1937.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

ELEVENTH ANNUAL REPORT

OF THE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

FOR THE

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CONTENTS.

CONTENTS—*continued.*

COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

ELEVENTH ANNUAL REPORT FOR YEAR ENDED 30TH JUNE, 1937.

I. INTRODUCTORY AND GENERAL.

1. *General.*—The Council for Scientific and Industrial Research was established in 1926 by the re-organization of the existing Institute of Science and Industry. The powers and functions of the Council are defined by the *Science and Industry Research Act* 1920–1926, and include the initiation and carrying out of research in connexion with, or for the promotion of, primary and secondary industries, the training of research workers, the making of grants in aid of pure research, and the establishment of a Bureau of Information relating to scientific and technical matters.

An important development of the Council's activities during the financial year 1936–37 has been the establishment of a Fisheries Section to conduct investigations into Australian fisheries problems that were placed under the control of the Council in the year 1935. Dr. H. Thompson, formerly Director of Fisheries Investigations in Newfoundland, arrived in Australia in March, 1937, to take up his duties as Officer-in-charge of the Section. Previous to his Newfoundland appointment, Dr. Thompson was for ten years biologist to the Fishery Board of Scotland, during which period he was closely associated with the work of the International Council for the Exploration of the Sea.

At the present time, the Fisheries Section is housed in temporary quarters in Post Office-place, Melbourne ; but it is hoped that it will be possible to establish, in the near future, a properly-equipped fisheries research station in a suitable location that will also be a convenient base for the investigation vessel at present under construction.

2. *New Laboratories.*—During the year, considerable progress was made in the provision of adequate laboratory facilities for the various sections of the Council's work.

Towards the latter end of 1936, work on the new Forest Products Laboratory in South Melbourne, and the new laboratory building at the Viticultural Research Station, Merbein, was completed, and the two buildings occupied. The Forest Products Laboratory was officially opened on the 7th April, 1937, by Mrs. Russell Grimwade, whose husband, the Chairman of the Council's Victorian State Committee, had generously donated the sum of £5,000 for the purchase of plant and equipment.

Building operations on the headquarters laboratories and experimental cool stores of the Section of Food Preservation and Transport commenced just before the end of the financial year ; it is anticipated that these will be ready for occupation before the end of 1937. These laboratories are located at Homebush, Sydney, and, when completed, they will enable the work of the Section, at present carried out in a number of widely-separated localities, to be concentrated in the one centre.

Work on the new Animal Health Laboratory in the grounds of the Veterinary Research Institute of the University of Melbourne was commenced early in 1937, and it is anticipated that this, too, will be ready for occupation by the end of the calendar year.

In the last Report, reference was made to the purchase of 800 acres of land near St. Mary's, New South Wales, to be used as a field station for various animal health investigations, and for work on fertility. The improvement of this area has proceeded during the year, fences, dams, a shearing shed, a cottage, &c., having been provided. The vendor of the land, Mr. Norman Buffier, has informed the Council that he would like to contribute £500 to be used for the erection of a building on the property which would serve as a memorial to his father. This generous offer has been gratefully accepted ; and it is proposed to build a small field laboratory which will commemorate the name of the late Mr. Buffier.

3. *Standards, Testing and Research for the Secondary Industries.*—It was mentioned in the last Report that the Commonwealth Government proposed to extend the activities of the Council to embrace investigations into the problems of Australia's secondary industries. Hitherto, because of the limitation of funds, and because of the more urgent needs of the primary producer, who is completely dependent on outside assistance for the solution of those of his problems which demand research and experimentation, the activities of the Council have been almost exclusively confined to research in connexion with primary industries.

In order to review the field, to determine the nature and lines of development of the organization required to undertake the secondary industries research work, to prepare a programme of work, and to make estimates of costs, the Government appointed a Committee broadly representative of the various interests concerned (*see* Appendix) to prepare a report and make recommendations on the whole matter. Early in 1937, this Secondary Industries Testing and Research Committee completed its report, which is now under consideration by the Government.

The main recommendations of the Committee were concerned with (*a*) the establishment of a Reference Standards Laboratory for the maintenance of basic standards (of length, mass, electrical units, &c.) essential for precision and manufacture; (*b*) the extension of the Council's existing Information Service for the collection and dissemination of technical information and the results of research; and (*c*) the initiation of a Research Service to deal with the problems arising in secondary industries such as cannot be handled by works' staffs and require the attention of a national organization.

In order to collect data on the organization and work of Information Services in science and technology, the Secretary of the Council, Mr. G. Lightfoot, left Australia in June, 1937, on a visit to the United States of America, Canada, and Great Britain, the greater part of his expenses being paid by a grant from the Carnegie Corporation.

4. *Grants from the Australian Wool Board.*—During the financial year, the *Wool Publicity and Research Act* 1936 was passed by Parliament, and the Australian Wool Board thus set up to administer the fund derived from the wool levy made under the provisions of the *Wool Tax Act* 1936. The Board held its first meeting in January, 1937. The Council, in common with other research organizations, was invited to submit a statement outlining its investigations in connexion with the sheep and wool industry, in order that the Board could review the whole field of research in Australia and decide which activities it might appropriately subsidize, and what new investigations it should support.

As a result of a meeting held in April, 1937, a number of grants, mostly for work in the field of animal health, were approved by the Board. The Council's share of the contributions for the first year (some of the grants are recurrent for two or three years) is very considerable. Grants totalling over £7,500 have been promised to the Council for the extension of its work in the following fields:—Animal nutrition, blowfly investigations, parasitology, genetics and fertility problems, toxæmic jaundice, footrot and ophthalmia. In addition, the Board has approved a grant of £10,000, to be followed by one of £7,500 in the second year, towards the establishment of a field research station in south-western Queensland to enable large-scale studies and experiments to be carried out in connexion with the blowfly and other problems affecting the grazing industry. The area of about 40,000 acres involved in this station is being made available by the Queensland Government at a nominal rental.

The provisions of the wool levy and the establishment of the Australian Wool Board form part of an international scheme in which other Empire wool-producing countries are co-operating. In connexion with this scheme, an International Wool Publicity and Research Secretariat has been established in London, the Australian representative on which is Dr. I. Clunies Ross, formerly Officer-in-charge of the Council's F. D. McMaster Animal Health Laboratory, Sydney.

5. *Reports by Sir David Rivett.*—Mention was made in the last annual report that Sir David Rivett, Chief Executive Officer of the Council, left Australia on the 26th May, 1936, on a visit to Great Britain and the Continent, in order to attend the British Commonwealth Scientific Conference held in London in September, 1936, and to make certain inquiries on behalf of the Commonwealth Government, particularly in regard to the production of oil from coal. Sir David returned to Australia in December, 1936, and submitted reports to the Minister-in-charge of the Council on the proceedings of the Conference and on the production of oil from coal.

In regard to the production of oil from coal, he was able to collect a considerable amount of information. From the information obtained, it was possible to arrive at an estimate of the probable cost of production, in Australia, of petrol from black and brown coal. The costs did not differ greatly in the case of the hydrogenation and synthetic processes; and in both cases the cost per gallon was some three times that of imported fuel from flow oil. The low-temperature distillation process can be ruled out as impracticable, since its success depends on the economic disposal of large quantities of "semi-coke", the principal product of the process. Thus, judged solely from the economic point of view, the production of oil from coal, either by the hydrogenation or the synthetic process, would be unjustifiable in Australia. There are, however, many other considerations entering the picture, for example, those of defence, the value to the country of a strong corps of industrial chemists and engineers, employment, and the like.

Sir David Rivett's report on the production of oil from coal was presented to the Minister on 21st December, 1936, and after consideration by Cabinet was referred to the Hydrogenation Committee*, which then prepared a report expressing general accord with the views it contained. Both reports were tabled in Parliament in June, 1937.

6. *Deaths of Dr. J. A. Gilruth and Dr. R. J. Tillyard.*—During the year Australia lost by death two of the Council's foundation Divisional Chiefs, Dr. J. A. Gilruth and Dr. R. J. Tillyard.

Dr. Gilruth, Consultant and former Chief of the Council's Division of Animal Health, died on 4th March, 1937. During the seven years of his chiefship, he lived to see many problems upon which he had worked in his more active laboratory life and with which his name will always be associated, brought nearer to solution, among them entero-toxæmia, black disease, caseous lymphadenitis and parasitism. Another of his interests was the introduction of Zebu cattle for tropical Australian conditions. When the Council took over the Queensland State Laboratory at Townsville for five years to carry out work on diseases of cattle in Northern Australia, Dr. Gilruth entered enthusiastically into the project, and mapped out a plan of research that during the five years' period yielded results of great and immediate practical importance. He will be long remembered by his staff, to whom he was a friend as well as a leader.

Dr. Tillyard met his death as a result of a motor accident in January, 1937. He was appointed Chief of the Division of Economic Entomology in 1928 ; and his first task was to select a suitable team of workers and to organize the new Division's activities. The problems initially selected for investigation were those of the sheep blowfly, buffalo-fly, termites, and the control of certain insect pests and noxious weeds by their natural enemies. Unfortunately, owing to ill-health, Dr. Tillyard was compelled to retire early in 1934 ; but much of the work he initiated still continues. Apart from the economic aspects of entomology, he was a world authority on certain fundamental aspects of the science, notably wing-venation and fossil insects.

II. PLANT INVESTIGATIONS.

1. *General.*—During the year the investigations of the Division of Plant Industry were mainly confined, as in previous years, to problems in five major groups :—Pastures, fruit, wheat, tobacco and weeds, each requiring long-time and steady effort to arrive at economic and practical solution. Material help was given to the officers of the Division by their colleagues in other Commonwealth Departments and particularly in the Departments of Agriculture of the several States ; by colleagues in the Universities, particularly the University of Sydney (Department of Organic Chemistry), the University of Adelaide (the Waite Agricultural Research Institute), the University of Queensland and the Agricultural College at Gatton (Lawes) where laboratory space and land have been made available for work in plant introduction, pasture plant breeding and weeds control, and the University of Tasmania where laboratory facilities have been provided for studies on diseases of storage and export apples.

Pasture plant problems constitute the most important group, and they may be divided into five types :—Those of (*a*) the monsoonal and (*b*) the winter rainfall zones enjoying more than 30 inches of annual precipitation ; (*c*) the monsoonal and (*d*) the southern zones with between 15 and 30 inches of rain ; and (*e*) the area within the 15-in. line of rainfall. Broadly there are three major phases of investigation, viz., pasture management, introduction of suitable plants, and the improvement of pasture plants.

Work in the field of pasture management has not yet been developed by the Division, though the investigation into the control of the galvanized burr (*Bassia* spp.), and the preparation of the recently published pasture map of the continent both have a distinct bearing on the broad question. Regarding plant introduction, among the nearly 1,000 grasses and like number of leguminous plants that have been collected by the Division since 1930, some very promising species have been obtained, including some reputedly useful drift-arresting plants. The testing of this large number will obviously call for long and patient work ; but so did the early trials with lucerne, rye grass, subterranean clover, &c., all plants which are generally accepted to-day as being highly valuable. As it is reasonably certain that there are some species and strains still to be found that would be valuable additions to our pastures, constant touch is maintained with other countries with a view to obtaining such types. Work on pasture plant improvement was initiated last year, and is now in progress at Canberra, Moss Vale (New South Wales), and Gatton (Queensland), and covers a reasonably wide range of pasture plants. The work embraces the selection of types, crossing for vigour, leafiness, palatability, persistence under grazing, &c.

For plant introduction trials in the north coastal zone, the Central Queensland Meat Export Company has made available an area of land at Fitzroy, near Rockhampton ; and for pasture plant breeding in the better rainfall area of the south, the Honorable Sir Norman Kater has provided an area on his estate near Moss Vale.

* A committee appointed by the Commonwealth Government in 1934 to inquire into the question of establishing a plant in Australia for the production of oil from coal by the hydrogenation process.

During the year, in addition to the normal work in the field of fruit investigations, a special survey was undertaken to ascertain the extent, importance, and causes of what is generally known as " die-back " in apple trees. No one cause of the trouble was found, though poor soil drainage is a general factor. The survey brought to light the fact that the incidence of the most important and widespread type of die-back is correlated with latitude, and has a distinct bearing on the suitability of the different districts for apple production.

Following the provision by the Commonwealth Government of a grant of £20,000 for technical assistance to the apple and pear industry, a conference was held in Melbourne between representatives of the Council and the State Departments of Agriculture. An allocation was agreed upon whereby £8,850 was made available for one year for advisory work covering cultural practices, re-working trees, packing, &c., and £10,170, spread over two years, for research into such problems as codling moth, diseases, stock studies, mineral deficiencies, &c.

Wheat investigations have been continued into the inheritance of yield characteristics and the grass-clump character, into diseases, and physico-chemical studies of saps in connexion with drought resistance. An account of the Division's weeds investigation work will be found in a separate section (No. IV.) of this Report. In the field of tobacco investigation, a considerable advance in the control of blue mould in the seed bed has been made with the development of the benzol method of control. This will enable growers to be sure, at least, of plants to set out in the fields. The problem of the control of field mould is in hand; and another disease of increasing importance, a virus dwarfing, is being investigated.

A conference of Commonwealth and State tobacco officers was held at Brisbane in July, 1936; and a very satisfactory interchange of experimental data, review of work, and co-operative arrangement for the year's programme took place. This ensures that efforts are turned in the direction of developing the industry on an Australia-wide basis.

Two other conferences of immediate interest to the Division were held in Adelaide in October, 1936. A conference of agrostologists of the States, representatives of the Waite Agricultural Research Institute and the Division of Plant Industry, met to review pasture problems and co-ordinate, as far as possible, experience and effort. The conference was undoubtedly successful in doing so. A conference of seed-testing officers reviewed testing methods, revised the list of weed seeds, and again reviewed standards with the aim of reaching uniformity in Commonwealth and State Acts.

During the year the Chief of the Division and the Director of the Waite Agricultural Research Institute collaborated in the preparation of a report on fibre plants, particularly those likely to be suitable for the production of fibre in Australia.

2. *Plant Introduction.*—(i) *General.*—During the year 309 additional plants were introduced, making a total of 5,815, received directly from 63 countries since 1930. The following is a classification of these introductions:—

Classification of Introductions.	Total number to 30th June, 1937.
Wheats	2,800
Grasses	979
Legumes	981
Miscellaneous plants	193
Barleys	165
Maizes	161
Vegetable and garden crops	97
Forage plants other than grasses and legumes	43
Oats	19
Tea plant varieties	11
Fruit crops	41
Fibre-producing crops	22
Rubber-producing crops	7
Insecticidal plants	5
Tobacco	289
Oil-producing plants	2
Total to date	5,815

These plants are briefly described in Plant Introduction Inventories Nos. 1, 2, 3, 4, 5 and 6 (in course of compilation). Seed of 78 species and varieties were sent abroad in exchange during the year, making a total of 1,118 lots of seed since the inception of the work.

(ii) *Cereals.*—The testing (for yield, freedom from disease, &c.) of introduced wheats, oats and barleys is being continued, but it is proposed to curtail this work as data covering at least three years in each test are obtained.

The average yields of a further large group of introduced wheats systematically tested over a period of three years at Duntroon revealed (*a*) the superior yielding ability of certain strains introduced from Portugal, these being equal in yield to Waratah, the highest yielding (42.42 bushels per acre) check; (*b*) the superior yielding ability of certain strains from Portugal, Canary Islands, Spain, Asia Minor, and Syria, these ranking in yield between Canberra and Nabawa, the second and third highest yielding checks, respectively.

Four years' average results with ten introduced oats, increased later to thirteen, showed the superiority of Red Algerian No. 61 (a strain introduced direct from Algeria) which gave during that period an average yield of 70.67 bushels per acre. Other good yielding introduced oats were Legacy (66.29 bushels), Kherson (63.6 bushels), Iowa No. 3 (62.06) bushels), and Prolific (58.44 bushels). All four varieties gave a higher average yield than Mulga, the best of the two checks, which yielded 57.98 bushels per acre.

Three years' average yields with barley showed that none out-yielded the check (Trabut—48.48 bushels per acre), though Charlottetown 80, Swedish Gold, Danish Island, and Club Mariout were practically the equal in yield of the check. Other good yielding varieties were Hannchen, Bay Brewing, Peruvian, Orge Carreé d'Algerie No. 42, and California Feed. Special tests have shown that Peruvian is also of particular interest from the malting standpoint.

(iii) *Grasses.*—During the year steady progress in the investigation at Duntroon of persistency (based on percentage ground cover), productivity, and palatability was made with a large number of additional introduced grasses; and data thereon will be available in December, 1937. Meantime, the following showed good persistency and palatability and were productive :—*Diarrhena americana*; *Poa scabrella*; *Poa pratensis* (Uruguayan); *Lolium perenne* (Moscow); *Dactylis glomerata* (South France); *D. glomerata* var. *lobata*; *Festuca varia*; *F. pratensis* (" Lyngby "); *F. pratensis* (" Otofte "); *F. spadicea*; *Arrhenatherum erianthum*; *A. avenaceum*; *Bromus inermis* (Kansas); *Agropyron caninum*; *Koeleria eriostachya.*

Introduced grasses which have been recorded as soil-binders include: *Elymus giganteus* (grows in sand); *E. multicaulis*; *Panicum obtusum* (Grapevine mesquite); *Agropyron ramosum*; *Calamagrostis epigeios* (salt-tolerating); *Bromus inermis*; *Digitaria pentzii* (for summer rainfall areas).

(iv) *Legumes.*—Five-year variety trials of lucerne at Duntroon have recently been completed. The data for average yield of air-dried forage per acre have shown that the introduced Hairy Peruvian variety is superior in productivity to the Hunter River variety which was used as the check, and that the Arizona Common and Chinese introduced varieties are at least the equal in yield of the check.

(v) *Trials at Gatton, Queensland.*—The 1936-37 season at Gatton was abnormally dry, except at the latter end of the season. Row studies of legumes, for forage and green manure, and row and plot studies with grasses, were continued at this station. Grasses found to be distinctly promising include: *Brachiaria brizantha, Paspalum scrobiculatum, Brachiaria dictyoneura, Dichanthium* sp., *Eragrostis superba, Ischaemum laxum, Sporobolus virginicus, Digitaria Pentzii*, and *Digitaria valida.*

The following legumes are considered as definitely promising pasture species :—*Lespedeza daurica, Lespedeza juncea, Lespedeza sericea, Lespedeza striata, Lespedeza stipulacea*, and *Stylosanthes procumbens. Stylosanthes guyannensis* demands a more frost-free climate that that of Gatton. Legumes which have been proved distinctly promising for green-manuring and cover crop purposes include *Calopogonium mucunoides, Calopogonium brachycarpum, Dolichos lablab, Stizolobium atterimum, Stizolobium deeringianum, Phaseolus ricciardianus, Phaseolus trinervus* (Jerusalem pea), and various species of *Crotalaria* and *Sesbania.*

Grasses which have proved palatable, nutritious, and capable of withstanding periodic grazing (with cattle) are *Brachiaria brizantha, Paspalum scrobiculatum*, a species of *Dichanthium*, a strain of *Panicum maximum, Eragrostis superba*, and *Digitaria Pentzii.*

(vi) *Trials at Fitzroyvale, Queensland.*—The tests conducted at the new station at Fitzroyvale, though of only one year's duration, have shown great promise, the growth in many instances being remarkable. The following grasses showed the greatest promise :—*Andropogon pertusus* (Indian strain), *Amphilophis glabra, Brachiaria brizantha* (outstanding), *Brachiaria dictyoneura, Chloris gayana* (Kenya strain No. 1), *Chloris gayana* (Javan strain), *Digitaria exilis, Ischaemum laxum, Melinis minutiflora, Panicum antidotale* (excellent for dry periods), *Panicum maximum* (Rhodesian strain), *Panicum maximum* var. *gongylodes* (outstanding), *Pennisetum ciliare* (Kenya strain), *Pennisetum gracile* (outstanding), *Polystrias diversiflora* (Tropical lawn grass), *Urochloa bulboides, Urochloa mosambicensis, Sorghum* sp. " Fara fara ", and *Sorghum* sp. " Jar Dawa " (both outstanding for silage and soilage).

Legumes which showed up the most promisingly for pasture purposes included :—*Alysicarpus longifolius*, *Alysicarpus rugosus*, *Alysicarpus vaginalis*, *Lespedeza striata* (Texas type—C.P.I. 3749), *Lespedeza striata* (Washington type—C.P.I. 1034), *Meibomia barbata*, *Meibomia discolor*, *Stylosanthes guyannensis*, *Stylosanthes guyannesis* var. *subviscosis*.

Legumes which showed great promise for use as cover and green-manure crops, the growth of which was in many cases very satisfactory, were the following :—*Calopogonium mucunoides* and *Calopogonium brachycarpum* (both outstanding), *Centrosema pubescens* (outstanding), *Canavalia ensiformis*, *Indigofera endecaphylla*, *Crotalaria anagyroides*, *Crotalaria goreensis*, *Crotalaria maxillaris*, *Crotalaria alata*, *Indigofera hirsuta* (Brazil and Trinidad strains), *Tephrosia candida* (Trinidad strain), *Dolichos lablab* (outstanding), *Doliches debilis*, *Phaseolus ricciardianus*, *Phaseolus trinervius* (Jerusalem pea), *Stizobolium atterimum* (very superior strain), *Stizolobium deeringianum*, *Stizolobium* sp. (Somerset velvet bean), *Stizoloblium* sp. (early speckled velvet bean).

(vii) *Pyrethrum.*—Trials of pyrethrum from several sources demonstrated the superiority in yield of C.P.I. 2288 (Japanese pyrethrum, the seed of which was introduced in 1931 from the Yokohama Nursery Company, Yokohama, Japan). Analysis of the powder produced from its dried heads has revealed its insecticidal efficiency, as determined by its satisfactory content of pyrethrins.

3. *Pasture Plant Improvements.*—(i) *At Canberra.*—At Canberra the first generation of the cross between Dwalgamup and Wenigup subterranean clover was raised, and the second generation sown in the autumn. Crosses between Wenigup and Tallarook were obtained. For areas too dry for successful growth of subterranean clover, annual legumes, particularly medics, have been collected, and in the first year are being grown at Canberra. Breeding work for districts similar to Canberra has been begun with *Bromus inermis*, cocksfoot, white clover, and with *Bromus* spp. for resistance to smut. A programme of interspecific crosses has been laid down for grasses and legumes and work has been commenced on them.

(ii) *At Gatton, Queensland.*—The pasture plant breeding work initiated at the Agricultural College, Gatton, Queensland, is concerned mainly with Rhodes grass, Mitchell grasses, Phalaris, and lucernes for grazing. Collections of material have been made from many sources, and on growing the plants have shown a tremendous amount of variation. As a first step towards improvement the best are being selected, and these will be multiplied. Queensland authorities are co-operating by making available land and facilities at the Westbrook Farm School. Mr. J. M. Newman has also been very generous in providing similar facilities at Caboolture. Some species have been planted on these areas for preliminary work.

(iii) *At Moss Vale, New South Wales.*—For work in more southern areas of higher rainfall, Sir Norman Kater very generously made available an area of 5 acres at Moss Vale. On this site a field laboratory has been erected and a water supply made available. An officer of the Division has been transferred there and is engaged in breeding work with higher rainfall plants including perennial rye grass, cocksfoot, red clover, white clover, and subterranean clover.

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

(i) *Apple and Pear Grant.*—A sum of £20,000 was made available late last year by the Commonwealth Government for assisting the growers of apples and pears. This grant is being administered by the Council. Following a conference between representatives of the Council and the State Departments of Agriculture £8,850 was allocated for advisory and demonstration work, including improvement of cultural practices, demonstration of re-working, &c. ; and £10,170 for research work. The expenditure of the money for investigational work has been spread over two years ; that being done by the Council concerns codling moth, spray injury, gas storage, and die-back in apple trees. Investigations undertaken by the State Departments of Agriculture and financed by this grant are (i) stock and scion studies, removal of arsenical residues and internal cork in the Kentucky district by New South Wales; (ii) codling moth in the Goulburn Valley, and mineral deficiencies in pears by Victoria; (iii) general horticultural problems in the Stanthorpe area by Queensland; (iv) spray and fertilizer trials by South Australia, (v) die-back and green-manuring practices by Western Australia; and (vi) black spot and other fungal diseases, Jassid and light brown apple moth by Tasmania.

(ii) " *Die-back* " *Survey.*—A survey of the incidence and relative importance of the diseases which cause " die-back " and " sour sap " in apple trees was made. The survey covered orchards in the main apple-growing centres of New South Wales, Victoria, South Australia, Western Australia and Queensland, and showed that (*a*) Fungal root rots, such as *Armillaria mellea*, wound parasites, such as *Polystictus versicolor*, malnutrition or lack of fertilizers, and loss of surface soil by erosion, are factors which cause die-back, but vary in incidence and

importance in different localities, and rarely constitute the most frequent causes of die-back in any district. (*b*) Inadequate soil drainage is responsible for approximately 20 per cent. of the die-back in nearly all districts. (*c*) In Victoria, and to a lesser extent in New South Wales, injury occasioned by the apple root borer is a very prevalent and important cause of tree decline. (*d*) The most important and widespread type of die-back is that known as pruning die-back in Western Australia and rosette or " little-leaf " in Queensland and South Australia. This disease, the cause of which is at present unknown, is developed in all districts north of latitude 36° S., becomes severe north of latitude 35° S., and, generally speaking, increases in severity as one goes northward. It appears to be closely correlated with, and the main factor determining, the longevity of the apple tree under Australian conditions. The life of the average apple tree is probably three times as great in Tasmania as it is in Queensland. This disease constitutes the main cultural problem in New South Wales, Western Australia and Queensland.

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

(*a*) *Storage Experiments* (*Fruit of* 1935–36 *Season*).—Investigations concerning the relation between the incidence of storage disorders and physiological and chemical tests on samples collected previous to, and at the time of, picking, climatic conditions, as well as storage temperatures and other storage factors were continued. The technique previously reported was employed. The chemical and physiological tests gave results which confirm the conclusions reported for 1934–35 and 1935–36. The 1935–36 season was one of the above-normal temperature and below-normal rainfall. On the basis of the data derived from these observations, a quite accurate forecast was made of general keeping quality and the incidence of storage diseases for this season's fruit on the overseas and local markets.

Investigations on the effect of pre-storage treatment with carbon dioxide as a means of preventing low-temperature breakdown, as well as experiments on the effect of storage temperatures, the concentration of respired carbon dioxide in the storage chamber, and delay in storage on the incidence of storage diseases, were continued and extended. Pre-storage treatment of 50 per cent. carbon dioxide for 36 hours was sufficient to induce brown heart in Sturmer Pippin and French Crab, but not in Cox's Orange Pippin, Scarlet Pearmain and Jonathan. True low temperature breakdown occurred only in Scarlet Pearmain in the later pick, when the treatment prevented pit breakdown in Cox's Orange Pippin; and Jonathan spot may have been increased and deep scald in Sturmer induced by treatment. Increase in the concentration of respired carbon dioxide in the storage chamber appears to increase liability to brown heart, induce Jonathan spot in mature Jonathan, and reduce incidence of late scald in Sturmer Pippin.

The incidence of storage disorders during this season was as follows:—Storage pit was more prevalent than in 1935 but not as severe as in 1934; light crops again suffered most. True low-temperature breakdown was not common; and the type which follows pit, water core or bruising was the most pronounced. No difference was apparent between fruit from limed or unlimed plots. The season was one of low liability for deep scald and Jonathan spot. The relative varietal susceptibility to brown heart was Sturmer Pippin most, then French Crab, and Jonathan least. Susceptibility to brown heart was lower than in 1935; and French Crab was the only variety in which alcoholic poisoning developed.

(*b*) *Disorders of Fruit on Trees*, 1936–37.—The 1936–37 season was one of very low liability to field disorders. Tree pit was relatively uncommon, even in highly susceptible varieties such as Cleopatra. This was probably due to the good rainfall and mild temperatures that occurred during the growing season. The incidence of both massive and radial types of water core was also low, and was probably related to the absence of high temperatures during the period January to March.

Internal cork was not so serious as in 1936. Experiments involving the application of boron were continued; but many of the plots gave no results, as the control trees which have been badly affected for the past three years were free of the disease this season. " Cork " of pears and " dimple " of Cleopatra again failed to respond to treatment.

(iv) *Investigations in the Irrigation Areas.*—(*a*) The progress of investigations concerning the alternate cropping of Valencia oranges in the Murrumbidgee Irrigation Areas is recorded under the Citricultural Research Station, Griffith, and work dealing with the sultana under the Viticultural Research Station, Merbein (Sections VIIA. and B.).

(*b*) As part of a comprehensive investigation dealing with the problem of the nutrition of citrus trees, investigations are being made to determine the role of mycorrhiza in citrus root absorption. Pot culture experiments in which seedling lemons are being grown with and without mycorrhiza, and subject to a variety of soil treatments, have so far failed to show any differences in growth due to the presence of mycorrhiza. Attempts to isolate the fungus concerned in the mycorrhiza have so far been unsuccessful.

(v) *Investigations in Queensland.*—The propagation of imported and local root stocks for apples, pears, and plums has been continued in the nursery area at Stanthorpe. The season was particularly dry until mid-December.

(*a*) *Apples.*—Satisfactory growth was made by most stocks except apple stocks Malling XII. and XVI. These grew poorly as compared with Northern Spy and other Malling stocks. Their failure is attributed to the drought conditions which obtained during the first half of the season. One-year-old trees of Jonathan and Granny Smith varieties have been produced on the following stocks :—Malling I., II., XII., XVI., Northern Spy and Pomme de Neige seedlings ; and of Jonathan on Merton Nos. 779, 789, 793, and two local stocks (D and E). These are ready for planting out for permanent field trial. Twenty-nine apple varieties were layered to produce own-rooted trees. Of these, 26 varieties have yielded over 80 per cent. rooted shoots suitable for transplanting. Nursery stock trials have been commenced to test (i) the capabilities of four Merton and four local stocks as compared with standard stocks, and (ii) the performance of root stocks (other than Northern Spy) which are immune to woolly aphis. Attempts to propagate apple varieties by means of hardwood cuttings were not successful. This failure may have been due to the dry spell experienced this season.

(*b*) *Pears.*—A survey has resulted in the selection of outstanding pear trees in the district and the propagation of root stocks has been commenced. The Malling pear stocks have been layered.

(*c*) *Plums.*—The English plum root stocks, Pershore, Brompton and Common Plum, rooted poorly in the layer beds. Myrobolan " B " propagates readily from cuttings. Outstanding plum trees in the district have been noted, and the propagation of selected local stock is proceeding.

(*d*) A soil survey of eight acres on the Government Reserve has been made preparatory to utilizing land for the permanent stock trials. Six classes of soil are present.

5. *Wheat Investigations.*—(i) *Flag Smut.*—Evidence was obtained that high soil temperature increases resistance to post-seedling development of flag smut in certain wheat varieties, but lowers it in others. Confirmatory experiments are in progress. Pot experiments showed that (1) the root systems of healthy plants of the wheat varieties used were better developed than those of flag-smutted plants, (2) the reduction of the root systems of diseased plants was influenced by the environmental conditions, (3) that the root system of Federation, a susceptible variety, was less affected than that of Ford which is moderately resistant, and that of Nabawa, a resistant variety. The experiments are being repeated.

In breeding wheats for resistance to flag smut the usual practice has been to inoculate the breeding material with flag smut spores, and later in the season to select the healthy plants. Previous work in Canberra on second generation material has shown that no progress is made by such selection since healthy plants produce just as much disease in the next generation as do diseased ones. Further work along the same lines with the third generation has given similar results. It may be concluded, therefore, that selection on an individual plant basis for reaction to flag smut is useless, at least, in the early generations of a cross. Selection on the basis of progeny tests is quite effective. Experiments conducted on the third generation on the crosses Cadia x Geeralying, Federation x Nabawa, and Bobin x Nabawa showed no association between susceptibility to disease and yield.

(ii) *Root Rot of Wheat.*—Field experiments failed to reveal any increase in the pathogenicity of *Ophiobolus graminis* due to the joint action of flag smut with this organism on wheat, such as that which occurs with another root rotting organism, *Fusarium culmorum.* Pot experiments made two years previously indicated that the addition of one of the minor elements to the soil controlled the foot rot of wheat caused by *O. graminis.* The experiments were repeated with a view to statistical analysis of yield, and the results were significant. Further work is in progress.

(iii) *Yield.*—The variety experiment was continued at Canberra in 1936. This experiment is being conducted in an endeavour to determine which characters of the wheat plant are most important in determining yield, with the ultimate objective of being able to breed better yielding varieties. The best yielding varieties in 1936 were :—Caliph, 50.9 bushels per acre ; Canberra, 49.0 ; Turvey, 47.6 ; Carlisle, 46.5 ; Gluyas Early, 46.2 ; Sepoy, 46.0 ; and Riverina, 46.0. Under the same conditions Yandilla King gave 44.2 and Waratah 39.9 bushels per acre.

The fourth generation of the crosses for investigation of inheritance of yield attributes were grown at Merredin and Wagga, respectively, last year. Data on yield attributes have been collected for four generations, and the analysis is now proceeding.

Last season was unfavorable for the development of rust in Canberra, and thus no progress was made in an effort to determine the loss in yield of varieties susceptible or resistant to rust.

(iv) *Physiology.*—The study of physico-chemical factors of expressed wheat saps has been continued with a view to obtaining a complete picture of the variations in the relationships between these factors throughout a series of different varieties and seasons. Such a complete picture should be useful to the practical plant breeder in connexion with problems of drought resistance, disease resistance, and the improvement of quality and yield.

(*v*) *Grass Clumps.*—Following upon the previous work, another 100 varieties of wheat have been crossed to determine their constitution for the grass clump character, and thus facilitate the formulation of breeding programmes.

6. *Tobacco Investigations.*—(i) *Diseases.*—Further experiments have been made with benzol and other hydrocarbon vapours for the control of downy mildew (blue mould). Attention was also given to modifications, desirable from a practical point of view, which can be made without affecting the efficiency of benzol vapour for the control of the disease. The study of yellow dwarf, a virus disease of great economic importance in some States, was continued.

(*a*) *Downy Mildew or Blue Mould.*—During the spring, seed-bed experiments in which benzol, X3, X300, Plume cracked motor spirit, and C.O.R. benzol mixture motor spirit were used at evaporation surfaces of 1/72nd and 1/144th of the seed-bed area, were made at Eurobin and Swan Hill, Victoria, and at Canberra, Federal Capital Territory. The beds were covered whenever rain was expected; but in another experiment seed-beds, in which benzol, X300, and C.O.R. benzol motor spirit were used, were uncovered on wet as well as on fine days. Benzol was also used in two beds that were uncovered during the day for eleven hours, instead of the usual nine hours. The prevention of fungal discolouration and of the loss of tensile strength of calico covers was investigated in an experiment in which untreated calico was compared with calico treated with paraffin wax, Shirlan W.S. plus Agral 2, and Shirlan A.G.

Of the fungicides tried, only benzol, toluol, and X3 solvent have proved to be satisfactory for commercial use. Benzol vapour always gave the best results. With relatively low temperatures and nearby sources of infection, an evaporation ratio of 2 sq. inches to each square foot of seed-bed is necessary; but half this ratio is effective if temperatures are high and sources of infection distant. Seedlings can be safely exposed for at least 11 hours per day on wet as well as on fine days. Calico covers treated with Shirlan compounds remained in good condition, and are likely to be serviceable for several seasons.

Benzol is now used by growers in practically every tobacco district in the Commonwealth, the commercial application being extremely simple and quite economical. As heavy losses frequently occur as a result of blue mould on plants in the field, attention is being given to methods of control under field conditions.

(*b*) *Yellow Dwarf* (*Dwarfing*).—This is a destructive and widespread disease that has been observed in fields in all States except Western Australia and Tasmania. It is most serious in Victoria, causing in some seasons crop reduction of 50 per cent. in certain districts, and total loss in some fields. The most obvious symptoms are dwarfing and yellowing of the plants, and bending down of the margins and tips of young leaves. The disease is transmissible by budding and grafting, and under field conditions, is probably transmitted by an insect vector. It is interesting to note that this dwarfed condition has been ascribed to such causes as poor transplants, root rot, downy mildew, &c.

(*c*) *Other Diseases.*—A disease known as bunchy-top or rosette, which has been observed in fields for a number of years, was fairly common in northern New South Wales this year. Preliminary investigations showed that it was due to a virus. Mosaic and spotted wilt have been observed in many areas, the former being most serious in northern New South Wales, and the latter in the Adelaide Hills area of South Australia. A fungal disease causing black stem and wilting is being investigated.

(ii) *Disease Resistance.*—Trials were undertaken at Briagolong in Victoria; but although mould developed fairly extensively throughout the commercial crops last season, very little developed in our field tests there. Some indications were noticed that varieties reacted differentially to field mould; and a few varieties were fairly heavily diseased, and can be rejected from further tests. By far the majority of varieties, however, gave a lesser reaction; and it will be necessary to repeat the test to be able to distinguish between them. Arrangements have been made for its repetition during the coming season.

Crosses were made between Dungowan and several better quality varieties, with the object of combining resistance to field mould of Dungowan with the desirable qualities of the other varieties.

The F_1 progency of those crosses grown at Briagolong last year were quite promising. Seed was obtained from some at Canberra, and they have all been re-sown in the glasshouse to obtain seed during the winter for raising the F_2's in the coming season.

(iii) *Chemical Investigations.*—The determinations of smoking quality by chemical means (experiments conducted in the Department of Organic Chemistry of the University of Sydney) is proving difficult; but nevertheless some progress has been made. Estimations were made of cellulose and sulphur content of leaves; but it was found that the methods applicable to tobacco were not sufficiently accurate. Total nitrogen and smoke alkalinity did not give satisfactory results. However, the lead, picric acid, and methylene blue "numbers" have been investigated for 53 samples. In general, the results are correlated with aroma and soil type; and it appears that these tests are likely to be of value in determining quality.

