.
F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, Griffith, New South Wales.

COMMONWEALTH RESEARCH STATION, MERBEIN—ADVISORY COMMITTEE.

D. C. Winterbottom, Mildura Packers' Association (*Chairman*).
S. P. Bromfield, State Rivers and Water Supply Commission, Victoria.
A. Lever, Mildura Shire Council.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, Griffith, New South Wales.
J. A. Lochhead, Mildura Shire Council.
A. E. Cameron, Red Cliffs Settlement.
D. F. Gordon, Citrus Growers' Association, Merbein.

COMMONWEALTH RESEARCH STATION, GRIFFITH—ADVISORY COMMITTEE.

F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, Griffith, New South Wales (*Chairman*).
A. G. Kubank, Murrumbidgee Irrigation Rice Growers' Co-operative Society.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
P. H. Rutlidge, Yenda Producers' Co-operative Society Ltd.
J. S. Vagg, Griffith Fruit Growers' Co-operative Co.
E. S. West, B.Sc., M.S., Commonwealth Research Station, Griffith.
V. C. Williams, Murrumbidgee Irrigation Areas Research Bureau, Griffith.

POISON PLANTS COMMITTEE.

H. Finnemore, B.Sc., Department of Pharmacy, University of Sydney (*Chairman*).
B. T. Dickson, B.A., Ph.D., Chief Division of Plant Industry, C.S.I.R.
Professor J. C. Earl, D.Sc., Ph.D., F.I.C., Department of Organic Chemistry, University of Sydney.
Colonel Max Henry, M.R.C.V.S., Department of Agriculture, New South Wales.
Professor T. G. B. Osborn, D.Sc., Department of Botany, University of Sydney.
Associate-Professor H. J. Priestly, M.D., Ch.M., B.Sc., Department of Physiology, University of Sydney.
H. Seddon, D.V.Sc., Glenfield Veterinary Research Station, Department of Agriculture, New South Wales.
G. P. Darnell-Smith, D.Sc., Botanical Gardens, Sydney.
J. A. Gilruth, D.V.Sc., M.R.C.V.S., &c., Acting Chief, Division of Animal Health, C.S.I.R.

CITRUS PRESERVATION COMMITTEE.

Associate-Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne (*Chairman*).
W. D. Bracher, Victorian Railways.
Captain D. Halhed, Victorian Central Citrus Association.
J. Hepburn, Works Manager and Chief Engineer, Government Cool Stores, Victoria Dock, Melbourne.
G. E. Kitchen-Kerr, Victorian Central Citrus Association.
F. M. Read, M.Agr.Sc., Department of Agriculture, Victoria.
W. Ranger, Committee of Direction of Fruit Marketing, Queensland.
J. R. Vickery, M.Sc., Ph.D., Section of Food Preservation and Transport, C.S.I.R.

RADIO RESEARCH BOARD.

Professor J. P. Madsen, B.E., D.Sc., Department of Engineering, University of Sydney (*Chairman*).
H. P. Brown, M.B.E., M.I.E.E., Postmaster-General's Department.
Electrical-Commander F. G. Cresswell, Department of Defence.
Professor T. H. Laby, M.A., Sc.D., F.I.P., Department of Natural Philosophy, University of Melbourne.

MINERAGRAPHIC COMMITTEE.

Professor E. W. Skeats, D.Sc., A.R.C.Sc., F.G.S., Geology School, University of Melbourne.
W. E. Wainwright, A.S.A.S.M., M.Aust.I.M.M., M.Am.I.M.M., Australasian Institute of Mining and Metallurgy.

FRUIT PROCESSING COMMITTEE.

(*Formerly Sulphuring of Apricots Committee.*)

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
W. R. Jewell, M.Sc., Research Chemist, Department of Agriculture, Victoria.
G. Quinn, Chief Horticultural Officer, Department of Agriculture, South Australia.
C. G. Savage, Director of Fruit Culture, Department of Agriculture, New South Wales.
F. de Castella, Department of Agriculture, Victoria.

ADVISORY COMMITTEE ON PASTORAL PROBLEMS.

A. C. D. Rivett, M.A., D.Sc., Council for Scientific and Industrial Research (*Chairman*).
G. L. Aitkin, Australian Pastoralists' Research Trust.
G. D. Kelly, LL.B., Australian Pastoralists' Research Trust.
Sir Charles Martin, Kt., C.M.G., M.B., D.Sc., LL.D., F.R.C.P., F.R.S., Chief, Division of Animal Nutrition.
J. A. Gilruth, D.V.Sc., Acting Chief, Division of Animal Health, C.S.I.R.

