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THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

FOURTEENTH ANNUAL REPORT

OF THE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH,

FOR

YEAR 1939-40.

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COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research

FOURTEENTH ANNUAL REPORT (FOR YEAR ENDED 30TH JUNE, 1940).

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* 1920–1939, 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; the testing and standardization of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardization; and the establishment of a bureau of information relating to scientific and technical matters.

2. *The War and the Council's Activities.*—With the outbreak of war, the Council at once considered the steps which it could usefully take to re-orientate its investigations with a view to rendering assistance in as direct a way as possible to the war effort of the British Commonwealth of Nations.

At first, and particularly in the case of those Divisions of the Council concerned with problems of primary industry, it was not easy to make an immediate change-over, but as time went on and as the national effort gained momentum, it was possible to devote more and more attention to studies directly related to the nation's war requirements. Briefly, these studies have covered questions such as what Australian materials can replace materials previously imported from outside countries, but which by reason of the necessity of conserving foreign exchange or for other reasons can no longer be obtained; how best can Australian materials be used in new industries; what can be done to reduce the difficulties caused by any particular damming up of Australian exports; and what can be done to alleviate the difficulties caused by the general upset of normal conditions. Amongst the older Divisions of the Council, the Division of Forest Products was particularly well placed to afford valuable assistance. For instance, it has accumulated over the years a large amount of information concerning the properties of different Australian timbers, and thus was able to act as an immediate source of information of how to replace imports with local products and how best to use local timbers in the many new constructions required for war purposes. It is also devoting much attention to studies of Australian timbers from the point of view of their use in different parts of aircraft. In addition the Division's work on flax is proving of particular value at the moment, not only from an Australian but from an Empire point of view. In the past, the United Kingdom and Australia have depended largely on European countries for the all-important flax which is so necessary in the production of cordage, tarpaulins, and the like. One of the main difficulties confronting the industry, namely, the problem of economically retting flax straw, has been minimized largely as a result of the Division's work. In passing, it is of interest to note that the Council's work on paper pulp, which is still being continued by the Division of Forest Products, has been of particular value during the present crisis, for as a result of it three large industries have come into existence in Australia and are producing, respectively, writing papers, newsprint, and wrapping papers.

The Division of Plant Industry is now looking into the production of medicinal plants in Australia and the production of different fibres, some from Australian indigenous plants. An interesting war-time problem which the Merbein Laboratory has solved concerns the supply of the necessary potash for the dipping of dried vine fruits. Potash is now difficult to obtain, but the Station has shown that the shortage can be overcome by extracting potash from vine prunings burnt in a particular way. The Fisheries Division is giving attention to the production of fish oils which are rich in vitamins and are needed to replace the cod-liver oil that it is no longer possible to obtain from Europe. This Division is also looking into problems of the production of tinned fish in Australia. The Division of Economic Entomology is handling the problem of the wheat weevil, which may become serious with the damming up of wheat exports. The Division of Food Preservation and Transport is working on the drying of various foodstuffs with a view to their export in that condition and a consequent considerable saving of freight space. Particular attention is being given to eggs.

So much for a brief account of the war work of the first formed and primary industry Divisions of the Council. The recent extension of the Council into the field of secondary industries, with the consequent formation of new Divisions, has also resulted in a considerable increase in the volume of the Council's war work. These Divisions, which are mentioned in the subsequent section, are all engaged on work either of direct defence value, as, for example, that of the Division of Aeronautics and of the National Standards Laboratory, or of indirect value through the assistance they are affording manufacturing industries.

3. *Secondary Industry Research.*—Considerable progress has been made in the Council's activities on the secondary industrial side. The building in the grounds of the University of Sydney to house the Australian National Standards Laboratory is complete, and the equipment is now beginning to arrive from abroad. Two of the three senior officers of the laboratory have returned to Australia after their visit to the National Physical Laboratory in England, and the third is expected at an early date. Six others are still at Teddington, and further staff is steadily being appointed here. Active assistance is already being given to industry in the direction of the production and checking of gauges and in other ways. With the rapid increase of war requirements of all sorts, there has been a heavy demand for gauges and measuring equipment in general.

The Division of Aeronautics went into its new building at Fishermen's Bend, Victoria, towards the end of the period under review, although the complete initial equipment of the laboratory has not yet been received; in particular the large wind tunnel for aerodynamical work will not be ready for some months to come. The Division is, nevertheless, actively engaged on a study of various problems confronting the Australian aircraft industry.

Plans for a laboratory for the newly formed Division of Industrial Chemistry are now complete. The building is to be erected alongside the Division of Aeronautics at Melbourne, but it is not expected that the erection will be complete until some time in 1941. The nucleus of a staff for the Division has now been appointed, and the authorities of various existing laboratories have very kindly offered to accommodate these investigators for the time being; some investigations are now being actively pursued in this way. The Division is already experiencing a considerable demand for its services on the part of different industries, and it is now deciding on its initial programme. It is proposed in the early years to make a commencement in the fields of industrial minerals, wool, leather and fellmongery, and dairy products.

Finally, the Information Section is meeting an ever-increasing demand on the part of industry for assistance in problems arising very largely out of abnormal conditions caused by the war. The staff of the Section has recently been increased, and much information has been given to Government organizations and individual manufacturers on methods of production of materials no longer readily obtainable in Australia, on the use of Australian substitutes for such materials, and on many other matters.

4. *Formation of Divisions.*—During the period under review the former Section of Food Preservation and Transport and the Section of Fisheries were given the status of Divisions.

5. *Prickly Pear Work.*—The year under review saw the disbandment of the Commonwealth Prickly Pear Board, the independent body which for many years had been controlling the programme of prickly pear research in which the Commonwealth and the States of Queensland and New South Wales co-operated. It had been generally felt for some time prior to the disbandment of the Board that the prickly pear problem had been satisfactorily solved by the introduction of *Cactoblastis*, and that while there undoubtedly remained some aspects of the problem requiring scientific investigation, the necessary basis for effective control of the pear had been obtained. It was, therefore, considered that the carrying out of the actual measures of control could well be left to the State authorities concerned. With the dissolution of the Board, it was arranged that the whole of the Board's staff, except two officers who had resigned, would be taken over either by the Queensland or New South Wales authorities or by the Council. It was also arranged that the Council would continue the Board's former overseas work on Noogoora burr, and that the two States would continue the prickly pear work within their respective borders. An account of the Board's work is being prepared and will be published at an early date. Thus ends the official life of a body which was responsible for the fundamental information which led to the recovery in Australia of a province of some 60,000,000 acres. The Council would like to point out that while it was a partner in this outstandingly successful application of science, the work was not its own as is believed in some quarters, but was definitely the work of a partnership controlled by an independent Board representative of the Commonwealth and the two States concerned. Further, much of the success obtained has been due to the energetic way in which the State authorities concerned applied the Board's results.

6. *Head Office.*—During the year, the land at 314 Albert-street on which the Council's head office has been situated for many years was acquired by the Commonwealth, and further accommodation was erected on it. In this way, the former very serious congestion of the accounts and records work of the office has been overcome. The new building also serves to house the Council's main library and the staff of the Information Section.

7. *Finance.*—The total expenditure of the Council during the financial year 1939–40 was £304,933, of which £74,030 was contributed from sources other than the Commonwealth Treasury. The Council is particularly gratified with the way in which the various contributing bodies continue to support it. Among the many contributions received, reference may be made to those of the Australian Wool Board, the Commonwealth Bank, the Australian Dairy Cattle Research Association, the Australian Pastoral Research Trust, the Dried Fruits Control Board, and the New South Wales Water Conservation and Irrigation Commission.

II. PLANT INVESTIGATIONS.

1. *General.*—Reference was made in the previous report to the importance of pastures and to the Division of Plant Industry's commencement of work in the field of agrostology or pasture study. Since his appointment, the Senior Officer of the Agrostology Section has made a pasture survey of the Wakool and nearby irrigation areas, and is at present engaged in surveying the main pasture areas of Queensland with a view to determining what lines of effort are most likely to maintain and improve the carrying capacity of those pastures.

Because of the fact that most of the weeds the Division is asked to investigate affect agricultural or pastoral areas, it has been arranged that the Council's weeds investigations shall be carried out under the aegis of the Agrostology Section dealing with pasture problems.

A conference of Commonwealth and State officers concerned with tobacco problems met in Western Australia in July, 1939. The meetings enabled these officers still further to extend their knowledge of the general position of tobacco in Australia, and particularly the importance of Western Australia. A visit was made to Manjimup, the centre of the industry in that State.

In view of the possible need of having local supplies of certain medicinal drugs, arrangements are being made to grow them in Australia. The first need is to determine suitable climatic and soil conditions; the Division has this work in hand.

2. *Plant Introduction.*—(i) *General.*—During the year, just over 300 strains and species of plants were introduced for testing, including a number of fibre, medicinal, and drug plants. Plant Introduction Inventory No. 7, which lists these, is being compiled. Samples of seed of 137 plants were distributed to the several States, 344 to other Sections of the Division, and 226 lots were sent abroad.

(ii) *Tests at Canberra, Australian Capital Territory.*—At the Black Mountain Experiment Area, 300 rows of grasses and legumes were planted for initial trial, while at the Duntroon Experiment Station 140 multiplier rows and about 200 grass plots and a similar number of legumes were established. The growing season was dry between November and April, but a number of introductions remained green throughout, including Agropyrons, Bromes, *Elymus* spp., *Dactylis* spp., lucernes, especially "Bolivian" and soy beans, notably "Virginia". Following good rains in April, some introductions made very promising autumn growth, particularly Agropyrons, *Elymus* spp., *Phalaris* spp., a strain of cocksfoot, Iraq, Turkish, Bolivian, and Smooth Peruvian lucernes. The grasses *Festuca Mairei*, *Phalaris stenoptera*, strains of cocksfoot, and South American strains of lucerne continued to make very good growth during the winter.

Examination of the persistency, productivity, and palatability of introduced pasture species was continued on the randomized plots at Duntroon; the data will be compiled after the spring of 1940. Sward plots established for periods of five, six and seven years still had good ground cover with certain *Festuca* spp., *Dactylis glomerata* v. *hispanica*, *Phalaris stenoptera*, and *Trifolium tumens*.

(iii) *Tests at Lawes, Queensland.*—A feature of the year's work was the establishment of half-acre blocks of *Brachiaria brizantha*, *Paspalum scrobiculatum*, *Urochloa pullulans*, *Panicum maximum*, and Rhodes grass, the last as a control, to determine their value for grazing. These four summer-growing grasses are deemed the most promising of the introductions now being tried at Lawes. From a series of replicated plots subjected to grazing by sheep, it was evident that *Paspalum scrobiculatum* is extremely palatable, while on a yield basis *Brachiaria brizantha*, *Dichanthum nodosum*, a selection of *Panicum maximum*, *Urochloa pullulans*, and *Paspalum scrobiculatum* were placed in that order.

A number of soy bean varieties were subjected to test, and the best yields were given by late varieties such as "Charlee", Haberlandt", "Creole", and "Georgian".

Regional trials of selected grass introductions were conducted at Caboolture, Brookstead, and Surat.

(iv) *Tests at "Fitzroyvale", Central Queensland.*—Various legumes are under test at "Fitzroyvale", including hairy and smooth Peruvian lucerne, Lespedezas, Arachis, *Glycine javanica* and *Stizolobium. Lespedeza stipulacea*, after trials covering three years, is the most successful, and is the only *Lespedeza* to produce seed satisfactorily. The outstanding legume is *Stylosanthes guyannensis*, which is tending to be known as "Brazilian lucerne"; it is being subjected to special study. It is strikingly promising at South Johnstone, where the officer in charge of the Queensland Tropical Research Station is carrying on trials. At "Fitzroyvale" it is a vigorous component of grass-legume plots, and can withstand grazing by cattle. Among grasses, *Brachiaria decumbens* and Kenya No. 1 strain of Rhodes grass are the two most outstanding, and these, together with a number of other good types, are incorporated with *S. guyannensis* in pasture plots for grazing trials.

3. *Pasture Plant Breeding.*—(i) *At Canberra.*—The species being investigated at Canberra include subterranean clover, other annual legumes, cocksfoot, wallaby grasses, and prairie grass.

With subterranean clover, the work is aimed at obtaining improved strains for the Southern Tablelands, and earlier flowering types for drier areas. The combination of early maturity with good autumn growth has not yet been achieved.

Annual medics and clovers have been collected extensively and examined to obtain types which would be suitable for areas too dry or too alkaline for subterranean clover. Some apparently promising material has been obtained and is ready for complete testing in the areas for which it has been selected. Extensive studies have been made on the flowering and fruiting characteristics of the more important annual species of *Medicago*, and further investigations connected with intra- and inter-specific hybridization have been conducted. The problems of hard-seededness and dormancy have also received attention.

Of the numerous strains of cocksfoot tested as single plants and swards, only two introductions, from the Mediterranean region, have proved satisfactory after three years of testing. A complete breeding programme has been inaugurated with these two varieties, and already partly improved strains are being produced from material selected from them.

The collection of seed of wallaby grass (*Danthonia* spp.) from all available sources has been continued. The necessary classification and seed increase of this material is being carried out, and preliminary observations are being made on the comparative behaviour of samples set out as single plants and sown pasture swards. An extensive experiment has been commenced to ascertain the capacity of three common species to grow in association with various strains of seventeen species of legumes. The problems associated with seed germination are also receiving attention.

The disease-resistant strains of *Bromus* produced by selection from certain of the many introduced samples examined have been grown with subterranean clover and tested under grazed sward conditions.

(ii) *At Lawes, Queensland.*—During the past year, the breeding work has been concentrated mainly upon the *Medicago* spp., chiefly lucerne, and on Rhodes grass. The investigations on lucerne are directed towards obtaining better hay and grazing types. Results obtained to date indicate that Australian hay types are at least equal to newly introduced varieties with respect to hay yield and plant survival. Under conditions of rotational grazing, hay types appear to be quite satisfactory, and they would doubtless be an advantage when sown with tall-growing grasses. Four strains of Rhodes grass have been multiplied, and are being tested at six centres in Queensland, extending from the Atherton Tableland to the Darling Downs. Selections from a strain derived from Kenya appear to be most promising. The programme with *Phalaris* has been continued in a restricted form, but little progress has been made with native species, owing to lack of assistance.

(iii) *At Moss Vale, New South Wales.*—Pasture plant breeding work at Moss Vale is being conducted with the following species:—perennial rye-grass, cocksfoot, white clover, red clover, and subterranean clover. With perennial rye-grass there is evidence that certain selected local material can be used as the basis of a strain which will be superior in several important respects to the Hawkes Bay strains. Attempts are being made to modify Victorian and Akaroa cocksfoot to obtain improved seasonal production. In white clover, Ladino and larger-leafed types appear most suitable, and a promising Italian Ladino is being mass-selected. In red clover it is found that, under the conditions at the Station, the generally accepted, long-lived types, such as Montgomery Late, are actually less persistent than the normally accepted, short-lived types of the broad red class. "Wenigup" strain of subterranean clover shows promise, particularly in regard to winter production, and improved types are being sought. Tests with subterranean clover seed indicate that germination is controlled by two independent factors—hard-seededness and dormancy.

4. *Pasture Investigations.*—(i) *At Canberra.*—The Australian Capital Territory is representative of an extensive tract of country that carries a relatively large number of sheep and produces some of the best fine merino wool in Australia. The object of the work at Canberra is to determine the most suitable methods of management of sown pastures and to learn more about the native *Danthonia* pastures. Attention is also being given to the improvement of depleted native pastures.

Ten experiments are in progress. The first is to determine the potentialities of a *Phalaris tuberosa*-subterranean clover pasture, the effects on the grazing animal and on the pasture of three different frequencies of grazing being studied in detail.

Another experiment was undertaken to compare the effects of cultivation, superphosphate, seeding with subterranean clover, and combinations of these treatments, on natural *Danthonia* grassland. Already the necessity for surface cultivation and superphosphate for the successful introduction of subterranean clover has been demonstrated. Top-dressing of natural pasture with superphosphate gave a large increase in the ball clover, and cultivation alone promoted the growth of native grasses. In another experiment on the effect of varying amounts of superphosphate per acre on subterranean clover, it was found that the superphosphate did not exert much influence on the actual establishment of the clover. The yield of clover was significantly increased as the application of superphosphate was increased from nil to $1\frac{1}{2}$ cwt.

At the Duntroon experiment area, a pasture species strain experiment is being made, in co-operation with the New South Wales Department of Agriculture. Strains of perennial rye-grass, Wimmera rye-grass, Italian rye-grass, *Phalaris tuberosa*, red, white, and subterranean clovers are being used. Survival of this year's severe summer drought was fairly satisfactory, except the red clover species.

An attempt was made to determine whether six other pasture species could be incorporated into a *Danthonia* sward by surface cultivation. A high percentage of five of them died out owing to competition from the other, which was subterranean clover.

Other experiments deal with summer-growing and winter-growing grasses and legumes, the influence of the calcium carbonate and sulphate and gypsum on subterranean clover, and the influence of strains of *Rhizobium* on unthriftiness of lucerne.

(ii) *In Western Australia.*—Work in Western Australia is concerned mainly with pastures in the 17-in. to 25-in. rainfall belt. The productivity and persistency of selected pasture species are being studied at seven centres, from Walebing in the north to Kojonup in the south. Stalling in subterranean clover, deterioration in Wimmera rye-grass swards, competition by weeds such as *Erodium botrys* and capeweed, and the climatic range and value of lupins are the main aspects of the problem. Wimmera rye-grass proved to be the most productive species during the year. Early subterranean clover was satisfactory at Walebing, and higher yields were obtained in association with grasses than alone.

Variation in *Ehrharta calycina* Thunb., lupins, clovers, and annual medics is being studied, and the vigour, yield, time of flowering, as well as taxonomic characters, are being compared. Blue lupins and subterranean clover are also being studied from the point of view of their influence on soil fertility, the yield of Wimmera rye-grass being one of the means of measuring their value. Experiments are also being made on the influence of some of the major and minor elements in relation to pastures in the unproductive areas of sandy soils north and south of Perth.

(iii) *In Queensland.*—In the region west of the 25-in. isohyet, which may be classed as semi-arid, improvement of pastures by the use of sown species, except perhaps native grasses, is impracticable. These areas have suffered from poor grazing practices and pasture management. Precise knowledge of the species forming the pasture complex, and data to serve as a guide for the correct utilization of pastures in the different associations are required. With a view to obtaining these, experiments are now in progress on an area of 600 acres at " Gilruth Plains " to determine the effect of different grazing systems on the yield and on the botanical and chemical composition of the pasture, and records are being made of the floristic composition of the major plant associations in southern Queensland and of pastures within those associations.

(iv) *Irrigated Pastures.*—At Wakool and Griffith, summer-growing and winter-growing pasture mixtures have been sown on different soil types, and experiments to determine how best to use irrigation water to produce the maximum dry matter per unit of water are in progress.

5. *Weeds Investigations.*—(i) *General.*—The weeds being investigated are chiefly those of agricultural and pastoral areas, and the most likely means of controlling many of them is by the proper use of pastures. The investigations undertaken in the Division of Plant Industry have, therefore, been allocated to the Agrostology Section.

(ii) *At Canberra.*—Physiological investigations have been continued, with a view to the determination of the concentration of organic and inorganic arsenicals required to kill deep-rooted weeds. The How ultra-micro method has been used in the analyses. For the determination of

labile carbohydrate in plant tissue, a micro-method has been devised, and analyses have been made of material collected in the course of life-history studies of nut grass and Cape tulip. These analyses have given valuable information regarding the optimal stage of growth at which to attempt control.

(iii) *In New South Wales.*—Spraying experiments to control skeleton weed (*Chondrilla juncea*) were continued at Wagga. Unusually wet conditions during October and November, 1939, prevented the execution of projected work under weather conditions approximating those in previous dry years. However, spraying during those months showed that arsenic pentoxide, with or without special penetrating agents, was translocated in skeleton weed, even though there was not a water deficit at the time of spraying, some plants being killed to a depth of 20 inches. In another experiment a greater killing effect was found to be associated with sprays in which the proportions of pentoxide to sulphuric acid were high. In this year's trials, arsenic pentoxide was found to be more toxic than the trioxide, various tar distillates, kerosene solutions of tetraethyl lead, or mercurated ethyl oleate.