(iv) *Physiological Studies.*—Estimations and analyses of the material from the 1935–36 experiment have been continued at the Waite Agricultural Research Institute. Special attention has been given to the influence of phosphorus supply and "topping" on the total nitrogen and protein-nitrogen content of leaves. A great number of routine analyses have been made, but, until these are completed, it would be premature to discuss the trends already apparent.

(v) *Smoking Tests.*—During the year, smoking tests were made on leaf samples (unblended and not processed) from growers' samples collected by State officers. Information is obtained, from the same source, on the soil type and climate, variety and cultivation, curing, &c. The results of the tests are charted and made available to the respective Departments of Agriculture; and thus an estimate of the qualities by districts is being accumulated. These results, combined with soil surveys being made by State officers, and the results of referee tests, will gradually make it possible to determine the suitability of areas and parts of areas for tobacco growing.

(vi) *Curing Experiments.*—Investigations into the curing of tobacco were continued at Wangaratta with a view to determining whether leaf which is rather of the heavy type likely to give a lower grade of smoking tobacco can be cured to yield a higher quality tobacco. The results of the year's work tend to show that, by modifying the curing to take from 30 to 40 days, instead of about six, the quality is raised from an average of fairly good to good or even better. These results were indicated by smoking tests.

(vii) *Ageing.*—Smoking tests showed that lighter-bodied leaf changes but little after ageing; and poorly-grown immature leaf made very little improvement, if any, after three years. On the other hand, well-grown, good-bodied leaf definitely improved over the same period.

7. *Virus Diseases of Potatoes.*—The survey of Australian potato virus diseases, which has been undertaken by the Division with the co-operation of the State Departments of Agriculture, has consisted of field inspections of potato crops in Victoria, New South Wales, and Tasmania, and greenhouse and laboratory work at Canberra with material from these States and Western Australia. In Victoria, the most important potato-growing State, counts of diseased plants and distribution maps have been made in commercial fields in representative districts. The surveys in New South Wales and Tasmania have been confined to estimates of infection and examination of the types of symptoms produced by virus diseases on the different varieties of potato. Material gathered during the inspections, or sent by officers of the State Departments of Agriculture, has been grown in the greenhouse and field at Canberra; and inoculations have been performed on virus-free potatoes and other host plants. Some progress has been made in the separation and examination of viruses from the mixtures found occurring naturally in potatoes.

(i) *Field Inspections*—The principal disease in early and maincrop Carmans in Victoria was mosaic caused by viruses of the X group. Infection varied from a fraction of 1 per cent. to 80 per cent. Up-to-Date and Snowflake (=White Elephant) potatoes were less susceptible to this disease. In the tablelands districts of New South Wales, the variety Factor (Up-to-Date type) was comparatively free from mosaic, and leaf roll was kept in control by mass-roguing. In Tasmania the early variety Bismark and the main-crop Brownell (= Adirondack) were each severely attacked by a characteristic mosaic.

(ii) *Greenhouse and Laboratory Work.*—The viruses causing destructive diseases in seventeen varieties grown in Victoria were found to be nearly all of the Y type. X type viruses were found latent or semi-latent in all samples of the common commercial varieties examined from Victoria, New South Wales, Tasmania, and Western Australia. One tuber from a lot of 500 apparently healthy Factors appeared to be quite free from virus infection; and it is possible that the virus-free potatoes of other varieties will be found.

The work of separating and examining potato virus has so far been mostly concerned with the latent viruses. Three groups have been distinguished, the X type (including ringspot, mottle, and yellow mottle), B, and F. Their effects singly and in combination on a number of hosts are being examined.

8. *Diseases of Peas.*—Root rot or "Take-all" is a limiting factor in the production of grey peas in Tasmania. It is caused by a fungus which, as the name implies, rots the roots and impairs the health and vigour of the plants to such an extent that sometimes almost total loss of the crop ensues. Laboratory, greenhouse, and field experiments in Canberra during the previous year

indicated that nitrogen fertilizers might be of value in the control of the disease ; but the results of the first year's plot test in Tasmania did not confirm these results. Recent experiments, in which Tasmanian soil was used under greenhouse conditions, have yielded results which warrant plot trials. They will be made during this year.

9. *Needle-Fusion of Pines.*—A progress report on this subject is being published as the Council's Pamphlet 72. Extensive grafting experiments have so far failed to give any evidence that the disease is infectious. The liability of pine trees to contract the disease appears to diminish markedly from three to eight years (according to the species) after they are planted out. Further studies are concerned chiefly with the possibility that the disease is due to soil deficiency or toxicity.

10. *Fungal Discolouration of Paint.*—No differences that were deemed significant were observed between paints made with different qualities of linseed oil. A preliminary test of the effect of three fungicides that were incorporated in paint is in progress.

11. *Brome Smut.*—An investigation of the position in Australia with regard to smut of *Bromus* species was commenced in October, 1936. An initial survey of the distribution of the smut in the southern tablelands and south-western slopes areas of New South Wales was made in December, and material collected. This, together with inoculum obtained from centres in Victoria and from Adelaide, was used to prepare a composite sample for use in testing for resistance. Experiments have been commenced to determine (*a*) the maximum, minimum, and optimum temperatures for infection ; (*b*) the longevity of the spores ; (*c*) the effect of de-hulling the seed upon the percentage infection ; (*d*) the resistance to *Ustilago bromivora*, as found in Australia, of promising introductions not known to be attacked here, but reported as susceptible overseas ; and (*e*) the value, as the resistant parent, of types agronomically suitable and not reported as susceptible to the smut, but not known to be resistant.

12. *Herbarium.*—Two notable additions to the collections have been made during the year. Since the receipt of 646 specimens from Papua in the previous year, duplicates of the entire collection—800 woody specimens and an additional 3,211 specimens of the general collection—of the late C. E. Carr in Papua have been acquired. The mounting and poisoning of these are almost completed. More recently, a collection of approximately 5,000 specimens of marine algae, bequeathed to the Commonwealth of Australia by the late A. H. S. Lucas, has been received. This splendid collection was made from the whole coast line of Australia and Tasmania. It is classified, labelled, and mounted, and has been housed in a separate section of the general herbarium.

III. ENTOMOLOGICAL INVESTIGATIONS.

1. *General.*—The Division of Economic Entomology is concerned primarily with the control of insect pests, and with the control of noxious weeds by means of insect enemies. Much of the work, particularly in the early years, was necessarily of a fundamental nature ; for it is usually impossible to devise practical control measures against insect pests without first acquiring detailed information on their life histories and habits. In many instances, also, it has been necessary to carry out taxonomic studies on groups of insects, where the existing knowledge was incomplete.

As a result of fundamental studies in the earlier stages of the work of the Division, knowledge of the details of the problems has been considerably increased, and in recent years the investigations have extended more into the field. At present, field tests are in progress in almost all the States of the Commonwealth.

Because of the special facilities available at Canberra, arrangements have been made for the Division to undertake investigations for the Division of Animal Health and Nutrition into the mode of transmission of certain blood parasites of cattle, and, more recently, of ephemeral fever of cattle. This work has been carried out by the staff of the Section of Veterinary Entomology.

Through the generosity of the Queensland Government and the Australian Wool Board, an area of 40,000 acres near Cunnamulla is being provided and equipped as an experimental sheep station. Here " economic problems affecting the sheep industry " will be studied. As one of the most urgent of these is the problem of blowfly strike, the proposed station will be of particular interest to the Division of Economic Entomology, as well as to the Division of Animal Health and Nutrition. It will provide the much needed facilities for testing preventative measures on a practical, commercial scale under conditions that will enable accurate records to be obtained, both of the efficacy of the methods and the cost of their application.

2. *Noxious Weeds.*—Work in this field is now conducted jointly by the Divisions of Economic Entomology and Plant Industry, and an account on both the entomological and botanical aspects of the investigations will be found in a separate section (IV.) of this Report.

3. *The Sheep Blowfly Pest.*—(i) *Studies of the Flies.*—Additional surveys of the distribution of the sheep blowflies have shown that *Lucilia cuprina* is widely distributed in western New South Wales, South Australia, and Victoria, and that *Calliphora nociva* replaces the other species of *Calliphora* in the drier parts of the continent. This species ranks second to *L. cuprina* in importance as a sheep fly.

Studies of the effect of different rates of desiccation on the growth of maggots in carcasses suggest that *L. cuprina* is more resistant to drying than the other species. They also indicate that desiccation of the carcass, by rendering food unavailable to the maggots, greatly reduces the number of flies that emerge. If desiccation has been so rapid that few or no maggots develop, the food materials in the carcass become locked up, but once more become available when the carcass is wetted. Thus, in the arid part of the country, it would appear that during a drought there is a progressive accumulation of small carrion, which becomes available for fly breeding as soon as rain falls.

It has been demonstrated that at Canberra many more maggots of *Lucilia cuprina* mature on a struck sheep than in a dead sheep; and general observations indicate that this is probably true also in other districts. Thus there is reason to suspect that the living sheep is the most important breeding ground of *L. cuprina* in Australia. The practical wisdom of paying strict attention to the destruction of maggots in crutchings is therefore obvious.

The demonstration that trapping will reduce the incidence of strike in sheep, and the pressing need for the discovery of an efficient repellent which would be incorporated in a lamb-marking dressing, have led to an intensification of the work on attractants and repellents. A laboratory method for studying attractants has been devised, and should prove a valuable adjunct to the field tests already developed. Similarly, a special technique for testing repellents has had to be worked out. The analysis of attractive baits has been continued, and the attractive fraction has been reduced to a relatively simple mixture of fatty-acid soaps and sulphides. That the ultimate attractive material may be a mixture of compounds rather than a single compound is suggested by experiments in which two odours, each unattractive by itself, are attractive when mixed together. An observation that only females of *L. cuprina* with fully developed eggs are attracted to struck sheep, whereas fertile and infertile females with developed and undeveloped eggs are equally attracted to carrion bait, shows the need for a more detailed study of the attractive properties of the fleece and secretions of the sheep.

(ii) *Studies of the Sheep.*—These studies have been confined chiefly to field investigations, to observations on breech conformation (which are not yet sufficiently advanced to report), and to studies of wettability and weathering of the fleece.

An examination of 1,334 strikes taken from merino sheep in all parts of Australia showed that 89 per cent. of the strikes were on the breech, 75 per cent. being on the inner breech area. These figures provide conclusive proof of the importance of the inner breech area, and have led to a modification of the classification formerly used for breech conformation. The remaining 11 per cent. is made up by head strikes of rams 3 per cent., body strikes 3 per cent., miscellaneous (including strikes of tailing wounds in lambs) 5 per cent.

Methods of demonstrating the distribution of free water in the fleece have been developed, but a satisfactory means of determining the relative amounts of free and absorbed water has not yet been discovered. It has been shown, however, that the distribution of free water is very irregular in the fleeces of sheep wetted naturally by rain, that the absorption of the water by the fleeces is slow, and that the suint portion takes up most of the moisture that is absorbed by the fleece. A delicate dye test for weathering of the fleece has been developed; it has shown that weather (probably sunlight) oxidizes the wax, which loses its protective qualities, thus exposing portion of the fibre to damage. The affected part of the fleece is much more accurately defined by the dye than by sight or touch, and is found to be much less in rugged than in unrugged sheep.

(iii) *The Prevention of Strike.*—(*a*) *Trapping.*—The search for a more efficient bait has been continued, but none more practically useful than carrion treated with sodium sulphide has been found. Further observations on baits treated with calcium sulphide indicate that they do catch rather more flies than those treated with sodium sulphide, but the difference does not appear to be sufficiently great to justify the extra cost of the calcium sulphide. The escape of maggots from traps has long been a problem, but it has now been found that, if the bait be treated with powdered borax, its attractiveness is not impaired and the growth of maggots is completely prevented. Routine testing of proprietary traps has been continued, but none of the several examined during the year compared favorably with the Western Australian trap.

(*b*) *The Mules Operation.*—Recent work has supported the conclusion that the operation is a valuable method of improving breech conformation and reducing strike incidence. (This work is reported in an article in the May, 1937, issue of the Council's Journal.)

(*c*) *Rugging.*—Observations on rugged sheep strongly suggest that rugging will prove to be an efficient preventative of body strike. Moreover, it has not been found that natural or experimental strikes commencing outside the rugged area extend further on rugged than on unrugged sheep.

(*d*) *Lamb-marking Dressing.*—During the year, 85 substances have been tested for possible repellent properties. They included reputed repellents, proprietary dressings, substances which are highly effective in rendering unattractive a bait with which they are mixed, and a variety of other preparations. Only a few gave sufficiently encouraging results to warrant further study and some of these have proved to be irritant to the skin, so the list of possibly useful repellents so far discovered is very small.

(iv) *The Treatment of Strike.*—The diboric dressing has continued to give good results but the cost of glycerine has seriously militated against its practical usefulness in commercial flocks. Consequently, a search has been made for an alternative vehicle for boric acid. Eventually, a method was devised for incorporating it in adequate concentration in bland oils, and dressings have been prepared which have given promising results in preliminary tests. The general survey of dressings has been continued; 63 preparations were tested during the year, of which 41 damaged the skin and were excluded from further examination.

4. *The Buffalo-fly Pest* (*Lyperosia exigua*).—As the parasites previously introduced appear to have failed, fresh inquiries were made, and it was arranged that Dr. J. G. Myers should make a survey of the natural enemies of the fly in certain West Indian islands. Dr. Myers' survey indicated that a predatory beetle (*Hister coenosus*) might prove useful, and steps are now being taken for these beetles to be sent to Australia for testing.

5. *Blood Parasites of Cattle.*—As previously reported, the work now consists mainly of the maintenance of pure strains of the various species for the use of outside workers; during the year several batches of blood containing *Anaplasma centrale* were sent to Queensland for immunization of stock destined for tick-infested country. In some recent experiments it has been found that both species of *Anaplasma*, and *Theileria mutans*, can be transmitted by inoculation of blood taken on the second day of the incubation period, and that the infection can be carried through several serial passages, all made at this early stage. It has also been found that, when infection with *Anaplasma marginale* and *A. centrale* is simultaneous, both develop fully, and an attack by the first to appear is immediately followed by a relapse due to the second.

6. *Parasites of Cattle Tick.*—During the year the United Graziers' Association of Queensland asked the Council to investigate the possibility of control of cattle ticks by means of parasites. A Chalcid wasp, *Hunterellus hookeri*, of wide distribution is known to parasitize cattle ticks, and before steps are taken to procure supplies of this insect from overseas, a careful examination of Australian cattle ticks (*Boophilus annulatus microplus*) is being made to find out if any parasites are already present in this country. So far none has been found.

7. *Ephemeral Fever of Cattle.*—Ephemeral fever, often called three day sickness, is an acute, but rarely fatal, infectious disease of cattle which is widespread in tropical and sub-tropical parts of the world. It had never been known in Australia until the autumn of 1936, when it appeared suddenly in the far north and swept through Queensland and parts of New South Wales. It was agreed that investigations should be undertaken by the Queensland Department of Agriculture and Stock, the New South Wales Department of Agriculture, and the Council. The programme of work was designed, firstly, to discover how the disease is transmitted, so that the means by which it entered this country may be determined, and, secondly, to obtain further information about its nature in order that adequate means of combating it may be devised.

The disease may be maintained indefinitely by inoculation from animal to animal; clean cattle are almost all susceptible; the incubation period is only two to four days, and the duration of the fever one to three days. An experimentally produced attack confers a complete immunity which appears to last at least two months; but so far it has not been possible to demonstrate the presence of immune bodies in the blood.

There are many reasons for suspecting that the disease is insect-borne, but all experiments set up to test this point gave negative results. Judging from these experiments it is doubtful whether stable flies (*Stomoxys calcitrans*) or mosquitoes transmit the disease mechanically, also whether stable flies or the common black bush mosquito (*Aedes vigilax*) transmit the disease after a period of development within the insect. A number of other blood-sucking insects are still to be tested, but the onset of winter made it necessary to postpone these experiments until next season.

The disease is not transmissible by contact, but can be transmitted sometimes by inoculation of nasal mucus. It is readily transmissible by intravenous injections of blood taken from an infected animal while the fever is high. That the organism is in the blood in considerable concentration is indicated by the fact that it can be transmitted by an intravenous injection

of 0.001 millilitre of virulent blood. The organism has been shown to be associated with the white cells ; and it can be kept alive outside the animal body for at least five days in blood, and at least seven days in white cell suspensions. In collaboration with Dr. F. M. Burnet, of the Walter and Eliza Hall Institute of Pathology, Melbourne, it has been proved that the organism causing the disease is small enough to pass through a filter which will retain ordinary bacteria. It is therefore, presumably, to be regarded as belonging to the group of filterable viruses.

8. *Orchard and Fruit Pests.*—(i) *Peach Moth* (*Cydia molesta*).—The estimated loss of peaches due to this pest in the Goulburn Valley district of Victoria during the 1936–37 season was 30 per cent., which, although very serious, was not as high as in the previous season. An outbreak of this pest also occurred this year in a circumscribed district in the Murrumbidgee Irrigation Area of New South Wales.

Although the number of larvae which hatched from the over-wintering generation was considerably less in 1936 than had been recorded previously, the numbers increased exceedingly rapidly in the first and second generations, until by January, 1937, the larvae were just as numerous as in previous years. Owing to the rapid tip growth of the peach tree, especially under irrigation conditions, protection of the tips by spraying is maintained for only a few days. This difficulty, combined with the fact that the moth population will increase rapidly from low numbers early in the season, indicated that it was probably uneconomical to try to combat the pest by spraying during the period of rapid vegetative growth. Spraying was therefore confined to an intensive campaign against eggs and larvae which began when the peaches of the main crop were becoming susceptible to attack, and was continued until about a week before harvest. During this period, sprays were applied at approximately weekly intervals in an effort to maintain a complete spray cover on the tree. The spray materials used (nicotine sulphate and bentonite ; nicotine sulphate and bentonite sulphur—" Kolofog ", white oil ; acid lead arsenate, zinc sulphate, and lime) had previously been tested in the laboratory and shown to possess the necessary toxic properties ; but, in spite of this, none of the spray schedules gave satisfactory results in the orchard. In America efforts to control peach moth by the use of sprays have been equally unsuccessful.

Last spring a second trial consignment of two peach moth parasites, *Macrocentrus ancylivorus* and *Glypta rufiscutellaris*, was generously supplied by the United States Bureau of Entomology and Plant Quarantine. The parasites were bred successfully in a special insectary at Mooroopna (Victoria), and some 2,000 were liberated in the orchards. Recoveries of parasites of two subsequent generations were made from moth larvae collected in the orchards, showing that the parasites had definitely established themselves. However, it is not possible to say whether they will survive the winter until recoveries have been made next spring. Meanwhile, an officer has been sent to the Peach Moth Parasite Laboratory in New Jersey, United States of America, to study parasites and to send consignments of all promising species to Australia, particular attention being given to *Macrocentrus* spp. Efforts will be made to introduce, breed, and liberate such large numbers of *Macrocentrus* that this promising parasite will certainly establish itself in the Goulburn Valley if conditions are favorable for its development there.

(ii) *Codling Moth* (*Cydia pomonella*).—(*a*) *Committee.*—In 1935 a committee consisting of entomological and horticultural officers of the State Departments of Agriculture and the Council was formed. This Committee met in 1935 and 1936, and on both occasions very useful discussions on the problem of control of this serious pest took place, thus ensuring closer co-ordination of the investigations in each State. It is not considered necessary to hold annual meetings in the future, and no meeting will be held during 1937.

(*b*) *Insecticide Investigations.*—Following the recommendation of the Codling Moth Committee, a chemist was appointed by the Council to study insecticidal problems. Because of the objections by public health authorities to the use of lead arsenate, some other toxic substance is required to replace it in codling moth spray schedules. One of the most promising new organic insecticides is phenothiazine, but, when finely divided as a spray deposit, this substance is oxidized leaving a black film over the fruit. Investigations are in progress with the object of preparing phenothiazine derivatives which will not oxidize on exposure. Combinations of nicotine with various Australian and imported bentonitic clays and with brown coal are also being studied for use as spray materials.

(iii) *Dried Fruit Pests* (*Ephestia* spp.).—Specimens of these insects sent in by the Councils' Viticultural Research Station, Merbein, have been indentified as *Ephestia figulilella*, an open-air breeder. It appears that mummified grapes have been allowed to remain on the vines, and under these conditions this pest has multiplied and entered the packing sheds.

9. *Field Crop and Pasture Pests.*—(i) *Grasshopper Investigation.*—During the year two periods were spent in the field investigating this problem. During the first, from 20th September to 28th November, a large part of the area of infestation of *Chortoicetes terminifera* in New South Wales and southern Queensland was visited at a time when swarms of over-wintering adults

were present in parts of the area. The source of origin of swarms was investigated, and evidence was obtained of the existence of circumscribed outbreak centres, the location and characteristics of which were studied and a provisional list of outbreak centres drawn up. Preliminary investigations of the life cycle of this species in the various areas visited were made. Observations were also made on the distribution of other species, especially the injurious *Austroicetes jungi*, *Oedaleus australis*, and *Phaulacridium vittatum*.

The second field trip, in February, was undertaken with the more specific object of investigating the areas which had been the nucleus of the 1933–35 outbreak in New South Wales, and which had been free from grasshoppers since 1935. The limits of the main outbreak centre were accurately determined, and a preliminary study of its general ecological characteristics was made. The positions, both of the main and of certain minor outbreak centres, were broadly the same as those established for 1933–34 by Mr. H. Barraclough of the New South Wales Department of Agriculture. Various topographical observations were made in an endeavour to explain certain regularities in the routes taken by swarms migrating westwards. The role of timber and mountains as barriers to migration was established.

In addition, two short visits, in May, 1936, and April, 1937, were paid to the outer wheat belt of Western Australia where grasshopper plagues had recently been severe, and observations were made on the type of country and the egg beds of the plague species, *Austroicetes jungi*. A parasitic fly which had not previously been recorded from *A. jungi* was found attacking the eggs.

A great deal of information about past outbreaks of various species of grasshoppers has been obtained from the records of the Departments of Agriculture of New South Wales, Queensland, and Western Australia, from field officers, and from the literature. This information, together with personal observations of officers of the Division, has been analysed and collated in the form of a paper on the regional and seasonal incidence of grasshopper plagues which is now practically ready for publication. Before this work could be undertaken it was necessary to determine the correct names of the species concerned, and an extensive revision of the genera *Chortoicetes*, *Austroicetes* and *Phaulacridium* was made. Most species have been determined.

As the result of preliminary breeding experiments in experimental cages under controlled conditions, a certain amount of information has been obtained on the biology of *C. terminifera*, *A. jungi*, and *A. pusilla*. A difference in morphology has been demonstrated between grasshoppers occurring singly and in swarms. These so-called phase differences occur in *Chortoicetes terminifera* and *Gastrimargus musicus*; and *Austroicetes jungi* is now being studied to see if such differences occur in this species.

(ii) *Underground Grass Grub* (*Oncopera*).—As *Oncopera rufobrunnea* is at present common in Canberra, plenty of material is available for experiments, under natural conditions, with the New Zealand parasitic fly, *Hexamera*. Arrangements were made with Mr. Salmon, of the Dominion Museum, Wellington, to send two consignments of parasites early in January. Unfortunately, owing to very bad weather, none were procurable this year.

During his visit to England and America last year, Mr. Tindale, of the South Australian Museum, made further inquiries about the natural enemies of *Oncopera*, especially the parasitic wasp, *Alomyia debellator*. It is hoped that the first consignment of these parasites from England will arrive this year.

The common European toad *Bufo bufo* introduced from England last year was tested under field conditions by means of a large cage placed on a lawn heavily infested with *Oncopera*. As there was no indication that the toads could attack *Oncopera* in its burrows, no further experiments will be made with them.

(iii) *Lucerne Flea or Clover Spring-Tail* (*Sminthurus viridis*).—Further field surveys were made in southern New South Wales, north-eastern Victoria, and in the central and south-western districts of Victoria last spring. Except in the districts in the far south-west of Victoria, this pest occurs only in isolated localities. In some places the predatory mite *Biscirus lapidarius* was well established, and in other places fresh consignments of mites from Western Australia were liberated.

(iv) *Red-legged Earth Mites* (*Halotydeus destructor and Penthaleus major*).—As the result of representations from Western Australia, an officer was recently appointed by the Council to study this pest. He has begun a programme of investigations on the influence of agricultural practice upon the abundance of mites. Through the courtesy of the University of Perth and the Western Australian Department of Agriculture, facilities for laboratory accommodation and field work have been made available.

(v) *Shelter Bag Moth* (*Ochrogaster contraria*).—The work on this pest has demonstrated that it is heavily attacked by a number of different kinds of natural enemies. The life cycle and seasonal history of two of these, a Chalcid wasp (a new species of *Eupelmus*) and a moth, *Titanoceros themoptera*, have been worked out from egg material. Five species of fly parasites (Tachinids)

and some cocoons of a hymenopterous parasite have been obtained from the bags. Considerable defoliation of the trees can be prevented if the bags are cut out early in the year when they are about the size of a hen's egg. However, if this procedure is adopted, care should be taken not to remove bags containing the predatory larvae of the moth *Titanoceros*. These bags can easily be recognized.

(vi) *Cabbage Moth* (*Plutella maculipennis*).—Efforts to introduce the parasite *Angitia fenestralis* into Australia from England last year were unsuccessful ; but this parasite has recently been introduced into New Zealand, via Panama. When it has become established in New Zealand, supplies will be obtained from there.

10. *Termite* (*White Ant*) *Investigations.*—Owing to the increasing demand for information about this destructive group of insects, a monograph on the Australian termites is being prepared.

(i) *The Direct Control of Termites.*—Powdered white arsenic has been used successfully in Queensland against *Mastotermes* and *Cryptotermes*—two wood-eating species responsible for much damage in timber. For the latter species a 5 per solution of paradichlorbenzene in kerosene has recently been found effective.

(ii) *Termites in Pastures.*—Tests of methods for destroying mound colonies of grass-eating species of termites were made at Townsville and Helenslee (Queensland). Powdered white arsenic was used to poison the termites ; and satisfactory ways of introducing the poison into the mounds were found. All the termites were killed in the treated mounds; and no sign of re-occupation of these mounds by economically important species has been seen. Grass is encroaching on the previously bare areas surrounding the mounds ; but it is not clear yet whether the destruction of the colonies of grass-eating species will result in an appreciable increase in the grazing value of the land.

(iii) *Termites on Aerodromes in Northern Australia.*—The method of destroying mound colonies of grass-eating species of termites with powdered white arsenic was also successful on aerodromes. This simple, inexpensive method has been recommended to the Civil Aviation Board ; but, unfortunately, it can only be used against colonies which have already formed mounds. The same species of termites often live underground for a considerable period before making mounds ; and such colonies are very difficult to find. During the coming year it is hoped that tests can be made of simple methods of destroying both mound-building and subterranean colonies of these termites.

(iv) *Field Testing.*—Experiments have shown that when a large number of samples of susceptible wood (e.g., *Eucalyptus regnans*) were placed in the earth around a mound containing *Eutermes*, the probability that all samples would be attacked was much higher than when only a few samples were used. It was therefore suggested that, if a continuous strip of susceptible wood were sunk in a circle around the mound, and the samples to be tested were placed against this strip, the termites might come more uniformly in contact with the samples. This method was tested with very satisfactory results ; and timbers or treated materials of low resistance to attack are reliably indicated in less than a year. This is a remarkably short time compared with the period of at least five years which was previously thought necessary for a satisfactory field test. This method has now been adopted for all field tests of treated and untreated timbers.

(v) *Laboratory Testing.*—During the past year the method of testing susceptibility to termite attack by means of standard laboratory colonies of *Eutermes exitiosus* has been used continuously and for a variety of substances, with very satisfactory results. By using this simple method an accurate quantitative measure of susceptibility can be obtained in twelve weeks. The susceptibility of four different timbers—*Eucalyptus regnans*, *E. pilularis*, *E. crebra*, and *Araucaria cunninghamii*—has been studied in detail ; and statistical analysis of the results indicates that resistance of timbers could be measured better by taking samples of each timber from several trees at the expense of the number of samples taken from one tree. In addition to testing the resistance of untreated timbers, standard laboratory colonies have also been used to determine the resistance of different materials to termite attack, such as certain underground cable-jointing compounds and prepared plaster boards and liners, and the relative value of arsenic trioxide and arsenic pentoxide when used to impregnate timber against termite attack.

A method of testing with standard laboratory colonies of *Mastotermes darwiniensis*, the large destructive termite of tropical Australia, is now being developed and promises to give satisfactory results.

11. *Pine Chermes* (*Pineus pini*).—Further liberations of the parasitic fly *Leucopis obscura* were made in pine plantations in the Federal Capital Territory this year. As there is no evidence of the survival of flies from this or previous liberations, no further introductions of this parasite will be made for the present. Of the lace-wing insect predators only about 200 larvae of *Wesmaeleus concinnus* have been liberated this year ; and none of these have been recovered from the plantation.

It is hoped that introductions of lady-bird beetles of the genus *Scymnus* will be more successful. A native species, *Sc. pumilio*, a predator on chermes, is fairly common in pine plantations at Canberra, but does not control the pest adequately. A consignment of this species has been sent to Queensland.

12. *Oak aphis* (*Myzocallis annulata*).—Arrangements have been made to introduce three parasites, *Praon volucre*, *P. flavinodes*, and *Trioxys aceris* from England, and to breed these parasites in the insectary at Canberra.

13. *Greenhouse White-fly* (*Trialeurodes vaporarium*).—The wasp *Encarsia formosa*, which was introduced two years ago, has proved to be an extraordinarily effective parasite; and recent reports received from New South Wales and Victoria indicate that it is well established and effectively wiping out white-fly both in glasshouses and in the field. Last September, supplies were sent to the Waite Agricultural Research Institute, South Australia, where the parasite also established itself rapidly.

14. *Silverfish* (*Ctenolepisma longicaudata*).—An extensive series of experiments with different toxic materials showed that barium fluosilicate and zinc borate are the most poisonous to silverfish. These substances, incorporated in sweetened paste and spread on cardboard, were subsequently tested extensively in infested houses, and barium fluosilicate gave the best results. It is therefore recommended that heavily infested places should be sprayed with a kerosene-pyrethrum spray at least twice, at intervals of about a week, and then cards baited with a paste made of 1 ounce flour, $1\frac{1}{2}$ ounces sugar, $\frac{1}{4}$ ounce barium fluosilicate, and 10 fluid ounces water, be placed where silverfish are commonly found. This procedure, when carried out thoroughly, has been very effective.

15. *Garden Snails* (*Helix aspersa*).—Two small batches of larvae of the English glow-worm *Lampyris noctiluca*, which feeds exclusively on small snails, have been liberated in the field this year. Some months later several adults were found in the locality where the larvae were liberated. Arrangements have been made to import further supplies of glow-worms from England and Belgium next spring.

16. *Systematic and General Entomology.*—As opportunities offer, studies have been made of the life histories, habits, and ecology of Australian insects, more particularly of species belonging to groups of economic importance. Several new life histories of blowflies have been worked out; some live on dead insects, others on snails, and others on small vertebrates. Perhaps the most interesting is *Helicobia australis* which develops in carcasses of grasshoppers. This species was formerly thought to be a parasite, but it is now known that it only breeds in grasshoppers which have been injured or killed by other agencies. Methods of rearing cultures of some of the more refractory species of *Calliphora* have also been worked out, and will be employed in a study of the very closely related forms, for example, *C. augur* and *C. nociva* which attack sheep, in order to determine whether they are really distinct species, or merely variations induced by differences in environment.

About 5,000 specimens have been added to the museum collections during the past year, of which about 2,000 were generously presented by Mrs. Tillyard from the collection of the late Dr. R. J. Tillyard, former Chief of this Division. A detailed revision of Australian grasshoppers is in progress; and representative collections of named specimens of economic species have been given to various State Departments of Agriculture. In addition, insects have been identified for various individual workers and institutions in Australia and abroad; and advice or practical assistance in treating insect pests has been given in response to various inquiries.

17. *Beneficial Insects Sent Overseas.*—At the request of the United States Bureau of Entomology and Plant Quarantine, two consignments of *Gambrus stokesii*, a native parasite of the codling moth and the Oriental peach moth, were collected in the Sydney district, and kindly shipped by officers of the Entomology Branch, New South Wales Department of Agriculture. Three consignments of the lady-bird beetle *Leis conformis* were despatched by air to the Entomological Section, Department of Agriculture, Egypt, to control aphides. The mortality in these, as in all consignments of insects received from overseas by air, was high. An inquiry into conditions during air transit is required before the advantages of this method of transport can be utilized.

18. *Index of Beneficial Insects introduced into Australia.*—By means of information kindly submitted by entomologists in the various States, Divisional records, and entomological publications, an index of all beneficial insects introduced into Australia for the control of insect pests and weeds is being prepared. The index will be reviewed annually in the future. Copies in tabular form will be widely circulated in Australia and abroad. The section dealing with beneficial insects introduced to control insect pests will be available shortly.

IV. NOXIOUS WEEDS INVESTIGATIONS.

1.—*General.*—A brief review of the circumstances of the formation of the Section of Weeds Investigations, and its early activities under the general control of the Chiefs of the Divisions of Plant Industry and Economic Entomology, are set out on page 29 of the Tenth Annual Report (1936). As indicated there, the problem of the control of noxious weeds is being investigated from all possible angles. Life history studies of individual weed species are carried out under controlled conditions in the laboratory ; and control in the field is attempted by means of (*a*) insects, (*b*) cultural methods, (*c*) weed-killers, (*d*) aggressive competing plants, and (*e*) pasture management.

Physiological and developmental studies of Cape tulip, skeleton weed, and nut grass are in hand, and have yielded information as to the stage of growth when weed-killers may be most effectively applied in the field. Experiments with weed-killers demonstrate that, because of the cost of application, their use will be limited to areas where new infestations occur, or to control in places not suitable for other methods. Weed control by systematic cultivation is being studied with skeleton weed and nut grass. The most promising line of attack appears to be by means of pasture improvement, involving the use of productive competing plants, adequate manuring, and systematic grazing management. Promising indications of control by this means have been observed with Cape tulip, skeleton weed and St. John's wort, and with galvanized burr, by modifying the grazing intensity alone.

During this year an officer has been transferred to Queensland where he is working, with head-quarters at the Queensland Agricultural High School and College, Gatton, on the nut grass and galvanized burr problems ; and another has been located at Griffith to work on cumbungi (bulrush) and other weeds of irrigation channels.

At the end of April, Dr. G. A. Currie, the senior officer of the section, left for six months overseas to enable him to meet the Council's entomologists stationed in England, France, and the United States of America, and to discuss with them their problems in obtaining and testing promising insects for use in the weed control work in Australia. He proposes, too, to visit institutions and workers concerned with weed research, and, by personal contact, to become familiar with the most recent developments in technique abroad.

Co-operation with officers of State Departments of Agriculture and of Lands has been effectively maintained. The existence of the special Weeds Co-ordination Committee directing the co-operative efforts of the officers of the New South Wales Department of Agriculture and of the Council has been of very definite assistance, particularly to the work on skeleton weed and St. John's wort.

The entomological side of the work has been continued by officers of the Division of Economic Entomology stationed in England, the south of France, and in the southern States of the United States of America, as well as by those working in Australia. Promising insects for use in the control of introduced weeds are studied overseas, and when it is found that they are unable to feed on plants of economic importance other than the specific weed for which they are required, consignments are sent to Australia for further intensive study and testing in quarantine insectaries at Canberra. If again found satisfactory and unable to attack plants of economic importance, trial liberations are made at chosen sites in the field.

2. *Entomological Control.*—(i) *St John's Wort* (*Hypericum perforatum*).—The search for insects attacking this weed has continued at Farnham Royal, England, and in the south of France. The centre for work in France has been moved from Hyéres to Le Lavandou, where facilities for the work have been provided in the form of a new laboratory. A survey of Algeria as a source of insects for use with St. John's wort indicated that the number of insects attacking this weed was smaller there than in the south of France. The insects studied include :—

Chrysolina (*Chrysomela*) *spp.*—The three species *C. varians*, *C. brunsvicensis*, and *C. hyperici*, which have so far failed to establish themselves in Australia, have been kept under observation while attention has been concentrated on *C. geminata*. This species is found in the south of France, where the climatic conditions are more like the Australian habitat than are the English conditions. It is hoped, therefore, that this species will be better able to establish itself here. When the present life-history studies and starvation tests are completed, this beetle will be introduced into Australia.

Lathronympha hypericaan.—A large number of root-stocks of St. John's wort containing over-wintering larvae of this species were received from England ; but, as in the previous year, the moths that emerged failed to oviposit in Canberra.

Anaitis plagiata.—In England, material of this species was very scarce in the field in this year. Of 6,000 over-wintering larvae imported to Australia in cool store, 2,600 arrived alive. From the following generation reared in the insectary, 2,000 larvae, together with a number of adults and eggs, were liberated neat Bright, Victoria. No sign of survivors from the previous season's liberations near Bright, nor any evidence of their activity, could be found.

Agrilus hyperici.—Life history studies and starvation tests with this stem and root borer continued in France and England, and indicate that this insect cannot harm plants of economic importance. With the completion of these tests the species will be introduced into Australia in the coming season. As it lives within the stems of St. John's wort, it is hoped that the insect will be able to escape the attacks of predacious animals.

Zeuxidiplosis giardiana.—Further observations were made on this gall midge ; and studies of its life history and local parasites were undertaken in France. In England, this species is undergoing starvation tests.

Aristotelia spp.—Two of these moths, *A. atrelia* and *A. morphochroma*, have been found to attack St. John's wort in France. The larvae feed on the young terminal leaves and on the flower heads, and also bore into the stems. The life histories are being studied in France ; and starvation tests are being conducted in England with *A. morphochroma.* It has been found that the larvae bore into, and feed on, many of the test plants, although they are unable to complete their development in them. Further careful studies will be undertaken before importation into Australia is considered.