COMMITTEE ON SUPPLEMENTS TO THE CATALOGUE OF SCIENTIFIC PERIODICALS.

E. R. Pitt, B.A., Public Library of Victoria.
W. H. Ifould, Public Library of New South Wales.
Miss E. Archer, M.Sc., Council for Scientific and Industrial Research.

B.—Committees Controlling Work in which the Council is Co-operating.

EXECUTIVE COMMITTEE, AUSTRALIAN TOBACCO INVESTIGATION.

J. H. Starling, Prime Minister's Department (*Chairman*).
The Hon. J. Gunn, Development Branch, Prime Minister's Department.
A. C. D. Rivett, M.A., D.Sc., Council for Scientific and Industrial Research.

SCIENTIFIC PUBLICATIONS COMMITTEE.

S. G. McFarlane, Commonwealth Treasury (*Acting Chairman*)
A. C. D. Rivett, M.A., D.Sc., Council for Scientific and Industrial Research.
H. J. Sheehan, Secretary, Commonwealth Treasury (Abroad).
W. G. Woolnough, D.Sc., Geological Adviser to the Commonwealth.

CATTLE RESEARCH ADVISORY COMMITTEE.

(For Townsville Station.)

E. E. D. White, Queensland United Grazier's Association (*Chairman*).
J. L. Wilson, Queensland United Graziers' Association.
F. M. Bell, Queensland United Graziers' Association.
R. C. Philp, Queensland United Graziers' Association.
N. Bourke, Queensland United Graziers' Association.
D. M. Fraser, Queensland United Graziers' Association.
P. A. Brown, Queensland United Graziers' Association.
Professor H. C. Richards, D.Sc., University of Queensland.
E. Graham, Department of Agriculture and Stock, Queensland.
A. H. Cory, M.R.C.V.S., Department of Agriculture and Stock, Queensland.

C.S.I.R. FOOD PRESERVATION COMMITTEE—QUEENSLAND BRANCH.

E. F. Sunners, Queensland Meat Industry Board (*Chairman*).
W. Ranger, B.Sc.,Committee of Direction of Fruit Marketing, Queensland.
Associate-Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne.
J. R. Vickery, M.Sc., Ph.D., Food Preservation and Transport Section, C.S.I.R,
Professor L. S. Bagster, D.Sc., University of Queensland.

C.S.I.R. FOOD PRESERVATION COMMITTEE—QUEENSLAND BRANCH.

FRUIT PRESERVATION RESEARCH SUB-COMMITTEE.

(Formerly Banana Maturation and Transport Committee.)

W. Ranger, B.Sc., Committee of Direction of Fruit Marketing, Queensland (*Chairman*).
Professor L. S. Bagster, D.Sc., Department of Chemistry, University of Queensland.
Associate-Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne.
G. Williams, Director of Fruit Culture, Department of Agriculture and Stock, Queensland.
T. E. Maloney, Commissioner's Inspector, Queensland Railways, Brisbane.
J. R. Vickery, M.Sc., Ph.D., Food Preservation and Transport Section, C.S.I.R.

ADVISORY COMMITTEE ON FRUIT COOL STORAGE INVESTIGATIONS.

Associate-Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne (*Chairman*).
D. B. Adam, B.Sc.Agr., Department of Agriculture, Victoria.
F. M. Read, M.Sc.Agr., Horticultural Division, Department of Agriculture, Victoria.
J. R. Vickery, M.Sc., Ph.D., Food Preservation and Transport Section, C.S.I.R.

"COAST DISEASE" COMMITTEE.

ADELAIDE.

Sir Charles J. Martin, Kt., C.M.G., &c., Chief, Division of Animal Nutrition, C.S.I.R. (*Chairman*).
J. A. Gilruth, D.V.Sc., M.R.C.V.S., Acting Chief, Division of Animal Health, C.S.I.R.
L. B. Bull, D.V.Sc., Government Laboratory of Bacteriology and Pathology, Adelaide Hospital.
Professor J. A. Prescott, D.Sc., Chief, Division of Soils, C.S.I.R.
H. R. Marston, Division of Animal Nutrition, C.S.I.R.
C. G. Dickinson, B.V.Sc., Division of Animal Health, C.S.I.R.
R. H. F. McIndoe, M.R.C.V.S., Deputy Chief Veterinary Officer, Stock and Brands Department, South Australia.

Printed and Published for the GOVERNMENT of the COMMONWEALTH of AUSTRALIA by
L. F. JOHNSTON, Commonwealth Government Printer, Canberra.