St. John's Wort (*Hypericum perforatum*).—A survey was made of the incidence of this weed in the district around Mudgee. There, as at Tumbarumba and in Victoria, it was a problem only in the hilly country. Observations were made on the Tumbarumba area, where it persists in the plots sown to white clover, but has apparently disappeared from those sown to subterranean clover.

Blackberry (*Rubus fruticosus*).—Good management of land has been shown to be the only practicable means of controlling blackberry elsewhere. Nevertheless, spraying experiments with a view to controlling it in the Batlow district were continued. The re-growth following the initial application showed greater resistance to succeeding applications of poisons.

(iv) *In Queensland.*—Experiments on the control of nut grass (*Cyperus rotundus*) include rotation of crops, cultivation every three weeks during the summer, the use of competing plants, and poisons. The rotation experiment, in which cereals are cropped in two seasons, with intense cultivation of the soil in the intervening periods, is now in its second year, and appears to promise well. Three other rotations are also in progress. In another experiment extending over four years, a competing grass, *Sehima nervosum*, greatly reduced the incidence of the nut grass. Unfortunately, the grass does not seed in the district, and only small supplies from other sources are available. A more palatable grass may be more suitable. Arsenic appears to be worse than useless against nut grass, because its use results in multiplication of the corms and the destruction of competing plants.

Experiments in the control of galvanized burr (*Bassia Birchii*) have been in progress for three years in the St. George district. It is interesting to record that changes in the flora of the experimental areas are already taking place, species of pasture plants that have disappeared for years again being seen in the experiment paddocks. No more trials of sown pastures are being made. Experiments with poisons are in progress.

Mintweed (*Salvia reflexa*) appears in the Pittsworth Shire and surrounding areas on country from which grass has disappeared as a result of overstocking. In some other places, *Urochloa panicoides* appears naturally and controls the growth of the weed; consequently, experiments are being made to determine its usefulness in the Pittsworth Shire. In experiments in which stock was excluded, no significant results could be observed. Cultivation after every rain that is followed by germination of seed, or after 10 per cent. of the weed is flowering, appears to reduce infestation considerably and to double subsequent crop yield. The work is still in progress. Sprays eliminate the developing plants, but re-infestation from seed in the ground immediately follows.

(v) *In Victoria.*—Hoary cress (*Lepidium draba*) is regarded at present as the worst weed in Victoria. Trials of the effect of sown pastures and of different cultivation practices are in progress. These trials will be of value not only in their application to the control of the weed but because of the better understanding gained of cultivation practices and pasture mixtures suitable for the district.

Spraying with poisons is also being tried; the effects of different poisons, of different penetrating agents, of seasons, weather conditions, and time of day, are all being studied.

(vi) *In Western Australia.*—Wild turnip (*Brassica tournefortii*).—Satisfactory weather conditions permitted the conclusion of the spray trials made in co-operation with the Department of Agriculture, Western Australia; 2 and 3 per cent. copper sulphate, also 5 and 7½ per cent. sulphuric acid, applied at 100 gallons per acre, significantly reduced the weed population, but did not significantly increase the wheat yields, probably on account of spray injury. A short account of the work is being published in the Journal of the Western Australian Department of Agriculture.

(vii) *In the Irrigation Areas.*—As the means of control of the bulrush (*Typha* spp.) already reported have proved eminently satisfactory, no more field work has been done. Pot experiments at Griffith on the effect of depth of water on the results of cutting the plants were completed.

Repeated cutting off of the water reed (*Phragmites communis*) at ground level did not significantly reduce the population, but the size of the plants was affected. Successful experiments were made with 5 and 15 per cent. sodium chlorate solutions, controlling the weed growing in dry soil and in water. Experiments to ascertain the effects of various concentrations of sodium chlorate are in progress. Already the New South Wales Water Conservation and Irrigation Commission has begun spraying with a view to controlling the reed on main canal banks.

6. *Horticultural Investigations.*—Investigations have been continued in regard to the non-parasitic and storage disorders of apples (Tasmania), deciduous fruit tree rootstocks (Stanthorpe, Queensland), problems of dried grape production (Merbein, Victoria), and of citrus under irrigation (Griffith, New South Wales). An additional problem has also been undertaken in connexion with the growing of certain drug plants in Australia.

A two-roomed weatherboard and fibro-cement laboratory has been erected on the site of the experimental plots at Stanthorpe, and a five-roomed weatherboard laboratory is being built at Huonville in Tasmania. The site upon which the Huonville laboratory is being constructed was made available to the Council at a nominal rental by the Education Department of Tasmania. Since the inception of the work in Tasmania in 1932, temporary laboratory accommodation has been provided in Hobart by the University of Tasmania. The investigations at Stanthorpe, which were commenced in 1932, were previously carried out under considerable difficulty owing to the absence of laboratory space and equipment. The facilities provided by the new laboratories will very materially assist in the efficient prosecution of research at these two centres. The progress of these investigations is described below.

(i) *In Tasmania.*—To assist the apple industry in adopting the most efficient method of harvesting and storing fruit to avoid wastage during the period of short shipping and refrigerated space occasioned by the war, a pamphlet was issued this season in conjunction with the Department of Commerce. This pamphlet contained the main points of immediate practical value gathered from export experience and experiments in Tasmania, and recommendations for picking varieties for export and local storage. The programme of work has been re-orientated in several aspects, and particular attention has been devoted to the problem of increasing the efficiency of present cool storage practice and of increasing the life of fruit held in common storage.

(*a*) *Field Disorders.*—The incidence of internal cork was low in 1939, and, as the borax treatment has become general horticultural practice, examples of this disorder were relatively uncommon. The effect of soil dressings of ½ to 2 lb. of borax per tree has lasted for four years. The incidence of tree pit was generally low and was associated with small fruit size.

(*b*) *Storage Disorders in Normal Atmosphere.*—Routine storage tests showed that, in general, reduced fruit size due to the dry season was associated with a low incidence of all disorders. Previous results on their relationship were confirmed. Experiments concerned with the effect of delay before storage on the incidence of disorders gave the following results :—Pit in Cleopatra was significantly reduced when storage was delayed for two weeks, but in Cox's Orange Pippin results suggest that more pit develops when fruit is delayed for one week than with immediate storage, or with two weeks' delay. In Jonathan, delay of up to three weeks produced a marked increase in the incidence of Jonathan spot over immediate storage or one or two weeks' delay ; lenticel scald also increased with delay. Breakdown increased with delay in storage of fruit from one plot, and in fruit from another plot was greatest with immediate cool storage.

There has been a significant correlation between the mean fruit size per tree and the amount of tree and storage pit developed in each of the past four seasons. Treatment with boron salts significantly reduced the size of fruit and also the incidence of pit. Studies on the relation between the physiology and chemistry of the fruit, varietal climatic and edaphic factors, and keeping capacity have been continued. Experiments again showed that Cleopatra apples reach the same stage of maturity in mid-February in different Tasmanian districts. Differences in maturity are more closely associated with local factors, such as crop and size and soil type.

(*c*) *Test with Methods (other than Cool Storage alone) to reduce the Incidence of Storage Disorders and to increase Storage Life.*—Pre-storage treatment with carbon dioxide has given inconsistent results in its effect on breakdown. Brown heart was induced in some varieties when mature. Colour change during storage at 32° F. to 34° F. was retarded, and the intensity of red colour increased. The commercial value of the treatment is doubtful, except, perhaps, for certain low acid varieties, but mature or light crop fruit should not be so treated. No satisfactory results have been obtained by treatment with maleic acid, either incorporated in various types of oil wrap or in different dips. Results using a proprietary wax emulsion were more promising. There was a general retarding

of the rate of colour change, and a reduction of pit, Jonathan spot, and shrivelling. No appreciable effect on the incidence of breakdown, deep scald, and lenticel scald was evident. As a means of increasing the common storage life of fruit, this method may be valuable.

Proprietary box-liners proved to be harmful in one case, and of no advantage in the other. The method of storing Jonathans at higher temperatures before transferring to a low temperature was tested. Results so far indicate that the incidence of breakdown and deep scald was reduced, while that of Jonathan spot was generally increased by the treatment.

(*d*) *Storage Disorders in Artificial Atmospheres.*—The disorders of brown heart, alcoholic poisoning, and breakdown, associated with gas-stored fruit, are more marked with any delay in storage. The variety Sturmer is the most susceptible, French Crab next; Worcester Pearman and Jonathan are very resistant. Fruit from trees bearing light crops is most susceptible to brown heart, and there is evidence which suggests that fruit from some soil types is more susceptible than fruit from others. Mature fruit of Sturmer in continuous storage for ten weeks may develop symptoms in concentrations of carbon dioxide as low as 3 per cent., while 6 and 9 per cent. may produce severe loss. For shorter storage periods, severe brown heart may occur in mature fruit when held for ten days at 9 per cent., and fruit picked six weeks earlier would be uninjured by 15 per cent. carbon dioxide for fourteen days. With rapid accumulation under completely restricted ventilation for up to ten days, the concentration of carbon dioxide must rise to more than 20 per cent. at 38° F. or 43° F. during that time before damage is caused. At room temperature, carbon dioxide concentration may accumulate to a very high level (50 per cent.), except with mature fruit, for a short period without damage.

(ii) *In Queensland.*—In the apple and pear rootstock investigations, the greater part of the work of propagating material for trial has been completed. The multiplication of only a few types for further trials of apple varieties on their own roots as compared with trees on rootstocks is in progress.

Six nursery trials in which trees are planted 2 feet to 3 ft. 6 in. apart in rows spaced at 5 inches have been established. Jonathan is being tested on 14 different rootstocks, Delicious on 5, and Granny Smith on 19. Already some differences are being noted, as, for example, the fact that both Granny Smith and Jonathan trees on the rootstock Neidwetzkyana are very dwarfed. Other rootstocks are being used in the guard rows of these plots, and their performance is being observed. Sufficient pear stocks of four types have been produced and budded to William bon Chretien and Packham's Triumph for a nursery trial.

Two field trials have been laid down. The first of approximately 4½ acres is to test the performance of Jonathan and Granny Smith upon the rootstocks Malling XVI., XII., and I., Northern Spy, and seedling Pomme de Niege. A manurial trial of five treatments has been superimposed upon the rootstock trial in this field. Both the Granny Smith and Jonathan trees, which are now four years old, are larger on Malling XII. than on any other stock used in the experiment. Tree size is more variable on seedling Pomme de Niege, although the best 60 trees were chosen from 100 two-year-old trees in this stock in the nursery. The second field trial of approximately 2 acres is to test the performance of Jonathan upon the rootstocks Malling II., Ivory's Double Vigour, and S4 (local selection). A pruning trial is to be superimposed in this field.

Two experiments with double-worked trees have been commenced, using Delicious and Jonathan as top scion varieties, with Scarlett, Duke of Clarence, Dunns, Emperor Alexander, Reinette du Canada, and Rymer as intermediate stem pieces. Three- and two-year-old apple trees of some 28 varieties on their own roots were excavated, and the distribution of their root systems noted.

(iii) *In Irrigation Areas.*—The investigations concerned with the maintenance of health and vigour in citrus trees in the Murrumbidgee Irrigation Area and the irrigation settlements of the River Murray have been continued along the lines described in last year's report under this heading and also in the section dealing with the work of the Irrigation Research Station, Griffith.

Seed of varieties which have proved most satisfactory as rootstocks in overseas trials was imported, and, though germination was poor in many cases, good stands of seedlings of a number of types were obtained. Root cuttings were collected from eighteen trees of outstanding longevity and vigour in the Murrumbidgee and Murray River areas. Only partial success was attained in the propagation of these cuttings; approximately 50 per cent. took successfully in the hot beds, and were planted in the nursery this season. Inquiries have indicated that the rough lemon seed supplied from Norfolk Island (this is the main source of seed used for raising citrus stocks) is derived from several distinct varieties and strains. Investigations in hand aim to determine which variety and/or strain is most suitable for use as rootstocks.

Inarching experiments have been laid down successfully in nine citrus groves. In these trials, new rootstocks of rough lemon and sweet orange, and in some cases sour orange also, are approach-grafted to the trunk of the tree. Other treatments, such as dehorning and pruning, have been combined with the inarching. It is desired to ascertain whether the replacement of the old root system may be effected and an improvement in the condition of unthrifty trees thereby obtained. Studies of shoot and root growth have been continued, by means of a root observation trench. Most instructive data have been obtained concerning root growth following a short period of waterlogging. A window in this trench allows continuous observations of root growth throughout the season.

Co-operation with the investigation of vine problems being carried out at Merbein has been continued. A microscopical examination of buds from sultana vines in the Murray River Irrigation Settlement was again made this winter. The examination and subsequent estimate of fruit bud formation made last season was of considerable value to the vignerons in indicating the amount of bearing wood to leave on the vines at pruning.

(iv) *Drug Plants.*—At the request of the Medical Equipment Control Committee, an investigation of the problem of satisfactorily growing certain essential drug plants in Australia has been undertaken. The chief drugs concerned are those obtained from the following plants :—*Atropa belladonna*, *Artemesia maritima*, *Cephaelis ipecacuanha*, *Claviceps purpurea*, *Cinchona* spp., *Datura* spp., *Duboisia* spp., *Digitalis* spp., *Dryopteris Felix-mas*, *Ephedra* spp., *Papaver somniferum*, *Strophanthus* spp., and *Strychnos nux-vomica*. Arrangements have been made for the Universities of Melbourne and Sydney to test the plants grown for content of active principles. Preliminary steps have been taken to obtain supplies of seed or propagating material of such of these plants as are not now present in Australia. The investigation will involve trials with these plants in areas judged suitable for their production and the establishment of stocks of propagating material of them. Substitute plants will also be sought.

7. *Wheat Investigations.*—(i) *Take-all and Root-rot.*—Field experiments on take-all in wheat are now being made on three farms, of which two are in South Australia and one near Duntroon, Australian Capital Territory. The work in South Australia is being done in co-operation with the Department of Agriculture, the Waite Agricultural Research Institute, and Messrs. Pearson and Sanders, of Brooker and Lowaldie respectively. The chief aim is to determine whether the disease can be controlled by good farming methods. On account of drifting sand, the Lowaldie plots were sown to pasture. On the 9-acre plot on the farm near Duntroon, the effects of fallowing, liming, and pasture rotations are being studied. Chemical and physical analyses of the soil of this field are in progress.

A plot experiment at Black Mountain showed that the pathogenicity of *Ophiobolus graminis* to wheat was not affected by a concentration of sodium chloride in the soil sufficient to depress the yield of uninoculated wheat by about 20 per cent., nor by small amounts of zinc or manganese salts added to the soil.

In the experiments in 5-gallon soil containers, significant numbers of severely tipped ears were obtained in plants grown in untreated soil, to which were added amounts of calcium sulphate, potassium, calcium, and magnesium carbonate, not exceeding the proportion found in some mallee soils. In more than 20 other treatments only a few mildly affected ears could be counted. The symptoms were indistinguishable from those in dozens of fields in New South Wales. This is the second season in which white heads or apparently related symptoms were obtained without contaminating the soil with the organisms usually associated with root trouble. More extensive experiments are in progress. By way of contrast, it should be noted that, although seedling blight has almost always resulted from contamination of the soil with *O. graminis* and other organisms reputed to be associated with take-all in the field, the production of white heads in experiments with those organisms has not been reported in this country nor abroad. The Division is therefore inclined to the tentative view that white heads are expressions of physiological trouble associated with the chemical composition of the soil.

Study of *O. graminis* is being continued. It was already reported that eight single ascospores from each of three asci were isolated, germinated, sub-cultured, and tested for pathogenicity. Segregation of two genetic characters is already evident in one of these cultures. A detailed study of the organism's growth factor and nitrogen and carbon requirements in artificial media is now almost completed.

(ii) *Yield.*—For a number of years, a wheat variety investigation was conducted, in order to obtain fundamental information which would be of value in selecting high-yielding plants in breeding programmes which would also enable higher-yielding varieties to be produced. Special attention was paid to the yield attributes, number of ears per plant, number of grains per ear, and average grain weight. The results show that, in general, these characters are quite independent of one another. It should be possible, therefore, to combine in one variety high

values of each of these attributes, and so produce higher-yielding varieties. This is being attempted now. The experiment on growth rate of ten varieties was repeated in 1939, and gave results similar to those obtained in 1938, viz., that there was no significant difference in growth rate as measured by dry weight increase. In a study to determine the cause of the large inter-plant variation in yield and yield attributes, it was shown that plants derived from large seed or seed of late maturity were able to develop at the expense of neighbours not possessing these characters.

8. *Tobacco Investigations.*—The Division's programme of research on diseases and smoking quality is part of the co-operative work undertaken, in conjunction with the States, under the terms of the Commonwealth Tobacco Grant mentioned in the previous report. All parties to the grant have continued to co-operate in the exchange of half-yearly progress reports, in conducting smoking tests on representative samples of tobacco, and in taking full advantage of the annual conference of tobacco officers to plan for the benefit of the industry as a whole.

(i) *Diseases.*—(*a*) *Downy Mildew.*—Seed-bed experiments involving the use of benzol, Solvesso compounds, and paradichlorbenzene were conducted at Canberra. The most satisfactory results were obtained with benzol, but Solvesso I. was promising, and will be tested again next year. Paradichlorbenzene, which is recommended in the United States of America, and has been tried at Canberra for several seasons and in Victoria during 1938–39, did not prevent the spread of the disease. Its relative inefficiency may be due to the comparatively low temperatures experienced during the seed-bed season. Investigations on the relation of seasonal conditions to occurrence and spread of downy mildew in tobacco fields were continued in the Ovens River Valley district of Victoria, but they were again unfavorable for the disease.

(*b*) *Yellow Dwarf.*—The work was continued at Shepparton, Victoria, where two insect-free plant houses to accommodate about 900 6-in. pots were erected and a field plot established. Most of the plants transferred from the plant houses to the field became infected only during the second half of December, even though transplanting was done at two-day intervals, commencing 20th October. This was in general agreement with what occurred in fields in other parts of the State ; nevertheless, in the two previous seasons, infection appeared to take place about one month earlier. Green jassids, canary-yellow jassids, capsid bugs, and Rutherglen bugs, all of which were present in large numbers in diseased crops, failed to transmit the disease. When brown jassids were used under similar conditions, typical symptoms of yellow dwarf were obtained on a number of previously healthy plants.

(ii) *Chemical Investigations.*—Statistical examination of analytical data has shown that there is a relationship between some of the group constituents of tobacco leaf as determined by chemical tests, and quality as judged by smoking tests on the samples. Nevertheless, the chemical tests so far developed have not as yet proved sufficiently satisfactory for the determination of quality. The search for new and more satisfactory analytical methods was continued throughout the year.

(iii) *Physiological Studies.*—As the quality of tobacco leaf is largely determined by the chemical composition of the leaf at the time of picking, a study has been made of the chemical changes that occur in the leaf throughout its development, the data being interpreted in terms of physiological processes. Particular attention has been given to the study of factors determining the amounts present in the leaf, at time of picking, of nitrogen compounds, sugars, and organic acids. The work has been concerned mainly with the effect on quality of phosphorus supply, of topping, of low water supply, and of soil type. The results indicate that, if environmental conditions are such as to inhibit late growth, nitrogen will tend to remain in the leaves, and ripening will be delayed. Increased phosphorus supply may cause earlier ripening, but in excess it has an adverse effect on organic acid content. Topping increased the amount of dry matter per unit area in the leaves, especially in the upper ones, and also decreased the percentage water content. Plants with low water supply were small, high in nitrogen, and had deep green leaves which failed to ripen normally. Under good growing conditions, good tobacco was produced on the heavy soil from Tamworth, New South Wales, but with low water supply quality was adversely affected.