Aphis chloris.—Breeding stocks of this aphid have been maintained in England, and consignments of over-wintering eggs have been received at Canberra. Although insects from these eggs passed through many generations and laid eggs on St. John's wort plants in the insectaries at Canberra, none of the eggs hatched in the following spring, and all were found to have collapsed.

Tenthredo spp.—Two sawflies, *T. zona* and *T. amoena*, have been found feeding on St. John's wort plants in the south of France, and studies of their life-histories have been commenced.

In France, observations are being made on several moths whose larvae feed on the leaves ; while in England studies are being made of the fly, *Pegomyia*, the larvae of which feed in the unopened flower heads.

(ii) *Noogoora Burr* (*Xanthium pungens*).—On this problem the Council has worked in close co-operation with the Commonwealth Prickly Pear Board in Australia and America. The Council's officer working in the United States of America has been transferred from Kansas to Texas to work with the officers of the Prickly Pear Board at Uvalde. The joint investigations at Uvalde are supervised by a senior officer of the Board. The location of the work in Texas was decided upon because the wider range of insect types for burr work exists there, and because the insect fauna of burrs in Kansas has now been thoroughly studied. Following careful study in the United States of America, the insects are received into quarantine insectaries in Canberra. After the insects have been bred there and freed from parasites, they are despatched to the Prickly Pear Laboratory at Sherwood, Brisbane, where final starvation tests are carried out. Subsequent liberations are made by the officers of the Board.

Euaresta aequalis.—The flies which were liberated in Queensland last year oviposited in burrs in the field. Adults of the following generation, however, emerged three months before burrs were available in which to oviposit ; and consequently the species was unable to establish itself. A large consignment of burrs containing larvae was received from Texas during the year. Some of this material was sent to the Prickly Pear Board's laboratory at Sherwood and the rest held at Canberra. In previous years at Canberra flies emerged from Kansas burrs during March-April. In this season flies have not emerged but have over-wintered in the insectaries as larvae. At Sherwood a number of flies emerged during April and May. As burrs are not produced in the field after May, the remaining larvae have been placed in cool store until next summer. It is possible that the life cycle is longer in Texas, and that this form may prove to be better suited to Australian conditions.

Dectes spinosus.—Four thousand root-stocks of Noogoora burr collected in the field in Texas, and containing larvae of this beetle, were received at Canberra during the year. From these, about 600 *Dectes* beetles and a large number of parasites emerged. The mortality from parasitism was at least 50 per cent. The beetles were bred in the heated insectary at Canberra and despatched at frequent intervals to Sherwood, where starvation tests were commenced. Of the 559 adults despatched to Sherwood, 231 were alive and active on arrival. Further consignments will be sent to Canberra from Texas ; and the starvation tests will be continued at Sherwood during the coming season.

Baris interstitialis (*B. callida*).—Six thousand adults of this beetle were sent to Canberra from Texas for quarantine purposes. These were later forwarded to Sherwood, where starvation tests were undertaken. It has been found that this beetle cannot feed on plants of economic importance other than artichoke.

Ataxia hubbardi.—A trial consignment of larvae in the stems of Noogoora burr was received in Canberra in good condition. Although this insect can feed on several plants of economic importance, it has been studied further in case importation into Australia is later desired.

Other insects for burr control.—A considerable amount of taxonomic work has been conducted in America on the new insects found on burr in Texas; and a large amount of material has been identified. Investigations with the following insects have been undertaken:— *Dectes brevisetosus, Cylindrocopterus adspersus, C. mammillatus, Baris socialis, Mecas inornata,* and *M. saturnina.*

During the year the investigators in America toured Texas, New Mexico, and Arizona. As a result, further information regarding the distribution of insects attacking burrs was gained; and a large amount of insect material was collected for further study at Uvalde.

(iii) *Lantana* (*Lantana camara*).—The lantana bug, *Teleonemia latanae,* has been bred in the heated insectary at Canberra, and has been treated to remove possible infection by the parasitic fungus which attacks it in Fiji. Two liberations have been made in Australia, one at Grafton, New South Wales, and the other at Atherton, Queensland, in co-operation with officers of the State Departments of Agriculture. At both places the colonies have disappeared. Further attempts will be made to establish the bugs in the field from stocks bred at Canberra. A consignment of 1,000 bugs was sent to Norfolk Island. Three hundred and thirty-five bugs survived the journey and were liberated at two different places on the Island.

(iv) *Ragwort* (*Senecio jacobaea*).—*Tyria jacobaeae.*—About 20,500 pupae of the cinnabar moth, collected in the field in England, were forwarded to Canberra. A large proportion of these were parasitized. From the following generation reared in the insectary, 5,000 eggs, 300 larvae, and 200 adults, were liberated at Beech Forest, Victoria. Working in co-operation with officers of the Department of Lands and Survey, Victoria, it was found that the moths and larvae on liberation were at once attacked and removed by scorpion flies (*Harpobittacus* sp.). A survey of the district subsequently demonstrated that *Harpobittacus* was particularly abundant and active in the area, and that it would be impossible to establish moths there in the presence of these predators. As *Harpobittacus* has a somewhat limited distribution, an attempt will be made in the coming season to establish the cinnabar moth in ragwort-infested areas in Gippsland, Victoria.

Pegohylemyia seneciella.—Twenty-five thousand puparia of this seed fly were collected in England and sent in cool store to Canberra. Only 210 adults emerged. These were placed on flower heads of ragwort in cages, but failed to lay eggs. Promising reports have been received of laboratory experiments with this insect in New Zealand.

(v) *Nut Grass* (*Cyperus rotundus*).—Arrangements have been made for further consignments of the moth *Bactra truculenta* and the weevil *Athesapeuta cyperi* to be sent to Canberra.

(iv) *Skeleton weed* (*Chondrilla juncea*).—*Melanagromyza cunctata.*—This leaf miner has been found attacking the leaves of skeleton weed in the south of France and its life history is being studied. Other insects of skeleton weed being studied in the south of France include *Trypetids* and *Cecidomviids,* which feed on the flower heads, and a species of black aphid.

(vii) *Other weeds.*—The insects attacking Mexican poppy (*Argemone mexicana*) and the ground cherry (*Physalis lanceolata*) in America have received some attention. A number of insects have been found attacking the St. Barnaby's thistle (*Centaura solstitialis*) in the south of France. These insects include seed flies and beetles which feed on the flower heads, moth larvae which bore in the stems, and scale-insects and aphids which feed on the stems and leaves.

3. *Chemical and Other Forms of Control.*—This phase of the work has still further developed during the period under review. Four officers of the section are working in the Division of Plant Industry on the problems involved.

An ecologist is collaborating with officers of the New South Wales Department of Agriculture in conducting field experiments on the control of skeleton weed and St. John's wort by chemical and cultural methods and by plant competition, and with an assistant ecologist in studing the effect of varying intensities and various systems of grazing on the balance of useful and weed species in pastures. The viewpoint is that of the plant ecologist who is concerned with discovering what factor or factors are responsible for the dominance of useful or noxious species in a particular pasture sward, and how such factors may be altered to permit useful plants to regain dominance where weed invasion has occurred. An assistant ecologist is investigating methods of control of weeds of irrigation areas. Detailed life history studies of weed species are carried out to obtain information on which to base field experiments.

The study of weed-killers and spreaders, and inquiries into the development of new compounds for use in spraying work, are carried out by a plant physiologist. Work with weed-killers so far indicates that the most satisfactory chemicals available act as soil sterilizers and not specifically on the weed plant. A highly toxic compound capable of penetrating into the plant and of translocation to all parts of it without affecting subsequent soil productivity is the ideal material for use in spray work.

(i) *Skeleton weed* (*Chondrilla juncea*).—At Canberra life history studies of the plant in the seedling year have yielded information on the production of leaf and stem, development of the perennial root-stock, set of seed, transpiration rate, and chemical composition at varying stages

of growth. This study will be continued with second year material. Seeds germinate very rapidly, and have a high germination capacity. Studies in pots indicate that skeleton weed seedlings have little if any effect on the yield of associated wheat plants, and that the very strong effect of established plants on the yield of crops is due to competition for water and nutrients and not to excretion by the weed of material toxic to other species.

At Wagga the experiments on the use of weed-killers conducted in collaboration with officers of the New South Wales Department of Agriculture, and still in progress, have shown that common salt and sodium chlorate are the most effective of the treatments applied. These materials also have the most pronounced effect in depressing subsequent soil productivity. The effective chemicals in the earlier work are applied at different concentrations and at different times, and untried materials are included as they become available. Work is also in hand on the question of the rapid restoration of soil productivity following chlorate applications. Early fallowing and frequent cultivations appear to favour the subsequent wheat crop in competition with skeleton weed. Species trials, experiments with competing plants, and combined factor experiments are continuing. The most promising line of attack on the problem of skeleton weed control at present appears to lie in modification of the farming system—the adoption of stock-raising in conjunction with wheat farming, involving as it does the use of temporary pastures crop rotations, and efficient grazing management.

(ii) *Nut Grass* (*Cyperus rotuncus*).—The work on this weed, which is a serious pest of cultivated crops in summer rainfall areas, has been intensified during the year. Life history studies have been carried out, and trials involving frequency of cultivation, the use of competing plants, and applications of chemicals have continued. No satisfactory spraying material has been discovered ; but efforts to find one will be continued if only for use where new infestations occur. Regular weekly cultivations for eighteen months have given some measure of control ; but it is not an economical procedure in practice. Two species of promise for use as competing plants in the Lockyer Valley have been found. Indications are that, failing entomological control, rotations of crops including efficient plant competitors will give a fair measure of control.

(iii) *Wild Turnip* (*Brassica Tournefortii*).—The experiments planned for the control of wild turnip in wheat fields in Western Australia in 1936 could not be carried out because of unfavorable seasonal conditions. It is expected that this work will be done in the coming season.

(iv) *Cape Tulip* (*Homeria collina*).—At Canberra pot-culture experiments have yielded information on the life history of this species, including the production of leaf, stem, roots, and seed, its water requirements, the translocation of reserves, and so on. Indications are that applications of weed-killers in the field will be found most effective in early September when the reserves of the old corm are exhausted and new corms are being formed. At Clare (South Australia) interesting results are being obtained from species trials, and the effects of plant competition are being studied. Further experiments with weed-killers are planned in the coming year.

(v) *St. John's Wort* (*Hypericum perforatum*).—During the period under review, experiments on the control of this weed were begun near Tumbarumba, New South Wales, and are being carried out in collaboration with officers of the New South Wales Department of Agriculture. The trials include a review of weed-killers in relation to their effect on this weed, and the discovery of suitable competing plants mixtures, and the best methods of establishing them in weed-infested country. Life history and germination studies are being undertaken in the laboratory.

(vi) *Galvanized Burr* (*Bassia Birchii*).—Work on this weed has been commenced on two properties in the St. George district, Queensland. The main experiment is concerned with the effect of varying the grazing intensity and management methods on the relative densities of burr and useful plants on an area heavily infested with *Bassia*. Trials with weed-killers are also under way, and an attempt is being made to establish species of possible value as competing plants. The questions of seed germination and seedling establishment are being studied at Gatton.

(vii) *Bulrush* (*Typha* spp.).—Following the appointment of an investigator, work on bulrush or " cumbungi " has been begun in the Murrumbidgee Irrigation Areas. Surveys of irrigation channels and natural watercourses show that the establishment of bulrush from seed is facilitated by low water velocities, the deposition of organic muck, and the absence of competition from other drain-side plants. A fluctuating water level in channels is dangerous in that it provides conditions suitable for *Typha* establishment. Individual plants produce large numbers of viable seeds. When established, vegetative spread is rapid. Experiments in progress include the use of foliage sprays, mechanical methods of removal, and various cutting treatments. Other weeds of irrigation channels are studied also.

(viii) *Other Weeds*.—The above weeds have been selected for immediate attention because of their importance. Experience at St. George in the *Bassia* work should indicate how far pasture

management can control weeds of pastures in the drier areas, and will permit the development of technique in such work. Experiments on control of Johnson grass with chemicals and a flame thrower are in hand, and surveys have been made in connexion with other weeds.

(ix) *Chemical and Physiological Investigations.*—Together with an attempt to discover substances of value as weed-killers and a study of the role of wetting and spreading agents in spraying work, some attention has been given to the question of soil sterilization by means of chemicals. The substances commonly used in weed spraying work are readily soluble in water and consequently are usually rapidly leached from the soil layers inhabited by plant roots. For this purpose substances which are relatively insoluble in water but which are dissolved by weakly acid excretions from roots and which are held reasonably permanently in the soil are desired. By adding solutions of two water-soluble salts and inducing precipitation of an insoluble toxic substance in the soil, some promising results have been obtained. Ferrous arsenite and copper arsenite, applied in this way, have proved more effective than sodium chlorate and copper sulphate, and may be useful for sterilizing banks of irrigation canals, for footpaths, &c. They have the advantage of being less poisonous to animals than are soluble arsenic compounds. The possibility of developing an instrument capable of measuring the moisture content of plants in the field is being studied, and when developed will be used in deciding the time at which to apply spray solutions.

Analyses in connexion with life history studies of weeds have been carried out to follow the mineral and carbohydrate metabolism of the plants. In addition some attention has been given to the problem of arsenical spray injury in apples.

V. ANIMAL HEALTH AND NUTRITION INVESTIGATIONS.

1. *General.*—Development of the work along the lines indicated in the previous report has continued in all the States, with the main centres for laboratory work in Sydney, Melbourne, and Adelaide. The Research Station at Townsville reverted to the control of the Queensland Department of Agriculture and Stock from 1st October, 1936. The laboratory studies on pleuro-pneumonia have been continued in Melbourne, while work on certain aspects of the tick fevers and studies on peg-leg disease have been continued in Queensland in co-operation with officers of the Department of Agriculture and Stock.

During the year, plans were prepared for the new Animal Health Laboratory in Melbourne, and building operations were started in the grounds of the University Veterinary Research Institute, Parkville, early in 1937. It is anticipated that the building will be ready for occupation towards the end of the year 1937. The general administration of the Division will be centred at Parkville as previously. The administrative staff has been strengthened during the year by the appointment of a Divisional Secretary to assist the Chief.

Progress has been made in the establishment of the field station on the property purchased near St. Mary's, New South Wales. Subdivisional fencing, yards, shearing shed, dips, dams, one cottage, and a hut were all completed before the end of the financial year, and the experimental sheep were transferred from " Hinchinbrook ".

During the year, the Queensland Government very generously offered to make available an area on which to establish an experiment station for the investigation of economic problems in the sheep industry. As a result of inspections and negotiations subsequently made, it was finally decided to accept the offer of the lease of an area in the Cunnamulla district. It is anticipated that active steps will be taken shortly to equip the area for the special purposes of the investigations to be undertaken of which studies in the blowfly problem are the most urgent.

Discussions on the problems in the pastoral industry were started in January, 1937, between the Australian Wool Board and the animal health research organizations in Australia. It was decided that the more urgent problems should receive first consideration; and the research organizations were invited to make application to the Board for financial assistance in the prosecution of their investigations. Very generous consideration was given by the Board to the applications made on behalf of the Division of Animal Health and Nutrition, with the result that new work and the extension of work on problems already under investigation have been made possible. This assistance has enabled extensions in the facilities for investigational work to be made in the Nutrition Laboratory, Adelaide, and the field station at St. Mary's, while it has been possible also to negotiate for an early start on the establishment of the field station at Cunnamulla.

In addition to the work carried out in the three main centres of Sydney, Melbourne, and Adelaide, the Division has continued to carry out investigational work in Tasmania in co-operation with the officers of the Department of Agriculture, and to assist financially and otherwise in the animal health problems under investigation in Western Australia by officers of the Department of Agriculture.

Following upon the Council's decision to proceed with the investigation of problems associated with the manufacture of dairy products, a research officer was appointed and commenced work in March, 1937. Arrangements were made for him to be stationed at the Dairy Research Institute, Palmerston North, New Zealand, where excellent facilities for this type of work are available. These arrangements are in accordance with the agreement by the Council and the New Zealand Department of Scientific and Industrial Research for an interchange of officers.

On the 18th March, 1937, Mr. H. R. Marston, Officer-in-charge of the Nutrition Laboratory, Adelaide, left Australia on a visit to Great Britain and the Continent. He will represent the Commonwealth at the International Grassland Conference to be held at Aberystwyth in July, 1937, work for some months at Cambridge, and visit nutritional research institutes in Britain and on the Continent. During his absence abroad, arrangements have been made for Professor M. L. Mitchell, of the University of Adelaide, to take charge of the nutrition work of the Division.

2. *Animal Health Research Laboratory, Melbourne.*—(i) *Pleuro-pneumonia in Cattle.*—Continued work on the artificial reproduction of pulmonary pleuro-pneumonia by exposure to atomized cultures has confirmed the earlier observations. The lesions are not always of the massive progressive type, and appear to depend upon the virulence of the strain to some extent; usually, typical pleuro-pneumonia is produced. The technique has been applied to compare the resistance of cattle vaccinated in the tail by culture vaccine with those similarly treated but reinforced by a subsequent subcutaneous inoculation. Results indicate the superiority of the latter method.

The culture vaccine in B.V.F.—O.S. is now widely used in Queensland and the Northern Territory. Over 400,000 doses have been distributed to date, including 130,000 in the last six months. No untoward tail reactions nor any authentic failures to immunize have been reported. A major difficulty with the production of pleuro-pneumonia vaccine is standardization. This matter is under investigation, but to date no satisfactory method has been found.

The complement-fixation reaction continues to give excellent results. A new antigen based upon centrifugates of cultures in B.V.F.—O.S. has been evolved; it is even more sensitive and more regularly suitable for use than the Ebert and Peretz antigen. It is so sensitive that the anti-bodies can still be detected in the blood many months after tail inoculation. An agglutination test using an antigen prepared from centrifugates of cultures in B.V.F.—O.S. gives positive results in a large number of acute cases of pleuro-pneumonia; but is not as reliable or as sensitive as the complement-fixation test.

(ii) *Entero-toxaemia.*—To determine the types of *Cl. welchii* responsible for this disease, a large number of strains have been isolated from the intestines of affected lambs in Tasmania, Victoria, and South Australia. These strains have been examined culturally and biochemically; but final identification and typing cannot be completed until a supply of mice for inoculation becomes available. Strains for examination have also been isolated from soils. Field tests at "Frodsley", Tasmania, with vaccine against type D given in two ways, viz. (*a*) 2 millilitres followed in fourteen days by 8 millilitres, and (*b*) 8 millilitres followed by 2 millilitres, gave no conclusive results, owing probably to the very low incidence of the disease. An experiment at Lismore, Victoria, has been commenced to test the value of pre-natal maternal vaccination with a potent vaccine followed by vaccination of the lambs.

(iii) *Black Disease.*—Work is progressing on the comparison of human and bovine types of *Cl. novyi*. The object is to ascertain, by antigenic analysis, if differences exist among strains of the black-disease bacillus, and between this type and the human or classical type.

(iv) *Caseous Lymphadenitis.*—The study of the relationship of the causal organism to soil has been continued on the same property in South Australia on which the study was initiated some years ago. In spite of favourable climatic conditions, the organism was not recovered from the soil during the spring months. Observations were completed on a small lot of 100 sheep which were protected from soil contamination of the wounds at shearing time by placing them immediately off-shears into a clean paddock with reasonably good pasture cover. The animals were selected as lambs, and passed through three annual shearing operations before being sent to slaughter. Approximately a 50 per cent. reduction in the incidence of the disease was found in these animals. The effect on the incidence of the disease of other methods of protecting shearing wounds from soil contamination is being investigated.

Further serological studies have revealed marked differences between ovine and equine strains of the Preisz-Nocard bacillus. The possibility of type specificity residing in the polysaccharide fraction of the organism is being investigated.

(v) *Bovine Haematuria.*—Observations on the effect of top-dressing of pastures with gypsum on the prevention of the disease were initiated on a property in the Mount Gambier district, South Australia, in September, 1933. Of six heifers grazed continuously on untreated pasture, three have died from the disease, one has shown clinical evidence, and the remaining two have shown blood in the urine by microscopic examination. More recently, the six cows

grazed on the pasture top-dressed with gypsum have shown blood in the urine by microscopic examination only. This is presumptive evidence of the presence of early lesions in the bladder. None of these animals on the pasture top-dressed with gypsum has shown any clinical evidence of the disease.

On the assumption that the soil in these areas might contain a substance which, when excreted by the kidneys, leads to lesions in the bladder, experimental animals hand-fed on chaff have had soil added to their diet since September, 1935. So far they have shown no evidence of the disease. In order to elucidate this aspect further, geo-chemical observations have been initiated and centred in the Nutrition Laboratory.

The observations on the effects of top-dressing pastures with gypsum and superphosphate are being continued in Gippsland (Victoria). So far the animals on the property, previously a notoriously bad " red-water farm ", have shown no departure from the normal..

(vi) *Myxomatosis of Rabbits.*—The virus was received in August, 1936. Observations have been carried out on the pathogenicity of the virus for wild and tame rabbits. Included in these observations is a colony experiment conducted on wild rabbits living under semi-natural conditions in burrows. The disease was introduced into the colony consisting of 38 rabbits, and in 51 days the colony was completely exterminated. A second colony experiment was commenced in February, 1937, to determine if the disease had the capacity to continue of its own momentum and without modification over a period of months. The disease was introduced into an established colony of 30 rabbits, and an attempt has been made to maintain the colony at this strength by adding fresh rabbits twice weekly. Up till 30th June, 221 rabbits had been added to the colony. The single introduction of the disease into the colony has been sufficient, and the disease has progressed without any modification up to the present time.

In addition, a representative collection of native animals, including birds, has been inoculated with the virus without in any case the development of any departure from normal. Wild hares have also been tested and found to be completely refractory to the disease. All the domesticated animals, including birds, have also been found to be completely refractory to the disease, even after artificial inoculation of large doses of virus.

(vii) *Bovine Mastitis.*—During the year, the numerical strength of the experimental herd was established at 50 head. At the end of June, 1937, 41 cows were in milk, 13 of them in their second lactation period. Most of the heifer progeny of the milking herd have been retained and at present number seventeen. The herd has been kept free from tuberculosis and contagious abortion, and the animals are regularly tested. Systematic bacteriological and cytological examinations of the secretion of each quarter of every cow have been continued. The health of the herd has been good. Systematic bacteriological examinations of the milk from each cow had shown, during 1936, the occasional sporadic occurrence of *Streptococcus agalactiae*; but only in one animal had the organism become established in the udder over a period of several months, without, however, the production of clinical symptoms. During the latter part of 1936 and the beginning of 1937, no isolations of streptococci were made from the secretions. From March, 1937, onwards, streptococci reappeared in the herd and were isolated from the milk of some of the cows. Since then two clinical cases of streptococcal mastitis due to *Strep. agalactiae* have occurred, and in each case the affected quarter has ceased to function.

Staphylococci have continued to play the major part in the microflora of the udder. High counts of these micro-organisms are sometimes found in the secretion of one or more quarters of a cow at the time of calving; but there is usually a fall in the numbers during the first week, after which the secretion may become sterile. Later in lactation, a rise in the bacterial count may occur, due to staphylococci; and this may become established over a period of months. Towards the end of lactation and during the dry-off period, a rise in the bacterial count may occur, a condition which is usually followed by a high bacterial count from the commencement of the next lactation period. These changes take place without the development of any abnormality in the secretion or in the tissues of the udder. The correlation between these changes and the subsequent development of a streptococcal mastitis is being studied.

The appearance of *S. agalactiae* in the herd, and the development of clinical cases of mastitis, have necessitated a slight alteration of plans. It has become unnecessary to seek other herds in which to make any extended study of the epidemiology of the disease, at least for the time being.

Classification of the streptococci isolated by biochemical and serological methods has been placed on a satisfactory basis.

During the year, we received assistance from Mr. Forsyth Stewart in the initiation of the serological methods of classification of streptococci; the Council is indebted to the Queensland Minister of Agriculture for making the services of Mr. Stewart available for a few weeks.

The present studies are only of a preliminary nature, and a progress report will be published in the near future.

(viii) *Toxaemic Jaundice.*—During the year, an investigation into the occurrence of a disease in sheep grazed on an irrigation area was commenced in co-operation with the University Veterinary Research Institute and the Department of Agriculture of Victoria. The disease is characterized by the development of jaundice and haemoglobinuria, and by a high mortality. The evidence strongly supports a diagnosis of chronic copper poisoning, but the investigation is still incomplete.

3. *The McMaster Animal Health Laboratory.*—(i) *Parasitological Investigations.*—(*a*) *The Effect of Administration of Iron, Copper, and Cobalt on Haemonchosis.*—The influence of the administration of iron ; iron and copper ; and iron, copper, and cobalt, on a group of lambs exposed to daily infestation with larvae of *H. contortus* was investigated over a period of some months. There was strong evidence that the combination of iron, copper, and cobalt markedly reduced the degree of infestation set up when compared with that in control lambs not receiving such supplements. An investigation is now being made into the possibility of supplying such supplements in the food. There was no evidence that allowing the animals continuous access to a lick of one part of tobacco dust, having 3 to 4 per cent. nicotine content, and five parts of salt, had any effect in reducing the degree of infestation set up in animals exposed to infestation in the same manner as the animals mentioned above.

(*b*) *Treatment of Oesophagostomiasis.*—Extensive tests have been made of the efficiency of oral administration of copper tartrate and copper arsenate for the removal of *Oesophagostomum columbianum*, the nodule worm. A very high efficiency may be attained in individual sheep, both under laboratory and field conditions, but in other animals treatment may be quite ineffectual. It is not yet possible to say on what this individual variation is due, and further study is being made of this point. In the meantime, however, it is thought advisable, in the absence of any other method of oral administration, to recommend this treatment. The efficiency, previously demonstrated, of rectal administration of large volumes of a solution of sodium arsenite has been confirmed in the case of *Oe. columbianum*, and shown to hold for *Chabertia ovina* also.

(*c*) *Treatment of Trichostrongylosis.*—Further tests of anthelmintics have been carried out. A mixture of copper sulphate and pure nicotine sulphate (as opposed to Black Leaf 40) has been tested, and from a limited number of experiments appeared to be less constantly efficient than the copper sulphate, Black Leaf 40 mixtures used.

(*d*) *Treatment of Dictyocaulus filaria.*—Critical tests were carried out of the value of treating lungworms (*D. filaria*) in sheep. A mixture recommended by the Department of Agriculture, New South Wales, was tried ; it consists of creosote, chloroform, turpentine, and olive oil. As an alternative, an iodine solution, as recommended by a Russian worker, was tried. The constituents were iodine, glycerine, and distilled water. In both cases, intratracheal injections were given in the doses recommended. With the Russian method, as recommended, the sheep was turned on its back while the injection was given. The results were rather disappointing, several of the treated sheep dying from the heavy infection, and the remainder showing worms in the bronchi on post-mortem examination.

(*e*) *The Efficiency of the Baermann Isolation Technique as Applied to Soil Isolation.*—Experiments were carried out to determine the efficiency of the original Baermann isolation technique when applied to soil isolation. In a series of experiments, soil samples measuring 71 millimetres in diameter (which represents 1/1,000,000 of an acre) were used. A given number of mature, free-stage, nematode larvae were evenly spread on the surface of the sample, and the percentage recovery by the isolation technique was ascertained. The recovery was not up to expectation, so experiments are in progress to improve the result by improving the technique. The isolation of larvae is important, in view of the fact that by this means the degree and type of infection can be determined on sheep-grazing areas.

(*f*) *The Longevity and Resistance of the Free-living Stages of Gastro-intestinal Nematodes of Sheep.*—This work has been continued, particularly in respect of the effect of low and sub-freezing temperatures on eggs and larvae of *Haemonchus contortus*, *Trichostrongylus* spp. and *Oe. columbianum*. The much greater susceptibility of eggs and larvae of the latter species to the lethal effects of cold indicates that measures for the control of this species, if practised during winter on the Northern Tablelands of New South Wales, might make it possible to effect eradication of the parasite.

(*g*) *Infestations by Nematodirus felicolis.*—Additional experiments were carried out on the pathogenic effect of this parasite, further evidence that the parasite is relatively benign being obtained. Although heavy infestation was not produced, 6,300 and 3,500 worms did not produce any clinical ill-effects or any pathological change in lambs up to two months of age. Further experiments are to be carried out before final conclusions are drawn. Heavy infestations, similar to those which are not infrequently met with in the field, will be established, and a larger number of experimental animals will be used.

(ii) *The Effect of Grazing Superfine-Woolled Sheep on Improved Pasture.*—An experiment was conducted for twelve months in which superfine Merino sheep were run both on natural and improved pasture. In spite of the fact that the improved pastures maintained three sheep per acre (an increase in carrying capacity of two sheep per acre), that the sheep gained 20 lb. more in live weight, and produced 2 lb. more greasy wool per head than comparable sheep on natural pasture, there was no major change noted in wool quality, other than in length of staple. This experiment suggests that genotypically fine-woolled sheep may continue to produce fine wool, even when maintained on a greatly improved plane of nutrition on rich pastures. With certain modifications, the experiment is being continued for a second year.

(iii) *Studies in Fleece Chemistry and Fibre Measurement.*—This work is now centred at the McMaster Laboratory, and is conducted in close association with other investigations in progress in the Division. Opportunity is thus presented to examine in detail all changes in the fleece resulting from the various experimental treatments. The examination includes tests on the wax, suint, and other characteristics of the staple, all of which have an economic importance in their effect on such qualities as colour, handle, and clean-scoured yield of the fleece. In one experiment samples of fleece were obtained from sheep running on improved pasture for six months until April, and then on natural pasture for a further six months, as well as from sheep rotated in the opposite way from natural to improved pasture. Samples were also taken from sheep of the same type running continuously on the two classes of pasture. The distribution of the fleece constituents along the staple was determined, and the ratio to the clean dry wool estimated. The skin of the sheep under the conditions of the experiment was more actively productive in the summer period than in the winter period. Such large variations were noted in all results between individual sheep, that no differences in the fleece constituents were apparent between sheep run on natural and those on improved pastures. The results, however, do show differences between sheep run on the improved-natural pasture sequence and those on the natural-improved sequence. The latter, on account of seasonal effects, provided a good diet through the whole year, while in the former it was good in the first six months but poor subsequently.

A large number of physical measurements of the fibre have been conducted during the year on wools collected from north-eastern Asia, and on material from sheep under nutritional and pasture management experiments.

(iv) *Physiological Studies.—The Passage of Fluids through the Ruminant Stomachs.*—Radiological observation has been applied to the problem of determining the passage of fluid when swallowed by the sheep. It has been shown that, in normal drinking by the weaned lamb, fluid will pass into the rumen and reticulum. On the other hand, when the lamb is running with its mother, the suckled milk passes to the abomasum. Further studies are being directed to the question of this change with age, and the part played therein by the oesophageal groove and the possibilities of controlling the passage of fluids into the ruminant stomachs.

When sheep are drenched, however, in about 50 per cent. of the cases, the fluid passes direct to the abomasum, because the particular method of administration has an active effect on the act of deglutition. Medicaments administered in the drinking water will most probably pass to the fore stomachs.

(v) *Bacteriological Investigations.*—(*a*) *Foot-rot.*—Investigation has continued along two main lines :—(1) the control of the disease in the field; (2) seeking to incriminate a causal microbe. The scheme for controlling the disease in the field depends on the apparent inability of the infective agent to remain viable for very long apart from the sheep's foot. A considerable number of tests have now been carried out to determine the viability of the infective agent under a variety of conditions. In one instance, it remained infective for two weeks in mud obtained from a property where the disease is endemic, but in most cases it died more quickly. Thus it seems fairly certain that, in districts where foot-rot occurs periodically, the infection survives the intervals between outbreaks not in the soil but in the sheep's foot. Unfortunately, field trials which were carried out to test the method of controlling the disease by eliminating all infected animals were fruitless, owing to an unusually dry season and the absence of an outbreak of foot-rot. During January, 1937, nine field trials were again initiated, but so far the seasonal conditions have been no more favorable than last year. However, one trial, at Werribee State Experimental Farm, is being carried out on irrigated pasture, and so is independent of seasonal conditions, the results there so far being encouraging. It has still not been possible definitely to incriminate a causal organism. A spirochaete previously reported has been isolated, fully studied, and named *Spirochaeta penortha*. This organism has continued to be found constantly present in lesions of the disease in several districts in New South Wales and Victoria and also in New Zealand. In addition to the spirochaete, a fusiform organism has been found to be also constantly present. This organism has been isolated. It has not yet been possible to produce the disease with cultures of either of these organisms, or of any other organisms isolated from the disease. Filterable viruses and some related organisms have been fairly conclusively eliminated as possible causal organisms.

(*b*) *Scabby Ulcer.*—" Scabby ulcer " is a superficial, erosive dermatitis of the vulva of ewes. A brief investigation was carried out without, however, any definite conclusion being reached. The condition could not readily be transmitted from one animal to another, although, in a few instances, the application of material from natural lesions to the vulva, together with scarification, produced a lesion which resembled that of natural cases, but which healed spontaneously after two weeks. " Scabby ulcer " is probably more common in very wrinkly sheep ; but it also occurs in perfectly plain sheep even when these have fairly short wool. It does not appear, therefore, that the condition can be explained entirely as being due to retention of moisture by wrinkles, as has been claimed.

(*c*) *Epididymitis.*—A number of semen apples, collected by Dr. R. M. C. Gunn from rams affected with epididymitis, have been examined bacteriologically. From a few samples, streptococci were isolated, and from others various Gram-negative bacilli. It does not appear that the condition is due to any one specific bacterium.

(*d*) *The Antigenic Relationship between Corynebacterium ovis, Corynebacterium diphtheriae, and Certain Pathogenic Diphtheroids from Human Throats.*—Rabbits have received courses of intravenous inoculation of living, untreated organisms of these strains in order to prepare precipitating sera for cross-precipitation experiments. It was found that, by long courses of inoculation with gradually increasing doses, sera with a fairly high precipitin content can be obtained, and cross-precipitation tests are now in progress. It is worthy of note that at least some rabbits treated in this way appear capable of withstanding both the toxic and pyogenic effects of live *C. ovis*, both of ovine and equine origin ; though many succumb to localizations in bones, more particularly of the vertebral column leading to paralysis of the hind limbs.

(vi) *Fertility in Sheep.*—It was stated in the previous report that analyses of stud flock records had shown observed levels of fertility to be affected by infective, environmental, and hereditary factors. It was also stated that an experiment flock of approximately 400 sheep had been established further to survey the position. These sheep, which are Merinos and Dorset Horns of high, normal, and low levels of fertility, were maintained under identical environmental conditions throughout the year, when group differences in each succeeding reproductive process were observed and recorded. Results obtained during the first year have been prepared for publication in the Council's Bulletin series. The observations are embodied in six studies : (1) the incidence and character of oestrus ; (2) the behaviour of ewes on heat and their discovery by rams ; (3) the association of oestrus with ovarian morphology ; (4) the rate of movement of the gametes in the female genital tract ; (5) mating experimental flock and observations arising therefrom ; and (6) the fertility levels of similar ewes when hand-mated, paddock-mated, and artificially inseminated. These reported studies, though related, are not consecutive ; together, they form a series throughout which the general procedure adopted was to establish normality for each reproductive process and to determine departures from it. By this method of survey, which is being continued, it is hoped to isolate the specific problems of reduced fertility.

4. *Observations Centred in Queensland.*—(i) *Peg-leg Disease.*—Investigations on this disease have been continued ; and since October, 1936, the Division has had the assistance and co-operation of the Officer-in-charge of the Animal Health Research Station, Townsville (of the Queensland Department of Agriculture and Stock).

Earlier work indicated that the optimum supplement of phosphate to the diet of cattle at " Helenslee ", Queensland, was 20 grams (of P_2O_5) per day. The present series of experiments, which are under way, are designed (*a*) to compare the effects of dicalcic phosphate and of bone flour in equivalent amounts when given *per os* ; (*b*) to determine the effect of monoammonium phosphate given in the drinking water in optimum concentration ; and (*c*) to determine the value of phosphatic licks given *ad libitum*. The animals were carefully selected, comprise both steers and heifers, and have been allotted, following statistical analysis, to groups after a long pre-experimental observation period. Monthly weighings and quarterly measurements are taken, and the results analysed statistically. To date, no significant differences have been observed ; but the long dry season is expected to show up differences.

(ii) *Tick Fevers.*—Investigations have been confined to an experiment to determine if winged insects can transmit *Anaplasma*. Observations have been made over a period of nine months, but no evidence of the parasite being transmitted in this way has been forthcoming. These observations are being carried out with the assistance and co-operation of the Officer-in-charge of the Animal Health Research Station, Townsville, and are being continued.

(iii) *Zebu Hybridization.*—Breeding activities have been continued in the four experimental herds. In these the hybrids now number 250, of which 224 are half-breds, seventeen are quarter, and nine are three-quarter-bred Zebus. All the imported animals are alive and well. The second progress report has been prepared in mimeographed form for limited distribution. It records observations to date ; but, because these are not sufficiently advanced, no conclusions

are drawn. Evidence is given, however, supporting the opinion that pure bred Zebus have a hereditary resistance to the effects of infection with *Piroplasma bigemina*. Observations also show that they are tolerant of heat, and that, under drought and adverse conditions, the hybrids (crosses with British cattle) maintain or increase their body weight.

5. *Dairy Products Research.*—Following upon the Council's decision to proceed with the investigation of problems associated with the manufacturing side of the dairy industry, Dr. W. J. Wiley was appointed as Dairy Research Officer and commenced work in March, 1937. As a result of an invitation from the New Zealand Department of Scientific and Industrial Research, arrangements were made for him to be stationed at the Dairy Research Institute, Palmerston North, New Zealand, where excellent facilities are available for work of this type. The immediate problem under investigation is that of the keeping quality of unsalted butter, particularly as affected by the acidity of the cream from which it is made. A comprehensive investigation is already in train with the object of obtaining information on the following matters: (*a*) the effect of acidity on keeping quality; (*b*) the effect, if any, of bacteria as distinct from the acidity they produce; and (*c*) the relative efficiency of certain storage temperatures. It would appear that there is need for a critical examination of factory processes in the light of recent work on neutralization and pasteurization, and such will be undertaken. The use of the pH determination, in conjunction with the present grading system for export butters, as an efficient indicator of probable keeping quality, is at present under consideration.

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

Botulism (*Toxic Paralysis of Sheep*).— The vaccine prepared at the Animal Health Laboratory, Melbourne, gave very good protection under experimental and field conditions. A more extensive field trial was carried out with a vaccine prepared in the same way under commercial conditions. Complete results are not yet available; but so far all reports have been favorable to the use of vaccine in the control of the disease.

Gingin Disease (*Ataxia in Lambs*).—The results from the more crucial experiments started in 1936 were disappointing, as seasonal conditions were unfavorable to the occurrence of the disease. Experiments started in 1937 have already given results which will probably prove of great interest. The observations are not yet completed.

7. *Investigations in Tasmania.*—Co-operative investigations have been continued with the animal health officers of the Department of Agriculture.

Rotational grazing, "Frodsley".—Previous field trials at "Frodsley" indicated that lambs did not make satisfactory gains in weight or fleece production on natural pasture, even when control of parasitic infestation was attempted by the use of anthelmintics. Subsequent trials showed that lambs maintained on improved pasture at the rate of one sheep to $\frac{2}{3}$ acre made very much better weight gains, and produced approximately 2 lb. more wool per head, than similar sheep on natural pasture at the rate of one sheep to $1\frac{3}{5}$ acres. Observations on rotational grazing have shown that much better results are obtained, as judged by growth and wool production as well as by the control of parasitism, than by continuous grazing at the same rate of stocking. The longer period of rotation gave better results than the shorter. The results of the observations are being published in detail.

8. *Animal Nutrition Laboratory, Adelaide.*—(i) *The Phosphorus Metabolism of Sheep.*—(*a*) *The Comparison of Mono-, Di-, and Tri-calcic Phosphate as Sources of Phosphorus Supply for Sheep.*—The details of this investigation were given in the last Annual Report. During the last twelve months, two animals in the monocalcic (superphosphate) group have died and a third is sick. This is undoubtedly due to the relatively high fluorine content of the "super". The Christmas Island rock phosphate also contains fluorine as an impurity, but in less amount. The sheep receiving this tri-calcic supplement show erosion of the incisor teeth, but the amount of fluorine has not been sufficient to affect the general health of the animals.

The experiment has now been in progress for two and half years. There has been no significant difference in growth between the "tricalcic" "dicalcic", and control groups, the last-named receiving only 0.6 grams of phosphorus daily. The lack of difference in condition between the control group and the "tricalcic" and "dicalcic" groups is in marked contrast to the inorganic phosphate contents of the blood. During the first year, the figure for the control animals has averaged 2.8 milligrammes per 100 millilitres, while for the others it has ranged consistently between 6 and 8 milligrammes per 100 millilitres.

The ability of the sheep to assimilate phosphorus from the different supplements has been investigated with animals confined in metabolism cages. The experimental periods have now been completed, but part of the analytical work remains to be done.

In the near future, it is proposed to mate the sheep in order to observe the effect on their phosphorus metabolism of the extra strain of pregnancy and lactation.

(*b*) *Phosphorus and Calcium Retention in Lambs.*—An experiment was begun in July, 1935, to determine the maximum retention of calcium and phosphorus of which Merino lambs are capable during the growing period. Three Merino lambs, trained in metabolism cages, were bottle-fed with cows' milk, and in addition were offered a mixture of hay, chaff, lucerne, and wheat bran. Balance periods of fourteen days were conducted continuously through the stages of rapid growth, and subsequently at monthly intervals.

At four months, just before weaning, they retained 0.7–1.0 grams phosphorus per day and as much as 1.15 grams calcium per day. After weaning retention fell away to less than 0.1 grams phosphorus, calcium retention to about 0.7 gram per day. At twelve months the phosphorus retention in all cases was fairly steady at approximately 0.4 gram per day, with calcium at 0.7 gram per day. The remaining analyses of collected material will be completed shortly.

(*c*) *The Influence of High Concentrations of Calcium and Magnesium on the Assimilation of Phosphorus by Growing Sheep.*—The results of this investigation, details of which appear in previous reports, will shortly appear in the form of a Bulletin.

(*d*) *Phosphatic Licks in the Pastoral Industry.*—Work is being continued with the object of determining whether it is necessary or advantageous to supplement the diet of grazing sheep with phosphatic licks. No conclusions can be drawn at the present time, as the results of the experiments will not be available until they have been in progress for at least two years.

At Penola, south-eastern South Australia, a field experiment is being conducted on the property of Mr. R. R. Rymill. A flock of ewe lambs was divided into two groups, one of which has access to salt only, while the other has access to a lick composed of dicalcic phosphate and salt. Half the sheep of the former group has been given potassium phosphate, by frequent drenching, in quantities sufficient to supply the animals with their full requirement of phosphorus. Of the latter group, half has been given potassium chloride in similar manner to supply an amount of potassium equivalent to that being received by the group treated with potassium phosphate. Observations on the growth rate, general health, wool production, and the content of phosphate in the blood are being made. Later, the ewes will be mated to observe the effects of the treatments on fertility and on the growth and general health of the second generation of lambs.

At "Wambanumba", Young, New South Wales, a second field trial is being undertaken. In this experiment, two groups of lambs are being used. One group receives regular dosing with a solution of potassium phosphate, while the control group similarly receives a solution of potassium chloride. Observations on these sheep will be made in the same manner as indicated for the experiment at Penola.

It is proposed to supplement the present field trials at " Wanbanumba " by an investigation into the effects of phosphatic licks upon sheep grazing on rich pasture. As a preliminary step, an area of 50 acres of improved pasture has been sown.

At " Manuka ", Winton, western Queensland, a third lick trial, undertaken in co-operation with the Australian Estates Company, is progressing satisfactorily. Mr. J. F. Kennedy, B.Sc., an officer of the company, is in charge of this investigation.

Somewhat similar field trials are being conducted at Avondale, Merredin, &c., Western Australia, by the Department of Agriculture.

(ii) *Pasture Experiments at " Wambanumba ".*—In order to determine the effect of sulphur, soluble phosphate, and insoluble phosphate on the yield of natural pasture at " Wambanumba ", a replicated manurial trial is in progress. Sixteen treatments have been given, and yield data are to be collected five times during the year.

(iii) *Coast Disease Investigations.*—(*a*) *General.*—During the past year, considerable advances have been made in the study of coast disease. Although the work is not sufficiently far advanced to draw final conclusions, the more recent studies have indicated that the disease is probably due to a deficiency of cobalt and copper in the pastures of the affected areas. While it is possible that other elements may be necessary to maintain sheep in health for long periods on these areas, it does not appear that they are involved in the primary cause of the disease. A detailed account of the investigations on coast disease, undertaken during the past five years, will be published shortly in the form of a Bulletin. Experiments are now being undertaken to investigate methods for the practical control of the disease ; and further studies, microscopic and chemical, are being made to obtain a more intimate understanding of the essential nature of the condition.

(*b*) *Investigations at Robe.*—The work described in the previous report at the Robe field station has been continued and considerably extended ; the excellent facilities made available by Mr. R. Dawson on his property have in a large measure contributed to the success of these investigations and has made possible their extension.

It had been found earlier that coast disease could be cured and prevented by frequent drenchings with solutions of pure cobalt and copper salts, the addition of iron to the curative solution appearing to exert no appreciable effect. It was accordingly decided to investigate the individual roles of cobalt and copper ; and it has been shown that copper alone will not prevent the onset or delay the fatal progress of the disease. Administration of cobalt alone has prevented the death of the animals ; but they have failed to grow normally, and have become anaemic. On the other hand, the administration of cobalt plus copper, with or without other mineral salts, has continued to maintain sheep in normal health and permitted normal growth. Observations on the surviving sheep in this experiment will be continued for at least another year.

In the experimental work outlined above, it has been the practice to administer the solutions to be tested three times weekly. Having found that this treatment could prevent the occurrence of coast disease, an experiment has recently been commenced to determine whether less frequent dosing would also prove effective.

Further work has been initiated in an attempt to determine the nature and cause of ataxia, a nervous disorder of lambs and young sheep, which frequently occurs on areas where coast disease is enzootic. Healthy ewes have been depastured at Robe and mated to healthy rams. Half the flock has been treated to prevent the onset of coast disease, while the other half has been left as a control group without treatment. The occurrence of ataxia in the lambs born from these ewes will be carefully observed. Dr. E. Weston Hurst, Director of the Medical Research Institute at the Adelaide Hospital, has generously offered to undertake a neuro-pathological examination of any lambs which develop ataxia.

(*c*) *Investigations at " Hawk's Nest ", Kangaroo Island.*—The lambs of the first generation, raised and maintained on " coasty " country with access to a salt mixture containing iron, cobalt, copper, zinc, and manganese, have maintained a heavier weight than the control animals. They also cut 10 per cent. more clean wool, which was more attractive and better grown than that shorn from the controls. When two years old, the ewes reared 83 per cent. of lambs and the controls 67 per cent ; the second lot of lambs is just being dropped.

The owners of the property have given their main flock a similar lick since April, 1935 ; in 1933 and 1934 their sheep cut at the rate of 32 bales per 1,000, while in 1936 the cut was 39 bales per 1,000. The percentage of lambs weaned has risen from 60 to 65 per cent to over 80 per cent., and there have been no cases of wasted or atactic lambs. As ataxia occasionally failed to appear in former years, however, some uncertainty still attaches to the significance of this latter observation. The owners are satisfied that the improvement in productiveness of their flock is attributable to the lick.

(*d*) *Coast Disease Investigations at the Laboratory.*—An experiment is being conducted to determine whether coast disease may be induced in normal animals while confined in cement pens and fed on chaffed hay from " coasty " areas, supplemented with gluten. If the disease develops, the sheep will be used for a more intensive investigation of the condition than is practicable at field stations. The animals have now been on the diet for over six months, but as yet there are no signs of the development of anaemia.

A group of young lambs is being fed upon an exclusive diet of cow's milk in an endeavour to produce " milk anaemia ", due to lack of metals. It is hoped that the study of milk anaemia in lambs may throw fresh light upon the blood changes associated with coast disease.

Observations will be continued on the tissues of " coasty " animals, both in regard to micro-pathology and chemical changes. Mr. A. C. Oertel, an officer of the Division of Soils, has kindly offered to undertake a spectrographic analysis for cobalt in the tissues of normal and affected sheep. This should assist in overcoming the difficulty that has been encountered in the determination of cobalt by ordinary chemical methods.

(*e*) *Pasture Experiments at Robe and on Kangaroo Island.—At Robe.*—Results from field trials conducted at Robe in 1936 indicate that the number of pasture species suitable for this highly calcareous soil is limited. Unfavorable climatic conditions in the early part of the year were partly responsible for the poor growth made by many of the species. Wimmera rye grass and black medic (*Medicago lupulina*) showed most promise, but their yield was not increased by phosphatic or nitrogenous fertilizers. There was some slight improvement with the application of a small quantity of sulphate of potash. Further species and manurial trials have been started for observation purposes.

On Kangaroo Island.—In field trials conducted in 1936 on freshly cleared ironstone soil at Hawk's Nest and Karinga, the growth of Wimmera rye grass was particularly poor when phosphatic or nitrogenous fertilizers were applied alone. When applied together, very marked increases in yield were obtained, but these were not further increased by elemental sulphur. With all treatments subterranean clover remained unhealthy, and it was found that in general the plants were not infected by root-nodule bacteria. Investigations on artificial inoculation with selected strains of *Rhizobium* have been undertaken by the Division of Soils.

Yield data were obtained from the species trial on improved ironstone soil at Hawk's Nest in 1936, and further cuts are to be made.

(iv) *The Effects of Ingestion of Fluorine by Sheep.*—(*a*) *The Effects of Continual Ingestion of Fluorine.*—The results of these investigations will soon be ready for publication. Sheep which received 60 or 120 milligrammes of fluorine each day for three years suffered no apparent impairment of general health. The smaller of these doses is rather more than would be taken under field conditions with a lick composed of salt and Nauru rock phosphate. The two groups of sheep showed considerable erosion of their teeth ; and in addition the concentration of fluorine in their bones and teeth was at least ten times that in similar organs of the control sheep. Nevertheless, the sheep receiving these amounts of fluorine grew normally. Continual ingestion of 160 milligrammes of fluorine as Nauru rock phosphate and 170 milligrammes of fluorine as Florida rock phosphate resulted in still higher concentrations of fluorine in the bones and teeth, and in addition there were harmful effects on general health and growth.

The remaining animals are now being given a fluorine free diet, and after two years the animals will be killed and various organs examined for their content of fluorine, in order to discover what degree of recovery takes place after the intake of fluorine has ceased.

(*b*) *The Effects of Intermittent Ingestion of Fluorine.*—It is not improbable that sheep which continually ingest sufficient fluorine to lead eventually to chronic fluorosis would suffer no untoward effect if the periods of fluorine intake were alternated with periods during which little or no fluorine was present in the diet. Such a state of affairs may be encountered when licks are offered under grazing conditions with alternating green and dry pasture due to seasonal changes.

To investigate this point, an experiment was started in December, 1936, with 30 ewe weaners generously donated by Mr. R. T. Melrose, of Rosebank, South Australia. These sheep were divided into three groups of ten. One group receives as a phosphatic supplement pure calcium phosphate, free from fluorine. Another receives Nauru rock phosphate in sufficient quantity to supply 60 milligrammes of fluorine daily, throughout the experiment. The third group alternates in six-monthly periods between a daily amount of rock phosphate containing 120 milligrammes of fluorine and a corresponding amount of the fluorine-free phosphate. The sheep will be allowed to graze for the entire period of the experiment, which is expected to last three years. A regular record of weights will be kept, and it is hoped to mate the animals in the final year. At the conclusion of the experiments, some animals from each group will be killed, and fluorine estimations will be made on the bones and teeth.

(v) *Energy Metabolism, Protein Metabolism, and Wool Growth.*—The inter-relation of these factors has been studied intensively during the year in a strong-woolled Merino sheep. This information forms an essential background for the assessment of the value of rations for hand feeding in times of drought. Papers on these studies and on the technique of accurate measurement of energy balances and wool growth are being prepared for publication.

To ascertain to what extent these findings are generally applicable, the observations are being repeated on fine-woolled Merinos. It is already apparent that the latter type of animals cannot maintain themselves for an extended period on the basal diet of two parts wheat straw and one part lucerne, as can the former. Supplementing the basal diet with cod liver oil, sodium bicarbonate, and salt has failed to maintain their appetites at maintenance level.

The diameter of the wool fibres produced by the fine-woolled type at different levels of protein intake will be measured to ascertain whether increasing the amount of protein in the diet will cause a comparable increase in fibre diameter.

(vi) *Drought Feeding.*—Observations at the laboratory over three years show that the Division's strain of strong-woolled Merino sheep can be maintained on a ration of two parts wheat straw and one part lucerne hay, supplemented with 5 millilitres of cod liver oil, 7 grams of salt, and 25 grams sodium bicarbonate. As 40–50 per cent. of the total energy of the straw is utilized, it would appear that an economical method of hand feeding during drought would be to supplement locally conserved roughage with purchased concentrates. Arrangements have, therefore, been made to measure the value of Mitchell grass hay as a fodder, and to test the effect on wool growth of a supplement of linseed cake.

(vii) *The Digestion of Roughage by the Merino Sheep.*—When the rations used in the drought feeding experiments are compared with the standards for sheep laid down in European and American text-books, it would appear that the Australian Merino sheep utilizes roughage much more efficiently than do other breeds. To confirm this, studies have been commenced to determine the extent to which our sheep digest the crude fibre and cellulose factions of roughage—particularly of wheat straw—a large amount of which is available in this country.

It has been found that the lignin of fodders is unattacked in the sheep. As this fraction comprises 8 to 12 per cent. of the dry matter, it affords a suitable base from which to measure the digestion of other fractions as the food passes through the alimentary tract. It has already been shown that the greater part of the digestion of crude fibre occurs in the rumen, apparently

as a result of bacterial action; and the production of methane by this fermentation has been measured. Nevertheless, a considerable amount of fibre also disappears during its passage through the large gut. About 45 per cent. of the crude fibre remains undigested, and 10 per cent. is lost as a mixture of methane and carbon dioxide. The remaining 45 per cent. is utilized by the animal.

During the year, investigations were started into the extent and rate of cellulose breakdown in the rumen and the factors influencing the process. It is hoped that these studies will reveal the conditions most favorable to the utilization of the crude fibre of the fodders.

(viii) *Bovine Haematuria.*—Preliminary investigations into the possible causes of bovine haematuria were started in this laboratory in October, 1936. The problem has been approached entirely from a geo-chemical aspect, as it seemed possible that some mineral deficiency or toxic inorganic substance in the soil or pasture might be responsible for the disease. This view is suggested by the observed persistence of the disease in certain restricted areas. By a study of the geo-chemical aspects of the soils from as many regions as possible where the disease is known to occur, it is hoped that some common factor may be established which may have a bearing on the cause of the disease. The observations already made have shown that, in the majority of the areas where the disease occurs, the soils are directly or indirectly derived from certain types of basic igneous rocks, the peculiar chemical composition of which is reflected in the resulting soils. In some instances, anomalies occur, and the above generalization is apparently not applicable. It is hoped that further work will throw some light on these apparently anomalous occurrences.

The geo-chemical investigations have been supplemented by chemical analyses of soils from typical " red-water " areas at Mount Gambier, Mount Schanck, and Thorpdale (Victoria). Field observations have been made in the Mount Gambier and Mount Schanck areas.

At the present stage of the investigations there is no definite evidence suggesting the actual cause of the disease; but the work already done has indicated the lines along which further investigations should be undertaken.

(ix) *The Role of Methionine in Nutrition.*—The high percentage of cystine in wool and the comparatively small amount present in plants make it important to determine whether, as has been suggested, methionine can be converted into cystine by the animal, thus increasing the effective supply of the latter amino acid. Experiments carried out elsewhere with this end in view have been inconclusive, because the basal diet has not been completely cystine-free. The question is being re-investigated, and for that purpose a cystine-free hydrolysate of casein and vitamin B extracts of negligible sulphur content have been prepared. Rats can, therefore, be fed on a cystine-free, but otherwise adequate, diet, and this will be supplemented with either cystine or methionine. It is hoped that a definite answer will thus be obtained to the vexed question of the replacement of cystine by methionine in the diet.

(x) *The Biological Quality of Fodder Proteins.*—This work is being carried out by Miss M. C. Dawbarn, M.Sc., chemist of the Animal Products Research Foundation of the University of Adelaide, who is working in the Nutrition Laboratory.

A technique having been evolved for estimating the biological value of protein for growth, maintenance, and fleece production by means of feeding experiments with rats, it is proposed to use it for determining the quality of certain fodder proteins. It is considered desirable to separate the nitrogenous constituents of the plant from the fibre which is indigestible by the rat. To do this, repeated grinding, crushing, and washing are required. The precise treatment necessary will have to be determined for each species of plant. The first species to be investigated will be Wimmera rye grass. Through the courtesy of the Director (Professor A. E. V. Richardson) a suitable area of the grass has been sown at the Waite Institute and will be ready for reaping at the beginning of September, 1937.

(xi) *The Effects of " Rugging " on Sheep.*—One of the claims made by the advocates of " rugging " of sheep is that the lambs of rugged ewes grow more rapidly than those of unrugged ones. As this implies a superior milk supply in the former, an attempt is being made to investigate the question. Twenty-four ewes were rugged after the 1936 shearing, and the same number of similar sheep were left as controls. The yield and composition of the milk of a proportion of each group is being determined this year; and in addition the gains in weight of the lambs of both groups up to the time of weaning will be noted.

(xii) *Pasture Investigation at " Anama ", Clare.*—The species trial at " Anama " is being continued for the third year. Botanical composition and yield were determined in December, 1935, and three times during 1936.

VI. SOIL INVESTIGATIONS.

1. *General.*—The Division of Soils has its head-quarters at the Waite Agricultural Research Institute about four miles from Adelaide, and is housed there in the Darling Laboratory and part of the Melrose Laboratory. The recently endowed Ranson Mortlock Laboratory will provide

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

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

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

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

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

The most recent development in some of the irrigated settlements along the river Murray has been the provision of extensive drainage schemes to which every farm will have access. The soil surveys are likely to prove of service in the planning of the drainage systems required for the individual farms.

2. *Soil Surveys and Chemical Investigations of Soils.*—During the year the laboratory work associated with the surveys in the irrigated areas of New South Wales, in the Denmark district of Western Australia, and in the north-west of Tasmania was completed, which has enabled the data obtained in the field and in the laboratory to be co-ordinated and prepared for publication.

Field surveys in the Mildura district have occupied the attention of the Division, work on the Merbein Settlement having been completed. Progress in the Mildura area proper is to be reported, and it will be the policy to maintain a party in this area until the surveys are completed. During the past year 5,500 acres have been surveyed in this district.

Further work in Victoria has arisen from a request from the Kerang Seepage Investigation Committee for a survey which will be a basis for experimental work in connexion with the reclamation of deteriorated land in the Kerang district. An area of 40,000 acres is involved, of which 13,000 acres have been chosen for detailed work as representative of the district, to be followed by a less detailed survey of the remainder. Ten thousand acres of this survey were completed during the year. It is hoped that sufficient information on the affected soils will be obtained to indicate the probable solution of the fertility problems involved.

In the State of Victoria, at Mildura and at Kerang, the surveys are of a co-operative character, field work being carried on mainly by the Division of Soils and laboratory work by chemists of the Victorian Department of Agriculture working in the State Chemical Laboratories in Melbourne.

Following on the report of a Royal Commission on Forestry in South Australia, the Department of Woods and Forests in that State requested that a survey be made of the soils devoted to soft-wood afforestation in the south-eastern district. The principal species concerned is *Pinus radiata.* Work was begun in April on areas already planted; and 7,000 acres were mapped at the end of the year under review. The adjacent grazing lands will also be examined, and the surveys will be linked to those previously carried out in this district. Surveys in these forest areas will be continued during the summer months, 1937–38.

As an aid to this work and as a record of forest growth, an aerial photographic survey over an area of 340 square miles was carried out on behalf of the Division by the Royal Australian Air Force. The photographs are taken with a sufficient degree of overlap to enable stereoscopic methods of examination to be adopted, and, with the assistance of the Federal Forestry Bureau, to enable the photographs to be used as an aid to forest assessment.

In Tasmania, a general reconnaissance of Flinders Island was carried out for the purpose of assessing the major soil and agricultural problems of the island; and surveys were undertaken at Illawarra and Maitland in the Longford district as a basis for the field trials conducted by the Department of Agriculture on the establishment of subterranean clover. Laboratory investigation into the properties of the basaltic soils of the north-west coast were completed.

In view of the steadily increasing demand for soil surveys, it has become the policy of the Division to strengthen its staff each year by the addition of one or two field officers. Co-ordination with the work in other States and countries has been secured by the seconding of officers to and from the State Departments interested, and by sending an officer for study in the United States of America.

In the laboratory, apart from the examination of the soils associated with the abovementioned surveys, work has been continued on the examination of soils characteristic of the red-brown earths of South Australia and of soils from the desert and semi-arid pastoral regions.

In view of the importance of elements required by plants and animals in minute quantities, the study of spectrographic methods of examination of soils and plant materials has been taken up. Up to the present the work begun in the University of Melbourne and now attached to the Waite Institute has been restricted to a study of the practicability of the method and of its possibilities and limitations. Enough experience has been gained, however, to make use of the method for general exploratory work for this and other Divisions, and to indicate the possibilities with regard to quantitative estimations of particular elements in soils. The importance of the element cobalt for example in the group of stock diseases including bush sickness in New Zealand, coast disease in South Australia, and wasting disease in Western Australia is an example of the need for detailed studies with soils and pastures. There is evidence that one or two parts of cobalt per million of soil is a quantity sufficient to ensure reasonably healthy conditions in stock.

3. *Bacteriological Investigations.*—The investigations, mentioned in the last Report, of the nodule-producing strains of bacteria associated with leguminous plants have been continued, and have been followed by field experiments, notably on Kangaroo Island, where over a period of many years considerable difficulty has been experienced in the establishment of subterranean clover. The undeveloped soils of the island are extremely deficient in phosphate and nitrogen, and carry in their native condition a sclerophyll scrub. On freshly cleared land, repeated failures have been experienced in the establishment of suitable pastures. There is evidence that the problem is associated with the absence of nodulation on the clover plants, an absence which is in part associated with the lack of the proper organisms in the virgin soil and in part with the extreme poverty of the soil. The field trials conducted during the year have been designed to throw light on these problems, to gain experience in the methods of inoculation suitable for field work on a large scale, and to test the strains of bacteria which have been selected as a result of work in the glasshouses at the Waite Institute.

As a result of tests made with strains of *Rhizobia* from various sources, it has been found that commercial strains effective for white clover may be ineffective on subterranean clover and vice versa. Cultures of the strains tested as efficient for subterranean clover have been made available to State Departments of Agriculture in Australia, and to the New Zealand Department of Agriculture.

The work is being extended to test the effectiveness of strains of *Rhizobia* for other crops important in southern Australia, such as lucerne, tick-beans, and field peas.

VII. IRRIGATION SETTLEMENT INVESTIGATIONS.

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

1. *General.*—The Commonwealth Research Station, Merbein, is established centrally in respect to the Murray irrigation settlements producing fruits. The Station comprises about 60 acres of land, on which a new laboratory has recently been erected. Of the irrigable portion, approximately 33 acres are planted with vines. The various plots are utilized as experimental fields; and the fruit for investigation of fruit processing problems. The major portion of the work of the Station is carried out in the field, supplemented by such laboratory determinations as are required.

As the production of the annual crop, the processing of the products, and the preservation of soil fertility are obviously matters requiring continual attention, the staff of the Station has a wide and useful field to which its activities may be directed. In particular, mention may be made of the investigations relating to the preservation and reclamation of the irrigated soils of the Murray. Until recent years, loss of productivity was accepted as inevitable on portions at least of all the irrigated settlements, with declining capital value accompanied by loss in revenue. As investigations gradually clarified the position, and ameliorative measures for prevention of salting and the general misues of irrigation water became known, reclamation work has become prominent. The significance of the changed viewpoint is best illustrated by the steps now in progress for soil preservation in the various irrigated settlements.

With the awakening of an irrigation conscience, there have been decided improvements in the incidence and method of irrigation, accompanied in most instances with increased efficiency at reduced costs. There is now a general recognition that surplus waters, arising either from storm

waters or excess irrigation, must be removed ; and comprehensive drainage schemes are in the course of construction in most of the important irrigation areas producing dried fruits. The relatively large expenditure, and the willingness of the settlers to contribute, are well illustrated by reference to the Mildura district. The total irrigable area (including Red Cliffs and Merbein) is about 33,000 acres, for which a comprehensive drainage scheme at a cost of approximately £400,000 is in course of construction. The settlers' contribution to the drainage mains is £5 per acre, and in addition the cost of the internal drainage is borne by the settler. Smaller works are in operation or in course of construction at Barmera, Waikerie, and Berri (South Australia), and in Woorinen (Victoria) ; in addition, investigations are in progress in Renmark (South Australia) and Nyah (Victoria) to determine the type of drainage suitable to these districts.

The part played by the Station in these works is to investigate the drainage potentialities of the various soil types ; to assist in the examination and location of unproductive areas ; and to suggest remedial measures. In addition, the Station is closely associated, through various State and local committees, in the planning of the drainage schemes suitable for each particular environment. The work covers a wide area, embracing the settlements along the Murray between Waikerie in South Australia and Kerang in Victoria, a distance of approximately 400 miles.

Soil investigations relating to soil preservation under irrigation conditions include the measurement of concentration, and the location in the soil horizons, of injurious salts in various irrigation and drainage environments ; and irrigation methods in reference to reclamation. The depth and spacing of drains, in relation to the soil profile is an important feature of this work. Other intensive investigations include a study of the rate of moisture losses at different seasons of the year ; and it has been found possible to relate this work to the periodicity of irrigation. Fertilizer experiments, more particularly the nitrogen supply in relation to the regular growth of cover crops, are being carried out, and the resultant reactions to vine growth and fruiting studied.

In purely viticultural works, attention has been especially directed to the reactions of such routine operations as pruning, shoot removal, and the general effects of controllable operations which affect the balance of foliage and fruit. These inquiries have been particularly necessary in the viticultural areas of the Murray Valley, on account of recent altered growth environments associated with changes in irrigation and fertilizer practices, drainage, and, in particular, the more regular use of leguminous cover crops as affecting soil nitrogen. It now appears possible that by controlling fruiting in relation to foliage development, a satisfactory annual yield can be obtained ; and in addition the nutrition of the vine kept at a sufficiently high standard to ensure satisfactory development of fruiting wood including buds for the next year's crop.

The work on fruit processing has been continued, and the overseas realization, in the case of the main crop—sultanas—has been well maintained in relation to other competitive countries. It has not been possible to hold the advances made in the quality of the Zante currants, which is still unsatisfactory in comparison with the produce of the Levant. The very variable nature of the Australian climate is responsible for this condition, as damaging January rains have been recorded in the producing centres in three of the past five years, compared with two bad seasons in the previous seventeen years. A return to average summer rainfall is necessary before further progress can be made in improving the currants.

Further investigations have been undertaken on the question of dipping solutions for sultana grapes. Proprietary lines of fine stable emulsions are now on the market, and are proving an advantage over the coarser home-made emulsions formerly used.

The association with State officials in horticulture and irrigation investigations has been maintained, and practically all the problems under investigation by the Station are being studied in co-operation with the State Departments concerned.

2. *Irrigation and Drainage Investigations.*—The steps taken for amelioration of lands rendered more or less unproductive by irrigation waters fall under three general phases. The work on irrigation, including measurements of soil moisture, is primarily to define the irrigation needs of the soil, in relation to the plants being grown, so that excess irrigation may be avoided. The investigations of the movements of injurious salts are for the correction or prevention of salt accumulations near the surface of the soil, which results from excess irrigation on certain soil types. Drainage investigations are designed to form a basis for the removal of excess water, and in certain cases for the leaching into the drains, owing to the deep sub-soil, of injurious salts. Drainage systems vary with the general environment ; and in this connexion, the nature of the soil and sub-soil, the elevation of the irrigated lands, and the geological formation are considerations on which each drainage system is planned.

There are two major considerations in defining a suitable drainage scheme for a community settlement requiring agricultural (or subsoil) drainage. The first necessity is an economic means of disposing of drainage waters as they are collected ; the second is a suitable method by which the free water of the subsoil can be drained out and collected.

In the Murray Valley in Australia, there are three general systems for the disposal of drainage waters :—

(*a*) A system of deep-seated pipes, with a gravitational outfall to a natural depression or a stream (as has been installed in the Mildura district). The subsoil waters collected by internal drains within the irrigated areas are discharged to these deep seated pipes.

(*b*) Pervious layers, of limestone or of sand, have been found underlying some of the irrigation settlements. In such cases deep wells are sunk to the depth of the pervious layer, and the drainage waters discharged into the wells.

(*c*) In cases where the contour and elevation does not permit underground gravitational discharge as in (*a*), and the geological formation does not include a pervious layer as in (*b*), the drainage waters are raised, by pumping, and then discharged by gravitation, in channels leading to a suitable depression or to a natural stream.

The free water in the subsoil is collected, for disposal as mentioned in (*a*), (*b*) or (*c*) above, from the subsoil. In Australia, three general systems are used :—(i) a system of underground pipes (agricultural drains) are suitably placed in the subsoil, and these pipes lead to the point of disposal, (ii) open drains, to which the subsoil waters may penetrate, are similarly used, and (iii) the subsoil may be sufficiently pervious to permit the lateral movement of free water direct to the points at which the waters are discharged, in which case, neither agricultural drains or open drains are required.

The work of the station in recent years has been to determine, in co-operation with the State authorities concerned, an economic method of disposing of drainage waters ; and more particularly to study the internal drainage requirements of the defined soil types of the irrigated lands. Such studies have been carried out in the Waikerie, Berri and Barmera districts, South Australia, and in Mildura, Red Cliffs, Merbein and Nyah, Victoria, and have followed free water and soil profile studies designed to explore the extent and nature of free subsoil water in relation to loss of soil production. Preliminary studies are in progress in the Nyah, Kerang, and Chouna districts, Victoria, with a view to examination of soil reclamation methods which may be suited to these districts.

In all the districts where subsoil drainage has been established, the removal of free water in relation to the soil type and to the depth and spacing of drains is being examined. On the station vineyard, in an area especially designed for the purpose, drainage investigations are intensified, and include the measurement of water applied to the soil, and the amounts of subsoil water collected by the drains.

3. *Salt Investigations.*—An area of land on which the salt content prior to irrigation has been intensively mapped has now been irrigated for five seasons. The changed location of the salts resultant on irrigation has been mapped for each of the last five years. The data disclose that the translocation of salt, and the preservation and improvement of soil fertility, bear a close relation to the method of irrigation, the quantity of water applied, and agricultural drainage. The annual survey has disclosed fairly consistent results, and it is proposed that future surveys shall be carried out less frequently, probably at two or three year intervals. The work on the " salt field " has been intensified, and now includes the leaching of salts by heavy applications of irrigated water on drained soils, and the specific reactions to soil conditions and the growth of vines on a site where the quantity of water applied has been controlled, and the depth of drainage varied. The investigation has primarily established that potentially salty land of this type deteriorates with the advent of irrigation without agricultural drainage. In the drained portions, productivity and the general health of the vines are excellent.

4. *Irrigation Methods.*—Investigational work dealing with moisture changes during the inter-irrigation periods throughout the season have been continued, in reference to defined soil types. The results of the investigations dealing with the method and frequency of irrigation are now being utilized increasingly over a wide range of irrigation settlements. An important feature of recent years has been the alteration of the periodicity of irrigation so as to include facilities for the satisfactory growth of leguminous plants as cover crops.

5. *Viticultural Studies.*—Experiments on the sultana vine dealing with the relations between shoot growth, the accumulation of starch and nitrogenous compounds, the current season's crop, fruit bud formation, and yield in the following season, have been continued. It has been found that the mean weight of prunings may be taken as a useful index for defining the vegetative vigour and also the yield potentialities of a block of vines. On the other hand, except in the case of vines of low vigour, there is little correlation between the amount of shoot growth and the yield of the following season in individual vines of the same vineyard. The quality of the shoot growth is more closely associated with the amount of fruit produced. Uninterrupted and sustained shoot growth during the period September to February is conducive to the accumulation of reserve starch, the proper maturation of the shoots, and the formation of fruit buds. These

findings are not in agreement with a current conception that the vines require a mid-summer rest in order to obtain the best results. One of the most important of the factors which depress shoot growth, and which retard the accumulation of reserve starch and the formation of fruit buds, is the presence of the current season's crop. The heavier the crop the more necessary it becomes to maintain continuous shoot growth during the September-February period, in order to ensure the proper development of fruit buds for the following season. The question of the renewal of shoot elongation growth subsequent to February (i.e., during period March-April) is being investigated.

Field investigations, in reference to the balance of fruiting wood, topping, and the removal of barren shoots, are being continued. The general results indicate that yields are more intimately associated with the growth environment than with treatment. On the other hand, an over-supply of fruiting wood, and the removal of portion of the leaves by removing barren shoots, have been shown to be detrimental.

Fertilizer experiments on a field scale have so far proved inconclusive, excepting that, in cases where growth is restricted, an increased growth accompanied by increased yields has been obtained by the application of a nitrogenous fertilizer.

Increased attention has been given to the nitrogen relations to growth in the first five weeks after sprouting in early spring. Preliminary results suggest that the nitrogen supply of the growing tissue is obtained to a considerable extent from the stored reserves. This may modify present views on the question of nitrogen applications during the growing period, particularly the Autumn period, during which reserves may be built up. Measurements of soil nitrates have again demonstrated that cover crops, regularly grown, modify the need for nitrogen fertilizers as supplementary manures.

In reference to the reactions of the vine to nitrogen, potash, and phosphates, singly or in all combinations, it is extremely difficult to discern significant yield differences except in the special case of a shortage of soil nitrogen. On the other hand, there is evidence of other reactions resulting from fertilizer treatment. It has been noted that vines receiving nitrogen hold their leaves and remain green longer at the " fall " period, and that the fruit from these plots is relatively more susceptible to wastage and moulds.

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

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

The fumigant, ethyl formate, has also been standardized, and is being used extensively throughout Australia. Further work is being done in testing the possible usage of other fumigants for sterilization of individual boxes of dried fruit.

7. *Pasture Plots.*—A series of pasture plots have been sown at the Research Station, Merbein, to demonstrate the type of pastures that could be established in the Mildura district, and to secure appropriate measurements as a guide to carrying capacity. It is considered that certain lands of marginal value within, and around, the settlements could be put to better use than at present, by providing grazing for working horses and for the cows kept on some holdings for house supplies. The pasture plots were established in September, 1935, on a basis of simple groups suggested as likely to be suitable to the district.

8. *Financial Assistance.*—Various bodies connected with the dried fruit industry grant financial assistance to the Merbein Station. The total annual contributions now exceed £3,000. The contributing bodies include the Australian Dried Fruits Control Board, the four chief packing companies of the Mildura district, and the Nyah-Woorinen settlers. The Dried Fruits Board of South Australia, the State Rivers and Water Supply Commission of Victoria, the Lands Department of South Australia, and the Renmark Irrigation Trust, also contribute, by constructional work and the supply of water, to the upkeep of various experimental plots.