(iv) *Smoking Quality.*—Tobacco leaf samples representative of the 1938–39 crop have been received from all States, and also other samples for special tests. The results of smoking tests, conducted in co-operation with the States, on representative samples of the 1935–38 crop from all States have been reviewed. These show that each district produces some good tobacco, and that sandy soils produce a bigger proportion of good tobacco than the heavier soils. However, the sandy soils of Pomonal, Victoria, South Australia, and northern Tasmania do not produce as good tobacco as that grown on sandy soils in other areas. The leaf colour-grade within any one type of tobacco is usually a good indicator of smoking quality, but the brightest colour-grades

do not necessarily have the best smoking quality. Objectionable aroma and immaturity are found in tobaccos produced under unfavorable climatic conditions and/or on soils unsuitable for the production of flue-cured tobacco. It is also evident that the same type of tobacco is grown in more than one district, and that a number of different types of flue-cured leaf are grown in Australia.

9. *Potato Virus Diseases.*—The effects of the more widespread viruses on most of the principal varieties of potato grown in Australia are now known ; attention is being given, therefore, to the transmission of the viruses by their insect vectors, to the less well-known diseases, and to the symptoms on other varieties.

The most important of the lesser-known virus diseases of the potato is one which is probably related to, or identical with, the American " spindle tuber ". The name is derived from the most characteristic symptom—a decrease in cross-sectional diameter of the tubers in relation to length. An attempt to establish this diagnostic feature of the disease on a quantitative basis has led to studies of tuber shape, and how it is determined during development and growth. It has been found that there are three district phases in the growth of a tuber. These are manifested in (i) radial swelling near the tip of an underground stem due to division of pith cells, and the formation of a tuber rudiment of a size and shape which are approximately constant for a variety; (ii) swelling of the rudiment without alteration of its shape ; (iii) subsequent growth along the long axis at a faster rate than radially, so that large tubers are not merely expanded copies of small ones. Only one virus disease—spindle tuber—affects the orderly succession of phases, and it appears to cause elongation of the tubers by inducing the transition from the second to the third phase while the tuber is smaller than corresponding tubers from normal plants.

Preliminary field surveys at Canberra and by an officer of the Department of Agriculture in Victoria suggest that the main insect vector of potato virus diseases in Australia is the peach aphis, *Myzus persicae.* Greenhouse transmission tests have shown its ability to act as a vector of viruses A, Y, and leaf roll under Australian conditions. These studies are being continued and expanded.

Wilt Diseases of the Potato.—Examination of wilt diseases of the potato in the tableland areas of New South Wales revealed two types—one associated with the fungus *Verticillium albo-atrum,* and one with a Fusarium, probably *F. oxysporum.* Verticillium wilt has so far been found in the cooler areas, and Fusarium wilt in the hotter areas of the tablelands. A field experiment with the Verticillium wilt showed that stem-end browning of the tubers was associated with wilted tops, but that it also often occurred in tubers of plants with normal tops, particularly if those plants were situated next in the row to wilted plants. Apparently, in Australia, as in other countries, *Verticillium albo-atrum* spreads by root contact from plant to plant through the soils.

10. *Vegetable Fibre Investigations.*—(i) *Linen flax* (*Linum usitatissimum*).—In the experiment to determine what differences, if any, are to be expected from the various strains of linen flax now available, Monarch and Liral VI., of which seed was obtained from Canada, gave very poor germination, and their straw weights were not considered in yield. The seed was sown at the low rate of 30 lb. per acre, and in order of yield of deseeded straw, varieties stood as follows :— Stormont Cirrus, Stormont Gossamer, Liral Crown Norfolk, and Liral Crown Egypt equal, Liral 4 Crown, Liral 9 Dominion, Liral II., and J.W.S. all equal, Liral II. Sussex and Ottawa 829C equal. Stormont Cirrus yielded at the rate of 43 cwt. per acre, Ottawa 829C at 22 cwt. per acre, and the average, excluding Monarch and Liral VI., was at 37.3 cwt. per acre. Stormont Cirrus, which was the highest straw yielder, was the lowest seed yielder, while Ottawa 829C was a high yielder of seed.

In another experiment sown at a higher rate of seed (90 lb. per acre), the four strains Liral Crown Egypt, Liral Crown Norfolk, Stormont Gossamer, and Stormont Cirrus yielded respectively at the rate of 46.7, 50.4, 50.4, and 53.5 cwt. of deseeded straw per acre. In a manurial experiment, using Liral Crown Egypt, Liral Crown Norfolk, and Blue Riga, phosphate increased the yield of deseeded straw and potassium decreased it.

The Department of Botany at the University of Sydney is co-operating in flax and other fibre work, by carrying out anatomical studies designed to ascertain what differences, if any, are characteristic of the strains of *L. usitatissimum.* In addition, work is in progress there to ascertain the characteristics of fibre from such plants as *Urena lobata* and *Sida rhombifolia* which make them useful or otherwise as substitutes for flax, hemp, or jute.

(ii) *Urena Fibre.*—By the co-operation of Mr. Schofield, of the South Johnstone Research Station, the Division has a sample of stems of *Urena lobata* growing wild in North Queensland, from which a creamy, lustrous fibre has been obtained.

(iii) *Sida Fibre.*—The plant commonly known as Paddy's lucerne and sometimes as flaxweed or Queensland hemp (*Sida rhombifolia*) is a weed of the coastal hinterland from Sydney northwards.

(iv) *Ramie.*—Rootstocks of *Bochmeria nivea*, from which ramie fibre is obtained, were planted in the experiment area at Black Mountain, but recent frosts have cut them back completely. Plants were seen near Innisfail, in North Queensland, but their growth was not as good as that of *Urena lobata.*

(v) Other plants are being examined for fibre content and quality.

11. *Diseases of Pine Trees.*—(i) *Needle Fusion.*—In most cases, trees treated individually or in small groups with boron compounds showed signs of recovery the first season after treatment, but reverted to needle fusion during the second season, unless the treatment was repeated. Trees similarly treated with superphosphate usually did not respond until the second season after treatment, but their recovery appeared to be more lasting than that following boron treatment. The first experiments in which the above compounds were tested on a larger scale were destroyed by fire. To replace and extend these, broadcasting experiments on trees of various species and ages were begun at four plantations in 1939. Measurements of height or trunk diameter made just before treatment and one year later showed that broadcasting phosphates or boron compounds did not produce any significant growth-response during the first season after treatment, although signs of recovery from needle fusion were more apparent in the foliage of treated trees than in controls.

(ii) *Diplodia Die-back.*—Inoculation experiments in Canberra plantations indicated that, although the fungus *Diplodia pinea* readily caused die-back of laterals and leaders on vigorous trees, the infections usually remained localized, and the tree as a whole was not seriously affected, unless weakened by unfavorable environmental conditions.

12. *Diseases of Maize.*—At the request of the Victorian Department of Agriculture, an investigation of the root, stalk, and ear rot of maize was begun. Field methods of inoculation, and the pathogenicity of the fungi concerned, were studied at Canberra, and a number of self-pollinations were made in commercial maize crops at Bega, New South Wales, with a view to their possible utilization in breeding work. An inspection of Victorian maize crops was made in company with a State officer, and a joint report submitted.

13. *Take-all in Peas.*—Experiments in co-operation with the Tasmanian Department of Agriculture, at the Cressy Experiment Farm, were repeated. As in the previous year, the application of superphosphate to the soil resulted in increase in yield ; nitrogen and potassium were apparently without effect ; copper, zinc and boron depressed the yields. Further work is being done.

14. *Disease of Grape Vines.*—A condition known to Murray Valley growers as " dying vines " was investigated. This trouble is usually associated with tillage injuries, and often occurs in soil which appears to be poorly drained. It may be partly due to invasion of the stem by weakly pathogenic soil fungi, but does not appear to be of much importance. At present, the only practicable remedy is to replace affected vines. Inoculation experiments with a fungus isolated from a number of affected vines gave negative results.

III. ENTOMOLOGICAL INVESTIGATIONS.

1. *General.*—During the year 1939–40, marked changes have taken place in the Division of Economic Entomology, which by the end of the year had lost three members of staff who had been associated with it for more than ten years. Dr. G. A. Currie, who has led the Weeds Section for many years, resigned to accept appointment as Hackett Professor of Agriculture in the University of Western Australia. Last August, Mr. S. Garthside, who had been stationed in England for ten years, carrying out work on St. John's wort insects and other problems, was drowned just prior to his intended departure for Australia ; he lost his life in a gallant attempt to rescue a bather in difficulties. In January, the Division suffered an irreparable loss by the sudden death of Mr. A. L. Tonnoir, an entomologist of world-wide renown. In addition, Dr. I. M. Mackerras, who has led the blow-fly investigations since their inception, was granted military leave last January to take up a position where his knowledge of both entomological and medical subjects is specially valuable. With such staff changes, considerable modification of the organization of the work has followed, and since the outbreak of war the investigations have been directed even more definitely than before towards achieving results of immediate practical importance. Certain projects have been dropped, either temporarily or permanently, and new problems of immediate urgency, such as weevil infestation of stored grain, have demanded investigation.

For many reasons the ideal method of controlling weeds is by means of their natural enemies, but unfortunately this is not always possible. For some years, the Division of Economic Entomology has been carrying out a large programme of work of this kind, but with little signs of success. However, during the year under review, lantana bugs have become

thoroughly established in many parts of North Queensland, where they appear to be exercising a real measure of control. A beetle introduced some years ago from England to attack St. John's wort has become extremely abundant at the point of liberation, where it is producing a devastating effect on this weed. It has now been spread to other areas in Victoria and New South Wales.

A parasite introduced from the United States of America to attack the oriental peach moth has been observed to pass the winter in the field in the Goulburn Valley. As it is well adapted to Australian summer conditions, there is good reason to believe that it will become established. Advances have also been made on the chemical control side of the Division's work. A new blow-fly dressing and a repellent lamb-marking fluid show considerable promise. Further progress has been made with the control of termites, and particularly with the testing of the resistance of timbers, both untreated and chemically treated, against the attack of the most important pest species. Knowledge of the factors leading to outbreaks of grasshoppers and of those which influence the abundance and distribution of these insects has been greatly increased. Although of less immediate practical importance, work on the physiology of insects has produced results of outstanding interest which ultimately should assist in the development and application of insecticides.

2. *Insect Control of Noxious Weeds.*—With the resignation of Dr. Currie early in the period under review, these investigations were linked with the Division's other biological control projects, and co-operation with the Division of Plant Industry was maintained through the Inter-Divisional Committee on Weeds Investigations. During the year, two officers working on Xanthium insects overseas, formerly on the staff of the Commonwealth Prickly Pear Board, were appointed to the staff of the Division.

(i) *St. John's Wort* (*Hypericum perforatum*).—The most outstanding development during the year was the discovery that the beetle *Chrysolina hyperici* is established in the field at Bright (Victoria), where the beetles were found vigorously attacking the weed over an area of 1½ acres. Beetles imported from England were liberated at this site in 1934. Many plants had been destroyed completely, and native plants and grasses were gradually re-establishing themselves in this area. Periodic observations during the season have shown that *C. hyperici* aestivates during the hottest part of the summer and appears again in the autumn, when mating occurs. In the late autumn and early winter, eggs are laid on the young winter growth of St. John's wort. During the year large numbers of beetles were liberated at other places in the Bright district, and at places in the Mannus–Tumbarumba district, New South Wales. This establishment of *Chrysolina* in the field is most opportune, as the present source of supply of St. John's wort insects, the Var district of the South of France, was hastily vacated by the Division's officer towards the end of May.

During the past season, efforts have been mostly concentrated on the study of *Chrysolina* in the field and on its distribution. However, in addition, a number of liberations of the root borer, *Agrilus hyperici*, were made in the Bright district. No further introductions of the moth *Anaitis plagiata* have been made, nor can further efforts be made at present to introduce the gall midge, *Zeuxidiplosis giardiana*.

(ii) *Lantana* (*Lantana camara*).—In the previous report the establishment of an extensive and virile colony of lantana bugs (*Teleonemia scrupulosa*) near Atherton (North Queensland) was reported. During this year, lantana bugs have been distributed from this colony over a large part of coastal Queensland, north of Rockhampton, by officers of the Queensland Department of Agriculture and Stock, and liberations have been made at selected sites farther south. Under natural conditions, the rate of spread of the bugs is said to be approximately 1 mile per month in areas where colonies are firmly established. All stages of host damage, up to complete defoliation and death of the plants, have been seen.

In Canberra, a stock of bugs has been kept, and large consignments have been sent to northern New South Wales and to Norfolk Island. Promising reports of a colony established near Casino were received, but it was unfortunately destroyed by a bushfire early in the year. Further supplies of bugs have since been sent to this area. There is also evidence to suggest that a generation of bugs has developed in the field in Norfolk Island, but definite confirmation of this cannot be obtained until next year.

(iii) *Noogoora Burr—Xanthium spinosum.*—In Central and Southern India, a careful study has been made of insects attacking Noogoora burr in that country. The most promising insect so far discovered is a Cerambycid beetle, *Nupserha antennata*, but feeding tests show that it may attack certain plants of minor economic importance, e.g., sunflower, so it will not be introduced into Australia. A similar survey of burr-infested areas in Assam and Burma is now in progress.

Large numbers of the burr seed-fly, *Euaresta aequalis*, were collected in the United States of America and sent to Queensland, where they were liberated in burr-infested areas. Officers of the Queensland Department of Lands have observed a second Australian generation of the seed-fly in the field. Sufficiently large numbers of the insect have now been liberated in Australia to give it every opportunity to become established if it finds conditions suitable. The phytophagous insects of Noogoora burr in Texas and the neighbouring States have been studied very thoroughly, and last year extensive feeding tests were carried out with *Dectes spinosus* and *Mecas saturnina*. However, as they fed on sunflower, Jerusalem artichoke, and other members of the natural order Compositae, and as they also attacked Noogoora burr plants after seeding, these insects cannot be introduced into Australia. It has recently been decided to discontinue the investigation in the United States of America, as no further work can usefully be undertaken there.

(iv) *Ragwort* (*Senecio jacobaea*).—No further insect enemies of this weed are to be introduced until results of certain experiments in New Zealand are known.

(v) *Nut Grass* (*Cyperus rotundus*).—Arrangements have recently been made for one of the Council's officers returning from the United States of America to visit Hawaii in order to study the phytophagous insects of nut grass, and possibly transport them in sufficient numbers to Australia to enable tests to be made with them.

3. *Sheep Blow-fly Investigations*.—During the year, attention of the workers in Canberra has been concentrated on the study of attractants and repellents, an investigation of poisons, and basic work on the physiology of the maggot, and preparation and examination of dressings. The study of field strikes in the experimental flock has been continued, and much of the earlier work has been prepared for publication. Promising measures of possible practical value developed in Canberra are now tested under conditions of station practice at "Gilruth Plains", and are mentioned in the report of the Division of Animal Health and Nutrition.

(i) *The Experimental Flock*.—All field strikes in the experimental flock were recorded, and *Lucilia cuprina* was again responsible for the majority of strikes, being the only species involved in 77 per cent. of strikes, and present in, and probably the initial cause of, 96 per cent. of all strikes. The strike incidence of the whole experimental flock was 75 per cent. Under the same conditions, the Ulooloo sheep showed a high degree of insusceptibility to strike, the incidence being only 25 per cent. The importance of the tail as a starting point of strikes in otherwise insusceptible animals has been emphasized by the number of pure tail strikes—17 per cent. of total strikes in the experimental flock. A lamb-marking fluid containing citronella has been developed, which reduced tail strike considerably (*see* below).

Observations on the effects of the Mules operation have been continued; one group of ewes, from which the breech fold on the left side only had been removed, have been observed for three years. The chief points of interest which have emerged from this study are briefly (*a*) that the effect of the operation is permanent in the great majority of cases, and the earlier the operation is performed the better; (*b*) that although some of the ewes definitely became plainer as they grew older, this was due more to a flattening out of the lateral folds than to any gross change in the medial folds; (*c*) that the folds tend to move laterally in a small proportion of cases; (*d*) that a definite reduction of strike on the left side occurred.

(ii) *Attractants and Repellents*.—It was found that reliable results could be obtained when the following conditions were maintained in the insectary:—(*a*) a high population of flies which had been fed regularly on liver; (*b*) sheep of the same age carrying fleeces of the same length and approximately the same general type. Most attention was paid to citronella oil, as this was shown previously to be a promising substance. When applied to the fleece around attractive areas (made artificially attractive by the application of a cotton-wool plug soaked in a solution of indole and ammonium carbonate), citronella considerably reduced oviposition by *Lucilia cuprina* in these areas. In tests carried out over a period of fifteen days, 50 per cent. solutions of citronella in liquid paraffin completely prevented oviposition. Although 10 per cent. citronella solutions allowed some oviposition, the numbers of egg batches were small compared with those laid on the untreated attractive areas.

A practical development of this work has been the use of citronella solution as a lamb-marking fluid. A cheap and effective citronella solution was prepared by dissolving 10 per cent. of the oil in a 10 per cent. aqueous soft soap solution. When applied to the breech area of lambs after tailing and castrating, citronella solutions significantly reduced the incidence of blow-fly strike on these areas during the subsequent period of healing. When diluted with an equal volume of water, it still conferred some protection. Thus, in a group of lambs treated with a 5 per cent. solution of citronella, only 53 per cent. were struck, whereas 85 per cent. of the control group were struck during the nine days after tailing. The corresponding figures for the 10 per cent. solution were 15 per cent. and 58 per cent. struck for the treated and control groups respectively. Full details of this work appear in the Council's Journal (Vol. 13, pp. 65–73).

An attempt is being made to determine which of the constituents of citronella oil is responsible for its repellent qualities. Seven constituents have so far been tested, but none equalled the natural oil in its repellency. Preliminary tests have been carried out to determine whether a recently evolved American repellent and lethal fly spray containing " butyl mesityl oxide oxalate " would prevent oviposition by *L. cuprina* on attractive areas ; they suggest that the repellent effect is initially of the same order as that of citronella, but that it is somewhat more lasting.

(iii) *Physiological Studies.*—The artificial enriched medium, mentioned last year, has been extensively used for the aseptic cultivation of maggots for physiological investigations. It has been used for metabolism studies which have shown that maggots of *Lucilia cuprina* excrete large quantities of ammonia. The rate of excretion increases rapidly during growth of the larvae, but ceases when they reach maturity. Apart from its direct bearing on the physiology of the maggot, ammonia production increases the susceptibility of a struck area to further oviposition, the extension of a strike to adjacent areas on sheep, and the enzyme activity in a strike wound.

The distribution of proteolytic enzymes in the gut of larvae of *L. cuprina* reared on enriched medium was revealed by means of a new technique. The freshly dissected and subdivided gut was placed on heat-coagulated egg white and incubated at 30° C. Protein breakdown was denoted by the formation of transparent areas. These occurred throughout the length of the midgut, and, occasionally, traces of activity were also detected in the hindgut.

Studies of the absorption, accumulation, and elimination of the minerals copper, iron, and barium have been continued. It appears that the epithelial cells of the acid midgut form a mosaic in which the accumulation of certain metallic ions takes place. This work is designed to give an understanding of the mechanism of the action of inorganic stomach poisons.

Iron and copper can be accumulated by larvae, possibly by virtue of the peculiar nature of the appropriate mid-midgut cells, in sufficient quantity to reach maturity on media poor in these elements. Iron is apparently not absorbed by the larva from the food after the midgut band of cells reaches saturation value. The toxic level for iron in the medium is, therefore, extremely high. The concentration of copper in larvae, however, is almost directly proportional to the concentration in the medium. On a protein-rich diet, such as the artificial medium, the larvae can reach maturity in the presence of high concentrations of copper (equivalent to 1 per cent. copper sulphate). The contact toxicity of copper solutions is also low. It seems unlikely, therefore, that copper will prove an effective poison for larvae of *L. cuprina*. Experiments showed that larvae which were able to reach maturity on copper-enriched media suffered a delayed toxic action causing a lowering of the percentage pupation and emergence. These tests also revealed that the enriched medium, while adequate for larval growth, seldom permitted more than 50 per cent. emergence of adults (cf. 95 per cent. or more from liver-fed larvae). Addition of a concentrated, though impure, extract of vitamin A in fish oil increased larval growth rate, percentage pupation, and percentage emergence (to 80 per cent. or more). Larvae were fully grown after one and one-half days, and this finding may prove to be a considerable time-saving element by shortening the period necessary to complete toxicological tests.