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

The Griffith Research Station was established twelve years ago in an extensive area of horticultural crops under irrigation. Citrus is a major product of the district, and the station has 34 acres of oranges which serve for experiments in green manuring, fertilizing, bud selection, citrus preservation, &c. In recent years attention has been paid to irrigation design and practice, and to more fundamental soil studies. Methods have been developed which will allow the rapid application of this information throughout the area when the soil survey conducted by the Council's Division of Soils is completed.

The New South Wales Water Conservation and Irrigation Commission contributes £1,250 per annum towards the working expenses of the station. Very helpful contact is also maintained with the Griffith Producers' Co-operative Company Limited, especially in the provision of special cool storage facilities for citrus preservation work.

1. *Green Manure Investigations.*—It has been found that a winter-growing, leguminous, green manure such as tick beans considerably increases the growth and yield of citrus trees. The influence of the green manure is noted very early in the life of the tree. Summer-growing green crops for green manure, such as cow peas, are not so effective, as the competition of the crops for soil moisture offsets the beneficial fertilizing effects.

An extensive survey shows that the green crops cause an increase in the nitrate content of the surface soil after the crops are ploughed under. However, where the soil is kept clean-cultivated and no green manure crop is grown, the total amount of nitrate throughout the root zone is greater than when green manure crops are grown. The beneficial effect of the green manure crop, therefore, is not explainable on the basis of simple nitrogen nutrition. It is also found that heavy dressings of inorganic nitrogenous fertilizers fail to have the same effect as leguminous green manure crops.

Besides this distinct fertilizing effect, continued use of green manures has certain beneficial effects on the soil. After soils have been under cultivation for some time, the original structure of the soil is destroyed. The effect is to make the soil appear heavier, and it becomes less easily cultivated and less permeable to water. Continued use of green manure tends to protect the soil against this serious loss of structure. Thus the soil of the green manure plots is now more easily worked, and will absorb irrigation and rain water much more readily, than will the soil of the clean-cultivated plots. Standardized methods of determining the rate of percolation of water into the soil have yielded important and interesting information on these questions. Trials have shown that the most suitable winter-growing leguminous crop to use for green manure is tick beans.

2. *Irrigation Investigations.*—The amount of water used in irrigation often departs widely from the optimal range possible under practical conditions, with resultant injury to the plant, and, in the case of excess water, possible severe damage to the soil. Resultant reduced growth and yields are particularly serious where establishment costs are heavy, as in vineyards and orchards. The rational application of irrigation water, however, is a much more complex problem than appears at first sight. Controlling factors, such as soil, slope, and lay-out, vary greatly both between farms and within individual farms; and irrigation practice must be varied accordingly.

During the year another series of furrow irrigation experiments was conducted to elucidate the relation between these variables. The slope, flow, and length of run factors were also considered in relation to the velocity, wetted perimeter, and the dynamics of erosion in furrows. Several important principles have been determined, and the preliminary results of this investigation have been prepared for publication.

With the co-operation of the Council's Division of Soils, preliminary results of the Division's soil survey of the Murrumbidgee Irrigation Areas are being utilized for determinations of the field permeability of various soil types. A comprehensive study is also being made of the various factors affecting soil permeability, a property which is of importance in drainage and soil erosion investigations as well as in irrigation. Soil texture is generally the chief factor involved, but, in many of the soils in this district, soil structure is important. With some of the heavier types, it is the predominant factor. A detailed study is therefore being made of the morphology and structure of the various soil types. This has involved the comparison of methods for taking soil monoliths—a difficult procedure under local soil conditions—and certain quantitative measures of structure, including porespace determination of undisturbed soil blocks. Methods of aggregate analysis are also to be used.

Investigations are in progress on methods for obtaining greater control of water in irrigation practice, and the general application of correct irrigation principles to soil conditions throughout the area. A more satisfactory basis of this work will be provided by the combination of existing contour maps with soil maps soon to be available.

3. *Fertilizer Experiments.*—The fertilizer requirements of citrus trees are being studied, both from the point of view of the effect on the size, yield, and health of the trees, and on the quality and chemical composition of the fruit. The soil can supply sufficient mineral nutrients when the trees are young ; but mature trees require heavy dressings of nitrogenous manures.

4. *Alternate Cropping of Valencia Oranges.*—The investigation of the objectionable habit of Valencia oranges in bearing alternate light and heavy crops is being carried out in co-operation with the Division of Plant Inudstry. Not only does this biennial bearing lead to marketing difficulties,.but the fruit of the light year crop tends to be over-large and coarse, while the fruit of the heavy year is often unduly small. It has been found that by removing some of the fruit of the heavy year crop while still small, the crop of the following year is increased. It has been found, however, that removing some of the fruit early has very little effect on the ultimate size obtained by the remaining fruit. Allowing fruit of the heavy crop to remain on very late (until February) slightly decreases the size of the fruit of the next crop, and slightly decreases the number of fruit set at the next heavy crop. These are important findings in view of the custom of allowing some fruit to hang late to supply a good market in late summer. Carrying out the practice on the heavy crop year tends to reduce the unevenness of the crops and the excessive size of the fruit the following light crop year. The effect of the time of application of nitrogenous manures on the alternate bearing habit is being studied.

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

6. *Relation of Rice Fields to Local Humidity.*—With the extensive cultivation of rice on the Murrumbidgee Irrigation Areas, the question arose as to the possibility of damage to vineyards adjacent to rice-fields. It was thought by some that the close proximity of the rice-field may cause increased damage by inducing the splitting of grapes or by encouraging fungal diseases. The question was investigated in co-operation with the Water Conservation and Irrigation Commission. It was found that although rice-fields caused an earlier deposition of dew and increased humidity, the effects were very localized, and no menace to neighbouring vineyards existed from this cause.

7. *Frost.*—In addition to work on the incidence of frost previously reported, successful trials and demonstrations on orchard heating were carried out during the year. In these trials the New South Wales Department of Agriculture co-operated.

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

9. *Soil Salt Studies.*—The movement of soil salt due to soil moisture relationship is being studied by means of specially constructed columns of soil in its undisturbed state. It has been found that, where a water table is maintained near the surface by means of supply of water from below, salts quickly accumulate at the surface ; but, where the water table is maintained by addition of water to the surface, the rise of salt is very slow.

10. *Soil Temperatures.*—Extensive and complete records of the soil temperature at varying depths from the surface down to 8 feet are kept. The data are being compiled and tabulated for publication in a form that will permit an accurate picture to be obtained of the soil temperature under a variety of conditions. Such information is of value to investigators in many fields of soil and plant research.

VIII. FOREST PRODUCTS INVESTIGATIONS.

1. *General.*—The outstanding factor in the year's work was the removal of the Division to its new quarters. The move began in October and occupied some months, as an attempt was made, as far as possible, to keep the sections at work. There were, however, many hold-ups due to faults developing in the newly erected plant. The result was a considerable interruption of the work, but this period has now passed and the Division is settled down in its new home. The building is giving great satisfaction, and its demonstration of the great beauty and utility of Australian timbers has attracted a great deal of attention. It is hoped that, with properly planned laboratories and reasonable room for necessary operations, the work of the sections will steadily grow in effectiveness and extent, and that still more satisfactory assistance can be given to the timber-using industries.

During the year, there were two important developments in the timber trade in which the Division was greatly interested, and in which it played a part. The first of these was the formation of a Timber Development Association in Victoria, which is attempting to unite all bodies interested

in the utilization of timber in a campaign to counter the over-development of materials which replace timber from its legitimate field. While the Division is not officially a member of this Association, the Chief of the Division and other officers have materially assisted in its work. The Chief of the Division has visited the majority of the municipal councils in the Melbourne metropolitan area, and has delivered addresses on the use of timber in house construction, the abolition of regulations re brick areas, and the unification of building by-laws on rational lines. These addresses have been very well received and, it is hoped, will help materially in overcoming many prejudices against the use of timber in buildings. Officers of the Division have prepared a Dictionary of Woods for an advertising campaign of the Timber Development Association, and have also co-operated with its slum abolition Committee.

The second development sprang from the above, and resulted in the holding in Sydney of the first All-Australian Timber Congress. This was attended by a large number of delegates from all States, and was a pronounced success. The main result was the laying of the foundations for an Australia-wide Timber Development Association and of plans for annual conferences.

Many gifts were received during the year in the form of money grants or materials. The Queensland Forest Service made a grant of £250 and the Queensland Plywood and Veneer Board £100. As a recognition of the value of the Division's work in preservation, the State Electricity Commission of Victoria indicated its intention of granting £100 per annum for five years and forwarded its first instalment. The New South Wales Forestry Commission donated £100 towards the cost of poles to complete the roadway over the canal. Donations were also received from Messrs. Henry Jones and Company, Hobart; Messrs. Gibbs, Bright and Company, Melbourne; Australian Wood Pipe Company, and Messrs. Gunnersen, Nosworthy Proprietry Limited, Melbourne. Additional gifts of timber were received from the Tasmanian Timber Organization, Messrs. D. and J. Evans, Messrs. J. Sharp and Sons, Messrs. Strahan and Davies, Messrs. Alstergren Limited, and a special discount from Messrs. Beale and Company, Sydney.

Arrangements were completed with each of two companies proposing to manufacture paper from hardwoods in Australia for grants of £500 per annum for a period of five years to assist the work on paper research. The third company is as yet not fully organized, but has indicated that, when its arrangements are complete in the near future, it will contribute a like amount. With this amount of £1,500 per annum, it will be possible to purchase much necessary equipment and to make permanent the present research staff in this section. The work done so far on methods of analyses and on chemical and physical studies of the wood of *Eucalyptus sieberiana* has yielded results of very great promise. The object of the plan of work is to develop fundamental chemical and physical studies of the fibres of our hardwoods to assist in the solution of the problems that will undoubtedly arise when these companies are in operation. It is very gratifying to record that as the result of many years of ground work on the part of the old Advisory Council of Science and Industry and of the present Council, the establishment of this important industry is now being actively entered upon, and several millions of pounds invested to develop it.

The Division has patiently awaited this development, as its belief in the possibility of establishing the industry has never wavered. It is perhaps necessary to make it clear that although all the basal work was done by officers of the Council, this was followed up by much work by the research chemists of the companies interested, without which present developments could not have been possible.

Another event of importance was the visit of Dr. L. Chalk, of the Imperial Forestry Institute of Oxford. This is the first time the Division has had the benefit of such a visit, and it desires to record its appreciation and to emphasize the value of the visit. Officers of the Division, especially those in the Section of Wood Structure, benefited greatly by their discussions with Dr. Chalk.

An outstanding feature of this visit was the first conference of Australian workers in wood structure, held in Sydney. This was attended by the workers in wood structure from the Commonwealth Forestry Bureau, the Forest Services of Queensland and New South Wales, and by the Senior Wood Anatomist of the Division. As a result there will be much closer co-operation in this section of the work between the States and between the Commonwealth and the Forestry Institute at Oxford.

A scheme for identification of Australian woods was laid down, and arrangements planned, which have now been implemented, whereby this Division acts as the co-ordinating centre for this work, and also for the preparation of slides, photomicrographs, and index cards for other workers in Australia.

Officers of the Division have continued to make contacts with the trade throughout the Commonwealth. The Deputy Chief of the Division visited North Queensland, where previously contacts had only been made by correspondence. He spent about three months visiting all the main centres in this important timber area, advising millers, giving lectures, and obtaining firsthand information on the problems of the districts. On this trip, for the first time, use was

made of the motor truck, which was especially fitted out with lantern and screen and with necessary equipment for demonstrations. Judging by the number of direct inquiries following on this visit, the interest created was considerable and much good will ensue. North Queensland has special interest because of its great wealth of magnificent cabinet timbers, which are extensively used in Australia and abroad.

Numerous visitors have spent some time in the laboratories, and it is gratifying that several firms have sent young members of their staff for periods of training. An officer of the New South Wales Forest Service has spent some months in the Division, and it has been arranged that others are to follow him.

The Division welcomes the establishment of a Technological Branch of the New South Wales Forestry Commission, and is arranging to co-operate closely in its activities by training its officers, exchanging reports, and generally preventing overlap in the solution of special New South Wales problems. This makes four States which now have utilization branches, and as these develop they will be able to relieve the Division of much routine work and enable it to concentrate more and more on purely research activities.

It is pleasing to be able to report the continued active co-operation of the Commonwealth Forestry Bureau and the State Forest Services. Without this, indeed, it would not have been possible to make the progress that is reported. Forest Products Laboratories throughout the Empire have also given considerable assistance which is gratefully acknowledged. All branches of the timber trade have freely assisted with material for test and with advice on various practical problems and also by allowing officers of the Division free access to their plants. The trade associations have also been most helpful.

2. *Section of Timber Seasoning.*—This Section, perhaps more than any other Section of the Division, suffered serious loss of effective time owing to the change-over to the new premises. There has been no change in policy in this Section, which aims at the most direct and immediate assistance to the industry. Some years ago, its more definitely research activities were transferred to the Section of Timber Physics, where they would be less liable to interruption by routine work. Undoubtedly the most urgent need of the industry is the help that can be given by direct contact, by the development of kiln schedules, and by educational work. The time, however, has arrived when it becomes increasingly desirable that more advanced study of some of the problems of drying hardwoods should be undertaken.

A thorough survey of Tasmanian kiln installations was made during the year, and many of those in New South Wales and Queensland were visited by officers of other sections. The total number of kiln installations of which the Division has records is set out in the following table :—

State.	Number of plants at which kilns are operating.	Number of Kilns operating.
Victoria	37	145
New South Wales	34	100
Queensland	25	84+
Tasmania	16	49
South Australia	8	33
Western Australia	8	18
Total	128	429+

Each year shows a steady increase in the number of kilns in operation, and also in the efficiency with which they are constructed and operated.

The utilization branches of the Forest Services in Queensland and Western Australia have co-operated most satisfactorily in maintaining contact with the trade, and it is hoped that in the near future the recently formed branch in New South Wales will be actively at work and performing a similar function. This will by no means eliminate the need for the Division's services in connexion with seasoning problems, but, on the contrary, should extend it.

Schedules were developed in the laboratory kilns for the following timbers :—*Eucalyptus rostrata* (red gum), *Tarrietia peralata* (red tulip oak), *Eucalyptus pilularis* (blackbutt—mature and immature), *Syncarpia hillii* (satinay), *Eucalyptus grandis* (rose gum—mature and immature), *Eugenia gustavioides* (grey satin ash), *Eucalyptus maculata* (spotted gum—immature).

Further tests of " salt seasoning " were carried out, and are being followed by commercial trials in New South Wales.

A major part in the work of the Section is the study of the drying problems of individual plants and the preparation of plans for kiln installations. In addition, kiln operators are trained by means of correspondence courses. A total of 192 have commenced this course, of whom 58 received training throughout the year.

The second part of " A Guide to the Seasoning of Australian Timbers ", and two trade circulars, " Faults in Wooden Floors ", and " Kiln Instruments " were prepared and issued, and a further trade circular on " Testing Seasoning Kilns " was sent to the printer. A report on coatings for walls of reconditioning chambers has been prepared.

3. *Section of Timber Physics.*—(i) *Density.*—This Section has carried out numerous determinations of basic density and shrinkage. The results of 1926 density measurements covering 198 species were published in the Council's Journal. These figures included estimated ranges of value for many species.

(ii) *Shrinkage.*—A pamphlet was prepared and published giving details of the method adopted for determining basic shrinkage and of various factors which affect this value. Results were also given for basic, tangential, and radial shrinkages of 158 species represented by 4,958 samples. Later work has extended these to 192 species and 5,952 samples. In addition, many measurements have been made on standard 1 inch x 4 inch x 1 inch samples. Longitudinal shrinkage has also been studied, and progress made in establishing a standard procedure for such work.

(iii) *Moisture Meters.*—The " blinker " moisture meter is now widely used in Australia, and correction figures continue to be estimated and issued to users. Correction figures have now been prepared for 1,235 species. It has been found that the light-duty batteries adopted for lightness do not give long enough life, and the tendency now is to adopt standard radio B batteries. Some firms are using the power mains through suitable rectifying equipment. This latter arrangement is satisfactory except when testing timbers below 10 per cent. moisture, in which case leakage is liable to give trouble. A new meter has been developed in co-operation with the Section of Utilization. The outstanding feature of this instrument is its use in testing moving timber, e.g., boards passing through a planing machine, and the arrangement whereby it automatically signals boards at a moisture content above any selected maximum.

(iv) *Collapse.*—A series of tests designed to investigate the effect of various drying schedules on the occurrence of collapse, and its removal at different reconditioning temperatures, have been completed. The value of using temperatures as high as practicable when reconditioning has been demonstrated. A comparison has been made of the extent to which collapse occurs in 1 inch x 4 inch x 1 inch samples and in 1 inch x 4 inch boards respectively, and of the reconditioning treatments required in the two cases. Other factors investigated have been the effect of moisture content on reconditioning, and the effect of subjecting green timber to high temperatures on its subsequent collapse and reconditioning. Further work along these lines is contemplated.

(v) *Miscellaneous.*—Other work has covered measurements of fibre saturation points and tests to determine the equilibrium moisture content conditions above concrete sub-floors, so as to decide whether the concrete is sufficiently dry for a timber floor to be placed above it without fear of the timber picking up moisture.

4. *Section of Wood Structure.*—(i) *General.*—The outstanding feature of the year for this Section was the visit of Dr. Chalk which resulted in the first conference of wood anatomists in Australia, at which the foundations of future procedure for identification were laid. This scheme, it is hoped, will be satisfactory until an international scheme is finalized through the International Association of Wood Anatomists when, if necessary, it can be modified.

The results of the investigation of the wood structure of some Australian timbers of the Rutaceae, which family includes the important Australian genus, *Flindersia*, have been analysed and prepared for publication. Australian timbers of the Lauraceae have also been examined, and when additional samples of several species are obtained, the results will be prepared for publication.

Further investigations have been carried out to determine more definite means of identifying many of the light-weight pale-coloured woods of the genus *Eucalyptus*. This work has progressed slowly owing to the many problems met in the attempt to discover satisfactory distinguishing features.

It has been found necessary to study in detail many of the timbers of New Guinea, since more and more of these are reaching the Australian markets under a great variety of names. To assist identification, arrangements have been completed (through the co-operation of Professor S. J. Record of the Yale School of Forestry) whereby 350 samples of timbers collected in New Guinea have been obtained for examination and reference.

During the year, the services of the Section were called upon for 300 identifications as well as for general information regarding trade and botanical names. Nearly 400 wood samples were added to the wood collection during the period under review. The Section continues to carry out the photographic work for all Sections, and for some other Divisions of the Council.

(ii) *Basic Density.*—Studies of the variation within a tree were continued with samples from butt, centre, and top log sections of two trees of *Eucalyptus sieberiana*. In addition, numerous

routine determinations were carried out on the woods of the pale-coloured group of eucalypts. The information on variation in basic density within a tree and between trees will shortly be prepared for publication.

(iii) *Causes of Brittleness.*—The investigations of brittleness were continued during the year. It was shown that, while prolonged exposures to high temperatures (up to and including 160° F.) materially reduced the toughness of *Eucalyptus regnans* and tended to produce brittle wood, there was no formation of broken fibres.

The type of brittleness referred to as " brittle heart ", and detected by means of the broken fibre test, has been found to be extremely widespread in Australian timbers. Five out of six trees of red tulip oak (*Tarrietia argyrodendron* var. *peralata*), which were received for mechanical tests, were found to contain varying amounts of brittle heart, and in two of the trees its extent was appreciable although erratic. It was found to be more abundant on one side of the centre portions of these trees. This eccentric distribution of the heart was also found in *E. sieberiana*. In the top section of one tree, the heart area was extended some 6–7 centimetres from the pith, except in one small sector where there was no heart right to the pith. These and other results favour the assumption that " heart " is related to the attack of some fungus or fungi. In other timbers, brittleness was apparently natural to the species, as, in these cases, the wood was uniformly low in toughness and broken fibres were not found. Definite experimental proof was obtained connecting broken fibres with the minute compression failures which were observed to be common in the areas around the pith of many timbers.

(iv) *Paper-Making Fibres.*—Pulps from the various " cooks " made on the wood from selected positions in three trees of *E. sieberiana* were examined microscopically both before, and after, beating in the laboratory Lampen mill. The reaction of the beaten pulps to swelling reagents appeared to be definitely correlated with their xylan content, even in the case of pulps obtained by varying the amount of alkali used in the cook.

The effect of the addition and removal of wood gum on the beating properties of fibres was further investigated. It was found, in these investigations, that the amount of wood gum present caused no significant difference in the reaction of the fibres during beating, and only a slight difference after further treatment with acid. At first sight, it would appear that the results were at variance with those previously reported; but the extracted pulps used in the two experiments were different, that previously used containing much less wood gum.

(v) *Cell Wall Structure.*—Further work has been carried out on the structure of the cell wall by swelling with 72 per cent. sulphuric acid and examination under polarized light.

5. *Section of Wood Utilization.*—(i) *General.*—Utilization studies have been advanced by personal visits of officers to Queensland, New South Wales, South Australia, and Tasmania. In Victoria the Division's officers are naturally in constant contact with the industry. The extent of this work grows steadily, and over 450 inquiries were dealt with during the year either by personal contact or by correspondence. The inquiries concerned timbers suitable for a wide variety of different purposes, and also the uses of specified timbers, both Australian and New Guinea species.

Two timber exhibits of the aspects of the Division's work which aim to promote improvement in manufacture and building practices were prepared during the year. One was displayed at the official opening of the Division's new building, and the other lent to the Forestry Department, Tasmania, for display at the Launceston Exhibition. The public interest shown in these exhibits was again most gratifying.

(ii) *New Moisture Meter.*—A development of considerable importance to the timber trade is a new electrical moisture meter which has been brought to a commercial stage. This instrument possesses several unusual features. The chief one is its application to testing timber on the move, for example, flooring boards emerging from a planing machine, or boards on a conveyor belt. The timber to be tested simply passes underneath a metal plate, and the actual moisture content may be read with a fair degree of accuracy on a dial; or, if preferred, a pointer may be set at any preselected maximum moisture content, whereupon any wetter pieces passing under the plate automatically ring a bell, light a warning lamp, or could be made to operate a trip or other device to deflect the rejected boards. An article giving full constructional details of this meter has been prepared for the August, 1937, issue of the Council's Journal.

(iii) *Dictionary of Woods.*—At the request of the Timber Development Association of Victoria, the text of descriptions of 48 timbers has been prepared, summarizing their general properties, availability, sizes, and uses. The Association intends to issue this compilation as an architects' dictionary of woods, and to include it in an architectural catalogue of building materials.

(iv) *Utilization Index.*—An index of wood producers, wood consumers, species used, and products manufactured within the Australian timber industry, was developed to give, in ready

reference form, information on producing or consuming industries. On many occasions the recorded information greatly facilitated the locating of sources of supply of special timbers and certain products.

(v) *Utilization Statistics.*—Progress was made in itemizing statistical records of wood production, imports, and consumption, and bringing these into readily accessible form. The system adopted is capable of extension to cover all industries in which wood is produced or used.

(vi) *Fibre Boards.*—There has been renewed activity with inquiries from people interested in the manufacture of fibre boards. Several proposals for commercial operation were examined, of which two seem likely to begin operations in the near future.

Pamphlet No. 36, prepared in 1932, has been of considerable use to such inquirers. The position in 1932 was, in the opinion of the Division, that Australian consumption had not reached the stage to justify even the smallest size economical unit of production. This position, however, is now changing. Demand is growing, and prices of competitive materials, such as plywood, have risen. It may still be a few years before consumption reaches the economic limit, which is in the neighbourhood of 20 million square feet, but it looks as if the industry will soon be established. Australian hardwoods can make excellent insulating and hard-pressed boards, as has been demonstrated in the trials carried out in United States of America for the Division.

(vii) *Butter Boxes.*—The need of sprayed hoop pine butter boxes is increasing, and more factories for their production have been installed, the Division supplying the necessary plans. The supply of New Zealand white pine having been very greatly reduced by the New Zealand Government, hoop pine millers are supplying much large quantities to fill the gap. Large-scale experimental shipments are being made to test the efficacy of sprayed hoop pine butter boxes. Trials of a new wrapping for use inside the boxes seem to be giving satisfaction, and, though it will be far more costly than spraying, it has certain advantages which may lead to its adoption for some purposes.

(viii) *Grading Studies.*—The secretarial work of the Timber Sectional Committee of the Standards Association of Australia was continued, and a meeting of the central Committee was held during the year to consider the progress made by the respective State sub-committees. Four draft specifications for (*a*) jarrah and karri, (*b*) milled flooring, lining, and weatherboard of radiata pine, (*c*) hardwood paving blocks, and (*d*) terms and definitions used in timber grading rules were approved, and arrangements made for them to be issued by the Association as Australian standards. Approval was also given for the issue, for public critical review, of draft specifications relating to (*a*) plywood, (*b*) milled lining and weatherboard of eucalypt and brush timbers of New South Wales and Queensland, (*c*) milled lining of hoop and bunya pines, and (*d*) standard common names. State sub-committees also made progress in the preparation of specifications for (*a*) grading rules for joinery stock, (*b*) doors and door sizes and (*c*) a list of botanical names of commercial timbers and essential oil producing Australian species for conservation.

Grading studies of hoop pine and cypress pine in New South Wales and Queensland were carried out over a period of some months. These studies included large scale inspection and mill studies. The results were reported to the industry. In New South Wales a comprehensive grading study was carried out covering poles, piles, sleepers, cross arms, and sawn structural timbers. Reports were prepared for the New South Wales Forestry Commission. The grading studies of Victorian and Tasmanian ash eucalypts were completed, and the results of three years' work has been prepared for publication.

(ix) *Sawmill Economics and Design.*—Studies in sawmilling economics were advanced during the year by conducting mill-scale investigations on the influence of size on value of output. At sawmills in New South Wales and Queensland, the products from different sized logs of *Araucaria cunninghamii* were tallied by width and grade. Utilizing statistical methods, a technique of computation was developed which established the relations between log diameter and (*a*) percentage recovery, (*b*) proportions of different widths produced, (*c*) average grade proportions, and (*d*) log values. Such relations have an important bearing on the technical rotation of forests, and it is considered that the information obtained from an organized industry marketing a native softwood should indicate possible developments of a future industry utilizing timber from forests of native or exotic softwoods.

In Queensland, studies in sawmills cutting *Callitris glauca* permitted an analysis to be made of sawing methods and sizes produced, and to show the dependence of recovery and value of production on log diameter.

Numerous designs of plants for manufacture and of sawmill equipment were planned for State and private bodies.

(x) *Miscellaneous.*—Among numerous miscellaneous studies on smaller projects, was the investigation of the breaking of 40 per cent. of bends in a sporting goods factory. The advice tendered reduced this serious loss to a negligible amount.

6. *Section of Timber Mechanics.*—(i) *General.*—Over 7,000 tests were carried out in this Section during the year. The computation and analyses of the results of these tests are very time-consuming, and it has been found necessary to allocate this computing to a special section under the recently-appointed Statistician. This will relieve the scientific officers of a large amount of laborious calculation, and enable more rapid analysis of results.

Two new Southwark-Emery hydraulic testing machines were installed, one Universal machine of 20,000 lb. capacity, and one compression and bending machine of 600,000 lb. capacity. Both these machines have given most satisfactory service. To calibrate these machines, two Morehouse proving rings of 25,000 and 300,000 lb. capacity were obtained.

(ii) *Box and Crate Design.*—Work on this project has mainly been concerned with the testing of types of containers for special purposes, for example, fibre-board boxes for shipping canned soup. It was found that board made with the corrugated centre of a wood pulp product was as satisfactory as that where straw pulp was used.

Two new types of special nails were tested. The efficiency of one of them, the surface of which is slightly roughened by sand-rumbling, was significantly higher than that of the plain nail, particularly in static holding-power when drawn three months after driving. The efficiency of the other type of nail, which was subjected to an anti-corrosive treatment, was no higher than that of the plain nail, and it was particularly low in impact holding power.

(iii) *The Bending of Wood.*—Very little is known as to the bending qualities of the majority of Australian timbers, and the experimental bending machine is proving very satisfactory in studying this property. In order to obtain some information as to the bending properties of a large number of species, it is proposed to conduct a reconnaissance of the various Australian species which might possibly be used for bending. In this survey, only about 100 super. feet of timber will be used, and the tests will be such that the timber species can be placed into three classes :—(1) good bending timbers, (2) timbers suitable for the less severe bends, and (3) timbers unsuitable for bending. In addition to the reconnaissance, comprehensive tests will be made on selected species as material becomes available.

The tests on red tulip oak showed that this species is one of the best Australian timbers for bending, successful bends having been made with 1 inch thick material at 3 inch radius. A series of bending tests were made on karri. These showed that this species, while suitable for mild and moderate bends, is not nearly so good as red tulip oak, and that the steaming time required for best results is considerably longer. A few tests on brown mallet indicated that this species should bend very well. It appeared to be much superior to karri and to be almost as good as red tulip oak. In order to obtain an estimate of the variability in bending quality, uniformity trials have been carried out on spotted gum and hoop pine. The results have not yet been analysed, but it appears that the variability is much greater than for most mechanical properties. Spotted gum appears to be somewhat similar to karri in its bending properties ; but hoop pine is definitely inferior, and is probably only suitable for very moderate bends.

(iv) *Toughness.*—It was mentioned in last year's Report that the stage was being reached where publication of the results of toughness tests on about 250 species would be possible. During the past year, many gaps were filled in, but there are still a number of species insufficiently represented.

In order to detect differences of the order of 10 per cent. in species averages, material from about 30 trees would be required. On a large number of species, material from only about five trees is available, and differences in species means of less than about 30 per cent. are in general not significant. In the proposed publication, it will therefore be possible only to classify the various species into groups. While this is fairly satisfactory, it is desirable eventually to obtain data from the larger number of trees.

(v) *Standard Mechanical Tests.*—Steady progress has been made on this project. Work on brown mallet (*Eucalyptus astringens*) has been completed, and a pamphlet on this timber is in the printer's hands. Spotted gum (green), karri (dry), cypress pine (dry), and hoop pine (green) were also tested.

(*a*) *Pinus radiata.*—The analysis of the tests on the 24 plantation-grown trees has been completed. A précis of the more important data has been prepared for publication in a general pamphlet on the properties of *P. radiata*. The more detailed results of the mechanical tests will be published later. The analysis showed that there was little difference in the properties of the timber obtained from the various districts, although the 33-year old trees from Kuitpo (South Australia) were distinctly higher in all strength properties than the 23-year old trees from the same locality. Taken as a whole, the properties of " clear " *P. radiata* conform very closely to those of American pines of the same density. *P. radiata* is inferior to Douglas fir (*Pseudotsuga taxifolia*) in practically all strength properties, but is equal or superior to western hemlock (*Tsuga heterophylla*), and it has much higher mechanical properties than western yellow pine (*P. ponderosa*).

The variation in properties with position in the tree was studied; and it was found that in most of the trees there was a pronounced rise in density and strength with increasing distance from pith. This was accompanied by a reduction in ring width. It was also found that, in general, there was a reduction in density with increasing height in the tree, and that the material from the lower 20 feet was slightly stronger, statically, than that from higher up. There was a remarkable variation in toughness with height in the tree, the wood from the butt being almost twice as tough as that from 16 feet and over. No information was available as to the variation between 1 foot and 16 feet from the ground, and consequently it is not known how quickly the toughness changes with increasing height in the tree. Statistical analyses of the effect of density, number of rings per inch, and percentage summerwood were made. It was found that the rate of growth affects the strength directly, independently of density.

(*b*) *Red Tulip Oak* (*Tarrietia argyrodendron* var. *peralata*).—The results of the tests on the green specimens have been computed, and the analysis is almost complete. It was found that red tulip oak is a strong timber, being comparable with karri in most strength properties. It is, however, not so hard as karri. There is a considerable variation in the properties of individual trees of the species, both in the density and average properties of the sound wood and in the distribution of " brittle heart ". Some trees were practically free from brittle heart, whereas in two of the trees it was very extensive. In these trees the brittle area extended right to the bark on one side, whereas on the opposite side of the trees the wood was comparatively tough, the distribution of brittle heart being very eccentric. This is the first time that brittle heart has been found to extend to the sapwood. The results of the toughness tests were confirmed by the " broken fibre " test.

(vi) *Special Tests.*—(*a*) *Split-ring Connectors.*—The test specimens built up from green jarrah and karri have all been assembled. Those to be tested after drying has taken place have been stacked in the open air under as severe drying conditions as possible. The remainder have been tested in the green condition, and the results of the tests are now being analysed. The results to date indicate that the load-carrying capacity with green jarrah and karri is very similar to that with dry Douglas fir.

Interest in modern connectors is increasing, and it is understood that a large Brisbane firm of contractors is going to use them for timber false work in the construction of large bridges. It is also probable that connectors will be used in the 90-ft. timber radio beacons which will shortly be erected at several aerodromes in Australia. The Postal Department is also investigating the possibility of using timber radio towers for short-wave stations.

(*b*) *Tests on Coach Screws.*—A detailed working plan has been drawn up, covering a comprehensive series of tests on the holding power of coach screws. Over 2,500 screws will be tested in four different species covering conditions of moisture content, size, and depth of hole, &c. Vibration tests will be carried out in addition to the main series, in which static holding power will be measured. The torque required to drive the screws will also be measured, arrangements having been made to use the equipment of the University of Melbourne Engineering School for this purpose. In order to obtain the utmost possible information from the tests, a " factorial " layout has been adopted, resort being made to " confounding " where necessary.

(*c*) *Sagging of Wooden Beams.*—It is well known that wooden beams subjected to long-time loading tend to sag. Practically no information is available concerning the sagging of beams, and, as it is an important factor to be considered in the design of timber structures, it has been decided to initiate experimental work to obtain data which can be used in design. This work is necessarily long-dated and the equipment required is expensive.

7. *Section of Wood Preservation.*—(i) *Field Tests.*—In co-operation with the Division of Economic Entomology, experiments have been carried out over the past five years, with a view to developing a satisfactory method of testing the relative susceptibility of timber samples to the attacks of termites. The chief difficulty has been to insure that all specimens being tested are actually submitted to attack during the period of observation, usually one year. A satisfactory method has now been evolved, an account of which has been given on a previous page (*see* Section III. : 10 (iv)).

The interest of the public utilities in the service testing of poles treated with different methods has been maintained. Untreated poles in the pole-test sites at Belgrave and Benalla (Victoria) were found to have been attacked to a fairly considerable degree, after approximately three and a half years' service. Decay was also developing in poles treated with arsenic and arsenic plus sodium fluoride collars, and in unseasoned poles treated (over sapwood) by the oxyacetylene scouring and charring process. In co-operation with the Victorian State Electricity Commission (which has met the expense of installing the new pole-testing site), a new test has been started at Ballarat. The Forests Commission of Victoria has co-operated by donating the poles free of royalty.

From previous experience at other test sites, it seemed likely that two years was the period of protection afforded by brush treatment with creosote combined with soil puddling. During the year an inspection of test poles installed in the Postmaster-General's Department line near Tynong, Victoria, further confirmed this conclusion. It was also shown that brush treatment with tar was ineffective, while treatment with arsenical collars was beginning to fail. It appeared that these could be expected to give protection for about four to five years under test conditions.

The treatment of fence posts promises to be of increasing importance in the future, and test sites have been established in Western Australia, Victoria, and New South Wales. Inspections of the Western Australian sites are now in progress. In Victoria, after about fifteen months, all the treated posts are sound, but termite attack has already commenced in some of the untreated controls. Tests of a large number of preservatives impregnated into *Pinus radiata*, *E. regnans* truewood, and *E. regnans* sapling billets are in progress in a number of sites.

In co-operation with the Queensland Forest Service, tests have been made on piling sections of creosoted brush box, blackbutt, and rose gum, the actual field testing being carried out by the Queensland Forest Service in their established testing localities. It was found that the creosoted timber is fairly resistant to attack by crustacean and certain other marine borers, such as *Bankia* and *Teredo* spp. ; but very little protection is given against *Nausitoria*, which occurs in waters of low salinity.

(ii) *Treatability of Australian Timbers.*—In connexion with the investigation of the value of various less durable Australian timbers for sleepers, preliminary tests were made on the treatment of small-sized samples using pressure, open tank, and brush treatments with creosote oil and zinc chloride solution. Four species of timber were tested, namely, *Eucalyptus australiana*, *E. regnans*, *E. obliqua*, and *E. viminalis*. No significant difference was found between brush treatments applied hot and cold, and no difference between species. Pressure treatment with creosote was no better than open tank, the absorption in both cases being low, and all penetration longitudinal. Pressure treatment with zinc chloride solution gave a much higher absorption than open-tank treatment. Further investigations using modified preliminary incising are planned in order to take advantage of the fairly good longitudinal penetration obtained, especially with *E. viminalis* and *E. australiana*.

(iii) *Preservation Processes.*—An investigation indicated that the sterilization of partly decayed poles obtained with coal gas both on, and immediately below, the surface was only about half of that obtained in previous tests using acetylene. A lower absorption of creosote oil was obtained in the treated poles. The determination of the probable added life due to the treatment of a partly decayed pole by means of the oxy-acetylene process is difficult, and can only be determined by extensive service tests. The Postmaster-General's Department has arranged for a test of the oxy-acetylene process on 50 poles in each of two localities.

(iv) *Preservatives.*—In co-operation with the Standards Association of Australia, work was carried out on the development of a specification for Australian creosote oil for wood preserving purposes. The British Specification was modified, and Creosote Type A.2 specification was accepted as suitable for Australian conditions. An Australian Standard based on this was prepared and issued by the Association.

The results of considerable experience and of experimental work have indicated that arsenicals are the best termiticides known in Australia. Usually, arsenious trioxide has been used, but difficulties are associated with preparing it in solution, the addition of caustic soda or sodium carbonate being at times detrimental to its use for certain purposes, particularly in the field. A comparative laboratory study has, therefore, been commenced in co-operation with the Division of Economic Entomology to determine the relative efficiencies of the tri- and pentavalent-arsenic oxides.

(v) *Lyctus Investigations.*—In continuation of the laboratory chemical investigations which have indicated that sodium fluosilicate in low concentrations gave protection against Lyctus attack, experiments have been carried out on the treatment of green logs and green and dry veneer. Treatment of green logs was found to be impracticable, as the full depth of the sapwood could not be penetrated with sufficient preservative in a boiling period of 40 hours. Treatment of $\frac{1}{16}$ inch and $\frac{1}{8}$ inch green veneers is practicable, the time varying from 15 to 30 minutes, depending upon the thickness and species of timber. Short open-tank treatment of air-dry veneer also gave good results. Further large scale plant tests are desirable to indicate the most satisfactory conditions under the factory layout available, and these are planned for the near future.

The starch survey of living trees, which is being carried out in co-operation with the Victorian Forests Commission and the New South Wales Forestry Commission, has been continued. In Victoria, the testing of samples of mature and over-mature trees of six commercial species has been concluded, and graphs of starch content prepared. No definite or consistent seasonal or locality variation has been found in any of the species examined.

In New South Wales, the survey has been commenced to cover *E. maculata*, *E. grandis*, *E. saligna*, *E. pilularis*, *Sloanea woollsii* and *Schizomeria ovata*. To date, a high starch content is being obtained in *E. maculata*, *S. woollsii*, and *S. ovata*, while *E. pilularis* is low, the remaining species being intermediate but variable.

A preliminary investigation was made of "included sapwood" in karri, particularly in regard to its inclusion in structural or building timber. It was found that the "included sapwood" was generally attacked by "sap-staining" fungi, these being dead, death having probably occurred in the living tree. In all cases, the "included sapwood" development was associated with borer attack in the living tree. There was no significant difference between the strength of normal "included sapwood" and truewood, and it was concluded that such should not be considered a defect in structural or building material when this is used under conditions which are not conducive to the development of decay.

(vi) *Gluing.*—The quality of casein as supplied in Australia appears to vary widely, and difficulties are often encountered in wood-working plants due to this factor. It is considered desirable to investigate fully the chemical composition and glue-making value of the Australian caseins, and endeavour to formulate a specification which will be saisfactory for glue-making purposes. The present American specification does not admit the bulk of Australian caseins, many of which, however, give very satisfactory glues. A detailed plan of study was prepared, and the various casein manufacturers have supplied samples of their products. To date, tests have been made on moisture fat, and ash; but these are not yet completed for all samples. In the samples tested, the fat variation is from 1 per cent. for lactic casein to 12 per cent. for buttermilk, while within the lactic caseins, the range is from 1 per cent. to 4 per cent. The ash contents are more regular, and all samples tested have less than 3 per cent.

8. *Section of Wood Chemistry.*—(i) *General.*—The work of this section has been directed towards investigations relating to the fundamentals of paper-making, and, in this connexion, it has been found necessary to continue to pay close attention to the methods of analysis, both for woods and for pulps. The paper-making investigations have been continued in co-operation with Australian Paper Manufacturers Limited, stress being laid on the commencement of a long-dated routine survey of the pulping qualities of Australian timbers. The study up to the present time has covered three trees of *Eucalyptus sieberiana*, an attempt having been made to correlate chemical composition of the wood, the evaluation of the pulps, the chemical composition of the the pulps, and the nature of the fibres. The results of the work will be used as a foundation for the study of other species, and considerable modifications are contemplated to permit large numbers of trees to be studied.

Work in connexion with the determination of furfural has been continued as time allowed. Also, following criticism of the methods used in the preparation of wood samples for analysis, a comprehensive sampling investigation has been commenced, and is now approaching completion.

(ii) *The Methods of Wood and Pulp Analysis.*—Early in the year, the final analytical work was completed in connexion with the revision of the methods for determination of the solubility of pulps and woods in hot water and hot 0.5 per cent. sodium hydroxide. Some further work was also carried out on the method of determining Cross and Bevan cellulose.

Little further work was carried out in connexion with the mannan determination. The method of Hägglund and Bratt (*Pap.—Fabr.* 34: 100, 1936) was studied, and an attempt was made to simplify the procedure using a shorter hydrolysis time. However, the results were unsatisfactory, and the determination as applied to eucalyptus remains unreliable.

The investigation of the pentosan determination is still proceeding. In earlier work, the precipitation of certain known breakdown products of glucose had been studied by means of both phloro-glucinol and thiobarbituric acid. To this end, formaldehyde, formic acid, laevulinic acid, and hydroxymethyl furfural were investigated; and further work this year has been confined to a careful study of the behaviour of pure furfural in relation to both of the above precipitants.

(iii) *The Sampling of Wood for Analysis.*—Work by Campbell and Bryant from the Section of Wood Chemistry, Forest Products Research Laboratory, Princes Risborough, England, was kindly submitted in manuscript form to this Section for criticism prior to publication. It was not found possible to agree with the method of selecting a fraction to represent the whole of the wood sample, especially as earlier published work of the Division (Pamphlet No. 32, pp. 15–19) had indicated the difficulty of preparing duplicate samples using a fraction only of the wood. However, the work of Campbell and Bryant indicated that grinding a wood sample down to a size to pass a 100-mesh sieve causes serious degradation of cellulose and loss of pentosan in cellulose. Consequently, further work was undertaken to check the main points raised.

(iv) *The Weathering and Decay of Wood.*—During the first quarter of the year, a long-dated investigation was undertaken in collaboration with the Section of Wood Preservation into the cause of the development of "brittle heart" in eucalypts. To test the possibility of fungal attack as a cause of the formation of brittle heart, it was decided to investigate matched samples

of the truewood of *E. regnans*. Four of these samples were first subjected to chemical analysis in order to determine the homogeneity or otherwise of the sections used for fungal attack. Caustic and hot water solubles, lignin, xylan, Cross and Bevan cellulose, and xylan in cellulose, were determined, and the results showed a general satisfactory agreement between the matched samples. After a long period of fungal attack under controlled conditions, corresponding samples will be tested for alterations in chemical properties.

(v) *The Formation of Plastics from Wood.*—Early in the year a number of small moulds were obtained on loan from Die Casters Proprietary Limited, and from Utilex Products Proprietary Limited. Work was then extended to a systematic study of the production of shaped articles using an untreated jarrah sawdust. Some success was achieved in this direction, but in the more severe tests, involving the formation of thin vertical walls, satisfactory articles could not be turned out. Attention was then turned to a search for a suitable pre-treatment or plasticizer to improve flow properties. It was found that "cellosolve" containing a little hydrochloric acid caused sufficient breakdown of the wood to permit considerable flow, but hardening was found to be slow and the surface of the article was poor.

A small autoclave capable of working at pressures up to 160 lb. per square inch has been obtained and will be used in carrying out non-acid hydrolyses along the lines suggested abroad. In addition, it is hoped to obtain a stainless steel bomb of acid-resisting properties which could be used in conjunction with the above autoclave for acid hydrolyses.

It was found that the incorporation of 1 per cent. paraffin wax with coarse sawdust to be used in the production of wall board gave greatly improved water resistance.

(vi) *Pulp and Paper Investigations.*—(*a*) *Routine Studies.*—The routine studies of the pulping properties of Australian timbers have been carried ahead during the past year. Two further trees of *E. sieberiana* have been obtained, and tests have been carried out on a number of samples from each. The results have helped in placing the investigation on a sounder basis; and it is hoped to effect considerable improvement in the methods used when work is commenced on the first tree of *E. regnans*.

Throughout the year, all pulp and paper investigations have been carried out in co-operation with Australian Paper Manufacturers Limited, who have done all pulping and sheet evaluations. As a result of grants of money from the paper companies, it has become possible to order equipment to carry out the above work; and it is planned gradually to take over the whole of these investigations, and so obtain a co-ordination which is not possible between separate organizations. Testing equipment, including British standard sheet-making equipment, Lampen mill, Canadian standard freeness tester, Mullen burst tester, Schooper tensile and elongation tester, and Marx-Elmendorf tearing tester, has already been ordered, and it is hoped to have it placed in position and a controlled temperature and humidity room erected during the coming year. A small rotary digester (capacity, 4 lb. of pulp) will also be installed.

(*b*) *Chemical Studies in Relation to Pulp Strength Properties.*—In connexion with the evaluation of pulps, a statistical investigation dealing with the strength data of sheets (burst, tear, tensile) was carried out. An experiment was designed to determine whether the procedure in use could be readily modified to lend greater significance to evaluation data, and to determine the alterations that might be necessary. As a result of the investigation, a modified procedure for the evaluation was adopted.

The results of the analyses carried out in three trees of *E. sieberiana* have proved throughout to be very difficult to interpret and to correlate with the strengths to the pulps. It has become increasingly evident that the analytical work is inadequate, and is tending in the wrong direction. From a study of the analyses of the five pulps prepared at different caustic concentrations from the one sample, it is suggested that some correlation of the analytical work with the evaluation data would be obtained through either the alpha-cellulose or the viscosity determination. To that end, the alpha-cellulose determination is being carried out on the five pulps, and the results will give some indication of the possible value of including this determination as a routine procedure.

The extraordinary variation in the chemical properties of these three trees from the one species leads to the immediate conclusion that to obtain any general knowledge of the pulping qualities of a species, it will be necessary to examine a very much greater number of trees.

(*c*) *The Constitution and Chemical and Physical Properties of Wood Pulp Fibres.*—The fundamental study of the effect of hemicelluloses on the beating and strength properties of eucalyptus sulphate pulps has been slowly carried ahead throughout the year. Preliminary work was first done on a pulp prepared from the composite outer sample of *E. sieberiana*. A quantity of this pulp was extracted with cold 5 per cent. sodium hydroxide and the wood gum was recovered from the extract. A series of one-hour beatings was then carried out on (*a*) the untreated pulp, (*b*) pulp after extraction of wood gum, varying amounts of wood gum being added in each case.

The fibres from these one hour beatings were examined and the percentages of wood gum and xylan in some of the test sheets was determined. It was found that the addition of wood gum causes considerable increase in strength in each case, the optimum amount being 12 per cent.

This work was then extended to include complete evaluations on samples of the same pulp. These were carried out on (*a*) untreated pulp, (*b*) pulp after extraction of wood gum, (*c*) pulp after the addition of 12 per cent. wood gum. The results indicate that the extraction of wood gum causes a very considerable loss in strength as compared with the original pulp, but this strength is almost entirely regained on the addition of 12 per cent. wood gum. The investigation is being rounded off by the fibre studies and chemical examination of the sheets.

(vii) *Miscellaneous Projects.*—Some preliminary work was carried out on the nature and treatment of effluent from flax retting vats. Other minor investigations included a study of the reason for the slipping of wrest pins in pianos, which was found to be affected by the wax present in the wood. Bleaching processes for willow and yellow walnut, the preparation of hardwood clothes-pegs which would prevent the staining caused by tannins, and the removal of a burnt odour from compressed cork sheets used in ice chests, were also investigated.

IX. FOOD PRESERVATION INVESTIGATIONS.

1. *General.*—Reference was made in the Annual Report for 1935–36 to the proposal to establish central laboratories in Sydney for the Section of Food Preservation. Owing to various unforeseen difficulties, the Sydney Metropolitan Meat Commissioner was unable to release the promised portion of an existing building until June, 1937. Preliminary building operations are now proceeding, and it is expected that the laboratories will be available for occupation toward the end of 1937.

On account of the delay in the transfer to Sydney of the major food preservation investigations, the opportunity has been taken to carry out a number of more fundamental investigations into various aspects of the preparation, cooling, and storage of chilled beef. A great deal of attention, for instance, has been given to a more detailed study of the factors governing the nature and extent of the microbial contamination of beef on the slaughter floors. The extent of the initial contamination is, of course, one of the chief factors governing the " life " of chilled beef during storage. Although not yet completed, these studies have already thrown considerable light on the causes of the day-to-day and seasonal fluctuations in the nature and extent of contamination, and also of the differences in the mean level of contamination from locality to locality. It is hoped that these data may enable reasonably accurate predictions to be made of the likely mean levels of contamination from month to month at some, at least, of the main centres for preparation.

The Council's participation in studies of transport diseases of bananas, carried out at the Queensland Department of Agriculture and Stock, ceased in December last. A fairly complete study had been made of " black-end " disease. Further, a promising method for the control of " squirter " disease which seems both practical and economic has been obtained. " Squirter " disease has been rather prevalent in fruit ripened in the Southern States during the winter and spring months, and at times has caused serious economic losses. When the control measures are applied in conjunction with hygienic measures in the plantations and packing sheds in all cases where experience suggests that losses are likely to occur, it is to be expected that serious losses will be virtually eliminated. The Senior Plant Pathologist of the Queensland Department of Agriculture and Stock and the Council's investigator have published an account of these experiments (*Queensland Agricultural Journal* 47 ; 542, 1937.)

From time to time, many complaints have been received concerning the quality of certain consignments of Australian eggs on arrival in Great Britain. In the absence of precise data, no clear-cut scheme was forthcoming whereby the recurring defects could be remedied. To clarify the position, therefore, it was decided that the Council should be responsible for conducting a scientific survey in Great Britain in order to obtain a picture of the nature, extent, and relative economic importance of defects occurring in Australian eggs. With the valuable help from the British Food Investigation Board, the Commonwealth Department of Commerce, and various exporters, this survey was initiated in the export season of 1936–37. At the same time, an investigation committee of the Egg Producers' Council undertook to carry out a survey in Australia of the methods of production, treatment prior to packing, and methods of handling and storage in the packing establishments and cold stores.

Owing to the detailed nature of the investigations in Great Britain, and the limited staff available, it was not possible to complete the survey during the last export season, and arrangements are being made actively to continue it for at least another season.

Early in 1937, certain studies of the performance of refrigerated cargo spaces on a modern ship carrying perishable foodstuffs from Australia to England were carried out by a survey party sent from England by the Department of Scientific and Industrial Research. Officers of the Council's Section of Food Preservation co-operated with the English investigators in obtaining detailed pre-shipment data on two experimental consignments of chilled beef; and they assisted also in the preparations for the tests on the carriage of apples without dunnage in lower holds having rapid, vertical air circulation.

2. *Chilled Beef Investigations.*—(i) *Studies of Initial Microbial Contamination.*—Studies of the factors influencing the nature and extent of the initial microbial contamination of beef have been continued. Under the improved hygienic technique which now prevails on the killing floors of all meatworks engaged in the preparation of chilled beef for export, the results indicate that practically the whole of the contamination of such beef is derived from the hides of the animals. The original infection of the hides is supplied by the surface soils in the areas in which the cattle are de-pastured. It has been demonstrated that the microbial populations of these soils are influenced by seasonal and geographical latitude variations: the relative percentages of "low temperature" types generally increase during the winter months and with increasing geographical latitude. A general relationship has been established between the nature of the contamination of beef and that of the soils from the areas in which the cattle are de-pastured. Numerous deviations from this relationship have occurred, however, and these have been traced to differences between the micro-flora of the hides and that of the surface soils in the same areas. The microbial populations on the hides are considerably reduced by the introduction of a high-pressure cold water spray applied either before or after the stunning of the animals. The possibility of the use of hot instead of cold water during the later stage has suggested itself. A study has, therefore, been made of resistance to elevated temperatures of the "low temperature" types of bacteria, yeasts, and moulds which are found on the hides.

In connexion with investigations as to the possibilities of using some form of radiation to control the initial contamination on chilled beef, it was mentioned in the last Annual Report that the successful laboratory results were not, at that time, capable of completely satisfactory transfer to slaughter floor practice. Work, then projected, to find the reason for this, has been carried out, and the apparent cause of the discrepancy between results obtained in laboratory and commercial practice discovered. The application in industrial practice, while quite feasible, would not at the moment confer as great an extension of safe storage time as the laboratory findings suggested. Full accounts of these studies are now being prepared for publication.

(ii) *Cooling of Sides of Beef.*—In the last Annual Report it was stated that, for purposes of study, the cooling of sides to the temperature of storage (30° F. approximately) could be conveniently divided into two phases, the first covering the initial 24 hours (approximately) and the second subsequent 48 to 72 hours. Further studies have confirmed the findings as to the optimum physical conditions to be maintained during the second phase. In regard to the first phase, however, the special experimental facilities required for detailed studies have seldom been available, and it is still impossible to correlate the biological with the physical data. Sufficient data have been obtained, however, to indicate that the main factors controlling the changes in the microbial population during the first phase are the rate and extent of desiccation of the surface tissues. In order to isolate these factors from the variable of decreasing surface temperatures, a series of simple experiments have been carried out wherein the surface temperatures of uniform slabs of ox muscle inoculated with a "standard" culture of bacteria have been maintained at constant values from 13° to 42° F. in excess of the surrounding air temperature (also maintained constant). The level of the microbial populations has been determined at regular intervals over a period of 24 hours. Although not complete, these results afford good evidence that the levels of the populations are governed by the rate and extent of surface desiccation of the muscle.

(iii) *Studies of Microbial Growth on Ox Muscle.*—In the last Annual Report, an account was given of the experiments on the relationship between the moisture content of ox muscle and the rate of microbial growth in air at 30.2° F. Full details and results have been published (in the Council's *Journal*, 9: 177, 1936). These studies have been continued at various temperatures up to 68° F. and the results will shortly be published.

Similar studies are being carried out at a temperature of 30.2° F., where the atmosphere surrounding the muscle substrate contains 10 per cent. carbon dioxide. These conditions approximate to those obtaining in ships' cargo spaces carrying chilled beef from Australia to Great Britain. The results would seem to indicate that, for each species of each microbial genus so far tested, the "critical" moisture contents of the muscle, below which growth cannot occur, tend generally to be higher in the case of muscle in air containing 10 per cent. carbon dioxide than in pure air.

These studies have, of course, been carried out on thin slices of ox muscle, the water content of which was in equilibrium with the aqueous vapour tension of its storage atmosphere. In order to test the applicability of the results to microbial growth on quarters of beef, storage experiments on beef quarters have been carried out at 30° F. both in air and in air containing 10 per cent. carbon dioxide. In each experiment, the rates of growth on inoculated exposed muscles of the quarters were similar to those on thin slices having moisture contents similar to those of the surface layers of exposed muscle of the quarters.

(iv) *Heat Sterilization of Beef-wrapping Materials.*—These studies, referred to in the last Annual Report, have been completed, and an account of the results of the laboratory experiments and the commerical scale tests has been published in the Council's *Journal* (10 : 57, 1937). The temperature-time relationships to effect complete " kills " of mould spores in the dry wrapping materials are rather complex. The wrapping material must be raised to a temperature in excess of 122° F., and the necessary minimum duration of such exposure is, of course, lower the higher the temperature. For instance, at 149° F. and 140° F., exposures of one and two hours respectively are required, while for material rising gradually from 125° to 137° F. a period of exposure of about twelve hours is necessary. Rigid standards for commercial practice cannot be outlined for the operation of sterilizing rooms kept at the maximum safe air temperature of 190° F. These will depend, among other things, on the layout of the room and its heating equipment, and the size and disposition of the stacks. In general, however, it would appear that when wraps, initially cold, are introduced into a room, the air temperature of which remains constant at 190° F. for 44 hours thereafter, the size of each stack should not exceed about 15 cubic feet, and an ample free air space should surround each stack.

(v) *Studies on Loss of Bloom.*—Further work as to the relationship between blood pigments and fat in the production of the grey fat which frequently appears on chilled beef during storage, has confirmed the findings of previous studies mentioned in the last Annual Report.

A storage experiment, designed to afford information upon which further work of a more exacting and quantitative nature might be based, was carried out on meat stored both in air and in air containing 10 per cent. carbon dioxide. Exact observations were made of surface moisture content and pH, together with careful qualitative observations on colour and general appearance. While the objective of the experiment was achieved, the data obtained would not, of course, warrant the drawing of any conclusions at the present juncture.

The Council has availed itself of the invitation of the Queensland Meat Industry Board to co-operate in connexion with several experiments which the Board is carrying out, chiefly concerning the pre-slaughter conditions and treatment of stock intended for export as chilled beef. While the Board is especially desirous of obtaining the response of the market to these varied factors, it is hoped to supplement the information obtained by the Board by observations, both in Australia and in England, as to loss of bloom during transport.

Instrumental equipment, the delivery of which is expected very shortly, will allow intensive quantitative post-mortem investigations to commence. These have as their aim the establishment, if possible, of a correlation between several of the fundamental changes occurring in the meat itself with the appearance of surface and sub-surface features collectively called " bloom ". Further studies will be made as to the dependence of these conditions on varying pre- and post-slaughter factors.

3. *Banana Investigations.*—(i) *" Black-end " and " Squirter " Diseases (at the Queensland Department of Agriculture and Stock).*—Detailed tests of dipping treatments for the control of squirter disease showed that many fungicides failed to give adequate control, or, when used in effective concentrations, resulted in severe injury to the fruit. It was found, however, that the proprietary fungicide, Shirlan A.G., when used as a 1 per cent. suspension, gave complete control of the disease in dipped single fruits (fingers), and did not cause any appreciable deterioration in appearance. For fruit dipped in the form of part hands and then broken into singles, the control, while good, was not as complete as that obtained with the direct dipping of singles. Since the great majority of cased bananas are packed as singles, dipping of the fruit on the plantation as soon as possible after they are removed from the bunch should prove an effective method for the complete control of squirter ; it need, of course, be applied only on fruit from plantations where previous experience suggests that squirter is likely to occur to an extent which is of commercial importance. It is worthy of note that this treatment also reduces black-end, particularly that due to *Nigrospora.*

The detailed studies of black-end disease caused chiefly through attack by *Gloeosporium musarum* have been completed, and the results will shortly be published.

An interesting result has been forthcoming from a study of stem-end rot caused by *Thielaviopsis paradoxa.* This organism is a well-known parasite of a number of agricultural crops, including pineapples and sugar-cane. It had been suggested, therefore, that bananas might

become infected from diseased pineapples and sugar-cane. More detailed investigations have now shown, however, that this is unlikely to occur, since a study of the strains of *T. paradoxa* from bananas, pineapples, and sugar-cane clearly shows that, in Australia, the banana strain constitutes a distinct variety, and the sugar-cane, and pineapple strains have a very restricted pathogenicity when inoculated into bananas.

(ii) "*Rubbery*" *Bananas* (*at the Biochemistry Department, University of Melbourne*).—In co-operation with the New South Wales Department of Agriculture, investigations on the nature and causes of the "rubbery" condition frequently occurring in Cavendish bananas have been continued but have not yet been completed.

4. *Citrus Preservation Investigations.*—(i) *General.*—Extensive programmes of investigation of the handling and storage of Navel and Valencia oranges, Emperor mandarins, and grapefruit, have again been carried out by the Council and the Departments of Agriculture of New South Wales, Victoria, and South Australia working in close co-operation through the Citrus Preservation Technical Committee. Only those experiments carried out directly by the Council are described below.

(ii) *General Storage Experiments.*—These experiments have been carried out at Newcastle and Griffith (New South Wales,) Melbourne, and Adelaide. While some striking results have been obtained over a period of two seasons concerning the fundamental importance in storage life of maturity at picking and temperature of storage, it is still considered necessary to continue the detailed experiments for a further period before reliable recommendations as to storage practice can be given.

It appears definite, however, that in Gosford (New South Wales coastal) Washington Navel oranges are abnormal in their behaviour, in that they do not conform with the optimal conditions found for fruit from other districts. Owing to its susceptibility to fungal attack and to rind lesions, further attention to the influence of pre-storage factors in the storage life of Gosford fruit would appear to be warranted in future experimental work.

(iii) *Classification of Wastage.*—The British Food Investigation Board and the Citrus Preservation Technical Committee have mutually agreed to the following classification of non-parasitic disorders in stored citrus fruits:—

1. Storage Spot—
   - (*a*) Button Lesions.
   - (*b*) Lateral Lesions.
2. Scald
3. Gooseflesh.
4. Flavocellosis.
5. Glazed Scab.

Both Valencia oranges and Washington Navels are susceptible to non-parasitic disorders which are apparently attributable directly to reduction of temperature in store. Susceptibility is greatest in early picked fruit and decreases with increasing maturity. Non-parasitic rind disorders appear generally to constitute the main hindrance to successful export of Valencias, with the possible exclusion of those from Gosford; and the problem, therefore, consists in an investigation of critical storage temperatures for "storage spot" production at different stages in the maturity of the fruit.

In addition to non-parasitic rind disorders, Washington Navels are, unfortunately, also susceptible to a number of rots, the chief of which are:—(i) green mould (*Penicillium digitatum*), (ii) blue mould (*Penicillium italicum*), (iii) stem-end rot (*Phomopsis* and *Diplodia* spp.), and (iv) septoria rot (*Septoria depressa*).

On the home market, fruit from districts other than Gosford is comparatively free from rotting in normal circumstances, and the same may be said of experimental fruit held in land store. On the other hand, a period of abnormally wet weather will predispose fruit with excellent keeping quality to rots, and the effect is accentuated when rain is accompanied or followed by heavy winds. In Australia blue mould (*Pencillium italicum*) is comparatively unimportant, rotting more usually being due to green mould (*P. digitatum*). Stem-end rot (*Phomopsis citri*) is responsible for an appreciable amount of wastage in stored fruit from the New South Wales coast. In commercial shipments to the United Kingdom, rotting commonly occurs in navel oranges from all districts in Australia, though not to an equal extent.

Citrus wastage due to rotting is not directly attributable to cool storage, since the bulk of the infection occurs in the field. Neither is it possible to control it by refrigeration alone, for the reason that temperatures to be effective in this regard must be reduced to such a point that non-parasitic disorders become inevitable. It is necessary, therefore, either to eliminate infection or to render it innocuous during the pre-storage period. This can be done, in theory,

by reducing the amount of inoculum at certain critical points in the chain of handling and storage, by avoiding injury to the fruit, and by the use of so-called " sterilizing " solutions. A considerable amount of time has been devoted to these aspects of citrus preservation.

(iv) *Citrus Packing House Investigations.*—(*a*) *Wounding—Detection, Effects, and Prevention.*—In a report on Australian citrus packing houses recently issued by the Committee, it was stated that commercial handling and general hygiene are, in general, given very little attention, and that apparently their importance as factors in citrus wastage is not appreciated. It was noticed that fruit was frequently wounded during picking and in transport to the shed, and again during processing and packing within the shed itself. It was decided to determine quantitatively the extent of wounding; this was done by the use of tannin and ferric chloride solutions which deposit ferric tannate within the wound and thus render it conspicuous. The result of this investigation showed that only 4 per cent. of coastal fruit tested escaped rind abrasions, and that 19 per cent. of the wounding occurred during picking, 34 per cent. during transport in field boxes, and the remaining 43 per cent. occurred in the packing shed. Fifty per cent. of the wounds were of the rub type resulting from friction, a type that permits of rapid infection, since the external walls of the oil glands are removed and penetration by mould organisms via the oil glands is much more readily accomplished than through inter-gland tissue. In a subsequent experiment, the use of wood wool in field boxes reduced wounding during picking and transport by some 40 per cent.; while elimination of prominent points of injury in the shed plant was responsible for a further reduction of 33 per cent., showing in all a total decrease of 73 per cent. in the number of fruits wounded.

The method of wound detection by ferric chloride was found to be time-consuming and exacting, and more recently a very satisfactory method was evolved. This consists in absorbing into the wound certain dyes such as Auramine (I.C.I.) which cause the wound to fluoresce brightly when irradiated with ultra-violet light.

In addition to its effect on mould wastage, wounding is thought to accelerate loss of moisture from the fruit, thereby inducing wilting and general loss of condition. A recent experiment to test this theory was conducted co-operatively with Mr. E. G. Hall (New South Wales Department of Agriculture) using fruit intentionally wounded, control fruit, and fruit waxed at the cut stem to retard possible moisture loss. Included in this experiment was a further batch of oranges treated with borax, since it has been previously noted that borax treated fruits show a marked tendency to wilt earlier than non-treated. Moreover, it is well known that the practice of dipping apples in acid solutions for the removal of spray residue is responsible for wilting. The results showed that borax treatment significantly increased moisture loss as compared with all other treatments, that increase in moisture loss due to wounding was probably significant, and that retardation of loss by paraffining the cut stem was also probably significant.

Early in 1937, a large-scale experiment with Valencia oranges was undertaken in co-operation with the New South Wales Department of Agriculture to determine the efficacy of waxing on moisture loss and maintenance of condition. Four treatments included wax, borax, borax and wax, and control; and fruit was stored at 40° F. and at 50° F. For this and subsequent experimental work, the waxing plant at the packing shed of Niagara Park Growers Limited, New South Wales, was modified to conform as nearly as possible with Californian (United States of America) equipment capable of applying wax by the hot fog method. Post-storage examination demonstrated the superiority of waxed fruit, and it was evident that boraxed fruit was more wilted than that of any other treatment.

(*b*) *Shed Hygiene and Mouldicidal Experiments.*—In the majority of Australian citrus houses, no effort is made to ensure freedom from atmospheric contamination; and exposure of agar plates have shown that the amount of infective material in the atmosphere is very high indeed. On a number of occasions, processing experiments have been carried out to gain data on the efficiency of various materials in solution as mouldicidal agents. Up to the present, borax treatment has invariably given excellent results and almost complete control of mould wastage even when fruit has been inoculated with spores of *P. digitatum* prior to treatment. None of the other materials used are comparable with borax in the degree of control exerted. It was shown, however, that borax does not possess any residual effect, and that re-contamination of the fruit after treatment will result in wastage.

In consequence of favorable reports received from California, United States of America, regarding the mouldicidal properties of nitrogen trichloride gas, wounded, inoculated, and unwounded Washington Navels from Gosford were intermittently fumigated over a period of seven weeks at 70° F. A control lot of fruit was held without gas treatment for a similar period. On examination it was found that nitrogen trichloride reduced the amount of wastage in wounded fruits by 76.2 per cent. and in control fruits by 58.5 per cent. No control whatever was exerted in the case of inoculated fruits, which were found to be completely wasty after six days in store.

The use of nitrogen trichloride for immediate gassing of fruit on its reception at the packing shed should prove of benefit to the fruit gassed, and indirectly beneficial since it is apparently an excellent fumigant for general shed disinfection purposes. Unfortunately, nitrogen trichloride is a dangerous explosive, and though apparatus is available in the United States of America for its safe application, it has been ascertained that there is no possibility of releasing it commercially in Australia in the immediate future.

Throughout the course of citrus preservation work, it has been patent that fruit from the Gosford coastal area shows much higher mould wastage than that from the inland areas. It was originally thought that these differences were due entirely to difference in resistance inherent in the fruit. It was, therefore, decided to test this possibility by direct inoculation of fruit from Griffith and Gosford using average daily increase of the surface area of the lesion as a measure of resistance. This method is a modification of that used by Rees Davies (Low Temperature Research Laboratory, Capetown, South Africa) who determined the margin of the lesions by pressure. It was found, however, that this could be done with greater accuracy and without damage to the fruit by visual examination under ultra-violet light. For the preliminary experiment small numbers of Valencia oranges were used, and differences between Griffith and Gosford were probably not statistically significant. In conjunction with the New South Wales Department of Agriculture, this work has now been repeated on a larger scale with Washington Navels, and the results tend to confirm those previously obtained. It would appear that the greater amount of mould wastage experienced in Gosford fruit is not due to any inherent factor, but rather that greater opportunity for infection occurs in the coastal districts.

(c) *Colouring Citrus Fruits (in co-operation with the New South Wales Department of Agriculture).*—This process is favoured commercially for the marketing of early Washington Navels and re-greened late Valencia oranges ; but in New South Wales it has been, and still is, conducted in a very haphazard manner in many centres. It should be possible with correct conditions of humidity, temperature, ethylene, and carbon dioxide concentration, to colour the fruit in from two and a half to four days, yet in a number of instances some six to eight days are required for the process. Long colouring periods are to be deprecated if marketing is delayed, because of the rapid propagation and extension of mould throughout the stack. It was consequently decided to institute inquiries into the methods practised. These revealed that of the seven rooms examined, only two were constructed and operated in such a manner as to permit the maintenance of constant conditions.

(v) *Storage of Citrus Fruit (at Melbourne, in conjunction with Victorian Department of Agriculture).*—(*a*) *Washington Navel Oranges.*—The effects of maturity at the time of picking, storage temperature, and various pre-storage treatments on the duration of life, have again been investigated with Washington Navel oranges from various localities in New South Wales, Victoria, and South Australia. The various determinations have included measurements of respiratory activity, juice and acid content, palatability, and colour. The optimum storage temperature is dependent on the maturity of the fruit at the time of picking, the locality from which the fruit has been gathered, and the conditions to which the fruit has been subjected between the time of picking and placing in store. Mid-May appears to be the earliest satisfactory picking time for fruit from most of the districts, the duration of life of this maturity being about twelve weeks at 45° F. Delaying the picking time usually reduces the subsequent duration of life by approximately the additional length of time the fruit has been allowed to remain on the tree.

Certain pre-storage sweating treatments have been effective in controlling subsequent rind defects at 40° F., but equally good results have been obtained by immediate storage at 45° F. The duration of life appeared to be influenced to some extent by the type of stock on which the fruit has been grown.

In the Victorian and South Australian fruit, life was terminated by loss of palatability : and mould wastage was only of importance after this stage. In the Gosford (New South Wales) fruit, mould wastage occurred prior to the loss of palatability.

The rate of respiration of Navel oranges is increased four times by a rise of temperature of 10° C, the corresponding value for Valencia late oranges being 2.4. An increase in temperature, therefore, should reduce the duration of life of Navel oranges much more than that of the Valencia late oranges.

Navel oranges picked towards the end of July have more flavour at picking time than those picked previously. For oranges subjected to a period of storage of six to eight weeks at 45° F., however, those picked early in June develop the best flavour by the end of the storage period. Early-picked fruit generally improves in flavour during storage, while later-picked fruit tends rapidly to lose its flavour. As a higher acidity can be tolerated in oranges with a good

flavour, it is suggested that a higher acidity might be allowed in earlier than in later shipments. The rate of loss of acid in store is about 2.5 per cent. per week, and is independent of temperature within the range 40° to 50° F.

Gas storage has not been found applicable to this variety of oranges as deterioration in flavour has occurred. The presence of amounts of carbon dioxide above 10 per cent. in the storage atmosphere results in a rapid increase in the alcoholic content of the juice.

(*b*) *Valencia Oranges.*—The results with Valencia late oranges have indicated that considerable wastage is caused through faulty methods of picking and handling prior to storage. It would seem that much more attention should be given in the future to this very important aspect of the citrus industry, and that some experiments should be conducted to demonstrate in a practical way the advantages to be gained by careful attention to pre-storage methods of handling and treatment.

Valencia late oranges stored at 40° F., appear to be susceptible to storage spot in the pre-climacteric stage and for about three weeks after the climacteric. Control may be effected by first storing the fruit for about three weeks at 50° F. prior to storage at 40° F., or by delaying the picking time.

(*c*) *Grapefruit.*—Experiments on grapefruit are being carried out, but insufficient progress has been made as yet to justify any conclusions being drawn.

(*d*) *Common Oranges.*—The duration of life obtained with common oranges from Gosford (New South Wales) has been relatively short compared with that of the Washington Navel orange. The various varieties of common oranges used as experimental material for the past two years have been very susceptible to storage spot.

5. *Non-tropical Fruit Investigations* (*Melbourne*).—Experiments have been conducted at the Government Cool Stores, Melbourne, in conjunction with officers of the Victorian Department of Agriculture, on apples, pears, peaches, plums, nectarines, grapes, passion fruit, and citrus fruits.

(i) *Apples.*—Attention has been directed during the last few years towards a study of the factors responsible for the development of soft scald, breakdown, and Jonathan spot in Victorian Jonathan apples. The fruit has been selected from one orchard in Red Hill, as fruit from this district has been susceptible in each year in which it has been stored. Previous experiments had indicated that these physiological disorders were usually spasmodic in their incidence from year to year. The many different factors which it was thought might be associated with these disorders were investigated, and it was found that the maturity of the fruit at the time of picking and the conditions which prevail (*a*) between time of gathering and placing in store, and (*b*) in store, are the factors of greatest importance. It should be possible after this year's experiments to indicate fairly precisely the method of control.

Investigations on (*a*) the effect of various pre-storage and wrapping treatments on the development of superficial scald in Granny Smith apples, and (*b*) the difference in storage behaviour at various temperatures between pre-cooled and non-pre-cooled Jonathan apples are now in progress.

Experiments on gas storage have shown that the Jonathan apple is fairly susceptible to injury from an atmosphere containing more than 5 per cent. carbon dioxide. There are indications, however, that Jonathan spot may be controlled by the use of atmospheres containing low concentrations of carbon dioxide. This work is being continued with gas mixtures containing 5 per cent. carbon dioxide, and various concentrations of oxygen other than those obtained by reduced ventilation.

(ii) *Pears.*—The effects of maturity at time of picking, locality, and temperature of storage on the duration of life and the various conditions essential for the normal ripening of William, Howell, Bosc, Packham, Josephine, Winter Cole, and Winter Nelis pears have been investigated. Of the various determinations which have been made at picking time and during storage, colour, and perhaps pressure, are of greatest practical value as standards for export in determining the latest time fruit may be left in store and still marketed in sound condition after removal. Attention has also been given this year to the commercial ripening of William pears after arrival in England, and to experimental shipments of other varieties of pears. Experimental shipments of William pears over a period of three years, carried out in conjunction with officers of the Low Temperature Research Station, Cambridge, have shown that the William pear can be exported successfully provided certain conditions are observed prior to shipment and that the fruit is carried in holds in which temperature conditions are uniform in time and space.