(iv) *Toxicity Studies.*—The main lines of these investigations outlined in last year's report have been followed this year, and papers dealing with three aspects of the work, stomach larvicides, contact larvicides, and the arsenicals, are now in the press. The following interesting points have been revealed :—(*a*) In stomach toxicity tests, poisons administered in the protein-rich enriched medium were less toxic than the same concentration of poison in the basal medium which contains $1\frac{1}{2}$ per cent. agar in place of egg white. (*b*) Of a series of dye-stuffs tested, methylene blue was the most toxic, and several compounds of the triphenyl methane class came next. The high toxicity of methylene blue is interesting in view of its structural relationship with the well-known insecticide, phenothiazine. (*c*) Of the arsenicals, the arsenites are more toxic than the arsenates. This is probably due to the greater instability of the former, which is responsible for the liberation of soluble arsenic in the artificial media. It is not yet clear whether arsenic administered in an artificial medium is absorbed mainly through the cuticle or from the alimentary tract. (*d*) The thermal death point of larvae of *Lucilia cuprina* immersed in water for ten minutes is 47.5° C. (*e*) The proportion of pupae from which flies emerge varies with different poisons, and thus the relative toxicities of liquids will vary according to whether prevention of pupation or prevention of emergence is used as the criterion of toxicity.

(v) *Dressings.*—The preparation of sheep blow-fly dressings follows naturally on the toxicity investigations mentioned above. So far, attempts to replace boric acid dressings with dressings containing other stomach larvicides have failed. Effective maggot poisons, such as chloracetamide and nicotine, exerted a systemic toxic effect on sheep, and the arsenicals, Paris green and calcium arsenite, produced severe local poisoning. Some arsenical sores failed to heal even

within six months of applying the dressing. However, a new preparation, containing 30 per cent. of boric acid together with bentonite, tar oil, and wetting agent, shows distinct promise. The special advantages of this dressing are cheapness and the easy availability of its components, the stability of the mixture, and its effectiveness in destroying maggots. It is completely bland, and wets the wool readily. If desired, the dry components can be supplied ready mixed to the grazier, who can prepare the dressing himself by gradually adding water and mixing to a uniform suspension before incorporating the tar oil. The dressing is now being tested under field conditions at "Gilruth Plains". A few proprietary and amateur dressings have been tested during the year, but nothing of outstanding value has been submitted.

4. *Buffalo-fly* (*Lyperosia exigua*).—Owing to the difficulty of transport, no further consignments of *Hister coenosus* have been received from the West Indies this year. Overseas officers of the Division in the United States of America and Europe have made a preliminary study of the life-history and habits of the dung-fly, *Scatophaga stercoraria*, which is a general predator on the larvae of muscid flies. The results so far obtained suggest that *Scatophaga* is unlikely to be of use in controlling buffalo-fly.

5. *Blood Parasites of Cattle.*—Pure strains of the protozoan parasites and the virus of ephemeral fever have been maintained in Canberra, and supplies of blood containing *Anaplasma centrale* have been sent to Queensland for vaccine purposes when required. Samples of serum, together with material for antigen, have been sent to the Division of Animal Health laboratory at Parkville for an investigation into the complement fixation test for ephemeral fever.

6. *Insecticides.*—On the outbreak of war it became apparent that the overseas supplies of certain insecticides might become irregular or even cease, and so a survey was made of the sources, supplies, and amounts required of the principal toxic materials used in Australia. On the whole, Australia is in a relatively satisfactory position, largely because she is almost self-sufficient in supplies of arsenic, but there are possibilities of shortages which, if they occurred in a season when insect pests were very abundant, might seriously affect the return of certain primary products.

7. *Orchard and Fruit Pests.*—(i) *Codling Moth* (*Cydia pomonella.*)—In previous reports, mention has been made of the role of nicotine in codling moth control. During investigations of the possibilities of increasing Australian nicotine production, it was seen that very little fundamental knowledge is available regarding the solubility of nicotine in the presence of salts, though the process of salting out has been patented as an extraction method for the alkaloid. This solubility has been investigated, with the result that, though the study is still incomplete, sufficient data are now available to provide valuable information regarding the equilibria involved in separating nicotine by salting out.

A study of the mode of action of arsenicals has been undertaken and, as readily applicable methods have been devised in the Division for such studies on the larvae of the sheep blow-fly (*Lucilia cuprina*), this was the first test insect used. The investigation will be extended to codling moth larvae as soon as a satisfactory technique can be evolved for feeding the larvae with known amounts of poison. When using sheep blow-fly larvae, the method of analysis for arsenic recently described by Cassil and Wichmann in America was found to be very useful after slight modifications were made, resulting in the final stage of the determination being made colorimetrically using the starch-iodine reaction. The amount of arsenic in larvae which have received a toxic dose of sodium arsenite has been found to be about 0.2 to 0.3 micrograms of arsenic pentoxide per larva. The work of tracing the seat of action of the poison is proceeding.

(ii) *Oriental Peach Moth* (*Cydia molesta*).—In the Goulburn Valley in the spring of 1939, there was a low initial moth population following the intense heat-waves of the preceding summer. Although the number of moths increased in the first generation, there was a marked decrease in abundance in the second and third generations during January and February. This was probably caused by cool evening breezes in December and January, and early frosts in February which prevented the moths from laying their eggs. The moth population increased slightly late in the season, and quinces were very lightly infested. Infestation was low (5 per cent.) in the late peaches. In the small infested districts in the Murrumbidgee Irrigation Areas, only a very small number of infested shoots were found in two orchards in the spring of 1939, and no moths were seen in the traps at any time during the season.

At the end of the 1938–39 season only small numbers of the American parasite *Macrocentrus ancylivorus* were recovered from one orchard after the heat-waves of the summer months. In the following spring, however, small numbers of parasites were recovered from this orchard before the release of any parasites this season. Thus *M. ancylivorus* survived the heat-waves during the 1938–39 summer, then successfully carried through the winter, and began breeding again in the spring. In the spring of 1939, further consignments of *M. ancylivorus* were introduced and released at numerous points throughout the Goulburn Valley. At the end of this season

a good number of parasites were recovered from seven different orchards scattered over a wide area, indicating that *M. ancylivorus* was established at a number of points, and that it was breeding in the orchards. Its abundance increased markedly during the latter part of the season. Further parasites will not be introduced from America next spring, but an extensive survey of the district will be made to see where parasites have become established and whether they are spreading naturally.

Much attention was given to the improvement of methods of breeding *M. ancylivorus* under laboratory conditions.

8. *Field Crop and Pasture Pests.*—(i) *Locust Investigations.*—(*a*) *General.*—As a result of the appointment of an additional research officer, it has been possible to carry out continuous field studies of the ecology of *Chortoicetes terminifera* in one of its main outbreak areas. The new officer has a small laboratory at Warren, New South Wales, but most of the work is being done on Bundemar Station, Trangie, by the courtesy of Mr. E. I. Body, whose co-operation in many ways is deeply appreciated. The work at Canberra has again consisted mainly of the analysis of data provided by the New South Wales Locust Information Service, and by the newly constituted Queensland Locust Information Service. A paper setting out the results of the examination of the 1937–38 and 1938–39 outbreaks is now ready for publication. Since December, 1939, monthly experimental forecasts of locust developments have been issued to a few interested persons. This work is being continued in an effort to reach greater accuracy and precision in forecasting.

(*b*) *Information Services.*—During the year, the Queensland Information Service came into operation. Reports are now being submitted somewhat earlier by the New South Wales Service to enable the monthly forecasts to be made in good time. In order to assist observers, especially in Queensland, to distinguish the six injurious species of locusts and grasshoppers occurring in Australia, a popular pamphlet has been prepared in which these are described and illustrated.

(*c*) *Analysis of Recent Outbreaks of Chortoicetes.*—The conclusions reached from the detailed analysis of data on the 1937–38 outbreak provided by the New South Wales Information Service have been checked and extended by a similar analysis of the 1938–39 outbreak. The climatic conditions which are favorable for the development of the species have been defined with greater precision from these data.

In addition to lower limits of temperature and moisture, below which development does not occur, there is also an upper limit of moisture which not only stops development, but is also fatal to all stages. All these limits are now fairly accurately known. Hoppers and fliers are killed if conditions remain outside the favorable zone for more than a few weeks, but eggs are capable of surviving unhatched for about three months under dry conditions (in the field) and for at least five months under cold conditions. Thus the stage in the life-cycle which has been reached at the commencement of a period of drought very largely determines the effect which such a period will have on the population level. The dates on which hatching and the other life-cycle stages occur in a given locality are primarily determined by the date on which the climatic conditions first became favorable, whether as a result of a rise of temperature or of soil moisture.

The tendency for swarms to fly towards regions of higher humidity has a survival value at first, and tends to prolong an outbreak by withdrawing the swarms from dry areas in the interior. Eventually, however, the same tendency leads to their extinction when over-moist conditions supervene in the invaded regions.

The number of generations passed through by the locust population at any place and in any season can now be estimated from monthly climatic data by means of a " climatic index ", which is the sum of all monthly mean temperatures over 57.5° F. (the threshold for development in terms of mean monthly temperature) occurring during the favorable months of the season. An index of 36.5 is required for one generation, 73.0 for two generations, and so on. Thus, an indication of the amount of breeding which has taken place in an outbreak area or other region may be obtained even when no swarms are present.

The outbreak of 1939–40 provided an excellent illustration of the force of the climatic controls which have been referred to. During November and December, swarms were spreading south and east at such a rate that another widespread plague seemed likely. However, drought conditions over most of New South Wales, and heavy rains in the Darling Downs, wiped out the greater part of the infestation, and little damage was done.

(*d*) *Laboratory Work.*—Experiments have now been started in four constant temperature rooms to determine the rate of development and mortality of *Chortoicetes* at different combinations of temperature and relative humidity. The results should help to explain the climatic correlations which have already been obtained on the basis of field data.

(e) *Ecology of the Outbreak Areas.*—Comprehensive field investigations are now being carried out in the Warren–Dandaloo outbreak area. Their object is to determine more precisely what conditions of soil and vegetation make these areas suitable for the production of swarms of *Chortoicetes*, and whether by appropriate measures these conditions could be modified and outbreaks prevented. Attention is also being paid to the effect of climatic changes on the locust population. Determinations of the locust population in a number of different habitats within the outbreak area are being made from time to time, as well as quantitative observations on the bahaviour of the locusts, their life-cycle, and their fecundity. Parallel quantitative estimations of micro-climate (especially temperature, relative humidity, and wind), soil factors, and vegetation will provide the information needed to explain the observed distribution of the population.

The greater part of the work has so far been carried out under drought conditions, during which the number of locusts in the area investigated has fallen to about one-fifteenth of the number present in November, 1939. It has been found that the insects are not uniformly distributed over the country, but tend to concentrate in comparatively small areas known as " concentration zones ". For adults these zones are usually located in slight depressions, and are characterized by the presence of comparatively tall tufts (2 feet to 3 feet) of grass or other plants, with more or less bare ground between them. The concentration zones for hoppers are somewhat different, and seem to be largely characterized, under dry conditions at any rate, by the presence of green feed. In both cases, the zones apparently satisfy the more important requirements of the species, so that locusts reaching them from adjacent areas tend to remain.

(ii) *Red-legged Earth Mite* (*Halotydeus destructor*).—During field surveys in Western Australia in previous years, attempts were made to estimate the damage inflicted by the earth-mite on subterranean clover pastures. Such knowledge was necessary to decide what expenditure on control measures was justified. As no definite conclusion could be reached from general observations, an attempt was made to determine the damage experimentally. Plots were sown with subterranean clover and were isolated by metal barriers smeared with creosote. Mites were added to some, whilst others were kept free of mites. In the first season, during which, however, the plots could hardly be compared with an established pasture, foliage yields of the subterranean clover were depressed by the heaviest mite attack to an extent which was just significant. The damaged plots were observed to wilt at the end of the season much earlier than those undamaged, and thus their growing period was reduced and production lessened. Seed yield of the clover was greatly reduced by the attack of the mite. Although very severely retarded in growth by heavy mite attack, subterranean clover seedlings were only rarely killed. Owing to the very dry conditions in the autumn of 1940, the clover on the plots stocked with mites suffered severely from their attack. The plants in the controls, however, remained healthy and far exceeded the attacked plants in growth.

(iii) *Pea Weevil* (*Brachus pisorum*).—A large consignment of the parasitic wasp, *Triaspis thoracicus*, was received from France and placed in quarantine in Canberra. From this material 1,640 parasites were sent to Western Australia, where they were liberated in three pea-growing areas. Subsequently, the wasp was recovered from one of these localities, which gives reason to hope that the parasites may become established in the field.

9. *Termite* (*White Ant*) *Investigations.*—As it is now known that by far the greater part of the losses due to termite damage in Australia are attributable to the activities of species of the genus *Coptotermes*, and also that *Eutermes exitiosus* (the species hitherto studied and worked with) differs from *Coptotermes* spp. in its food preferences and apparently to some extent in its susceptibility to poisons, the emphasis of the experimental and testing work has been changed, attention now being concentrated on *Coptotermes*.

(ii) *Laboratory Testing.*—The most important development during the year is probably the successful adaptation of the standard laboratory-colony testing technique (developed with *Eutermes exitiosus*) to *Coptotermes lacteus*. *C. lacteus*, though not as abundant in the neighbourhood of Canberra as *E. exitiosus*, is a common and widely ranging species. It is not as destructive as its congener *C. acinaciformis* (Australia's principal pest termite), and this has to be taken into account when interpreting the results of tests carried out with the former species. The genus *Coptotermes*, however, comprises a group of very closely allied species ; and the belief that the results of tests with *C. lacteus* can be applied, in general, to *C. acinaciformis* has been supported by the data already obtained. The structure and size of *Coptotermes* mounds renders the separation of the termites more difficult than in the case with *E. exitiosus*. So far, it has not been possible to obtain as high a percentage survival (in colonies fed with the susceptible *Eucalyptus regnans*) at the end of the twelve weeks test period as is normal with *E. exitiosus* ; but the amount of wood eaten—about 25 grammes—is similar to that consumed by an equivalent weight of *E. exitiosus*. (*C. lacteus* workers are smaller than those of *E. exitiosus*, and the 6,000 adopted as the standard population is equivalent in weight to the 5,000 of a standard laboratory colony of the latter termite.)

During the year a nest of *Coptotermes acinaciformis*, taken from a living ironbark, was sent to Canberra from southern Queensland, and was used to install a series of laboratory colonies, Apart from demonstrating that this species could be used successfully for laboratory testing, if supplies could be arranged, the results obtained from these experimental colonies provided evidence that the destructive powers of *C. acinaciformis* are considerably greater than those of *C. lacteus and E. exitiosus*, for upwards of 40 grammes of *Eucalpytus regnans* was consumed per colony.

Until laboratory tests with *Coptotermes* were a practical possibility, it was considered inadvisable to undertake a comprehensive testing programme with a view to determining which of the native timbers possessed a sufficient degree of natural resistance to termite attack to be employed in unprotected positions, for it was known that some timbers which were resistant to *E. exitiosus* were liable to attack by *Coptotermes*, and vice versa. A large-scale testing programme has now been launched, attention being centred chiefly on those hardwoods reputed to be usefully " durable ". Each timber is studied systematically, for the variation in the property of termite resistance, as well as its degree, have to be determined. The New South Wales and Queensland Departments of Forestry have given valuable co-operation in this work by supplying samples from trees grown in different districts. Nearly thirty timbers are being studied, some of the tests being of a preliminary nature. The long-term objective of this work is to prepare the way for the more efficient exploitation of the useful property of natural resistance possessed by many native timbers, which, if it could be achieved, should help to reduce the losses due to termite damage, particularly in certain types of buildings.

In addition to the timber-resistance studies, the standard laboratory colony technique has been used during the year to test proprietary products for manufacturers ; and, in one instance, the results obtained have enabled the Division to give the firm concerned advice of considerable practical value. A promising timber preservative, developed by the British Forest Products Research Laboratory, has been subjected to laboratory tests, with very gratifying results. Studies of the various chemicals used or recommended for anti-termitic preservatives have been continued. In last year's report, reference was made to tests of the chlorinated naphthalenes. Similar tests have been undertaken with chlorphenols and chlorphenates, and with certain metallic naphthenates. The samples exposed in the laboratory colonies are prepared by impregnating the various chemicals, at different concentrations, either in cellulose blocks or in some even-pored susceptible timber. Tests have shown the yellow carabeen, *Sloanea woollsii*, to be satisfactory for this purpose.

During the year, means were discovered of shortening and simplifying the rather laborious laboratory-colony testing technique. The total number of colonies installed in the twelve months' period (including the developmental *C. lacteus* colonies) exceeded 500, a number greater than the aggregate of all colonies set up in any three previous years.

(ii) *Field Testing.*—Experience has revealed that *Eutermes exitiosus* attacks softwoods much less readily than do species of *Coptotermes* ; and therefore it was decided to reinstall those samples consisting of impregnated softwoods around mounds of *C. lacteus*, using the now standard " connecting-strip " method. Hardwood samples have been reinstalled round *E. exitiosus* mounds, with new strips. As it was considered advisable to carry out tests in districts which differed from Canberra in climatic conditions and also in their termite faunas, a search for new test sites has been initiated. An area of sandy ground near Griffith in the Murrumbidgee Irrigation Area has been selected, and with the help of the staff of the Commonwealth Research Station, rows of test blocks (of *Pinus radiata* and *Eucalyptus regnans*) have been buried with connecting strips to determine the degree of termite infestation. In this part of New South Wales, the small inland race of *Coptotermes frenchi* appears to be responsible for most of the damage to timber.

(iii) *Direct Control.*—Laboratory experiments have again failed to discover any substance more effective against termites than finely powered white arsenic ; and they indicate that the insects are not actively repelled by this substance. Some evidence has been obtained which suggests that *Eutermes exitiosus* is more susceptible to this poison than is *Coptotermes lacteus*. No success has been achieved in attempts to discover a material which can be added to arsenic to render it attractive to termites.

The conditions existing in a termite-infested building are so difficult to duplicate that experimental treatments of naturally occurring infestations cannot be used satisfactorily for the comparison of treatments. In order to compare the effects of different dosages of poisons, and of treatments made under various conditions, the special structure of the mounds of *Coptotermes lacteus* has been utilized. The thick clay outer wall of these mounds contains relatively few galleries, in which, under normal conditions, only small numbers of termites are found. By the removal, with a mattock, of a slab of the hard outer wall (which is subsequently replaced and sealed in its original position) dust poisons can be introduced into these outer galleries at

a point some distance away from the reproductive centre of the colony, and without damaging the main mound structure or disturbing the inhabitants. The effect of the treatment on the colony as a whole depends on the picking up, transportation, and dissemination of the poison by workers passing through the treated galleries; in other words, on precisely those factors on which the effectiveness of the treatment of an infested building depends. Using this " outer gallery treatment technique ", a series of experiments, involving over fifty mounds, and treatments with different dosages and under different climatic conditions, has been carried out. The mounds are examined four weeks after treatment, particular attention being paid to the nursery. A few more experiments are required to round off the series; but the results obtained so far indicate that under conditions which ensure the return of the termites to the treated galleries, complete extermination of a populous mature colony can be achieved with as little as $\frac{1}{16}$ oz. of white arsenic.

(iv) *Incipient Colony Studies.*—Observations on incipient colonies of several species of termites have been continued. All the evidence obtained indicates that decayed or partially decayed wood is essential for successful colony foundation. Young colonies also have high moisture requirements; and while development can continue at 95 per cent. relative humidity, no colonies have survived when exposed to a relative humidity of 90 per cent. Over a period of eighteen months the numerical increase of incipient colonies of *Porotermes adamsoni*, *Rhinotermes intermedius*, and *Coptotermes lacteus* parallels the estimated average populations of mature colonies of these species.

(v) *Termite Taxonomy.*—In the systematic revision of the Australian termites, the last of the fourteen genera represented in this country is now receiving attention. The completed revision, when published, will fill the need for an authoritative reference work on this important group of insects.