Experiments on the gas storage of William pears have previously given uncertain results; but in the present season the storage life is being definitely increased by the method of reduced ventilation. The optimum concentration of carbon dioxide has still to be determined. Experiments are still in progress on the gas storage of other varieties; but information has been

obtained concerning the incidence of brown heart under conditions of reduced ventilation in four varieties of pears during an export period of eight weeks. Severe brown heart has been obtained after eight weeks' storage only in concentrations of carbon dioxide greater than 10 per cent. Traces of brown heart have been found after storage in lower concentrations of carbon dioxide; but the commercial importance of this requires further investigation on a larger scale.

(iii) *Peaches.*—It is necessary that peaches should be picked in a fairly well-coloured but firm condition to develop satisfactory quality after ripening. When stored in air under the most favorable conditions at 32° F., the early-maturing varieties have not kept longer than five to six weeks, which makes overseas export impracticable. A slightly longer duration of life has been obtained with the later-maturing varieties, e.g., Crawford and Catherine Anne. A small consignment of the former variety was sent overseas this year by the Victorian Department of Agriculture, and its out-turn was fairly satisfactory.

Such shipments, however, would always be attended by a certain amount of risk which could be avoided by the use of gas storage which has increased the duration of life of peaches by 50 per cent. The most suitable atmosphere has been obtained by reduced ventilation, and contains 8 to 10 per cent. of carbon dioxide. When reduced ventilation is used, there is a corresponding reduction in the concentration of oxygen; but this is possibly of less importance in increasing the storage life than the amount of carbon dioxide present. The later-maturing varieties have given the best results, and they can be ripened at lower temperatures and develop better quality on ripening. The problem of losses due to brown rot is, however, serious; and commercial shipments can scarcely be justified until some measures for the control of this disorder are forthcoming.

(iv) *Plums.*—Plums may be picked in an immature condition and will ripen to poor or moderate quality at temperatures which prevail at the time of arrival of this fruit in England. Good quality can only be developed by leaving the fruit longer on the tree. It is necessary, however, to pick plums in an immature condition for overseas export, as the duration of life at 32° F. of immature fruit does not exceed eight weeks (about the minimum required for safe export), while that of mature fruit is considerably shorter. Of the varieties tested, those suitable for export are the European varieties Grand Duke, Coe's Golden Drop, and Jefferson. The duration of life of Japanese varieties, however, is relatively short at 32° F., and better results have been obtained with storage at 45° F. Further investigations are essential, however, before this temperature could be recommended.

No advantage has been gained by the use of atmospheres containing various percentages of carbon dioxide at temperatures ranging from 32° F. to 45° F.; and, with most varieties, there has been definite injury to the fruit.

(v) *Nectarines.*—Experiments with nectarines have indicated that this fruit will develop satisfactory quality after ripening if picked in a fully coloured but firm condition. The duration of life at 32° F. is about eight weeks, which makes overseas export a possibility, provided there is no undue delay between the time of picking and shipment.

(vi) *Grapes.*—Small-scale trials extending over several seasons have shown that certain varieties of grapes will retain their flavour and be free from mould attack for a period of at least eight weeks at 32° F., provided they are carefully handled prior to storage. A semi-commercial scale experiment consignment of Gordo, Waltham Cross, Purple Cornichon, Red Prince, and Red Malaga varieties was picked and packed by officers of the Victorian Department of Agriculture in (*a*) sulphite paper, (*b*) granulated cork, and stored in the experimental chambers at 32° F. After eight weeks' cold storage and one week subsequently at atmospheric temperatures, all varieties were in sound condition; but, after a longer cold storage period, the fruit packed in cork was in much better condition than that wrapped in paper. The use of moderate concentrations of carbon dioxide in the storage atmospheres of grapes has no injurious effects but has not increased the duration of life.

(vii) *Passion Fruit.*—Experiments conducted with fruit from Victoria and New South Wales during the past few seasons have indicated that the optimum storage temperature lies in the range 45 to 50° F.; but, even in this range, the storage life is seldom longer than four weeks, the fruit being very susceptible to shrivelling and non-parasitic breakdown of the rind. The best keeping fruit is rather immature and acidic at picking time: it becomes sweet, however, during storage. The storage life has been increased by storage in atmospheres containing low percentages of carbon dioxide and also by waxing the rind. It is possible, therefore, that further detailed investigations may reveal a technique through which the export of passion fruit from the Eastern States to European markets may be feasible commercially, and, to this end, detailed experiments are being planned.

6. *Overseas Transport Investigations.*—(i) *General.*—This work has again been carried out chiefly through close collaboration with the British Food Investigation Board and the

Commonwealth Department of Commerce. The liaison officer in London of the Council's Section of Food Preservation has been responsible for supervising and carrying out much of this work in England, and considerable help and advice was also given by the Council's adviser in food preservation investigations (Dr. W. J. Young) on the occasion of a private visit to England.

(ii) *Survey of Flesh Temperatures of Fruit on Arrival in England.*—The range of flesh temperatures at discharge of fruit at a large number of positions in ships' cargo spaces probably gives a good indication of the efficiency of the spaces in respect to uniformity of temperature once the so-called steady state has been reached. With the co-operation of the several shipowners this survey of the flesh temperatures in cargoes of various kinds of fruit is being carried out by the liaison officer.

(iii) *Survey of the Out-turn in England of Australian Eggs.*—In order to obtain more precise data relating to the nature and extent of deterioration, a survey in England of Australian eggs has been commenced. In the first season's work, eleven experimental consignments of known history were forwarded from three States for careful examination and report, and a number of cases from commercial shipments were also examined. Owing to the limited staff available and the time-consuming nature of the examinations, the number of examinations could not be very large, and it would be unsafe to outline definite conclusions until the work has covered at least another season's exports.

(iv) *Chilled Beef.*—Work on experimental consignments of chilled beef has been directed mainly towards the improvement of "bloom," and, to this end, tests have been made to determine the extent to which the moisture content of the surface tissues of the meat can be controlled.

(v) *Experimental Shipments of Fruit.*—As indicated in the preceding sections, a number of experimental consignments of oranges, pears, peaches and plums have been forwarded to England in order primarily to determine the nature and extent of wastage under commercial conditions, and to compare these results with those obtained in land storage experiments in Australia. The new Covent Garden (London) Laboratory of the British Food Investigation Board was recently opened; and the work of examination of experimental fruit from Australia will be greatly helped by the generous grant by the Board of facilities, as required, in this conveniently situated laboratory, and by the collaboration of its staff with the Council's liaison officer.

X. FISHERIES INVESTIGATIONS.

1. *General.*—Since his arrival in Australia, Dr. Thompson, the Officer-in-charge of the Fisheries Section, has been engaged in a general survey of the problems requiring investigation, in determining the most suitable location for a fisheries research station, and in drawing up a programme of work. This includes—

(1) The exploration of fishing grounds—especially those where pelagic fish (swimming in the upper water layers) abound. Demersal (bottom-dwelling) fish, shellfish, and other marine resources will also be investigated. For these purposes of exploration, a specially designed research vessel of the Californian purse-seine type is under construction.

(2) The determination of the chemical composition of the more abundant species of fish, together with the Vitamin A and D content of their liver oils, with a view to evaluating their commercial possibilities when reduced to fish meal and oil.

(3) Tests of methods of curing and preserving the most important species by pickling, smoking, canning, or sharp-freezing. Pending the establishment of laboratory facilities this work has been postponed.

(4) Marine biological and hydrological investigations, including systematic and racial studies of the principal fishes, together with their distribution, seasonal migrations, life histories, and fluctuations in quantity. The intensive prosecution of this work also awaits the provision of the requisite facilities.

During his journey to this country, the Officer-in-charge made a special tour of the North American fisheries and oceanographic laboratories, including laboratories of the United States Bureau of Fisheries, laboratories of the Californian State Fisheries, the International Fisheries Commission's laboratory at Seattle, the laboratory of the Biological Board of Canada, Namaimo, British Columbia, and the Fisheries Experimental Station, Halifax, Nova Scotia. Visits were also paid to various fish hatcheries and works for the conservation of fresh-water fish. While in America, Dr. Thompson was also able to make contact with Captain Flett, the recently-appointed master of the Council's fisheries investigation vessel, who had been sent overseas to make an intensive study of the American Pacific Coast fisheries.

Captain Flett has had seventeen years fishing experience in England, Scotland, New Zealand, and Australia, and has a knowledge of the various fishery methods adopted in these countries. While on the Pacific Coast he accompanied the various types of fishing vessels out to sea on their

fishing voyages, and studied the correlated processes ashore. In connexion with the latter, frequent visits were made to canneries, fish-reduction plants, ship-building yards, and net-making establishments. Two special nets were secured for the preliminary stages of the work of the Australian research vessel. In addition, a study was also made of the conditions under which all branches of labour are organized, and also of the methods of finance adopted for securing ships and outfits, as well as for partitioning the proceeds of voyages into shares. Captain Flett found a marked tendency toward the building of larger and more powerful vessels, especially for long-distance tuna fishing.

As was mentioned in the last Annual Report, steps are being taken to build up a properly trained staff for fisheries work. An Australian graduate, with suitable qualifications, is at present undergoing training abroad in the scientific aspects of fish preservation and will return to take up his duties in this country next March. A second graduate, with some previous experience in marine biology, is proceeding abroad immediately to visit European and American marine laboratories, where he will give particular attention to the tuna group of fishes. These visits are being financed from the Science and Industry Endowment Fund.

In order to initiate a critical study of the relative efficiency of existing methods of handling and processing fish in Australia, and to indicate the directions in which improvement could be made, the Council is appointing an experienced bacteriologist, who will commence work almost immediately. Temporary arrangements have been made to have this work conducted in the laboratories of the University of Melbourne.

It is anticipated that the Section will be called upon to supply information on many aspects of fisheries problems; and with this in view, a records department has been instituted. This will enable the results of research, both overseas and Australian, to be made readily available.

2. *Investigation Vessel.*—The investigation vessel now under construction at Williamstown Dockyard, Melbourne, is of the purse-seine type used on the Californian coast. The overall length of the vessel will be 82 feet, with a moulded breadth of 19 feet and a displacement tonnage of 132 tons. A 215 horse-power Atlas Polar diesel engine is to be installed, with a 28 horse-power Ruston Hornsby diesel engine to provide auxiliary power. Owing to delay in delivery of certain steel material and machinery, constructional work by the contractors has been retarded. The vessel will, however, be placed in commission shortly before the end of 1937.

The ship will be equipped for automatic depth-sounding; and a full range of gear for the making of hydrographic (sea currents) and plankton (e.g., fish eggs and fry) investigations will be carried. In the small deck-laboratory there will also be installed a refrigerating cabinet capable of maintaining small quantities of fish and other material at minus 5° F., pending their transference to a similar cabinet ashore, and their subsequent use for various processing tests or analyses.

A crew for the vessel will be selected from Australians possessed of suitable fishing experience, and they will be trained in the use of the unfamiliar equipment. Work will then be undertaken in a field new to Australian fisheries, that of locating and capturing pelagic or surface-swimming fishes, such as tuna, mackerel, sardines, Australian salmon, anchovies, &c. Fishing methods to be introduced will include purse-seining and live-bait fishing—methods that have both proved successful in Japan and on the Californian coast where immense quantities of fish similar to those frequenting Australian waters are landed. In addition, Danish seine nets will be used where suitable conditions exist to locate demersal or bottom-dwelling fishes, and hand lines and long lines will be utilized for investigating rocky ground.

3. *Aerial Reconnaissance.*—Having in mind the length of coastline and extent of waters to be explored, it was decided to carry out experimental flights to determine to what extent aerial observations might assist the work of the investigation vessel. After consultation with the Air Board, and with the approval of the Minister for Defence (the Hon. Sir Archdale Parkhill), tests were arranged, on each occasion a Seagull Amphibian with the necessary personnel and fuel being made available by the Air Board. The observations were carried out by an officer of the Fisheries Section.

The main objectives of the flights were—

(*a*) To ascertain to what extent, if any, aerial observation might assist the work of the fisheries investigation vessel now under construction.

(*b*) To obtain pictorial records of occurrences of pelagic fishes, of certain existing and potential fishing bases, and of shallow grounds likely to be suitable for the operation of certain types of fishing gear.

(*c*) To obtain pictorial records of physiographic features of the area under observation and of phases of the fishing industry such as crayfishing, trawling, and Danish seining.

(*d*) To obtain such other information as might be useful to the fisheries investigation vessel and the fishing industry.

The first flight commenced on the 21st October, 1936, and ended on the 1st December, 1936; and the second flight commenced on the 25th February, 1937, and concluded on the 28th March, 1937. The area covered in both instances embraced the south-east portion of the Victorian coast, the south coast of New South Wales, Bass Strait (including the Furneaux group of islands), and the east and south coasts of Tasmania. During the progress of both series of flights, valuable assistance and co-operation was rendered by the Air Board, the Fishery Departments of Tasmania, New South Wales, and Victoria, the Cinema and Photographic Branch of the Department of Commerce, Red Funnel Trawlers Limited of Sydney, and by Fisheries inspectors and fishermen at the various ports. The action of the Tasmanian Sea Fisheries Board in making available the services of the patrol boat *Allara* greatly assisted the work during the Tasmanian flights.

During the periods of the first flights the greatest concentration of pelagic fish and bird life was observed in the vicinity of Montague Island off the south coast of New South Wales. Large shoals of fish of potential commercial value were observed in this area. During the course of the second flights, the greatest concentration of pelagic fish life observed was at about five to fifteen miles off the east coast of Tasmania, from Schouten Island in the south to Babel Island in the north, a distance of about 140 nautical miles.

Identification of the species of fish comprising shoals observed from the air is not easy but, in both flights, huge shoals of Australian salmon were definitely identified. In the second series of flights, great shoals of tuna were also seen and recognized. In both instances the shoals were observed under conditions which should render possible their capture by modern fishing gear.

A considerable number of photographs—both " motion " and " still "—were taken of the fish shoals and assemblies of birds observed, of entrances to bays and estuaries, and of coastal features. These photographs indicate that it might be possible to construct havens, at comparatively low cost, in places where at present no safe anchorage is available for fishing craft.

These trial flights successfully demonstrated the value of aerial observations for the location of shoals of pelagic fish, and for determining the area containing the greatest concentration of fish life; and it is considered that the co-operation of aircraft with the investigation vessel would, in consequence, be advantageous.

4. *Analyses of Common Australian Fish and Fish Oils.*—Pending the establishment of a fisheries research laboratory, arrangements have been made with the Department of Chemistry, University of Melbourne, for some preliminary analyses to be carried out in that Department. The object of this work is to determine the degree of suitability of the commoner fish species, season by season, for :—(*a*) consumption in the fresh state, (*b*) canning, (*c*) reduction into fish meal and oil, and (*d*) preservation by refrigeration; and to ascertain the available yield of liver and fish oils, together with their vitamin A contents. (Arrangements have since been made for the determination of vitamin D content by another agency.)

Analyses have already been made of consignments of barracouta, sea mullet, Australian salmon (*Arripis trutta*), and school shark (*Galeorhinus Australis*,) while the pilchard will shortly be examined. All of these fish have proved to have a considerable body-oil content, which, especially in the case of mullet, can vary very greatly according to season. It would be necessary to pay attention, therefore, to the season during which catches of this fish are to be selected for canning, smoking, &c. All the above-mentioned species give fish meals of the highest class, providing that a sufficient proportion of the oil is previously removed by pressure under steam heat.

Among these species, the commonly caught school shark is the most productive of liver oil, which is readily obtained from the large livers by steaming. The liver oils of this species, and of barracouta, are highest in vitamin A content; but it should also be noted that, in comparison with the liver oils of the common fish of the northern hemisphere, the vitamin A content of each of eight Australian fishes so far examined is decidedly high, approaching in the two cases mentioned that of halibut. Also, as is the case in the northern hemisphere, the value is considerably higher in the feeding (summer) season than in winter. The combination of high yield of oil with high vitamin A content, is, in the case of the school shark, considered to be a finding of economic importance. While the vitamin A content is rather lower than that of most halibut, weight for weight the liver yields about twice as much oil. Little squalene appears to be present in the oil; hence it can probably be as readily assimilated as are other commercially important edible liver oils.

XI. OTHER INVESTIGATIONS.

1. *Commonwealth Prickly Pear Board**.—The continued control and eradication of prickly pear by *Cactoblastis cactorum* has been most satisfactory during the year. In Queensland, the destruction has been very thorough; in most districts of former heavy pear, later succeeded by a vigorous regrowth, one finds nothing more serious than scattered to very scattered secondary growth and seedling plants. Isolated regrowth areas of a few hundred to a few thousand acres

* This Board is an independent body financed by the Commonwealth (through the Council for Scientific and Industrial Research) and the States of Queensland and New South Wales.

remain here and there, and are valuable breeding grounds for the insects. Seedling pear continues to appear for some years, and will no doubt persist in developing on improved grazing lands in the vicinity of former dense infestations.

The maintenance of the *Cactoblastis* population is a matter for favorable comment. Where regrowth and seedling pear, even of a very scattered nature, occurs, the proportion of plants infested by the larvae is relatively high in most sectors. The heavier areas of regrowth and seedling pear are being vigorously attacked by the insect. There are, however, a few localized areas in south-west Queensland where *Cactoblastis* is not, at present, concentrated in large numbers.

In New South Wales, the position in north-western districts is much as in Queensland. In general, regrowth is light or scattered, but in the Collarenebri-Mungindi section there is a good deal of secondary pear among which the *Cactoblastis* population is rather light. On the other hand, the insect's numbers are very great in the Bingara-Inverell country, and in this district are effecting excellent destruction of resistant pear on timbered hills and ridges, more especially on areas where ringbarking of the timber has resulted in an improvement in the quality of the prickly pear. In the Hunter Valley, the pear infestation continues to be reduced steadily.

The reclamation of former dense pear country in Queensland, made possible by reason of the success of biological control, is making rapid progress. On every side, one can see evidence of new development. Very large tracts of country are being improved for wool production; in a few years the State's sheep flocks must, in consequence, increase very appreciably. Similarly timber destruction, fencing, water storage provision, and other improvements, are being pushed ahead in districts suitable for dairying and fat cattle raising. Towns and smaller settlements in the pear territory generally reflect, in the number of new business premises and residences, the position so radically changed within a few years.

Concerning the lesser pest pears, the beetle *Lagochirus funestus*, introduced from Mexico in 1935, promises to control the tree pears of Central Queensland, *Opuntia tomentosa* and *O. streptacantha*. Large numbers have been bred and released during the year, and already many of the liberations show considerable damage caused by this insect. In the case of the tiger pear, *O. aurantiaca*, the Argentine cochineal (*Dactylopius confusus*) has continued to effect marked destruction in various localities.

In collaboration with the Council, experimental investigations have been continued with the Noogoora burr seed-fly, *Euaresta aequalis*. Certain tests on economic plants have been conducted with two other *Xanthium* insects from America. Further attention has been paid to the insect enemies of *Bassia* and related plants.

Overseas investigations have dealt entirely with the biological control of *Xanthium*. Two officers have made extensive surveys in the United States, and have studied the life history and other phases of various insects. Another officer has carried out *Xanthium* surveys in Argentine, Brazil, Peru, and Chile.

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

The Sydney investigators of the Board are giving a considerable amount of attention to a study of the ionosphere, through which radio transmissions of any distance are carried. It is hoped that, with further information concerning conditions in the ionosphere and their effect on radio transmissions, it will be possible to develop improvements of value to all the radio services of the country.

During the year, work was completed on a simple and flexible method of measuring the polarization of radio echoes from the ionosphere. The method employs pulse emissions, and is, therefore, applicable where more than one echo is receivable, but avoids the difficulty of radio frequency phase instability by a partial employment of the frequency-change technique. The results obtained afford strong evidence of magneto-ionic effects in the E region of the ionosphere. A report of this work was published by the Royal Society of London in February, 1937. Subsequently the method was extended so as to measure not only the polarization but also the angles of incidence and lateral variation of downcoming echoes.

Recently, in collaboration with the Commonwealth Solar Observatory, important discoveries have been made on the connexion between ionospheric disturbances, "fade-outs," and bright hydrogen solar eruptions. It is found that a type of ionospheric disturbance accompanies every bright hydrogen eruption, and when the disturbances are large they cause fade-outs in short-wave communication.

As part of the Sydney work, much attention has been given to the design and improvement of instruments whereby to obtain the desired observations. Work in this field has included the design of an automatic high-frequency recorder, an electronic-type oscillographic frequency-response curve apparatus, and an electron switch. The Sydney work has been very considerably assisted by University and other research workers quite apart from the Board's own officers.

In Melbourne, work in the field of atmospherics has been continued. The year of joint investigation of the usefulness of directional observations on atmospherics for weather forecasting and aviation warning carried out in collaboration with the Commonwealth Weather Bureau was completed at the end of July, 1936. The results showed that further improvement in the accuracy of wireless location of thunderstorms is necessary before final conclusions on the points under consideration can be drawn. It has now become fairly evident, however, that the close correlation between thunderstorms and fronts over the Australian Bight, as found some two years ago, does not always hold. In general, many, but by no means all, fronts bring thunderstorms with them, and when thunderstorms do occur they are often so far removed from the front that it is doubtful if they are strictly of the frontal type. Often, they occur at a subsidiary front which does not bring the main weather disturbance. By comparing radio locations of thunderstorms over land areas with those obtained from meteorological observations, it was found that for adequate accuracy two, but preferably three, direction-finding stations should always be used and steps should be taken to avoid night errors by using Adcock aerial systems.

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

During the past year, 27 investigations have been made on ores, mill products, and rocks submitted by mining companies and institutions. Twelve of these have been related to investigations carried out by the Council's ore-dressing investigators in Victoria and South Australia. These concerned auriferous ores from Yackandandah, Dart River (Victoria), and Peelwood, New South Wales; flotation concentrates from New Occidental Mine at Cobar, New South Wales, Tyrconnel mine at Mareeba (Queensland), Stockyard Creek (South Australia). Dart River (Victoria); and mine dumps at Costerfield (Victoria), and Delamere (South Australia),

A series of ore and mill products from the Lancefield gold mine in Western Australia were studied. Gold in this ore is partly embedded in quartz partly in pyrite, and to a lesser degree in arsenopyrite and pyrrhotite. The flotation concentrates show that pyrite is the chief sulphide, and that some of the gold remains encased in pyrite and arsenopyrite after crushing, and such gold as remains in the calcine tailing and is thus lost is probably due to such inclusions which have not been exposed during the oxidation of the sulphides by roasting.

The examination of telluride-free concentrates prepared by N. I. Haszard at the Melbourne University, from flotation concentrates from the Lake View and Star Mine, Kalgoorlie, in connexion with his researches on tailing losses, determined that gold occurs as free particles, as particles on the margin of pyrite and gangue, and as particles totally encased in pyrite. The examination of the similar concentrates after cyanidation determined that similar gold particles remained encased in pyrite.

Another series of mill products from telluride ores have been examined for the Kalgurli Ore Treatment Company. A small particle of gold in gangue was detected in the flotation tailings. Gold occurs as inclusions in pyrite, as gold tellurides, and as an occasional free particle in flotation concentrates prepared after straight cyanidation. The gold content of these flotation concentrates after bromocyanidation occurs largely as inclusions of free gold in pyrite, though an occasional particle of gold telluride may be found. When the residual concentrates are roasted, and the pyrite converted to iron oxides, much of the gold is exposed, but, in the final residue, after cyanidation, gold particles have been observed to be encased in particles of iron oxide.

The examination of strake concentrates collected from the residue cone underflow at the Rosebery mill revealed numerous gold particles comparable in size with the pyrite particles. The effect of an incomplete roast on these concentrates proved interesting in showing transitional changes of the oxidation of pyrite from graphic intergrowths of pyrite and magnetite to intergrowths of magnetite and hematite, and in showing the possible growth of iron oxide around particles of gold.

A series of bore cores from the No. 2 diamond drill, Tennant's Creek, were petrologically examined for the Aerial, Geological, and Geophysical Survey of Northern Australia. It was determined that the magnetic anomaly penetrated by this bore was due to a mass of talc-carbonate magnetite rocks containing disseminated chalcopyrite. This material is probably the metamorphosed equivalent of an ultra basic igneous rock. All the mineragraphic investigations discussed above have been facilitated by contributions from a number of mining corporations through the Australasian Institute of Mining and Metallurgy. The University of Melbuorne has also assisted by granting the investigators laboratory accommodation at the Geology School.

4. *Ore-dressing Investigations.*—As indicated in previous reports, these investigations are being carried out with the co-operation of the Kalgoorlie School of Mines, the Adelaide School of Mines and Industries, and the Metallurgy School of the University of Melbourne.

The Kalgoorlie laboratory has continued to be in considerable demand from the relatively large number of leaseholders in Western Australia. In consequence, the investigating officers have been fully occupied with tests of numerous ore samples drawn from many different parts of the State. A number of milling and treatment plants have also been erected in Western Australia from designs drawn up as a result of the experimental work of the laboratory. As distinct from the experimental work, the advice of the laboratory has also been constantly sought by mill operators who have had difficulties in treatment. An investigation on a dump of tailings which have been untreated for 30 years and which a number of attempts to treat had proved costly failures, resulted in a discovery of a method of treatment; the treatment of the dump has now been practically completed on lines laid down by the laboratory, and with a substantial profit to the owner.

In the Adelaide laboratory work on some samples gave indications that a study of the alkalinity of pulps undergoing cyaniding would be of value. As a result, new knowledge of general advantage to the gold-mining industry in Australia was obtained. Other lines of work consisted of a study of gold ores carrying large quantities of antimony and thus difficult to treat by cyaniding. Attention was also given to a study of the harmful effect of calcium sulphate in cyanidation.

In the Melbourne Laboratory, the examination of 52 different ore samples was completed during the year. In general, these samples have been submitted by small development companies, but in several cases tests were carried out for large operating plants to check certain features of the current practice. From the technical point of view, the outstanding work has been a series of tests on the copper arsenical gold ores of north-eastern Victoria.

Another development has been the adoption of a routine for the cyanidation and filtration of samples from alluvial slum dumps of which there are many large examples in the Victorian deep leads areas. As one development of such work a plant of a capacity of 250 to 400 tons per day is now being erected at Maryborough.

5. *Standards Association of Australia.*—The Standards Association of Australia, for which the Council is the means of liaison with the Commonwealth Government, reports a year of increasing activity. A wider recognition of the value of standard specifications, and particularly of standard codes of practice, is resulting in a large number of appeals to the Association to undertake new work, much of which must be regarded as of urgency and importance. New activities cannot be undertaken with a limited staff without prejudicially affecting the rate of progress in work already in hand which is being carried forward as fast as the capacity of the staff will permit. Some measure of improvement resulted from the appointment of two additional technical officers during the year; but much more assistance will be necessary before adequate measures can be taken to meet the demand.

Considerable progress has been made in the preparation of new specifications and codes and in revising existing standards in order to keep them abreast of industrial developments. The Association has been able to arrange, when necessary, for experimental investigations to be carried out in order to ensure that the best and most modern practices are incorporated in the standards. For the same purpose, inquiries have been made abroad, and much valuable information has been made available to the Association. The link with other national standardizing bodies has been maintained, and particularly close co-operation exists between the various associations within the Empire.

The Association's highly specialized technical library has had heavy demands made upon it; and an active library service has been given to Government officers and to industry and commerce. A new branch of activity which promises to be of considerable value to State

Governments is the assistance given in the preparation of suitable standards and the organizing of examining committees in connexion with systems established for controlling the sale and use of electrical appliances with a view to protecting the public from electrical hazards.

6. *Biometrical Work.*—There is a generally increasing appreciation of the value of statistical methods in experimental work, and with it a growing demand for the services of biometricians. The biometrical staff of the Council has been increased by the addition of Dr. M. M. Barnard, who returned from England in August last year. She spent several months in Canberra assisting in the work there, and made an analysis of some of the wheat variety experiment data. After leaving Canberra she visited the McMaster Laboratory in Sydney before proceeding to Melbourne, and is now located with the Division of Forest Products where many statistical problems occur in connexion with the testing of timbers.

In the Division of Plant Industry, biometrical questions and analyses have been dealt with in regard to experiments on footrots and flag smut of wheat, on the general physiology of the wheat plant, on the effect of weed competition, and on the technique of sampling pasture plots. Attention has also been given to problems in plant genetics, and to tobacco investigations and virus studies. Results of experiments on problems relating to peach moth, termites, blowflies, and grasshoppers, have been analysed for officers of the Division of Economic Entomology. A statistical analysis was made of the results of an experiment conducted by the Division of Animal Health and Nutrition to test the effect of fluorine on sheep. Biometrical tests were done on data from an orange-picking experiment at Griffith; and an analysis is in progress of an investigation into the effect of tick beans on the seasonal variation of nitrates in the soil. Advice on statistical questions has been given to officers of the Research Station at Merbein.

The statistical planning and analysis of experiments concerned with the diseases of animals has been carried out by Miss H. N. Turner, who is attached to the McMaster Animal Health Laboratory.

A bulletin dealing with statistical methods for the non-mathematical research worker is in preparation.

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

(i) *Primary Industries.*—Containers for fruit juices, control of evaporation of water, purification of bore waters, bran germ, potash, insect killing devices, cheap methods of refrigeration, rabbit control, bird guano, utilization of banana stems, iodized wraps for fruit, apricot pits, soya bean, lemon peel, citrus oil, waste straw, droughts, *Phormium tenax.*

(ii) *Manufactures.*—Mirror, pottery, building materials, mill white, leaf oil, tung oil, eucalyptus oil, cold water pastes, pottery glazing, extraction of oil from vegetable matter, linoleum polishes, fly sprays, oat oil, glue and gelatine making, water-proofing textiles, car wash, coco-nut shell, magnesium chloride, citric acid, cellophane, milk sugar, reconditioning grinding mops, wood distillation, oxygen and hydrogen, life of rubber, salt by freezing, tanning of Australian leathers, lactose, tinning, potato starch, casein products, and bronzing.

(iii) *Industrial Minerals.*—Diatomaceous earth, sulphur from iron pyrites, magnesite, magnesium oxide, tantalite, beryllium ores.

(iv) *Miscellaneous.*—Frost prevention, mistletoe, storage of flowers, silverfish, conversion of sugar, Australian research, seaweed, producer gas-driven vehicles, mutton bird oil, geophysical prospecting, lanital, dugong oil, water softening, power alcohol, koalas, literature on irrigation, ambergris, Queensland kauri gum, soil erosion, material for grader, butter lubricants, colour test, book varnish, wool pack.

XII.—FINANCIAL MATTERS, STAFF, AND PUBLICATIONS.

1. *Finance.*—The statement of expenditure from 1st July, 1936, to 30th June, 1937, is as follows:—

	£	£	£
1. Salaries and contingencies	..	..	17,659*
2. Remuneration of Chairman and Members of Council	..	..	2,334†
3. Investigations—			
(i) Animal Problems—			
(*a*) Sheep diseases: footrot, black disease, preputial disease, caseous lymphadenitis, enterotoxaemia, pregnancy disease and equine navel ill ..	3,189		
Less contribution from the Australian Pastoral Research Trust	200		
		2,989	
(*b*) Mastitis (Victoria)	4,552		
Less contribution from Australian Cattle Research Association and part Berwick Farm Revenue	4,552		
		..	
(*c*) Rabbit myxomatosis	1,317		
Less contributions from Council of Advice, Rabbit Destruction Fund	825		
		492	
(*d*) Tick and tick fevers, pleuro-pneumonia, &c.	6,674		
Less contributions from Queensland Government, part proceeds from sale of vaccine, and C.P.P. Revenue Fund..	2,583		
		4,091	
(*e*) Haematuria (Victoria and South Australia	..	138	
(*f*) Toxaemic Jaundice	83		
Less contributions from Australian Wool Board ..	83		
		..	
(*g*) Parasitology	6,447		
Less contributions from the Australian Pastoral Research Trust, University of Sydney, Australian Wool Board, and Parasitology Revenue Fund	1,297		
		5,150	
(*h*) Bacteriology	1,951		
Less contributions from Australian Wool Board ..	43		
		1,908	
(*i*) Biochemical Problems	1,733		
Less contributions from Australian Wool Board ..	264		
		1,469	

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

3. Investigations—*continued.*

(i) Animal Problems—*continued.*

	£	£	£
(*j*) Genetics (New South Wales and Queensland)	1,639		
Less contributions from the Australian Wool Board and Infertility Revenue Fund ..	357		
		1,282	
(*k*) External Parasites Investigations ..	90		
Less contributions from Australian Wool Board ..	90		
		..	
(*l*) Entero-toxaemia (Braxy-like disease), Moora (Gingin) disease, Ataxia in lambs, &c. (Western Australia) ..	..	300	
(*m*) Nutrition Laboratory	7,790		
Less contributions from Nutrition Laboratory Revenue Fund	160		
		7,630	
(*n*) Waite Institute	..	1,361	
(*o*) Field Station, Young, New South Wales	..	210	
(*p*) Field Station, Kangaroo Island, South Australia	..	119	
(*q*) Coast Disease Investigations ..	615		
Less contributions from the Australian Pastoral Research Trust	100		
		515	
(*r*) Drought feeding experiments at Waite Agricultural Research Institute, Glen Osmond, South Australia ..	1,063		
Less contributions from Australian Pastoral Research Trust, Commonwealth Bank (Rural Credits Development Fund) and Jericho Wool Committee	509		
		554	
(*s*) Field Experiments on Phosphorus Deficiency, South Australia ..	552		
Less contributions from the Australian Pastoral Research Trust	300		
		252	
(*t*) Agrostological Investigations at Waite Agricultural Research Institute, Glen Osmond, South Australia ..	..	600	
(*u*) Central Office—			
Annual	3,891		
Capital	101		
	3,992		
Less contributions from balance of grant to Dr. Georgina Sweet	75		
		3,917	
		32,977	
Less contributions from Commonwealth Bank (Rural Credits Development Fund) ..	..	7,000	
			25,977

3. Investigations—*continued.*	£	£	£
(ii) Plant Problems—Division of Plant Industry—			
(*a*) Central Laboratory—			
Annual	5,377		
Capital	439		
		5,816	
(*b*) Experimental plots		505	
(*c*) Plant pathology		2,625	
(*d*) Plant genetics		3,978	
(*e*) Plant introduction		1,434	
(*f*) Agrostology		686	
(*g*) Herbarium		150	
(*h*) Weeds Investigations		2,640	
(*i*) Fibre Investigations		138	
(*j*) Experimental Farm, Duntroon		690	
(*k*) Potato Virus Studies		492	
(*l*) Pasture Plant Improvement		376	
(*m*) Pasture Plant Breeding, Gatton, Queensland		327	
(*n*) Plant Introduction Garden, Gatton, Queensland		687	
(*o*) Plant Introduction (State Farm, Middle Queensland)		580	
(*p*) Apple root stocks, Stanthorpe, Queensland		365	
(*q*) Fruit Problems	2,350		
Less contributions from Department of Commerce	235		
		2,115	
(*r*) Tobacco Investigations	5,805		
Less contributions from Tobacco Trust Fund ..	5,805		
		..	
(*s*) Cumbungi Weed Pest, Murrumbidgee Irrigation Area, New South Wales	321		
Less contributions from New South Wales Water Conservation and Irrigation Commission and Victorian State Rivers and Water Supply Commission ..	321		
		..	
			23,604
(iii) Entomological Problems — Division of Economic Entomology—			
(*a*) Central Laboratory—			
Annual	3,805		
Capital	222		
		4,027	
(*b*) Agricultural Entomology and Museum		1,742	
(*c*) Agricultural Entomology (Orchard and Fruit Pests)		30	
(*d*) Agricultural Entomology (Grasshopper Investigations)		1,009	
(*e*) Noxious weeds		3,425	
(*f*) Veterinary Entomology	5,010		
Less contributions from Australian Pastoral Research Trust and Australian Wool Board	755		
		4,255	

	£	£	£
3. Investigations—*continued.*			
(iii) Entomological Problems, &c.—*continued.*			
(*g*) Forest Entomology	2,493		
Less contributions from Department of Interior ..	16		
		2,477	
(*h*) Oriental Peach Moth	668		
Less contributions from Department of Agriculture, Victoria	581		
		87	
(*i*) Constant Temperature Chambers ..	3		
Less contributions from Sir MacPherson Robertson ..	3		
		..	
			17,052
(iv) Horticultural Problems of the Irrigation Settlements—			
Citricultural—			
(*a*) Research Station, Griffith—			
Salaries and incidentals ..	5,569		
Capital	145		
	5,714		
Less funds provided from Station Revenue ..	220		
	5,494		
Less contributions by New South Wales Water Conservation and Irrigation Commission	1,300		
		4,194	
Viticultural—			
(*b*) Research Station, Merbein—			
Salaries and incidentals ..	6,169		
Capital	873		
	7,042		
Less funds provided from Station Revenue ..	446		
	6,596		
Less contributions by Dried Fruits Control Board and Nyah-Woorinen Dried Fruits Inquiry Committee	1,762		
		4,834	
(*c*) Ripening, processing, &c., of vine fruits, Mildura District ..	871		
Less contributions by Irymple Packing Pty. Ltd., Mildura Co-op. Fruit Co., Red Cliffs Co-op. Fruit Co. Ltd., Aurora Packing Pty. Ltd., Swallow & Ariell Ltd., and Aden Packing Co.	857		
		14	
			9,042

	£	£	£
3. Investigations—*continued.*			
(v) Soil Problems—			
(*a*) Investigations at Waite Institute, Irrigation Areas and Tasmania—			
Salaries, &c.	6,791		
Capital	45		
		6,836	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	..	2,500	
			4,336
(vi) Food Preservation and Transport—			
(*a*) Meat and fish investigations (Brisbane Abattoir)	3,389		
Less contributions by Queensland Meat Industry Board	290		
		3,099	
(*b*) Banana investigations (Queensland University)	350		
Less contributions from Commonwealth Banana Committee	350		
		..	
(*c*) Citrus Preservation	2,045		
Less contribution from Niagara Park Growers Ltd. ..	5		
		2,040	
(*d*) Non-tropical fruits (Melbourne) ..	..	1,147	
(*e*) Engineering problems	..	414	
(*f*) Central Laboratory, Homebush, New South Wales—			
Annual	18		
Capital	400		
		418	
(*g*) Meat Investigations (Homebush, New South Wales)	..	148	
(*h*) Fish Investigations (Homebush, New South Wales)	..	102	
(*i*) Non-tropical fruits (Homebush, New South Wales)	326		
Less contributions from New South Wales Department of Agriculture	326		
		..	
(*j*) Adviser on Food Preservation ..	..	295	
		7,663	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)	..	2,000	
			5,663
(vii) Prickly Pear—			
(*a*) Grant for investigations	..	4,438	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)	..	4,438	
			..