(vi) *Advisory Work and Identifications.*—During the year, visits were made by officers of the Termite Section :—(*a*) to New Zealand, to advise the Dominion Government on methods of dealing with the problems that have arisen as a result of the introduction of certain destructive Australian termites into that country ; (*b*) to various places in Victoria, to assist the State Railway Department, with demonstrations and advice, in their campaign of termite control ; and (*c*) to points on the Port Kembla–Goulburn power line, to advise the New South Wales Department of Works and Local Government on the treatment of termite mounds. Numerous inquiries relating to problems of termite control, and specimens submitted for identification, were dealt with during the year.

10. *Grain Weevils.*—Towards the end of the period under review and at the request of the Australian Wheat Board, the Division undertook an investigation of the problem of weevils in stored grain in Australia. The first step is a thorough survey of the problem in the field, and this task has been simplified by the ready co-operation of the State Departments of Agriculture. In addition, preliminary laboratory experiments have been set up to test the insecticidal value of a large range of substances.

11. *Book Pests.*—Some time age the Division was asked for advice about the treatment of books to protect them against insects and moulds in libraries in the tropics. Some experiments were undertaken and as a result an alcoholic solution of boric acid was recommended. This solution is much safer than the corrosive sublimate which is usually recommended, and it does not tarnish gold lettering. It has not previously been used, but tests carried out in Rabaul show that it is thoroughly satisfactory. It was recently reported that no damage was done to treated books except on small untreated paper labels which were fixed on to the books after they had been treated.

12. *Beneficial Insects sent Overseas.*—Lantana bugs have been successfully sent to Norfolk Island and by air to Java, but, so far, efforts to send adults of this insect by air to India have been unsuccessful.

13. *Systematic and General Entomology.*—During the year, the Museum has received some 25,500 additional specimens. More than 2,000 of these came from the late Mr. Garthside's collection of natural enemies of St. John's wort and other insects in England, while 134 Hymenoptera of economic importance were received in exchange from Brazil. In addition, the Division received a valuable bequest consisting largely of Australian Coleoptera under the will of the late Mr. H. J. Carter, a noted authority on Australian beetles. With the addition of the Carter collection to other collections of Coleoptera it already possessed, the Division now has an outstandingly good reference collection of Australian beetles.

As in the past, a number of insects have been identified for individual workers and institutions in Australia and overseas, and advice or practical assistance has been given in response to inquiries.

IV. ANIMAL HEALTH AND NUTRITION INVESTIGATIONS.

1. *General.*—General progress has been made in all branches of the work of the Division of Animal Health and Nutrition. Soon after the declaration of war, officers were called up for military duty, and thus it was not possible to press forward with some of the work. An attempt was made to concentrate on those aspects which might be calculated to have the more ready application to practical problems in the animal industry.

The preparation of the new field station at Werribee (Victoria) has now been completed. During the year, the farm was graded, check banks, irrigation and drainage channels put in, and 81 acres laid down in grasses and clover. Farm buildings, milking shed, dairy, and a small residence for the farm manager were completed just before the end of the financial year preparatory to starting active operations with a restricted milking herd for a continuation of the mastitis investigations on the first day of the next financial year.

The work of the Division of Animal Health and Nutrition has been carried out at the three main centres in Sydney, Melbourne, and Adelaide, as well as at the field stations at Cunnamulla (Queensland), Badgery's Creek (New South Wales), and Berwick (Victoria). In addition, co-operative work has been carried out with the State Departments of Agriculture in each State. Co-operation with the Division of Economic Entomology has been maintained through the Veterinary Entomological Committee and with the Division of Plant Industry through the Inter-Divisional Committee for Agrostology.

The secretarial work for the Committee on Animal Production, appointed by the Australian Agricultural Council, has been carried out during the year and has added appreciably to the Division's responsibilities. In addition, considerable time and energy have been devoted by some officers to the work of the several technical sub-committees on animal production.

The work of the Division has been greatly facilitated by the continued generous financial assistance of the Australian Pastoral Research Trust, the Australian Wool Board, the Australian Cattle Research Association, and the Queensland Government.

2. *Animal Health Research Laboratory, Melbourne.*—(i) *Pleuro-pneumonia in Cattle.*—In the report for the year 1938–39, reference was made to an experiment on the duration of immunity to pleuro-pneumonia after vaccination at the tip of the tail with the standard culture pleuro-pneumonia vaccine prepared for the various State Departments of Agriculture. This experiment is still under way, and the groups of vaccinated cattle are being built up at regular intervals for the immunity test for 1941. Pleuro-pneumonia vaccine issued during the current year amounts to nearly 300,000 doses, and has given every satisfaction until quite recently when failure to immunize, in spite of proven ability to produce reactions (sometimes excessive) in the tail, has been claimed in some quarters. These claims are being investigated.

(ii) *Entero-toxaemia of Sheep.*—The causal organism of this disease, *Clostridium welchii* Type D, differs from the " classical " *Cl. welchii* Type A in producing an additional toxic component known as the epsilon component, which is absorbed from the gut of affected sheep. The most strikingly clinical signs of the disease, especially in lambs, are severe convulsions. In order to study the mode of action of the toxin, a study of certain aspects of its pharmacology was carried out in collaboration with Dr. C. H. Kellaway and Dr. E. R. Trethewie, of the Walter and Eliza Hall Institute of Pathology, Royal Melbourne Hospital. Toxin consisting mostly of the epsilon component and very little alpha component was used. It was shown that the convulsions are not due to the production of a state of hypoglycaemia, hypocalcaemia, anoxaemia or uraemia, nor to the anhydraemia that frequently occurs, but to a direct action upon the central nervous system, probably the basal motor ganglia in the brain. Furthermore, the toxin has an injurious effect upon various tissues ; it allows the liberation of histamine from the lungs, which leads to pulmonary oedema, and of adenyl compounds from the heart, which produce a disturbance of conduction. These studies have tended to confirm the view that the only treatment which present knowledge suggests is prophylactic vaccination or prophylactic administration of antiserum. The enhancing effect of trypsin upon the epsilon component first described by Bosworth and Glover (1934) has been confirmed. The evidence to date suggests that the degree of enhancement may vary greatly between the toxins from different strains. Studies have been commenced upon the conditions that govern the production *in vitro* of epsilon component. With one strain it was found that maximal production of toxin occurred after approximately 48 hours, and that efforts to keep the hydrogen-ion concentration low, by the addition of calcium carbonate, yielded a greater amount of toxin. By arrangement with the University of Melbourne, a study of the antigenic constitution of strains of *Cl. welchii* belonging to the four known types A, B, C, and D were carried out under the direction of the Division by Mr. A. W. Rodwell, M.Sc., and it was found that a great degree of overlapping exists between the antigenic components of the four strains. Results of precipitin tests with extracts prepared with 1 per cent. sodium carbonate solution suggests that it might become possible to determine, merely by this test, if a strain belonged to Type D.

(iii) *Black Disease.*—The antigenic analysis of strains of *Cl. novyi* (*Cl. oedematiens*) was completed. Strains were included from human sources, from ovine sources (black disease in New South Wales, Victoria, Tasmania, and New Zealand ; bradsot in Germany (=B. *gigas*)), bovine sources (black disease in Victoria), equine sources (black disease in Tasmania), as well as the bacillus of osteomyelitis of buffaloes in Dutch East Indies and *Cl. haemolyticum* from bacillary red-water of cattle in Nevada, United States of America. Study of " H " and " O " agglutinins showed (*a*) that there is a common " O " antigen to most of these strains ; (*b*) that " H " analysis reveals a further very close relationship between them ; for example, one large group contains a large proportion of the strains of the black disease bacillus from Australasian sources, the *B. gigas* of bradsot in Germany, strains of *Cl. haemolyticum* and of the O.B.B. bacillus. The very close relationship of all these bacilli of animal origin is thus stressed. None of the strains of classical *Cl. oedematiens* from human sources had common " H " antigens with any of the animal strains or the closely related bacilli mentioned above. Since there is a common " O " antigen, it does not appear to be necessary to make anacultures against black disease polyvalent, if we presume that the " O " antigen in the bacillary bodies contributes to the production of immunity.

(iv) *Caseous lymphadenitis.*—The work along the lines outlined in the last report was continued. Examination of the polysaccharide antigen has shown it to contain as components a polypeptide containing half the total nitrogen, a hexuronic acid, and a still unidentified nitrogenous substance. Hexose-6-phosphoric acid also appears to be present. Isolation and examination of a nucleo-protein fraction is also proceeding. Serological studies on strains of ovine and equine origin showed that (*a*) the ovine strains appear to have the same antigenic make-up ; (*b*) the four equine strains differ between themselves and from the ovine strains. Further trials of large groups of guinea-pigs showed that a vaccine prepared from bacteria disrupted by freezing and thawing gives a substantially better degree of protection than any others tested to date.

(v) *Bovine Haematuria.*—Further evidence obtained from the field experiments on the use of gypsum top-dressing of pastures in the prevention of haematuria indicated that this procedure delays the onset of the disease considerably (up to two years), but may not prevent it entirely. On the assumption that excessive intake of a trace element may be the cause of the disease, soil from Mount Gambier, concentrated by sieving through a fine mesh, and other mineral mixtures are being fed to cows.

(vi) *Myxomatosis of Rabbits.*—Experiments conducted during the year showed that the rabbit stickfast flea, *Echidnophaga myrmecobii*, and various mosquitoes are capable of transmitting the disease from infected to healthy rabbits under laboratory conditions. Attempts to obtain infestations of rabbits with the flea at Wardang Island failed because the environment was unsuitable to the flea. Studies on the virus have included the relationship between the natural virus and the artificial variant neuro-myxoma virus, and attempts to produce immunity to myxomatosis by vaccination with formalinized suspensions.

(vii) *Mastitis in Dairy Cattle.*—The systematic study of the experimental herd was continued during the year. Much time was devoted to the correlation of the data collected during the first two lactation periods. The results of this examination were submitted for publication. At the end of the year the experimental herd was removed to the new farm in the Werribee district.

(viii) *Toxaemic Jaundice.*—The co-operative investigation was continued. Examination of material from further outbreaks of toxaemic jaundice again showed its constant association with large amounts of copper in the livers and pre-clinical rise in copper in the blood. Work has largely been concerned with attempts to depress excessive absorption and storage of copper. Tests have given encouraging results, and a field test is now under way on a 400-acre property at Barooga.

(ix) *Tuberculosis.*—In any scheme to eradicate tuberculosis from cattle, a serious handicap is that many advanced cases of infection no longer react to the tuberculin test. We have attempted, with some success, to develop a complement-fixation test to permit the detection of such cases, using as antigen human tuberculosis bacilli, defatted, disintegrated in a ball mill, and extracted by boiling in distilled water. Unfortunately, the antigen is relatively labile. The test has enabled the detection of advanced cases of tuberculosis which were negative to the tuberculin test, and it appears that, once the problem of preparing stable antigens is overcome, the complement-fixation test may prove a very useful adjunct to the tuberculin test.

(x) *Contagious Abortion.*—Repeated testing by means of a complement-fixation test, combined with segregation of reactors, has allowed the elimination of an outbreak of contagious abortion in the experimental herd (" vealer production "). The test has also contributed in large measure to the elimination of the disease from the mastitis herd at Berwick.

(xi) *Ephemeral Fever of Cattle.*—Using materials forwarded from Canberra, a useful complement-fixation test was developed for the diagnosis of this disease. The antigen was prepared by disrupting in distilled water suspensions of leucocytes and blood platelets prepared from infected cattle, then boiling the suspensions and making them isotonic with sodium chloride. Unfortunately, the antigen, although specific and sensitive, is relatively labile, and before this disadvantage could be overcome the investigation had to be abandoned.

(xii) *Observations centred in Queensland.*—(*a*) *Peg-leg.*—The experiment referred to in the last report was concluded. The animals have been disbanded, and the results are being subjected to statistical analysis. In these experiments the use of monoammonium phosphate in the drinking water gave the most interesting results; there was a much lower incidence of peg-leg, bone chewing, and losses in this group than in its controls. A further experiment is being started to determine simply, under well-controlled conditions, the value of a phosphatic lick (bone flour) in the nutrition of cattle at Helenslee, and the prevention of peg-leg.

(*b*) *Anaplasmosis.*—This experiment has been concluded. The results showed that if winged insects at Townsville are capable of transmitting the infection, as appears possible from the two instances of otherwise unexplained transference during three years' observations, it must be only under exceptional circumstances, and it does not therefore appear to be a factor of much practical importance. For all practical purposes, ticks may still be considered the only important vectors of anaplasmosis in the Townsville area.

3. *The McMaster Animal Health Laboratory.*—(i) *Parasitological Investigations.*—(*a*) *Studies on Phenothiazine as an Anthelmintic.*—Much attention has been paid to this drug owing to the very promising results obtained in the preliminary trials referred to in the last annual report. Unfortunately, the war restricted supplies. In suitable doses it has been found highly effective against all species of nematodes of economic importance to the sheep industry of the Commonwealth. During the year it was established that phenothiazine is highly efficient (*a*) against *H. contortus*, *Trichostrongylus* spp., and *Oes. columbianum*, and (*b*) against immature forms of *H. contortus* which are considerably resistant to other forms of treatment and cause severe damage to the sheep. The fact that, on the evidence, it was found to be equally effective whether it enters the rumen or the abomasum is of great practical significance. Small repeated doses have been found to show an encouraging degree of efficiency against *H. contortus* and *Oes. columbianum*, and this may prove of practical value. Nematode larvae did not develop in the faeces of treated sheep for periods up to four days after dosing. About 32 per cent. of the dose administered by the mouth was recoverable in the faeces during the three or four days following dosing. The urine of treated sheep was found to contain unchanged phenothiazine, phenothiazone, and thionol, and to redden on exposure to air and stain wool which it contaminates. This wool colouration is not removed by ordinary scouring, but observations have shown that, in practice, the amount of wool so stained, about the sheath, crutch, and hocks, is negligible. The toxicity of phenothiazine for sheep is extremely low, and it appears to be one of the safest anthelmintics known. The most effective and most economic dose rate has yet to be determined. Phenothiazine is likely to prove more expensive than anthelmintics now in common use, and needlessly large doses must be avoided in consequence. Methods for administering the large and bulky doses of this highly insoluble substance have been investigated. Administration in the form of a relatively stable suspension by means of a drenching funnel has, so far, been found to be the most satisfactory for Australian conditions. Several compounds related to phenothiazine have been tested, but none has shown the association of high anthelmintic efficiency and low toxicity characteristic of phenothiazine. The compounds tested were: diphenylamine, phenothiazone, phenoxthin, thionol, and phenarsazine chloride.

(*b*) *Comparative Efficacy against Trichostrongylosis of Phenothiazine, Tetrachlorethylene Emulsion, and the Copper Sulphate-Nicotine Sulphate Mixture.*—The search for a highly effective anthelmintic against *Trichostrongylus* spp. in sheep has been one of the major objectives of the parasitology section for several years. In 1935, it was shown that copper sulphate, nicotine sulphate mixture was reasonably effective, and since then it has been widely used in Australia. However, on many occasions its efficacy in the field has been very low. In 1936, tetrachlorethylene, administered after a preliminary dose of copper sulphate solution to close the oesophageal groove, was found to be effective, but this method was not widely advocated because of the time and trouble involved by the dual dosing and the cost of the drug. During the past year, a field trial comparing the efficacy of these two methods of treatment with one involving the use of phenothiazine has been carried out, and the results have been published. It was found that if a 70 per cent., or greater, reduction in faecal egg count be taken as satisfactory, effective treatment was attained in 83 per cent. of sheep with phenothiazine, in 76 per cent. with the tetrachlorethylene emulsion, and in only 21 per cent. with the copper sulphate-nicotine sulphate mixture. Study of the individual results suggests that, where the two latter drugs failed, this failure may have been due to the absence of closure of the oesophageal groove. This occurred

less frequently with the tetrachlorethylene emulsion than with the copper-nicotine mixture and, on experimental evidence, is believed to have been due to the fact that a few seconds elapsed between the administration of the copper sulphate solution and the dose of tetrachlorethylene. The copper sulphate nicotine drench was given as one dose with no interval to increase the chance of reflex closure of the oesophageal groove. The results suggest, *inter alia*, that better results with copper-nicotine may be obtained if the dose is given in two parts, a few mils followed after a few seconds by the rest of the dose.

(*c*) *The Efficiency of Copper Sulphate, Nicotine Sulphate and of Carbon Tetrachloride against Haemonchosis in Adult Sheep.*—It has been found that the copper sulphate-nicotine sulphate mixture is efficient, but fails in a proportion of cases in which there is repeated failure of the oesophageal groove reflex. These cases remain heavily infected, despite repeated treatment, and are a serious source of contamination for animals grazing with or after them. In a field trial carried out during the year, it was found that the sheep in which copper sulphate-nicotine sulphate mixture was not effective were effectively cured by the use of carbon tetrachloride, which is effective against haemonchosis even though it enters the rumen, whereas the copper-nicotine mixture and tetrachlorethylene are not effective unless they pass direct into the abomasum.

(*d*) *Immunological Studies on Haemonchosis.*—Previous observations that the administration of infective larvae to resistant sheep is followed by an eosinophilia were confirmed. It was also observed that the injection of living infective larvae subcutaneously in resistant sheep resulted in an eosinophilia, but when the larvae were heat-killed prior to injection there was no such response.

(*e*) *Nematodes affecting Army Horses.*—Nearly 100 faecal samples were examined from horses in a Light Horse Militia camp. It was found that 52 per cent. carried infestations with strongyles (*Strongylus* spp., *Triodontophorus* spp., and *Trichonema* spp.) great enough to be considered harmful. Some 15 per cent. were infested to a degree capable of causing serious interference with the performance of work, and a further 22 per cent. carried infestations that were at least sufficient to warrant treatment.

(*f*) *Pathogenicity of Nematodirus spp. in Sheep.*—This work was continued, but no conclusive results were obtained. A simple and effective method was devised for obtaining pure cultures of infective *Nematodirus* spp. larvae from sheep harbouring mixed nematode infestations; the details have been published.

(*g*) *Recovery of Nematode Larvae from Soils and Pasture.*—This study was continued throughout the year as opportunity offered. A preliminary report, describing a modification of Baermann's technique which gave consistent results over several trials, has been published. Various steps involved in this technique are now being studied in an effort to simplify it and enhance its reliability.

(*h*) *Parasitological Field Trial at "Frodsley", Tasmania.*—This trial, now in its third year, gave interesting results. It was commenced in February, 1938, with two groups of 80 Corriedale ewe weaners, each group being maintained in rotation on four plots of 5 acres each. Grass hay and agricultural salt were available *ad libitum* to each group. One group was drenched repeatedly as a means of controlling internal parasitism, while the other group was left untreated. The two groups showed no significant differences in body weight or wool production during the first year of the trial, and the degree of parasitism was relatively low in both groups, although less in the drenched group. The sheep were mated in the autumn of 1939 and lambed in August. The grazing and hay feeding carried the ewes and lambs till weaning time in February, 1940, when the weaners were disposed of. The ewes were still retained on the plots and a further 20 weaners were added to each group. The area, therefore, carried four sheep per acre for a period of two years and later five per acre. The lambing percentage was good, despite very severe weather at the time, and the lambs thrived excellently. Under these conditions of management at "Frodsley", internal parasitism has not increased in either the drenched or the undrenched group, but has declined since the commencement of the trial in 1938, and from March, 1939, onwards only occasional positive faecal egg counts in individual sheep have been recorded. Despite the relative absence of worms from both groups of sheep, the drenched group was significantly heavier by 5 lb. and cut 0.3 lb. more wool per head than the undrenched group. The continued assistance and co-operation, often under great difficulties, of the owner, Mr. Keith Brodribb, and officers of the Tasmanian Department of Agriculture, is gratefully acknowledged.

(i) *Parasitological Studies at Armidale, New South Wales.*—Work at this centre has been carried on under considerable difficulty during the year as the time of the research officer concerned has been much occupied with military duties. (1) *Epidemiological Trial at "Saumarez".*—The periodical faecal examinations were continued. The survivors of the original lambs were taken over from the station, and a further lot of weaners were purchased to keep the experimental flock up to the original number. The yearly addition of weaners is essential in this study as

the older sheep tend to become resistant to the parasites. It has been found during the period from the commencement of the trial, in June, 1938, up to January, 1940, that *Haemonchus contortus* (the large stomach worm) is a parasite of most importance during the warmer months. It may be acquired from early spring onwards, and during summer heavy infestations are related to rainfall. Treatment for the control of this species should therefore begin, especially with ewes and young sheep, in late winter or early spring. It should be repeated twice before lambing begins in order to protect the lambs as far as possible. During the remainder of the period when this parasite may be serious, treatment should be repeated at short intervals and with special reference to rainfall. Treatment is especially indicated three or four weeks after good falls of rain associated with overcast weather. *Trichostrongyles* (hair worms of the small intestine) are parasites of the cooler months. Infections start late in autumn and early winter and reach maximum severity in the late winter months. Treatment should begin at weaning and be repeated during autumn and winter at intervals not exceeding four weeks. The precise relationship between weather conditions and severe infections has not yet become clear. Infections by *Oesophagostomum columbianum* (nodule worms of the large bowel) are acquired in late summer and early autumn. The largest number of worms appeared to be present in the sheep in late winter and early spring, but they resulted from infestations acquired some two or three months previously. The sheep apparently acquire little or no infection from the pastures during winter, and hence thorough treatment before or during the winter and spring can be calculated to go far towards controlling this troublesome and costly parasite.

(2) *Trial on Control of Haemonchosis at "Gostwyck" (Large Stomach Worm Infestation).*—In the early winter of 1939 a new trial was commenced in which two groups of weaners were used. One group was grazed continuously at the rate of one sheep per acre and the other group was rotated at three-weekly intervals between two plots. The actual rate of stocking was the same for both groups. Both groups were treated at three-weekly intervals with carbon tetrachloride, and subsequently each group was treated with phenothiazine (twice in August and again in October). Despite this treatment worms were not eradicated, but the degree of infestation was reduced to a very low figure. The treatments with phenothiazine were particularly effective, but since the sheep were on infected ground some re-infestation was inevitable between doses. An interesting feature, and one likely to have a considerable influence on sheep husbandry in New England, was that the group which was rotated gained an average of 11 lb. in body weight between April and November, whereas the group grazed continuously on the same area gained less than 4 lb. per head. The rotated group maintained and increased its lead during the summer and autumn, indicating that this system of management is not only desirable but is suitable for use on the natural pastures of the northern tablelands.

(3) *Survival of Eggs and Larvae of Sheep Nematodes in Faeces exposed to Atmospheric Conditions at Armidale.*—This study was continued, but it will be some time before the mass of results so far obtained can be sorted and correlated with the climatic conditions obtaining at the time each observation was made. Observations have shown that the eggs of *Trichostrongyles* will survive much longer than those of either *Haemonchus* or *Oesophagostomum*. The longest periods of survival in faeces are, for *Haemonchus* 105 days, for *Oesophagostomes* 81 days, and for *Trichostrongyles* over 150 days (upper limit not yet recorded). In most cases *Haemonochus* and *Oesophagostomes* survive for much shorter periods. Not only the maximum time of survival, but also the rate at which eggs and larvae perish in relation to climatic conditions, is of great importance in relation to rotational grazing and the control of internal parasitism by management.

(4) *Trial of Lentin.*—This drug was tested as a possible means of treatment against the nodule worm and other internal parasites of sheep. It is a very powerful purgative and might remove the parasites mechanically if in no other way. It was found to be both ineffective and dangerous, several of the sheep dying shortly after treatment.

(5) *Survey of Internal Parasitism of Sheep.*—This survey was continued in conjunction with the District Veterinary Officer of the New South Wales Department of Agriculture and the Inspectors of Stock in his district. A start was made with the correlation of outbreaks with climatic and seasonal conditions.

(ii) *External Parasites.—Sheep Dipping Investigation.*—In last year's report, progress was recorded in studies of the sheep ked. It was pointed out that a fuller knowledge of this parasite might enable better results to be obtained merely by the modification of existing dipping practice. Observations on the life-history of the ked have shown that the female may copulate a few hours after emergence from the pupal stage. In this case, however, the first pupa is not deposited until after fourteen days or longer and thereafter pupae are deposited at the rate of approximately one a week. If copulation is deferred until the third day after emergence, the female still deposits the first pupa on about the fourteenth day of adult life. This suggests that the female is not sexually mature till some days after emergence. In the case of male keds the evidence suggests that sexual maturity is not reached till about the tenth day after emergence, so that if newly emerged males and females are put together, the first pupae do not appear for at least eighteen

days, and generally longer. These are important points in relation to dipping practice. To date no seasonal difference has been observed in the times taken by males and females to reach sexual maturity. The duration of the pupal period is usually 19–22 days. It has never been less than 19 days but not uncommonly extends up to 26 days and, in one experiment, the maximum period was 32 days. Seasonal variations in temperature at Sydney, for example, appear to have little effect on the duration of this stage, but observations under more severe winter conditions are required. Laboratory tests indicate that the temperature range within which pupae will develop, and the keds emerge from them, is probably quite a narrow one. The length of life of the ked is difficult to determine accurately, but it may be said that few males live beyond 80 days and few females beyond 100–120 days. Hence, a female may be expected to deposit at most about fifteen pupae during her lifetime. As recorded previously, many keds placed on experimental sheep disappear, and an attempt was made to discover their fate. It was found that a few drop off the animal either by accident or design, a few die and fall from the fleece or become entangled in the wool, while there is evidence that sheep destroy some by biting at the part irritated by the parasite. The migrations of keds about the body of the host have been studied in some detail. The females tend to wander towards the belly and crutch for the first fortnight after emerging from the pupae. Thereafter there is a general tendency for them to move forward to the shoulder, brisket and neck, where most pupae are deposited. The position on the sheep of some 11,000 pupae has been noted. Of these, 45 per cent. were found on the lower neck towards the brisket. The lower sides were the next commonest position and then the belly and crutch. Only about 7 per cent. were found in the latter position. As regards the position of the pupae on the wool fibre, it can be said that they are never deposited less than about a quarter of an inch from the skin surface and as the wool grows the pupae are deposited farther from the skin surface.

It was mentioned in the last report that there appeared to be a seasonal decline in ked populations during the hotter months of the summer and autumn. Further attention has been paid to this, and it has been observed on several occasions at the laboratory that the extent to which keds will survive and multiply on a sheep depends greatly on the animal's bodily condition. For example, sheep which keds would persistently leave in favour of others became susceptible and sustained heavy infestations when their bodily condition was impaired by artificial infection with intestinal parasites. On removal of the worm infestation by treatment, the sheep regained its former condition and the ked infestation declined. Hence it is apparent that such factors must be taken into consideration, and that what appears to be a seasonal fluctuation related to climate may, in fact, be related also to the better general condition of sheep during that period of the year. It has not been possible to keep keds alive for many days off the sheep. Usually all are dead within five days and this is in general agreement with other workers' results. Under laboratory conditions of constant temperature at 4° C. and 90 per cent. humidity, eleven keds out of eighteen survived for fifteen days and one survived until the 24th day.

Research on sheep dips has again been restricted through the pressure of other work. Some progress has been made, however. Using the experimental dip and draining pens provided by the Wool Board it was found that sheep carrying ten to twelve weeks' wool remove from $1\frac{1}{2}$ to 2 gallons of fluid on emerging from the dip, and of this quantity, approximately one-half drains away, leaving each sheep with $\frac{3}{4}$ to 1 gallon of dipping fluid retained in its fleece. About 95 per cent. of the fluid draining from dipped sheep leaves them in the first seven minutes after they emerge from the bath, and 75 per cent. of it within one minute. Tests were conducted with six different forms of arsenic in an endeavour to find one which could be used as a basis of comparison for testing the efficacy of other dipping agents. Sheep infested with keds, and in some cases with lice also, were dipped in these six preparations, each being made to contain the same equivalent of arsenic. In addition to noting the effect upon the parasites, analyses were made of the dipping fluids before and after use and of the drainings from the sheep. When soluble arsenicals were used, it was found that the arsenic content of the liquors draining from the sheep was approximately the same as in the main dipping bath. It was noted, however, that the later drainings after dipping in sodium arsenite and sodium arsenate had a slightly higher arsenic content. Dipping with insoluble arsenic trisulphide suspensions gave draining fluids with only half the arsenic content of the original dip, indicating that some of the insoluble arsenic was retained in the fleece by filtration. It follows that drainings from sheep passed through such a dip would dilute the main body of dipping fluid if allowed to flow back into it. The passage of sheep through dipping fluid consisting of a suspension of insoluble arsenicals stabilizes the suspension and this is probably due to suint and wax from the fleeces of the dipped sheep. In another series of tests, pupae were immersed in solutions of sodium arsenite, phenol, rotenone, and a commercial arsenical powder dip used at the strengths generally prescribed for dipping sheep. None of these agents materially affected the percentage emergence when pupae of mixed ages were used. It was found in a smaller, subsidiary trial, however, using sodium arsenite and the commercial dip, that both were effective in checking the further development of one-day old pupae. From this whole investigation, so far as it has gone, certain practical indications have emerged. During

the year, the New South Wales Stock and Brands Branch has, through members of its field staff, supplied large numbers of pupae. These have been of the greatest assistance and the help so afforded is gratefully acknowledged.

(iii) *Blowfly Problem.*—(*a*) *Trial of the Mules Operation at Dungalear Station.*—This trial was concluded during the year. The observations on the treated and control group of ewes were continued until March, 1940. These have shown that the benefit conferred by the operation was permanent, the treated ewes still showing the same very low incidence of crutch strike compared with controls after a period of over two and a half years. In June, 1939, strikes were common among the control sheep, but the treated group continued to show very few. A routine crutching was carried out on the control group only. Despite this, the treated group carried through till shearing, at the end of August, with a negligible incidence of crutch strike. Observations showed that the treated group produced an average of 5 oz. more greasy wool per head than the controls as a result of the lower incidence of fly strike. Another trial in connexion with the Mules operation has been commenced at Noondoo. One of the main objectives is to determine the extent to which the operation can be performed satisfactorily on lambs in conjunction with marking.

(*b*) *Blow-fly Dressings.*—Good reports were received from the field on the use of the boracic acid, camphor oil, emulsion (C.B.E.) which was devised as a cheap substitute for the glycerine, diboric dressing. As the onset of war increased the price and the difficulty of procuring certain of the ingredients, its use was restricted. Preliminary observations were made with a solution of sodium pentaborate. Solutions containing the equivalent of about 20 per cent. of boric acid in water can be prepared very easily, and tests on a number of strikes have shown that the solution is highly effective in killing the blow-fly larvae. It is non-irritant and does not rapidly drive the larvae from the dressed area. They are killed after several hours. There has been no opportunity as yet to test the ability of this preparation to prevent restrike. The particular merit of sodium pentaborate solution, apart from its effect upon the strike, is that the ingredients, caustic soda and boracic acid, can be purchased cheaply by graziers and others who could easily prepare the dressing for themselves. The cost of such a dressing, home-made, need not exceed about 1s. 6d. per gallon at present prices.

(iv) *Infectious Diseases.*—(*a*) *Footrot and Foot Abscess Investigation.*—These two diseases have now been clearly distinguished as a result of close study in the field and in the laboratory. Footrot has been proved to be a contagious disease, and the causal bacterium is carried over from season to season on the feet of cases that have apparently recovered but which on close inspection show imperfect healing. The results of field trials in the control of footrot have been published. Clean sheep have been retained for long periods on ground previously stocked with affected sheep without developing any sign of the disease. Eradication of footrot was successfully carried out on certain properties, one of which carries 30,000 sheep, and has remained quite free for a period of three years. In this work of eradication, advantage has been taken of the very low incidence of the disease in the dry, hot summer months. All lame sheep have been isolated or culled and the feet of the remaining sheep have been carefully examined for chronic lesions, and animals showing these have also been isolated or culled. When adequate precautions have been taken against the re-introduction of the disease by travelling stock, sheep on agistment, or newly purchased sheep, complete success has been attained. Foot abscess has been found to be non-contagious and to be troublesome mainly in abnormally wet seasons. Treatment of affected feet and persistent use of the foot-bath have given some measure of control.

(*b*) *Infectious Ophthalmia (Pink Eye) of Sheep.*—This investigation was commenced in the latter part of the year, when an opportunity occurred to procure some suitable infected sheep. The disease was maintained at the laboratory by infecting the eyes of normal sheep in series. Observations have shown that the disease is readily transmitted by contact or by instilling tears from an infected eye into the conjunctival sac of a normal eye. Attempts to induce the disease by the use of various cultures from infected eyes failed. Similarly, the observations of workers elsewhere that filtrates of tears are not infective was confirmed. Gradocol membranes having an average pore diameter of 0.6 microns were used in the preparation of filtrates, and not only tears but ground-up conjunctival membrane from infected eyes were tested. An organism, resembling a rickettsia and conforming to the description of *R. conjunctivae*, described as the cause of this disease in South Africa, was regularly present. In acute cases most of the epithelial cells were found to be crowded with them. No conclusive proof that this is the cause of the disease was obtained, although it was seen in only one among 125 apparently normal sheep. It was found to persist for several weeks in eyes which had recovered from the disease. Numerous attempts made to cultivate this rickettsia in eggs by serial passage on the chorio-allantoic membrane, the yolk sac and in the amniotic fluid failed. Several other special culture methods, including the tissue culture method, also failed. Recovered animals were closely observed and tested from time to time in an attempt to assess the duration of immunity. Attempts were made to infect other species of animals, including goats, dogs, mice, guinea pigs, and rabbits, but without success.

(c) *Balanitis in Wethers and Rams.*—During the year a field veterinary officer visited areas where this disease is prevalent among wethers, and a considerable body of general information has been built up regarding it. Close observations were started on a flock in which the disease is frequent. Wethers in various stages of the disease have been received at the laboratory for experimental use.

(v) *Biochemistry.*—(a) *Carbon Tetrachloride Poisoning.*—A commonly accepted view has been that a lime deficiency in the ration will render sheep more susceptible to carbon tetrachloride poisoning. Experimental evidence to support this theory has not been entirely satisfactory. During the year, ewes and their lambs have been maintained on a lime-deficient diet over a period of nine months. No difficulty was experienced in this work in inducing a severe hypocalcaemia both in adult ewes and in young growing sheep. Repeated drenching of these animals with carbon tetrachloride, however, did not result in the loss of a single animal. It was found, however, that after being dosed with carbon tetrachloride certain individuals showed a temporary fall in the serum calcium, the decrease in some instances amounting to approximately 50 per cent. The fall in the blood calcium was not manifested by any unusual symptoms when the sheep were not exercised. Further experiments suggested that factors, such as too vigorous exercise, may seriously affect animals in a hypocalcaemic state. The evidence collected suggests that some of the sheep losses in the field associated with carbon tetrachloride drenching may be the result of the hypocalcaemia induced by carbon tetrachloride or of aggravation of pre-existing hypocalcaemia.

(b) *Nutritional Studies on Internal Parasites of Sheep—A Study of the Influence of Trichstrongylus spp. on the Digestibility of Feed Constituents.*—Work was started on this study during the year.

(c) *Biochemical Studies on Pregnancy Disease in Sheep.*—(1) *Field Cases.*—The differential diagnosis between lambing sickness in ewes and pregnancy disease is difficult. Field observations have indicated that a more extensive use of calcium borogluconate, or other suitable calcium preparations, injected either intravenously or subcutaneously into ewes thought to be affected with pregnancy toxaemia, would result in economic saving annually since a proportion of the cases are due to so-called " lambing sickness " (hypocalcaemia) and not to pregnancy toxaemia. Biochemical examinations of material from field cases of suspected pregnancy toxaemia have failed to throw any clear light on the aetiology of pregnancy toxaemia.

(2) *Aetiology—Biochemical Studies on Vitamin B*1.—Work was commenced in November, 1938, to test the hypothesis that a deficiency of vitamin B1 may be responsible in whole or in part for the occurrence of pregnancy toxaemia. Attempts were made to produce vitamin B1 deficiency. Normal non-pregnant ewes maintained on a diet free from vitamin B1 for 80 days failed to exhibit symptoms of vitamin B1 deficiency, or any marked diminution of vitamin B1 in the blood. Attempts to demonstrate chemically the presence of vitamin B1 in the rumen proved unsuccessful, despite the fact that vitamin B1 added to ruminal contents of sheep has been successfully recovered. Biological tests, however, tend to confirm the results of other workers as to the presence of vitamin B1 in ruminal material. Studies on pregnancy toxaemia are a joint project of the Division, the University of Sydney, and the New South Wales Department of Agriculture. In addition to the aspects of the problem already referred to, special attention was paid to the possibility that endocrine disturbances, particularly of the anterior pituitary, may be important as a cause of this disease. This work is in the hands of a research worker, engaged under the Commonwealth Research Grant to Universities, and working in close touch with the McMaster Laboratory. Attention was also given to the effect of certain substances in bringing about the recovery of affected ewes.

(vi) *Chemical and Physical Studies on Wool.*—(a) *Fleece Chemistry.*—Fleece samples taken from sheep at the F. D. McMaster Field Station when they were 13, 17, 22, and 28 months old were analysed and the results prepared for publication. The observations concern the production of wool fibre, wool wax, and suint at different points on the body surface, the changes resulting from seasonal and climatic differences, pregnancy and lactation, and the increasing age of the animal. Results showed that suint production is not materially affected by changes from winter to summer grazing, but is relatively high in young animals and then declines to a fairly uniform level. Wool and wool wax production both respond markedly to improved nutrition, but they do not respond proportionally. More detailed studies of wool wax were conducted during the year as time and opportunity offered. A new and simple laboratory method for the isolation of cholesterol from wool was devised, and the presence of lanoceric acid, questioned by some workers, has been established. Cholesterol is a relatively valuable substance, present in large quantities in wool wax, but the cost of its isolation and purification are such that this source is not exploited commercially as yet. Preliminary examinations were made of some scouring liquors as regards their content of potassium. As was indicated in the last report, the process for rendering wool unshrinkable held great promise and a very large amount of time was devoted to it during the year. Details of the laboratory work leading to its discovery have been published (Pamphlet 94). There

are still difficulties to be overcome in its adaptation to factory conditions involving large-scale treatment of wool. This problem has now been placed under the direction of the Council's newly-formed Division of Industrial Chemistry, although the investigation is still centred at the McMaster Animal Health Laboratory.

(*b*) *Physical Properties of Wool.*—Much time was spent examining wool fibres and yarns in connexion with the new unshrinkability process, the object being to determine whether the treated fibres were adversely affected. No differences were found in the stress-strain curves of treated and untreated wool at pH values from 4 to 9. This implies that the treated wool absorbs acid and alkali similarly to untreated wool and, apart from the strength and elasticity of the fibres being unchanged, their bulk also remains the same. No change was detected in the rigidity modulus of fibres (determined by a torsional method). Any chemical change in the fibre substance, which did not penetrate beyond the cuticle, should be more apparent in a change of rigidity measured in this way than in extensibility. That no change occurs on treatment with the new process emphasizes again that the effect is brought about on the surface of the fibre.

(vii) *Wool Biology.*—A programme of work was built up to establish the main facts of structure in wool fibres, skin, and fleece, and to define the range of variation occurring; the work is designed to elucidate the important factors governing the quantity and quality of wool production. During the year a start was made on the following specific problems:—(*a*) *The Pre-natal Development of the Merino Skin and Fleece.*—The results obtained have yielded preliminary information on the factors determining hairiness in the fleece, density, tip formation, and uniformity of fibre length and thickness. (*b*) *Fleece Density and "Development" or Wrinkliness of Skin in Merinos.*—Material was collected from animals showing all types and degrees of fold development on the neck, body, and breech, but the studies have not been completed. (*c*) *Survey of Skin and Fibre Characteristics in the Australian Merino.*—A start was made on a survey including observations on the regional differences and gradients in fibre characteristics and skin structure on individual representatives of various types of the Australian merino. (*d*) *Classification of Merinos according to the Development of Skin Folds.*—During the year a descriptive method of grading fold development in the merino was established to cover the full range of neck, body, and breech folds encountered among Australian types. (*e*) *Influence of the Plane of Nutrition on the Structure of the Merino Skin and Fleece.*—This work was started in association with the Animal Nutrition Laboratory. The experiment aims to determine what permanent effects, if any, on the wool-producing capacity of sheep result from a low plane of nutrition during the growing period.