3. Investigations—*continued.*

	£	£	£
(viii) Forest Products—			
(*a*) Central Laboratory—			
Annual	8,382		
Capital	1,496		
		9,878	
(*b*) Seasoning	..	1,388	
(*c*) Preservation	..	1,712	
(*d*) Chemistry	..	1,085	
(*e*) Wood Structure	..	1,314	
(*f*) Timber Mechanics	..	1,816	
(*g*) Timber Utilization	..	1,381	
(*h*) Timber Physics	..	952	
(*i*) Grading Studies	..	1,036	
(*j*) Queensland Timber Problems ..	66		
Less contribution by Lands Administration Board, Brisbane, Queensland	66		
		..	
(*k*) Plant for new Laboratory ..	1,947		
Less contribution by Russell Grimwade, C.B.E. ..	1,947		
		..	
(*l*) Paper Pulp	431		
Less contribution by Australian Paper Manufacturers Limited	431		
		20,562	
Less sundry cash donations ..	..	81	
		20,481	
Less contribution from Commonwealth Bank (Rural Credits Development Fund)	..	1,500	
			18,981
(ix) Mining and Metallurgy—			
(*a*) Mineragraphic Investigations ..	..	768	
Less contribution by Australasian Institute of Mining and Metallurgy	..	368	
			400
(x) Radio Research—			
(*a*) Melbourne and Sydney Universities ..	4,790		
Less contributions by Postmaster-General's Department ..	3,593		
		1,197	
(*b*) Advisers on Radio Research ..	..	98	
			1,295
(xi) Library	..	..	986
(xii) Gold Mining—			
(*a*) Mineragraphic Investigations (Melbourne University)	..	726	
(*b*) Ore Dressing (Melbourne University)	..	1,336	
(*c*) Ore Dressing (Adelaide School of Mines)	..	955	
(*d*) Ore Dressing (Kalgoorlie School of Mines)	..	764	
(*e*) Advisory Committee	..	182	
			3,963
(xiii) Fisheries Investigations—			
(*a*) Administrative—			
Annual	3,720		
Capital	390		
		4,110	
(*b*) Fish Analyses	..	441	
			4,551

3. Investigations—*continued.*

	£	£	£
(xiv) Apple and Pear Investigations—			
(*a*) Grants to States		8,494	
(*b*) Thrips		124	
(*c*) Survey of "Die-back" and Sour Sap ..		187	
(*d*) Spray Injury		75	
(*e*) Codling Moth		314	
(*f*) Experimental Consignments Pears Overseas		225	
(*g*) Gas Storage		426	
(*h*) Apple Root Stocks, Stanthorpe, Queensland		163	
(*i*) Experimental Consignment Apples Overseas		24	
		10,032	
Less contributions from Department of Commerce		10,032	
			..
(xv) Miscellaneous—			
(*a*) Dairy Research		300	
(*b*) Ephemeral Disease		224	
(*c*) Tomato Wilt		232	
(*d*) Mineral Deficiency in Pastures		934	
(*e*) Statistical Section		468	
(*f*) Watery Whites in Eggs Investigations	150		
Less contribution by Egg Producers' Council	50		
		100	
(*g*) Red-legged Earth Mite		17	
(*h*) Buffalo-fly		329	
(*i*) Catalogue of Scientific and Technical Periodicals		70	
(*j*) Secretarial, Waite Institute		226	
(*k*) Various		816	
			3,716
Total of Item 3—Investigations			119,566

2. *Contributions.*—The following statement shows the receipts and disbursements during the year 1936–37 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 1935–36.		Expenditure 1936–37.
	£		£
Commonwealth Bank (Animal Health and Nutrition, Horticultural, Food Preservation and Transport, Prickly Pear and Forest Products Investigations)	17,500	..	17,438
Commonwealth Bank (Erection of Drought Feeding Building)	5	..	5
Commonwealth Bank (Bee Investigations)	92	..	..
Postmaster-General's Department (Radio Research) ..	3,750	..	*3,600
Australian Pastoral Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,259	..	†2,179
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	1,300	..	1,300
New South Wales Water Conservation and Irrigation Commission (Cumbungi Investigations)	200	..	160
Carried forward	25,106	..	24,682

* Includes £123 on account 1935–36 expenditure. † Includes £860 on account of 1935–36 expenditure.

	Receipts including balances brought forward from 1935–36.		Expenditure 1936–37.
	£		£
Brought forward	25,106	..	24,682
Victorian State Rivers and Water Supply Commission (Cumbungi Investigations)	200	..	160
Department of Commerce (Fruit Problems, Tasmania)	238	..	235
Queensland Government (Animal Health Investigations —Cattle Research)	2,557	..	*2,557
Australian Wool Board (Animal Health and Nutrition Investigations—Sheep Research)	2,260	..	1,441
Australasian Institute of Mining and Metallurgy (Minerographic Investigations)	368	..	368
Dried Fruits Control Board (Dried Fruits Investigations)	1,999	..	1,702
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	60	..	60
Australian Dairy Council (Wood Taint in Butter Investigations)	20	..	..
Queensland Meat Industry Board (Food Preservation Investigation)	300	..	†300
Sir MacPherson Robertson (Entomological Investigations)	183	..	3
Department of Interior (Termite Investigations—Division of Economic Entomology)	16	..	16
Australian Oxygen and Industrial Gases (Forest Products Investigations)	50	..	..
Commonwealth Banana Committee (Banana Investigations)	350	..	350
University of Sydney (Animal Health and Nutrition Investigations)	188	..	188
Revenue Fund—Contagious Pleuro-pneumonia Investigations (Animal Health and Nutrition Investigations)	150	..	69
Revenue Fund—Oonoonba Research Station—Sale of Vaccine (Animal Health and Nutrition Investigations)	1,547	..	817
Revenue Fund—Parasitological Investigations (Animal Health and Nutrition Investigations)	116	..	109
Revenue Fund—Infertility Investigations (Animal Health and Nutrition Investigations)	197	..	196
Revenue Fund—Nutrition Laboratory (Animal Health and Nutrition Investigations)	195	..	160
Revenue Fund—Entomological Investigations ..	55	..	..
Revenue Fund—Griffith Research Station (Citricultural Investigations)	3,284	..	220
Revenue Fund—Berwick Farm (Mastitis Investigations)	744	..	602
Revenue Fund—Merbein Research Station (Viticultural Investigations)	3,057	..	446
Revenue Fund—Ore Dressing Investigations ..	149	..	..
Plywood-Veneer Board, Queensland (Forest Products Investigations)	138	..	..
Lands Administration Board, Queensland (Special Forest Products Investigations)	250	..	66
Russell Grimwade, C.B.E. (Forest Products Investigations)	2,361	..	1,947
Niagara Park Growers Limited (Citrus Preservation Investigations)	5	..	5
Tobacco Trust Fund—Prime Minister's Department (Tobacco Investigations)	11,259	..	5,805
New South Wales Department of Agriculture (Meat Investigations)	3,000	..	326
Carried forward	60,402	..	42,830

* Includes £7 on account of 1935–36 expenditure. † Includes £10 on account 1935–36 expenditure.

	Receipts including balances brought forward from 1935-36.		Expenditure 1936-37.
	£		£
Brought forward	60,402	..	42,830
Department of Commerce (Apple and Pear Investigations)	15,047	..	10,032
Mildura Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	194	..	194
Irymple Packing Company (Dried Vine Fruits Investigations, Merbein)	194	..	194
Red Cliffs Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	194	..	194
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	194	..	194
Swallow & Ariell Limited (Dried Vine Fruits Investigations, Merbein)	40	..	40
Aden Packing Company (Dried Vine Fruits Investigations, Merbein)	40	..	40
Australian Dairy Cattle Research Association (Mastitis Investigations)	3,950	..	3,950
Council of Advice, Rabbit Destruction Fund (Work on Rabbits)	825	..	825
Dr. Georgina Sweet—Balance of Grant (Animal Health Investigations)	75	..	75
Jericho Wool Committee, Jericho, Queensland (Sheep Research)	4	..	4
McLaren & Company Proprietary Limited ..	11	..	11
Holden's Motor Body Builders (Forest Products Investigations)	37	..	37
Department of Agriculture, Victoria (Oriental Peach Moth Investigations)	581	..	581
Melbourne Electric Supply Company (Pole Tests in Victoria)	28	..	*28
Newcastle Municipal Council (Pole Tests in New South Wales)	22	..	..
Sydney Municipal Council (Pole Tests in New South Wales)			
Department of Public Works, New South Wales (Pole Tests in New South Wales)			
Australian Paper Manufacturers Limited (Paper Pulp Investigations)	577	..	431
Associated Pulp and Paper Mills Limited (Paper Pulp Investigations)	500	..	..
South Australian Railways (Treatment of Railway Sleepers)	36	..	..
Egg Producers' Council (Watery Whites in Eggs) ..	52	..	50
Revenue Fund—Mining and Metallurgy	3	..	..
Sundry Contributors (Forest Products Investigations) ..	330	..	33
Sundry Contributors (Council for Scientific and Industrial Research Publications)	2	..	†2
	83,338	..	59,745

3. *Staff.*—The following is a list of the staff of the Council as at the 30th June, 1937. The list does not include typists, laboratory assistants and labourers, &c.

1. Head Office Staff.

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

* Incudes £28 on account 1935-36 expenditure. † This contribution was credited to Publications Vote.

Library—
Librarian and Scientific Assistant—Miss E. Archer, M.Sc.
Assistant Librarian—Miss A. L. Kent.
Assistant Librarian—Miss F. V. Murray, M.Sc.
Library Assistant (part-time)—Miss B. H. Anderson, B.Sc.
Accounts, Staff, Stores—
M. G. Grace, L.I.C.A.
D. J. Bryant.
R. Viney.
M. A. Elliott.
V. Leonard.
A. Patterson.
C. Munro.
J. Smithwick.
Orders and Transport—
J. M. Derum.
J. J. Foley.
Records—
P. Domec Carré.
W. Gillespie.
P. Knuckey.
F. Butler.
R. McVilly.
Head Typist—
Miss M. Polwarth.
Clerical Assistant to Chief Executive Officer—Miss A. Slattery, B.A.
Clerical Assistant to Chairman—Mrs. N. Roberts.
Clerical Assistant, Waite Institute—Miss J. L. Thomas.
Local Secretary, Canberra—R. F. Williams.
Clerk, Canberra—K. Prowse.
Junior Assistant—S. Young.
Clerk, Division of Animal Health and Nutrition Head-quarters, Melbourne—
H. T. Chadwick.
Local Clerical Officer, Sydney—H. H. Wilson.

2. Secretaries of State Committees.

New South Wales—
Mrs. N. Roberts, 906 Culwulla Chambers, Castlereagh-street, Sydney.
Victoria—
G. A. Cook, M.Sc., B.M.E., A.A.C.I., 314 Albert-street, East Melbourne.
Queensland—
Miss H. F. Todd, Commonwealth Offices, Anzac-square, Brisbane.
South Australia—
J. Ward Walters, Animal Nutrition Laboratory, University of Adelaide.
Western Australia—
L. W. Phillips, M.Sc., A.A.C.I., Technical College, St. George's-terrace, Perth.
Tasmania—
F. J. Carter, c/o. Premier's Office, Hobart.

3. Australia House, London.

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

4. Division of Plant Industry.

At Canberra—
Administration—
Chief—B. T. Dickson, B.A., Ph.D.
Librarian (part-time)—Miss F. Stops, B.A.
Pathology—
Senior Research Officer—H. R. Angell, B.S.Agr., M.S., Ph.D.
Assistant Research Officer—J. G. Bald, M.Agr.Sc., Ph.D.
Assistant Research Officer—W. L. Geach, B.Sc.
Assistant Research Officer—F. W. Hely, B.Sc.Agr.
Assistant Research Officer—W. V. Ludbrook, B.Agr.Sc., Ph.D.

Genetics—
Senior Research Officer—J. R. A. McMillan, D.Sc.Agr., M.S.
Assistant Research Officer—J. Calvert, M.Sc., F.L.S.
Assistant Research Officer—L. Corkill, B.Sc., M.Agr.Sc.
Technical Officer—S. G. Gray, B.Sc.Agr.
Plant Introduction—
Senior Research Officer—A. McTaggart, B.S.A., M.S.A., Ph.D.
Assistant Research Officer—W. Hartley, B.A., Dip.Agr.
Horticulture and General Botany—
Research Officer—C. Barnard, D.Sc.
Weeds Investigations—
Senior Research Officer (part-time)—G. A. Currie, B.Agr.Sc., D.Sc.
Assistant Research Officer—A. B. Cashmore, B.Agr.Sc.
Assistant Research Officer—C. G. Greenham, M.Sc.
Chemistry—
Technical Officer—E. H. Kipps, B.Sc.
Tobacco Investigations—
Officer-in-charge, curing and testing—G. E. Marks.
Technical Officer, curing and testing—G. H. Marks.
Assistant Research Officer (Pathology)—A. V. Hill, B.Sc.Agr., M.Sc.
Assistant Research Officer—J. M. Allan, B.Agr.Sc.
Technical Officer (Genetics)—E. T. Bailey, B.Sc.
At University of Sydney—
Adviser on Chemical Problems of Tobacco Investigation—Professor J. C. Earl, D.Sc., Ph.D., F.I.C.
Assistant Research Officer (Chemistry and Tobacco)—A. J. Tow, B.Sc.
At Moss Vale, New South Wales—
Assistant Research Officer (Genetics)—K. L. Hills, B.Agr.Sc.
At Griffith, New South Wales—
Assistant Research Officer (Weeds Investigations)—R. W. Prunster, B.Sc.Agr.
At Queensland Agricultural High School and College, Lawes—
Assistant Research Officer (Genetics)—C. S. Christian, B.Sc.Agr., M.Sc.
Assistant Research Officer (Plant Introduction)—T. B. Paltridge, B.Sc.
Assistant Research Officer (Weeds Investigations)—R. Roe, B.Sc.Agr.
At Stanthorpe, Queensland—
Assistant Research Officer (Horticultural Investigations)—L. A. Thomas, M.Sc.
At Fitzroyvale, Central Queensland—
Assistant Research Officer (Plant Introduction)—J. F. Miles, B.Sc.Agr.
At University of Tasmania, Hobart—
Senior Pathologist (Fruit Investigations)—W. M. Carne, F.L.S. (Seconded to Department of Commerce for fruit inspection work, London).
Assistant Research Officer (Fruit Investigations)—D. Martin, B.Sc.

5. Division of Soils.

At Waite Agricultural Research Institute—
Chief—Professor J. A. Prescott, D.Sc., A.A.C.I. (part-time).
Soil Survey Officer—J. K. Taylor, M.Sc., B.A.
Assistant Field Officer—T. J. Marshall, M.Agr.Sc. (Abroad on Studentship.)
Assistant Field Officer—G. H. Burvill, B.Sc.Agr. (*vice* T. J. Marshall).
Chemist—J. S. Hosking, M.Sc.
Chemist—A. Walkley, B.Sc., B.A., Ph.D.
Chemist (Chemical analysis by optical spectroscopic methods)—A. C. Oertel, M.Sc.
Technical Officer—P. D. Hooper.
Soil Microbiologist—T. H. Strong, B.Agr.Sc.
Assistant Field Officer—J. G. Baldwin, B.Agr.Sc.
Assistant Field Officer—G. D. Hubble, B.Agr.Sc.
Assistant Field Officer—R. L. Crocker, B.Sc.
Assistant Soil Survey Officer—B. E. Butler, B.Agr.Sc.
At Commonwealth Research Station, Griffith—
Assistant Soil Chemist—H. N. England, B.Sc., A.A.C.I. (Seconded to New Wales Water Conservation and Irrigation Commission.)
At University of Tasmania—
Assistant Soil Chemist—C. G. Stephens, M.Sc.

6. Irrigation Settlement Problems.

At Commonwealth Research Station, Griffith—

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

At Commonwealth Research Station, Merbein—

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

7. Division of Animal Health and Nutrition.

At Melbourne—

Chief—L. B. Bull, D.V.Sc.
Administrative and Secretarial Assistant to Chief—A. J. Vasey, B.Agr.Sc.
Chief Bacteriologist and Officer-in-charge—A. W. Turner, D.Sc., D.V.Sc.
Senior Veterinary Officer (Mastitis Investigations)—D. Murnane, B.V.Sc.
Senior Veterinary Officer (Bovine haematuria, Caseous lymphadenitis)—C. G. Dickinson, B.V.Sc.
Senior Veterinary Officer (Pleuro-pneumonia)—A. D. Campbell, B.V.Sc.
Research Officer (Caseous lymphadenitis Investigations)— A. T. Dann, M.Sc.
Assistant Research Officer (Bacteriologist—Mastitis)—E. Munch-Petersen, M.Sc., Ph.B., M.I.F., F.L.S.
Assistant Research Officer (Bacteriologist)—A. T. Dick, B.Sc.
Technical Officer—Miss C. E. Eales, B.Sc.
Technical Officer—Miss S. E. R. Clarke, B.Agr.Sc.
Biological Assistant—Miss J. Maclean, B.Sc.

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

Acting Officer-in-charge—D. A. Gill, M.R.C.V.S.
Senior Research Officer (Geneticist)—R. B. Kelley, D.V.Sc.
Research Officer (Parasitologist)—G. Kauzal, D.V.Sc.
Research Officer (Parasitologist)—H. McL. Gordon, B.V.Sc.
Research Officer (Footrot, Caseous lymphadenitis, Parasitological Investigations in field)—W. I. B. Beveridge, B.V.Sc.
Assistant Research Officer (Chemistry of Wool)—M. R. Freney, B.Sc.
Assistant Research Officer (Physiologist)—R. H. Watson, B.Sc.Agr.
Field Officer—N. P. Graham, B.V.Sc. (Seconded to Australian Pastoral Research Trust).
Veterinary Field Officer (Fertility of Sheep Investigations)—H. E. B. Shaw, B.V.Sc.
Technical Officer—E. Parrish.
Assistant Technician—H. Munz.
Technical Officer (Statistics)—Miss H. A. Newton-Turner, B.Arch.

At Animal Nutrition Laboratory, University of Adelaide—

Chief Nutrition Officer and Officer-in-charge—H. R. Marston. (On leave abroad.)
Acting Officer-in-Charge—M. L. Mitchell, M.Sc.
Chief Assistant—J. Ward Walters.
Senior Research Officer (Metabolism)—E. W. Lines, B.Sc.
Assistant Research Officer (Chemist)—R. G. Thomas, B.Sc.
Assistant Research Officer (Biochemist)—J. W. H. Lugg, D.Sc., A.I.C., A.A.C.I. (On leave abroad.)
Assistant Research Officer (Biochemist)—I. W. McDonald, B.V.Sc.
Assistant Research Officer (Biochemist)—H. O. Moore, B.Sc., up to 20th April, 1937, thereafter vacant.
Assistant Research Officer (Agrostologist)—D. S. Riceman, B.Agr.Sc.
Junior Research Officer—H. J. Lee, B.Sc.

Technical Officer—J. D. O. Wilson.
Technical Officer—F. C. Farr.
Statistical Recorder—G. W. Bussell.

At Waite Agricultural Research Institute—
Assistant Research Officer (Mineral requirements and field work)—A. W. Peirce, B.Sc.

At Palmerston North, New Zealand—
Dairy Research Officer—W. J. Wiley, D.Sc.

8. Mineral Deficiency of Pastures Investigation.

At Waite Agricultural Research Institute—
Assistant Research Officer (Chemist)—R. E. Shapter, A.A.C.I.
Assistant Research Officer (Agronomist)—C. M. Donald, B.Agr.Sc.

9. Division of Economic Entomology.

At Canberra—
Administration—
Chief—A. J. Nicholson, D.Sc.
Librarian (half-time)—Miss F. Stops, B.A.
Veterinary Entomology—
Principal Research Officer—I. M. Mackerras, B.Sc., M.B., Ch.M.
Assistant Research Officer (Sheep husbandry)—J. H. Riches, B.Sc.Agr., Ph.D.
Assistant Research Officer (Blowfly Investigations)—Mrs. M. J. Mackerras, M.Sc., M.B.
Assistant Research Officer (Blowfly Investigations)—Miss M. Fuller, B.Sc.
Assistant Research Officer (Blowfly Investigations)—D. J. Lee, B.Sc.
Assistant Research Officer (Biochemist)—F. G. Lennox, B.Sc.
Technical Officer—D. L. Hall, Dip.Ag.
Forest Entomology—
Senior Research Officer—G. F. Hill.
Research Officer (Termite Investigations)— F. G. Holdaway, M.Sc., Ph.D.
Assistant Research Officer (Termite Investigations)—F. J Gay, B.Sc. (On leave abroad.)
Technical Officer (Termite Investigations)—T. Greaves.
Agricultural Entomology and Museum—
Senior Research Officer—A. L. Tonnoir.
Assistant Research Officer—T. G. Campbell.
Assistant Research Officer (Grasshopper Investigations)—K. H. L. Key, M.Sc., Ph.D.

At Mooroopna (Victoria)—
Assistant Research Officer (Peach Moth Investigations)—G. A. H. Helson, M.Sc.

In Western Australia—
Assistant Research Officer (Earth Mite Investigations)—K. R. Norris, M.Sc.

Weeds Investigations—
At Canberra—
Senior Research Officer—G. A. Currie, B.Agr.Sc., D.Sc.
At Farnham Royal, England—
Research Officer—S. Garthside, B.Sc.Agr., M.S.
Technical Offlcer—H. T. Galsworthy, B.Sc.
At Le Lavandou, France—
Assistant Research Officer—F. Wilson.
At Uvalde, Texas, United States of America—
Assistant Research Officer—S. G. Kelly, M.S.(Agr.)

Insecticide Investigations—
At University of Sydney—
Assistant Research Officer—J. S. Fitzgerald, Ph.D.

10. Division of Forest Products.

At South Melbourne—
Administration—
Chief—I. H. Boas, M.Sc., A.A.C.I.
Deputy Chief—S. A. Clarke, B.E., A.M.I.E.(Aust.).
Librarian and Records Clerk—Miss M. I. Hulme.

Chemistry Section—
Officer-in-charge—W. E. Cohen, D.Sc., A.A.C.I. (On leave abroad.)
Assistant Research Officer (Chemist) (Acting Officer-in-charge)—A. W. Mackney, M.Sc.
Assistant Research Officer (Chemist—Paper Pulp Investigations)—Miss T. M. Reynolds, M.Sc., Ph.D.
Technical Officer—A. G. Charles.

Seasoning Section—
Officer-in-charge—C. S. Elliot, B.Sc.
Assistant Research Officer—G. W. Wright, B.E.
Technical Officer—J. T. Currie.

Preservation Section—
Officer-in-charge—J. E. Cummins, B.Sc., M.S., A.A.C.I.
Assistant Research Officer—S. F. Rust, M.Sc.
Assistant Research Officer—H. B. Wilson, B.Sc., A.A.C.I.

Wood Structure Section—
Officer-in-charge—H. E. Dadswell, M.Sc., A.A.C.I.
Assistant Research Officer—Miss A. M. Eckersley, M.Sc.
Technical Assistant (part-time)—Miss J. Ellis.
Technical Assistant (part-time)—Miss J. Galbraith.

Timber Mechanics Section—
Officer-in-Charge—I. Langlands, B.E.E.
Assistant Research Officer—R. S. T. Kingston, B.Sc., B.E.
Technical Officer—A. L. Gunn.

Timber Physics Section—
Officer-in-charge—W. L. Greenhill, M.E., Dip.Sc.

Timber Utilization Section—
Officer-in-charge—R. F. Turnbull, B.E.
Assistant Research Officer—F. E. Hutchinson, B.Sc.For., M.N.Z.I.F.
Assistant Research Officer—A. J. Thomas, Dip.For.
Assistant Research Officer—W. R. Ferguson, B.E.

Computation Section—
Technical Officer—B. Whitington.

Maintenance Section—
Technical Officer—S. G. McNeil.

11. Cold Storage Investigations.

At Brisbane Abattoir—
Officer-in-charge—J. R. Vickery, M.Sc., Ph.D.
Research Officer (Biochemist)—E. W. Hicks, B.Sc.
Assistant Research Officer (Biochemist)—W. A. Empey, B.V.Sc.
Assistant Research Officer (Biochemist)—W. J. Scott, B.Agr.Sc.
Investigator—A. R. Riddle, B.A., M.Sc.

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

At Department of Agriculture, Sydney—
Assistant Research Officer (Citrus Preservation)—L. J. Lynch, B.Agr.Sc.

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

12. Radio Research.

At University of Melbourne—
Adviser—L. H. Martin, Ph.D. (part-time).
Investigator—A. F. B. Nickson, B.Sc.
Investigator—F. G. Nicholls, B.Sc.

At University of Sydney—
Research Physicist—D. F. Martyn, A.R.C.Sc., D.Sc., Ph.D.
Research Physicist—G. H. Munro, M.Sc.
Investigator—A. H. Mutton, B.E.
Investigator—W. K. Clothier, B.E., B.Sc.

13. Ore Dressing Investigations.

At University of Melbourne—
Investigator—J. G. Hart, B.Sc.
At School of Mines, Adelaide, South Australia—
Investigator—L. M. Abell.
At School of Mines, Kalgoorlie, Western Australia—
Investigator—G. H. Payne, B.Sc.

14. Other Investigations.

Mineragraphic Investigations—
Investigator—F. L. Stillwell, D.Sc.
Assistant Research Officer—A. Edwards, Ph.D.
Fisheries Investigations—
Officer-in-charge—H. Thompson, M.A., D.Sc.
Adviser (part-time)—Professor W. J. Dakin, D.Sc., F.L.S., F.Z.S.
Fisheries Officer—S. Fowler.
Assistant Research Officer (Chemist)—W. G. Jowett, B.Sc.
Clerk (Records, &c.)—R. D. Elder.
Master of Fisheries Vessel—Captain A. Flett.

Biometrics—
At Canberra—
Research Officer (in charge of Section)—Miss F. E. Allan, M.A., Dip.Ed.
At Melbourne—
Assistant Research Officer—Miss M. Barnard, M.A., B.Sc., Ph.D.

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

(i) *Bulletins.*

No. 102—Studies of Selected Pasture Grasses : The Measurement of the Xerophytism of any Species ; by T. B. Paltridge, B.Sc., and H. K. C. Mair, B.Sc.

No. 103.—*Wojnowicia graminis* (McAlp.) Sacc. and D. Sacc. in relation to Foot Rot of Wheat in Australia ; by W. V. Ludbrook, B.Agr.Sc., Ph.D.

No. 104.—Investigations on the Occurrence and Inheritance of the Grass Clump Character in Crosses between Varieties of *Triticum vulgare* (Vill) ; by J. R. A. McMillan, B.Sc.Agr. (Sydney), M.S. (Cornell).

No. 105.—Investigations on the Associated Growth of Herbage Plants.

(1) On the Nitrogen Accretion of Pasture Grasses when Grown in Association with Legumes ; by H. C. Trumble, M.Agr.Sc., and T. H. Strong, B.Agr.Sc.

(2) The Influence of Nitrogen and Phosphorus Treatment on the Yield and Chemical Composition of Wimmera Rye-grass and Subterranean Clover, Grown Separately and in Association ; by H. C. Trumble, M.Agr.Sc., and R. E. Shapter, A.A.C.I.

(3) The Yield and Nitrogen Content of a Perennial Grass (*Phalaris tuberosa*) when Grown in Association with Annual Legumes; by H. C. Trumble, M.Agr.Sc., and R. E. Shapter, A.A.C.I.

No. 106.—Investigations on " Spotted Wilt " of Tomatoes—III. Infection in Field Plots ; by J. G. Bald, M.Agr.Sc., Ph.D.

No. 107.—A Soil Survey of the Coomealla, Wentworth (Curlwaa), and Pomona Irrigation Settlements, New South Wales ; by T. J. Marshall, M.Agr.Sc., and Allan Walkley, B.Sc., B.A., Ph.D.

No. 108.—The Basaltic Soils of Northern Tasmania ; by C. G. Stephens, M.Sc.

No. 109.—The Variability of Plant Density in Fields of Wheat and its Effect on Yield ; by H. Fairfield Smith, B.Sc.(Agr.), M.S.A.

(ii) *Pamphlets.*

No. 65.—A Survey of the Sheep and Wool Industry in North-eastern Asia. With special reference to Manchukuo, Korea, and Japan ; by I. Clunies Ross, D.V.Sc.

No. 66.—The Sheep Blowfly Problem in Australia : Results of Some Recent Investigations ; by I. M. Mackerras, M.B., Ch.M., B.Sc.

No. 67.—The Shrinkage of Australian Timbers. Part 1.—A New Method of Determining Shrinkages and Shrinkage Figures for a Number of Australian Species: (Division of Forest Products—Technical Paper No. 21); by W. L. Greenhill, M.E.

No. 68.—A Guide to the Seasoning of Australian Timbers, Part 2: (Division of Forest Products—Technical Paper No. 22); by W. L. Greenhill, M.E., and A. J. Thomas, Dip.For.

No. 69.—Observations on some Wool Samples from North-eastern Asia; by H. Munz.

No. 70.—Further Observations on Soil Erosion and Sand Drift, with Special Reference to South-western Queensland; by F. N. Ratcliffe, B.A.

(iii) *Trade Circulars.*

No. 32.—Causes and Detection of Brittleness in Wood.

No. 33.—Deterioration of Timber Caused by Fungi. Part 1 Decay.

No. 34.—Sawing Methods. I.—Quarter Sawing.

No. 35.—Faults in Wooden Floors.

No. 36.—Termites (White Ants).

No. 37.—Kiln Instruments.

No. 38.—Deterioration of Timber Caused by Fungi. Part 2—Staining Fungi.

(iv) *Quarterly Journal.*

Vol. 9, No. 3, August, 1936.
Vol. 9, No. 4, November, 1936.
Vol. 10, No. 1, February, 1937.
Vol. 10, No. 2, May, 1937.

(v) *Annual Report for the year ending 30th June,* 1936.

(vi) *C.S.I.R.—Ten Years of Progress* 1926–1936.

XIII. ACKNOWLEDGMENTS.

In various sections of this report reference has been made to the valuable assistance afforded by many organizations and individuals. The Council desires to express its gratitude for the help given by these bodies and persons in providing laboratory accommodation and other facilities and in many other ways. In particular, it desires to make special reference to the help given by the various State Departments, particularly those of Agriculture, and by the Universities, and to the contributions either in money or in kind provided by such bodies as the Australian Pastoral Research Trust, the Australian Wool Board, the Australian Dairy Cattle Research Association, the Australian Dried Fruits Control Board, and by other bodies, companies, and individuals. The Council also wishes to acknowledge the assistance it has received from its State Committees and other Committees, the members of which have placed their knowledge and experience so freely at its disposal.

G. A. JULIUS, Chairman
DAVID RIVETT
A. E. V. RICHARDSON
} Executive Committee.

G. A. COOK, Acting Secretary.

8th September, 1937.

APPENDIX.

A.—PERSONNEL OF THE COUNCIL AND OF ITS VARIOUS COMMITTEES.

COUNCIL (AS AT 30TH JUNE, 1937).

EXECUTIVE.

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

CHAIRMEN OF STATE COMMITTEES.

Professor R. D. Watt, M.A., B.Sc. (New South Wales).
Russell Grimwade, C.B.E., B.Sc. (Victoria).
Professor H. C. Richards, D.Sc. (Queensland).
T. E. Field (South Australia).
E. H. B. Lefroy (Western Australia).
P. E. Keam (Tasmania).

CO-OPTED MEMBERS.

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

STATE COMMITTEES (AS AT 30TH JUNE, 1937).

NEW SOUTH WALES.

Professor R. D. Watt, M.A., B.Sc. (*Chairman*).
E. C. Andrews, B.A., F.G.S.
Professor Sir Henry E. Barraclough, K.B.E., V.D., B.E., M.M.E., M.Inst.C.E., M.I.Mech.E.
Professor W. J. Dakin, D.Sc.
W. R. Hebblewhite, B.E.
C. H. Hoskins.
The Hon. Sir Norman Kater, Kt., M.L.C., M.B., Ch.M.
F. Leverrier, K.C., B.A., B.Sc.
J. Nangle, O.B.E., F.R.A.S.
Sir Frederick McMaster, Kt.
R. J. Noble, B.Sc.(Agr.), M.Sc., Ph.D.
E. D. Ogilvie, B.A.
Professor T. G. B. Osborn, D.Sc.
Professor J. D. Stewart, M.R.C.V.S., B.V.Sc.
G. D. Ross.
Professor J. C. Earl, D.Sc., Ph.D., F.I.C.
F. J. Walker.
Lieut.-Col. H. F. White, C.M.G., D.S.O.

VICTORIA.

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

SOUTH AUSTRALIA.

T. E. Field (*Chairman*).
E. H. Bakewell.
Professor Kerr Grant, M.Sc., F.Inst.P.
W. A. Hargreaves, M.A., B.C.E., D.Sc., F.I.C.
J. H. Gosse.
Professor T. H. Johnston, M.A., D.Sc.
Professor A. J. Perkins.
F. T. Perry.
Professor J. A. Prescott, D.Sc.
L. K. Ward, B.A., B.E., D.Sc.
T. M. Hardy.

QUEENSLAND.

Professor H. C. Richards, D.Sc. (*Chairman*).
Professor H. Alcock, M.A.
Professor L. S. Bagster, D.Sc.
J. D. Bell.
A. E. Graham.
J. B. Henderson, O.B.E., F.I.C.
T. L. Jones.
Professor E. J. Goddard, B.A., D.Sc.
Professor J. K. Murray, B.A., B.Sc.Agr.
Professor T. Parnell, M.A.
W. L. Payne.
Professor H. R. Seddon, D.V.Sc.
R. Veitch, B.Sc.Agr., B.Sc.For., F.E.S.

WESTERN AUSTRALIA.

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

TASMANIA.

P. E. Kearn (*Chairman*).
N. P. Booth, F.I.C.
Professor A. Burn, M.Sc., B.E.
F. H. Foster, M.H.A., B.M.E., A.M.I.E.Aust.
Professor A. L. McAulay, M.A., B.Sc., Ph.D., F.Inst.P.
D. O. Meredith, A.Inst.M.M., M.I.E.Aust., M.A.C.S.
A. K. McGaw, C.M.G.
W. E. MacLean, M.I.E.Aust.
F. H. Peacock.
The Hon. R. O. Shoobridge, M.L.C.
S. W. Steane, B.A., F.R.G.S.
F. E. Ward.

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

Professor J. A. Prescott, D.Sc., Waite Agricultural Research Institute, University of Adelaide (*Chairman*).
B. T. Dickson, B.A., Ph.D., Chief, Division of Plant Industry, C.S.I.R.
A. L. Johnstone, Commonwealth Dried Fruits Control Board.
P. Malloch, Commonwealth Dried Fruits Control Board.

COMMONWEALTH RESEARCH STATION, MERBEIN—ADVISORY COMMITTEE.

D. C. Winterbottom, Mildura Packers' Association (*Chairman*).
A. R. McConchie, State Rivers and Water Supply Commission, Red Cliffs, Victoria.
A. Lever, Mildura Shire Council.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein
F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, Griffith, New South Wales.
J. A. Lockhead, Mildura Shire Council.
A. E. Cameron, Red Cliffs Settlement.
J. Gordon, Citrus Growers' Association, Merbein.
W. Heaysman, Cardross, Horticultural Society.
L. W. Andrew, Waikerie, South Australia.
O. Weste, Renmark, South Australia.

COMMONWEALTH RESEARCH STATION, GRIFFITH—ADVISORY COMMITTEE.

F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, Griffith, New South Wales (*Chairman*).
A. G. Kubank, Murrumbidgee Irrigation Rice Growers' Co-operative Society.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
T. T. Morley, Griffith Producers' Co-operative Co. Ltd.
L. J. Rydon, Yenda Producers' Co-operative Society Ltd.
E. S. West, B.Sc., M.S., Commonwealth Research Station, Griffith.
V. C. Williams, Murrumbidgee Irrigation Areas Research Bureau, Griffith.

CITRUS PRESERVATION TECHNICAL ADVISORY COMMITTEE.

J. R. Vickery, M.Sc., Ph.D., Section of Food Preservation and Transport, C.S.I.R. (*Chairman*).
Associate-Professor W. J. Young, D.Sc., University of Melbourne.
E. S. West, B.Sc., M.S., Commonwealth Research Station, Griffith, New South Wales.
C. G. Savage, Director of Fruit Culture, Department of Agriculture, New South Wales.
R. J. Benton, Fruit Instructor, Department of Agriculture, New South Wales.
F. M. Read, M.Agr.Sc., Chief Inspector of Horticulture, Department of Agriculture, Victoria.
J. Hepburn, Manager, Government Cool Stores, Melbourne.
A. G. Strickland, M.Agr.Sc., Chief Horticultural Officer, Department of Agriculture, South Australia.

RADIO RESEARCH BOARD.

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