(viii) *Statistical Work.*—Continuous assistance was given to members of the staff in the planning and experiments and statistical analysis of results. In addition, work was carried out in relation to investigations proceeding elsewhere in the Division, such as that on myxomatosis and bovine mastitis, respectively, by the Melbourne staff, and survey work in regard to fertility in sheep is being carried out by the staff of the F. D. McMaster Field Station.

4. *The F. D. McMaster Field Station.*—(i) *Seasonal Conditions.*—The year has been one of outstandingly deficient rainfall. During the period, 11.63 inches fell as compared with 24.37 inches for the corresponding period ending 30th June, 1939. Further to the total shortage, falls estimated to be efficient (i.e. falls of over 0.5 inches) have occurred only upon six occasions in the twelve months during which there have been only 45 or 12.3 per cent. of rainy days.

(ii) *General.*—The period under review was unfavorable for plant growth. An examination of the available records shows that only two other similarly unfavorable periods have been experienced in this area during the last 100 years. Under these conditions, practically all attempts at pasture improvement failed. *Phalaris tuberosa* and Rhodes grass maintained life, subterranean clover regenerated itself but did not provide other than stunted plants possibly incapable of reseeding, and the survival of perennial rye-grass in 140 acres of sown pasture was extremely low. In January, and again in June, 1940, acute water shortage occurred. The first was slightly modified by aggregate autumn rain of approximately $3\frac{1}{2}$ inches, spread over three days, but that in June promised to become progressively more serious. To render the position more secure in subsequent years, water storage from natural catchments was increased by the provision of two new dams and the enlargement of another. From summer-growing native grasses and from sown winter-growing varieties alike, the yield was negligible, and at the end of the year there was not a paddock upon the property with complete vegetative soil cover, regardless of the age or class of vegetation. All experimental animals were fed supplements. At the end of the year there were upon the property 93 rams (entire and vasectomized), 614 ewes of all ages, and 127 sheep under fifteen months of age, including 9 early lambs, a total of 843.

(iii) *Fertility in Sheep.*—Studies on the periodicity of oestrus in Australian sheep have been continued along two major lines. The first was arranged to determine the degree of control exercised by genetic factors. For this purpose, five lots of sheep of known breeding were compared throughout the year. The ewe groups were Camden Park Merinos (these sheep, descendants of

the original flock, were graciously loaned by the Trustees of the Camden Park Estate), Border Leicesters, half-bred Border Leicester x Camden ewes, Dorset Horn, and Austin-Wanganella Merinos. Observations are being continued until all groups have been maintained throughout comparable periods. All five groups have shown marked periodicity, similar to that already reported. Although February to July covered the period during which the higher percentage of Camden ewes came on heat, some could have been bred as late as September. On the other hand, the breeding season of the Border Leicesters was most restricted of all, 100 per cent. being confined to the months of March, April, and May. The cross between these two breeds had a longer breeding period than the Border Leicesters and a shorter period than the Camdens. The observations clearly indicate that, whereas all five kinds of sheep show marked periodicity, the breeding season is more restricted in some than in others.

The second study was arranged to determine whether the observed periodicity of oestrus was confined to sheep in this area or whether it was common to those in a number of localities. The principal observations were for similar sheep in dissimilar environments and, for this purpose, ewes of similar breeding were sent to Hughenden (Northern Queensland), Gilruth Plains (Cunnamulla, Queensland), and to Cressy (Tasmania). In addition, a similar ewe group was retained upon the Field Station. Although the data are incomplete, sufficient have been secured to show that, with regard to breeding activity in all areas, the calendar year was divisible into two parts. In one of these, 100 per cent. of the ewes came on heat, but very low percentages of ewes were capable of being bred in the other. Except at Hughenden, the autumn months were those in which the highest percentage of ewes came on heat. A further series of observations was arranged wherein interested pastoralists observed their own sheep and reported the data. These observations were made near Burketown (Northern Queensland), at Hughenden, and at Cunnamulla. The sheep used were ordinary station merinos and again in all locations a marked periodicity of oestrus was disclosed. Meteorological data accumulated upon the Field Station were examined for possible associations with the reproductive rhythm of the ewes. The work disclosed only one possible association, which was placed under further investigation. Data with regard to available nutriment were examined to discover if this controlled the observed rhythm. Further investigations along these lines, particularly the possible effect of green feed made available in prearranged seasons, were started. In a practical application of this information it was shown that, if a ewe flock be examined for oestrus by vasectomized rams and the fertile rams be not introduced until a period of marked sexual activity has been determined, then the subsequent lambing can be restricted within very narrow limits.

(iv) *Inheritance of Colour in Sheep.*—Surveys among the sheep of interested pastoralists have shown that only 0.42 per cent. of lambs, which they described as coloured, occurred in the progeny of 19,237 ewes. Further, matings on the Field Station between coloured and white sheep, both for the coloured ram and white ewes, and the white ram and coloured ewes, gave only white-woolled lambs. Close study of apparently white-woolled sheep, however, disclosed that, even among carefully bred merinos now on the Field Station, there was a considerable incidence of black spotting. Upon occasion these pigmented spots gave rise to white wool fibres, but frequently the fibres arising from them were coloured. In one line of aged station bred ewes, apparently with white fleeces, 29 per cent. had small body spots with coloured wool fibres. Examination of the sheep upon the Field Station disclosed that 15 per cent. of all merinos had such spots. Among 1,598 sheep examined at shearing on another property as samples of a ewe and wether flock totalling 22,139, 10 per cent of the seven and a half year old ewes had spots with pigmented wool. The examination was made in age groups and showed an incidence ranging from 0 to 2 per cent. among wethers up to five and a half years of age, and from 0.5 to 10 per cent. among ewes up to seven and a half years of age. The investigation is proceeding.

(v) *Inheritance of Wrinkling in Merinos and Crossbred Sheep.*—Sixty lambs (16 rams, 12 wethers, and 32 ewes) were obtained from the mating of wrinkled C type Merino rams and Border Leicester ewes. When examined at between 69 and 140 days of age, 56, 3, and 1 were adjudged to be A, B, and C class respectively. One ram, wrinkled equally with the other two, left all A class progeny. Similar matings, reciprocal matings (Border Leicester ram x Wrinkled Merino ewes), and Wrinkled Merinos x Wrinkled Merinos were made during the season.

(vi) *Establishment of an Inbred Flock of Australian Merinos.*—All the ewes and the ram were examined and classified with regard to fleece characters and conformation. Further, they were classified with regard to their degree of wrinkling. The breeding programme was commenced.

(vii) *Inheritance of Horns in Sheep.*—Nineteen lambs were bred in the pooled merino flock. Examination of these and of their parents, also of all other sheep upon the Field Station and of approximately 1,600 merinos (ewes and wethers) in the north-east of New South Wales, showed that polledness is associated with 4 degrees of characterization among sheep. The frontal bones may have, at the customary horn site, a depression, a skin-covered projection, small ill-formed horns replacing the skin-covering on the projection, or well-formed horns.

Exploratory matings were made to investigate the independence or otherwise of these characters. As the maintenance of hornlessness is a problem in some breeds of sheep for stud-breeders, the investigation has a wider application than to the merino breed.

(viii) *A Genetic Study of the Jersey Breed of Cattle in Australia.*—For the reasons given in the last annual report, little further progress was made with this study.

(ix) *Zebu Hybridization.*—No inspection was made of the experimental herds in the year under review. Mr. C. W. Wright, of "Waverley", again competed with success in the Rockhampton Chiller Competition. Although his exhibit of Zebu x Hereford crossbreds was disqualified because one of the steers was over age and weight, the published aggregate of points for all entries placed the hybrids second in order of excellence as judged. Arrangements have been made for the collection of killing floor data from crossbred bullocks for carcass appraisal. The report upon one group of half-bred, quarter-bred, and wholly British-bred cattle from "Waverley", killed at Lakes Creek, was received and shows the following grading for all three kinds.

Kind.	Number.	First Grade.	Second Grade.	Reject.
½-cross	12	89.6	6.3	4.1
¼-cross	15	86.6	11.6	1.8
British bred	402	75.6	17.1	7.3

The inspecting veterinary officer reported as follows:—"Examined as sides of beef after a week-end three-day 'chill', the Zebus with two or three exceptions, had a beautifully 'hammy' appearance of the butts (a splendid point) and a full depth of meat over the rumps and loins which were broad and had not that depressed look so prevalent on each side of the spine, as seen in cattle here when they begin to age, i.e. the loin sunk in only. On quartering, the Zebus mostly showed good 'marbling' of the rib roast but the selvedge seemed too abundant for ordinary shop purpose here, nevertheless good for export to cold countries. Some seemed over fat."

(x) *Co-operative Work.*—In addition to the investigational work centred at the Station, assistance was given to officers of the Division stationed at the McMaster Laboratory in (*a*) the maintenance of inbred flock for experimental purposes, (*b*) the maintenance of sheep for periodic fleece sampling, and (*c*) the maintenance of sheep for parasitological investigations. A factual review of the fat-lamb industry was started and is being carried out in association with the State Departments of Agriculture and other bodies. Six meetings of Technical Sub-committees of the Australian Committee on Animal Production were convened and reports prepared. Two other meetings of Technical Sub-committees were attended.

5. *The Animal Nutrition Laboratory, Adelaide.*—(i) *General.*—The principles and methods evolved in the Nutrition Laboratory have been applied to the determination of the relative nutritional value of a number of fodders which economically might be employed to support flocks during drought in Australia. For this purpose, the two indirect calorimeters have been in constant use throughout the year. Recommendations have been made for the application of some of the findings to station practice. Progress has been made in the study of the processes underlying the digestion of cellulose by ruminants. During the year, comprehensive experiments were started to determine the nature and degree of the changes in conformation and in wool-producing propensity which occur at different levels of nutrition during the growing period of sheep. In the field of inorganic metabolism, the researches have resulted in the accession of many important facts to existing knowledge, and in the widespread application of the findings to the pastoral industry.

(ii) *Phosphorus Metabolism of the Sheep.*—During the last few years, the findings from experimental studies in the Nutrition Laboratory have seriously challenged the validity of a very general assumption that grazing sheep in Australia often, if not always, suffer ill effects owing to the relatively low concentration of phosphorus in the natural pastures. At frequent intervals, the Division has expressed the opinion that the widespread use of phosphatic licks is uneconomic and certainly not justified by experimental observations. In an attempt to bring final judgment on the validity of the assumption, rigidly controlled observations were initiated in 1935–36 at several sites in Australia where the soils are singularly devoid of phosphorus. These trials, for the most part, have now been conducted over a long enough period to provide the answers that were sought. The information obtained in every case upholds the original contention.

(*a*) *Wambanumba, Young, New South Wales.*—Experiments initiated with ewe–weaners in 1936 have been extended another year in order to study the effects of phosphatic supplements on the capacity of ewes to carry and rear a second lamb. The flocks which have been dosed with sufficient phosphate solution to provide an additional 1 gramme of phosphorus per day are not significantly different in general health or in their productivity from those which have received no phosphatic supplement; the mean body weight, quantity and quality of wool produced, and the number of lambs dropped and reared, were taken as quantitative criteria. At their second lambing during the year over 80 per cent. of lambs were dropped by both the supplemented and control groups of ewes. In 1939 an experiment was started at this site in order to determine if additional phosphorus might be required by young sheep to provide for their more rapid development when grazed on improved pasture. Four identical groups of ewe–weaners were selected. Two of these groups were grazed throughout the year on a sown pasture and two were grazed on an immediately adjacent area of unimproved natural pasture. The sheep in one group of either pair received a supplement of 1 gramme of phosphorus per day. While both groups on the sown pasture have grown better than those on the natural pasture, and at this period are 25 per cent. heavier, the phosphatic supplement has been observed to exert no effect in either case.

(*b*) *Penola, South-east of South Australia.*—The experimental observation undertaken in 1937 at this site will be concluded shortly with the study of the early growth of the second crop of lambs. In this experiment, phosphatic supplements have exerted no beneficial effect on body weight or on productivity as measured by wool weight and number of lambs.

(iii) *Energy Metabolism.*—During the year, study of the energy metabolism of the sheep has been directed mainly to the immediately practical end of evaluating the capacity of various fodders to support their living processes. It has become obvious that the combustible energy of the digested material cannot all be utilized for this purpose. A large proportion of the energy derived through the metabolism of the products of cellulose digestion is useful only for maintenance of body temperature, and is wastefully dissipated when extra heat is not required for this purpose. A much greater proportion of the combustible energy derived from the digestion products of starch is useful for general maintenance. An experiment was started to determine the net efficiency of energy utilization by sheep when subjected to different levels of feeding.

(iv) *The Digestion of Cellulose.*—Although the bacterial degradation of cellulose in the ruminant paunch to products which may be utilized by the animal is, economically, perhaps one of the most important single factors in animal industry, very little is known of the processes involved. The results of several studies of certain aspects of this phenomenon may be summarized as follows:—(*a*) *The Micro-flora Responsible.*—Attempts to isolate the micro-organisms which digest cellulose in the ruminant paunch have everywhere met with little success. A number of strict and partial anaerobes have been isolated which are capable of attacking cellulose, but the rate of digestion and the nature of the end products of such cultures renders it clear that any one of these species is not alone responsible for the remarkable *in vivo* activity. It has been reported previously that the physico-chemical environment of the paunch contents is maintained remarkably constant, and, with little doubt, this *milieu* favours the development and activity of a mixed culture of organisms which are responsible for the extraordinarily rapid cellulose digestion by ruminants. (*b*) *Methane Production.*—Whereas methane is a gaseous end product invariably observed to arise from cellulose digestion in ruminants, cellulose-splitting organisms isolated from the paunch, as a general rule, produce hydrogen. The hypothesis that at least two distinct types of micro-organisms are concerned in the normal digestive process is supported by the observations that (1) methane production by the sheep decreases rapidly during fasting and disappears almost completely by the fourth day; (2) recovery of methane after resumption of feeding is variable; (3) methane production returns to normal within four days after the resumption of feeding subsequent to fasts of short duration, whereas after longer periods of fast which extend for fourteen days or more it may be delayed for several days and under these conditions hydrogen is invariably present. The organisms which convert the hydrogen evolved during the fermentation to methane evidently are not sufficiently resistant to withstand the change of environment within the rumen during a fast of long duration. The evolution of hydrogen was observed to be changed rapidly and completely to methane by drenching the animal with the mixed culture of organisms in normal rumen contents. (*c*) *The Nature of the End Products.*—Study of large numbers of samples of contents has revealed that reducing sugars do not appear as products when cellulose is digested by micro-organisms in the rumen. The main products of the bacterial cleavage of cellulose are methane, carbon dioxide, and the fatty acids, acetic acid, propionic acid, and butyric acid. These acids form the main energy source in ruminant nutrition. (*d*) *The Utilization of the Products of Cellulose Digestion.*—Investigations of the energy transactions of sheep maintained on diets in which cellulose provides the major source of energy supply have shown that the metabolic rate of the animals is very materially enhanced, and it appears that, irrespective of the loss as methane, over 50 per cent.

of the combustible energy of the digested straw is dissipated in the increased metabolism. This is in reasonable quantitative agreement with the observed facts discussed in the previous section and suggests that sheep, like other animals, are unable to store the energy of acetic acid or to utilize it for any function other than the maintenance of body temperature. Evidently, propionic acid is converted to glucose and utilized normally. It was observed that ewes deprived of glycogen stores by starvation and injection of phloridzin increased their urinary output of glucose and decreased their output of nitrogen after consuming 400 grammes of pure cellulose.

(v) *Drought Feeding.*—Several lines of research developed during the last few years have converged on the broad subject of drought feeding, where the main problem is to support sheep over long periods at minimum cost. The knowledge obtained from fundamental energy studies has been applied to the problem of assessing the comparative usefulness of various grains, concentrates, and roughages which are economically feasible for hand feeding. During the year, over 150 individual energy and nitrogen balances have been conducted with sheep fed on different combinations of foodstuffs, and from the data thus obtained the capacity of each fodder to supply both useful energy and energy for heat production has been determined, as well as the comparative capacity of each fodder to supply the raw materials for wool growth. Feeding tables for the maintenance of sheep on these fodders have been drawn up. As a further test, observations were started on sheep confined in pens and fed at the very low levels which the energy balance determinations suggest will be sufficient to maintain life. This project is supported by grants from the Australian Wool Board. During the year a detailed study was made of the changes in metabolism of the sheep during lengthy periods of fasting.

(vi) *The Influence of the State of Nutrition on Wool Production.*—The study of the effect of the level of protein and of available energy in the diet on the wool production of the mature merino sheep was extended during the year, and the relationships previously reported were amply confirmed. Preliminary studies suggested that the adequacy or otherwise of the diet during development influences to a very considerable degree the subsequent efficiency of the sheep as a converter of matter and energy. Experimental observations were started to determine the effect which the nutritional level during the growing period exerts on the subsequent wool producing propensity of the merino. These include a detailed study of the conformation, skin characteristics, wool-producing capacity, and of the efficiency of each individual of two matched groups each containing fifteen fine-woolled merino lambs. One group is being fed at a level typical of a poor nutritional environment, and the other at a level which ensures a maximum rate of growth. Changes in conformation and striking alterations of wool type were manifested early. Two further groups, matched by taking one from each of fourteen ewe twins of South Australian strong-woolled ewes, have been selected and placed in pens for similar observations.

(vii) *Bovine Haematuria.*—Investigations into the possible association with the disease of continued ingestion of certain trace elements have been continued. The majority of the unusual inorganic components of the fodder from areas where the disease is enzootic have been successively eliminated from suspicion as possible causal factors. In this manner, attention was finally focused on molybdenum. It is recognized that traces of molybdenum are present in very many biological samples, but it appears that the molybdenum content of the pasture from at least three areas in South Australia and Victoria, where the disease is still occurring, is consistently higher than normal. Cows depastured on these areas show an abnormally high storage of molybdenum in the liver, while the faeces and urine also show a notable molybdenum content. It has been found that the application of gypsum to the soil of the affected areas results in a marked decrease in uptake of molybdenum by the pasture. This is in accordance with the observed fact that top-dressing the pasture with gypsum delays the incidence of the disease appreciably but may not prevent its eventual onset. It is considered that the effect of the gypsum in lessening the uptake of molybdenum by the pasture is probably brought about by the modification of the clay complex in the soil whereby the molybdenum is rendered less available to the pasture. The disease of cows known as " teart ", which occurs in Somerset, is also attributed to ingestion of molybdenum-bearing pasture, but the amounts of molybdenum involved are far in excess of those which obtain on haematuria areas. It is considered possible, therefore, that the pharmacological symptoms associated with long-continued ingestion of much smaller amounts of molybdenum may differ widely from those claimed to be caused by relatively large intakes of the same substance. With the object of deciding this point, an experiment was started in which both stall-fed cows and animals on pastures are receiving additions of molybdenum, as ammonium molybdate, to their fodder in amounts calculated to approximate those obtaining from the natural pasture on certain areas where haematuria is enzootic.

(viii) *Plant Proteins.*—Investigations described in the last report have led to the tentative conclusion that the amino acid composition of the whole protein of the leaves of all monocotyledonous and dicotyledonous plants is very similar, and it was pointed out that if this generalization is established, it should follow that the nutritional difference between fodder proteins should not be great. The purely chemical studies have been extended and analyses

of preparations of the protein from the primitive species *Selaginella* and from the fronds of *Pteredium aquilina* indicate that the chemical make-up of the protein of *Selaginella* departs relatively little from that of the leaf proteins previously studied whereas the protein of *Pteredium* is distinctly lower in tyrosine and trypophane. Preparations have also been made from healthy and from mosaic-virus infected leaves of *Nicotiana tabacum*, and the analytical observations suggest that the properties of much of the non-virus protein in the infected tobacco leaves undergoes considerable change. The hypothesis which implies that the protoplasmic proteins of leaves are all of very similar composition is of far-reaching nutritional importance. In consequence, the possibilities of overcoming the technical difficulties which are encountered when an attempt is made to separate quantitatively the protein of plant tissues in a form suitable for the determination of biological value have been examined further. The activity of the Animal Products Research Foundation chemist has been devoted entirely to this latter project. Separations from perennial rye-grass resulted in a fraction containing 12.1 per cent. nitrogen and one containing 5 per cent. nitrogen, the former representing 40 per cent. and the latter 35 per cent. of the total nitrogen of the leaves. The unrecovered 25 per cent. was accounted for in various fractions of the discarded washings and fibrous residues. The protein contained in the former fractions was found to have a biological value of approximately 70, which compares favorably with that of 68 for the whole protein of wheat and with that of 70 for the whole protein of maize, when estimated by the standard balance sheet methods at fixed intake with the mature rat. Similar preparations have been separated from subterranean clover, Wimmera rye-grass, Kikuyu grass, and lucerne for the estimation of comparative biological values. During the year, the problem of the biological value of fodder proteins has been investigated from an entirely different angle by measuring their capacity to support wool growth in the mature merino sheep. By this means, a marked supplementary relationship has been demonstrated to exist between leaf and seed proteins.

(ix) *Physiological Studies.*—(*a*) *The Process of Deglutition in Sheep.*—The study of the course taken by imbibed fluids through the complex forestomachs of the sheep has been continued. Observations on the passage of milk when sucked from a bottle have been extended to sheep with a wider range of age, and it has been found that, providing the animals are allowed to suck frequently, the general tendency is for the fluid to pass direct to the abomasum. Although both the act of sucking and the composition of the fluid are positively involved, the reflex is not directly dependent on either of these factors. Investigations of the influence of age on the path taken by water mixed with the X-ray opaque material, barium sulphate, when administered by gravity drenching, have been continued until the animals have reached approximately four years of age; the results indicate that there is no uniform influence of age on the passage of fluids administered in this manner. Passage of fluids to the abomasum when administered by gravity drenching has been found to be due in part to mechanical stimulation of the mucous membrane of the mouth during drenching. The area susceptible to mechanical stimulation and the degree of response would appear to vary in different animals. Solutions of copper sulphate have been found to have a uniformly strong influence on the passage of fluids in many animals, a variable influence in some and no influence at all in a few. Solutions of copper chloride and copper acetate have been observed to exert a similar effect. This evidently is not associated with the astringent action of the copper solutions because solutions of strong astringents such as potassium alum, lead acetate, and tannic acid were observed to have no influence.

(*b*) *The Passage of Inorganic Materials in and out of the Intestine.*—Previous reports have mentioned investigations which have demonstrated that lignin is totally undigested in the sheep. This normal dietary constituent provides an inert reference ideally suitable for the study of absorption and excretion within the intestinal tract. By utilizing the ratio that lignin bears to the various inorganic constituents in the contents at various levels of the intestinal tract, it has been indicated that potassium salts are rapidly washed out of the rumen contents and absorbed mainly in the large intestine. Sodium salts which are added in considerable amount to the rumen contents through the constant flow of saliva, and to the duodenal contents through the pancreatin secretions, are absorbed mainly in the caecum. Calcium salts are absorbed in the ileum, excreted to a great extent in the caecum, and voided in the faeces. The absorption and excretion of heavy metals is being investigated further.

(x) *Coast Disease.*—(*a*) *Experiments at Robe, South-east of South Australia.*—The experiments at this site have been continued. In order to establish the quantity of copper necessary to fulfil completely the requirements of sheep when depastured on the deficient calcareous sands, it is essential that observations be conducted over a period of years. The groups of ewes which in addition to 1 milligram of cobalt per day have received 5 milligrams of copper and 10 milligrams of copper per day, respectively, have been submitted to the strain of a second pregnancy. In order to determine if ataxia in the young lamb is the invariable result of uncomplicated copper deficiency of the parent ewe, the observations are being continued on ewes which since the beginning of the experiment in 1938 have received only cobalt.

(*b*) *Copper Deficiency.—Copper Metabolism of Sheep.*—Field experiments at Robe have revealed that sheep grazing on the calcareous sands may ingest licks which contain sufficient copper to provide an average consumption of up to 100 milligrammes of copper per day for at least eighteen months without apparent harmful effect and without storing unduly high amounts in their tissues. As this is contrary to experience with sheep fed under different conditions with similar quantities of copper, experimental investigations of the factors which control copper assimilation and storage have been initiated. Field experiments have shown that, although a supplement of 1 milligramme of copper per day is insufficient, 5 milligrammes of copper per day will maintain sheep in normal health for at least three years while grazing at Robe. Experiments in Adelaide have indicated that sheep do not readily develop copper deficiency symptoms when fed in pens on fodder produced at Robe. It has been reported previously that appropriate treatment allows the separate study of either cobalt or copper deficiency, deficiencies which when combined give rise to coast disease. Further study of copper deficiency has indicated that merinos are particularly prone to the effects of a shortage of copper in the pasture and that they will develop untoward symptoms and die under conditions which are withstood by cross-bred sheep for a much longer period. The reason for this is obscure at present. The appearance of symptoms in flocks grazing on copper-deficient pastures appears to be governed not only by age and previous nutritional history of the sheep but also by seasonal factors, and intensive studies of the physiological mechanisms which are adversely affected in copper-deficient sheep reveal the serious impairment of the normal utilization of iron and the fact that the concentration of the oxygen carrier, cytochrome c, in the tissues is reduced, and the enzyme, cytochrome c oxidase, which catalyses the re-oxidation of reduced cytochrome, is seriously depleted.

(*c*) *Cobalt Deficiency in Sheep.*—In order to provide the knowledge which is necessary if the areas where grazing sheep suffer from an incipient deficiency of cobalt are to be readily recognized, experimental observations have been undertaken to determine the minimum amount of cobalt which is essential to fulfil the nutritional requirements of the sheep. Chemical studies have clearly indicated that the amount ingested from normal pastures is extraordinarily small and that the quantity retained by the tissues of normal animals is minute. The difference between the cobalt concentration in the tissues of healthy ewes on normal pastures and that in the tissues of ewes supplemented with 1 milligramme of cobalt per day while grazing on seriously deficient country, indicates that the intake of the quantity supplied in the supplement is apparently far in excess of the actual mineral requirement. This is supported by the results from field experiments at Robe, where a group of ewes supplemented with only 0.1 milligramme of cobalt per day have remained perfectly healthy for the past twenty months and have lambed twice while depastured on country where untreated controls exhibited typical deficiency symptoms in a few months and died within a year. At this site, the therapeutic effects of doses of 0.1 milligramme cobalt per day are being contrasted with those which follow dosing with 1.0 milligramme of cobalt per day. The seasonal variation of cobalt in the main pasture species is being determined. Results from studies at the laboratory indicate that, although the therapeutic administration of cobalt to cobalt-deficient animals by drenching or by incorporation in the food results in dramatic recovery, similar amounts injected intravenously are without effect on the progress of the deficiency symptoms. Cobalt injected intravenously has been found to be excreted rapidly in the urine and in the faeces.

(*d*) *Ataxia.*—Experimental observations at Robe indicate that some ewes transferred from sound country to copper-deficient areas may retain sufficient copper for one normal lambing, although the concentration of copper in their blood may be reduced to very low levels. Although the degenerative changes in the central nervous system leading to ataxia occur characteristically in the lamb, one of three surviving animals of a group given only 1 milligramme of cobalt per day since 1936, while continually depastured on the coasty country at Robe, recently developed the clinical symptoms of ataxia at the age of approximately four years, after manifesting copper deficiency symptoms for two years previously. The identity of the disease was established by observation of typical lesions in the spinal chord.

(xi) *Agrostological Investigations.—Sown Pasture and Cereals on Copper Deficient Soils at Robe.*—Further investigations have been undertaken in connexion with the establishment of improved sown pastures and cereal crops on the copper-deficient soils in the south-east of South Australia. Trials and observation have shown that the soils which respond to dressings of copper extend along almost this entire coast-line, and often many miles inland, from Port MacDonnell to Meningie. In these affected areas, yields of oats have been increased from under 10 bushels to over 20 bushels per acre, and pronounced improvement in pastures has been obtained by copper application. Experimental observations indicate that copper is most conveniently applied when the seed is sown. Withholding the application until October was observed to reduced the grain yield by 38 per cent. A dressing of 14 lb. of copper sulphate per acre is to be recommended for general purposes, but the most economic rate for different crops on each of the

many responsive soil types must be determined by experience. The marked benefit which supervenes on the application of copper to pastures and crops in the affected areas has been observed for three years after a single application. Special superphosphate and copper mixtures are now available on the market. Plants in the field at Robe that had responded to treatment with copper sulphate were found to be not entirely normal in appearance and in yield characteristics. The effect of several trace elements, in addition to copper, has therefore been investigated. It was found that oats responded to the application of zinc sulphate. With copper alone, the grain yield of oats was 10.6 bushels per acre, but with the further addition of zinc sulphate the yield obtained was 18 bushels. Symptoms apparently due to zinc deficiency were observed in oats when grown in pot cultures of Robe sand in 1939. Experiments to determine the effect of zinc on several different crops and pasture species are in progress. Nitrogen deficiency is common on the calcareous sands. The application of nitrate of soda in the autumn did not improve the grain yield of oats, but when carried out in the spring it was observed to increase the grain yield by 55 per cent. and the straw yield by 90 per cent. Sulphate of ammonia, applied either in autumn or in spring, was quite ineffective. The growing of peas before cereal crops is to be recommended. The beneficial effect of potash dressings in these areas has been confirmed. An increase of 76 per cent. in the grain yield and 65 per cent. in the yield of straw was obtained on the loose sand by the application of 1 cwt. per acre of sulphate of potash. On a better class of calcareous soil, an application of 56 lb. sulphate of potash per acre in the spring increased the yield of oats by 25 per cent. Further investigations into the depressing effect of superphosphate under field conditions have shown that the phosphate itself is responsible. Lime and gypsum had no effect. In pot culture, the application of phosphate increased the grain, and particularly the straw yield of oats grown on the Robe sand, and there is evidence to suggest that a phosphate-trace element interaction is the cause of the anomaly. Great differences have been shown to exist between the cereal varieties in their resistance to copper deficiency and in their response to applied copper. It has been observed, however, that most varieties of wheat, oats, and barley grown in the calcareous soils to which copper has been applied gave greater yields than rye, which hitherto has been the standard cereal crop in the severely affected areas. Satisfactory stands of lucerne have been established on the loose sand at Robe. Treatment with copper sulphate was observed to be essential. Small applications were used and the lucerne was observed to be in a healthy and vigorous condition two years after the original treatment. Black medic and perennial rye-grass pastures sown down with copper sulphate have developed well, and the value of cover crops in the establishment of pastures on the calcareous sand has been demonstrated. Experimental results obtained with the cereal "indicator" plants are being investigated in relation to pasture establishment.

6. *National Field Station, "Gilruth Plains", Queensland.*—The year was not a very good one from a seasonal point of view. Fair rains fell in August, but later only showers of less than 1 inch were received; in consequence, the Mitchell grass made no growth and feed generally became scarce. Stock, however, remained "in good heart". A fairly severe fly wave was experienced in the early spring, but none at all in the autumn. Thus observations on the control of fly strike were restricted and results from many experients have been delayed.

(i) *Fly Strike Observations.*—(*a*) *Dr. Watt's Blue Treatment for Strike Prevention.*—This experiment was concluded during the year; the results showed that the blue raddle applied to the breech of sheep had no effect in preventing strike. An account of the experiment has been published.

(*b*) *Manchester's Treatment for Strike Prevention.*—A fairly large-scale experiment was started to test the efficacy of this treatment in comparison with the Mules operation and with untreated controls. The experiment was commenced in October, immediately after the sheep were shorn. The treated sheep required some after-care, and the end results were unsatisfactory in some cases but more satisfactory in others. The method does not lend itself to application on a wide scale on large flocks. Observations on the protective value against fly strike are not completed.

(*c*) *Effect of Tail Length on Susceptibility to Strike.*—Observations on strike incidence during the autumn and spring of 1939 in the weaners with different tail lengths indicated that animals with short tails were more susceptible and those with tails about 4 inches long less susceptible to strike than were sheep tailed at the usual length. The percentage of strikes in the long, medium and short tailed groups between lamb marking in November, 1938, and shearing in August, 1939, was 36.3, 75.0 and 81.9, respectively. These figures do not include strikes in tailing wounds. These sheep were classed and the culls disposed of, the remainder being retained under observation. There did not appear to be any significant differences between the groups in the proportion culled from each. It would appear, therefore, that the higher incidence of fly strike in the short and medium tailed groups has not influenced the classing of the sheep.

(*d*) *Effect of Tail Length and Mules Operation Performed at Marking on Susceptibility to Strike.*—Observations were commenced with the 1939 drop of lambs using four different tail lengths with and without the Mules operation. The object is to determine if the longer tail length, which by itself offers some protection against strike, will supplement the protective value of the Mules operation.

(*e*) *Dressings for Lambs at Marking.*—At lamb marking in November, 1939, a test was carried out of several repellent substances which have shown promise in the laboratory and in small-scale tests. Owing to the cessation of fly activity at marking time, however, no results of value were obtained.

(*f*) *Breech Conformation of Sheep and Strike Incidence.*—Observations have been made periodically on the breech conformation of all the ewes, more particularly the younger ones, on the property, and these observations are being studied in relation to one another and to strike incidence. The observations so far on the younger sheep tend to show that big changes in breech conformation may take place as the animal grows and that they are to some extent related to seasonal conditions. The observations are being continued.

(*g*) *Fly Population Studies.*—Three traps have been set up in three different situations, typical as far as possible of different types of country, and are cleared weekly. The catches are sorted into the more important species from a fly-strike point of view and counted. Sufficient data have not yet been accumulated to enable comments to be made at this time.

(*h*) *Observations on the Breeding of the Sheep Maggot Flies.*—Studies have been commenced on the flies bred from carcasses of small animals under various conditions. Plans have been made to extend these studies, in collaboration with the Division of Economic Entomology, to include sheep and other animals to determine the species of flies bred from carcasses and from strikes. In this way the main breeding grounds of the sheep maggot flies will be determined.

(ii) *Shearing of Lambs.*—An experiment, commenced in January, 1939, was designed to measure the difference in results obtained from shearing lambs at about four months of age and again as hoggets on the one hand, and of leaving lambs unshorn until the hogget shearing on the other. Results have been obtained which show that in mean body weight the twice-shorn sheep were slightly heavier than those shorn once; the difference, however, was not statistically significant. Strike incidence was very markedly higher in the once-shorn group although they were crutched once during the autumn fly wave. The total wool cut was 9 oz. greater from the twice-shorn group than from the once shorn, but cost and returns were slightly against two shearings. No definite conclusions can be drawn from the experiment as there are too many variables which cannot be allowed for in one year. The experiment is to be repeated in the near future.

(iii) *Fertility in Merino Ewes.*—Observations were continued on the periodicity of oestrus in merino ewes. These observations form part of the work which is centred at the McMaster Field Station.

(iv) *Observations on Routine Sheep Classing as related to Strike Incidence.*—Observations made so far tend to show that, even when predisposition to fly strike is disregarded in classing, there is a much higher percentage of the highly predisposed sheep culled than there is of the less predisposed class. This would tend to reduce the incidence of strike in a classed flock. These observations will be continued and extended where possible.

(v) *Greasy Dressings for Prevention of Wasty Tip.*—Observations have been carried out in collaboration with the McMaster Laboratory on the possible advantages to be gained by applying greasy dressings to the wool in order to prevent wasty tip. The observations so far have not yielded any promising results.

7. *Investigations in Western Australia.*—Co-operation with officers of the Western Australian Department of Agriculture was continued during the year. This was chiefly accomplished by the assistance given to these officers by a biochemist of the Division working under their immediate direction. Studies on mineral deficiency diseases of stock were continued. The diseases are known locally as Gingin, falling, and wasting disease respectively. Gingin disease and falling disease appear to be manifestations of copper deficiency, and wasting disease, although mainly due to a deficiency of cobalt, appears to be complicated by a copper deficiency, at least in some instances. The work of the biochemist was concerned mainly with analyses of blood and other body tissues and fluids as well as of pasture plants.

8. *Investigations in Tasmania.*—Co-operative investigations were continued with officers of the Department of Agriculture on problems of sheep husbandry.

V. SOILS INVESTIGATIONS.

1. *General.*—The work of the Division of Soils has continued from last year with a wide programme of investigations. The Division is associated with, and works in close accord with, the Waite Agricultural Research Institute of the University of Adelaide, which provides head-quarters and laboratory facilities. A considerable part of the Division's activities lies in the field, and work has proceeded in three States—South Australia, Victoria, and Tasmania—during the past year. In the coming year interests will become active in both New South Wales and Queensland as well as the other States. A pleasing feature throughout has been the ready co-operation of the forestry, agricultural, and irrigation services in the States concerned. All scientific effort in agriculture should be directed towards a better and fuller use of the land. The soil is of prime importance in this regard, and the soil survey provides the essential basic information for the proper development of land resources. The main object of the Council's soil investigations are, therefore :

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

(*b*) To make soil surveys of virgin areas for future settlement and development and of such settled areas as present problems of immediate importance.

The various State authorities have given increasing co-operation and support to the surveys and particularly in regard to the interest shown and reliance placed on data supplied. The time is not far distant when no move in land development will be made without adequate soil studies being made previously.

In April, 1940, one officer was seconded for a period of two years to the Research Division of the Queensland Department of Agriculture specifically for investigations into the relationship of soils to cotton growing with and without irrigation. An officer of the Queensland Department began a twelve-month period of research in the Division's laboratories.

During the year two officers returned from the United States and Canada, where they were engaged in soil investigations, one in connexion with soil surveys and cognate subjects, and the other in research on the character and properties of clay minerals.

In August, 1939, a highly successful "school" for those interested in soil science was organized by the Division under the auspices of the Council and of the University of Adelaide. Lectures, demonstrations, and discussions over a period of ten days were fully appreciated. An official attendance of 58 included 37 representatives from other Divisions and of State Departments of Agriculture, Forestry, Lands, and Chemistry. New Zealand was also represented.

2. *Soil Surveys.*—Field work has continued on two large projects, and the survey of four new areas has been opened in three States.

(i) *The South-east of South Australia.*—In March, 1937, a soil survey was commenced in the lower south-east of South Australia. In this locality there are considerable areas, totalling about 100,000 acres, of softwood plantations, principally *Pinus radiata*, controlled by the Woods and Forests Department of South Australia and by private companies. There is also considerable promise of increase in settlement and development of the pastoral industry with both sheep and dairy cattle. Apart from restricted areas around the chief towns, Mount Gambier and Millicent, and in the Glencoe valley, where settlement is very close on an area of good volcanic soils, most of the country is held in large areas in various stages of development or as virgin land. The rainfall, which is well distributed throughout the year, is in the neighbourhood of 30 inches per annum.

The first units in the survey to be undertaken were the pine plantations of the Woods and Forests Department of South Australia. In these areas there are a number of features which show a relationship to soil type, such as the incidence of die-back disease and the association of tree growth and timber quality. During the course of the survey one of the officers of the Woods and Forests Department accompanied the field parties. By this means an intimate knowledge of the soil types was passed to the Woods and Forests Department, and since the completion of the survey the Department has undertaken an assessment of the value of the various soil types for timber production and an investigation of the cause of any variation in tree growth on any particular soil type. Data collected during the course of the survey suggested that die-back disease might be caused by a deficiency of copper, and the State Department is investigating this further.

After the completion of the forest areas, the survey was extended to cover the remainder of the hundreds of Riddoch, Hindmarsh, Grey, and Nangwarry. Here, except for private pine plantations and some natural hardwood forests, the country is almost exclusively used for pastoral purposes. The survey of this 400 square miles of country was completed in May, 1940.

The land forms of the south-east of South Australia consist of a series of old coastal ranges parallel to the present coast-line and separated from each other by flats or plains of variable width. At the southern end of the ranges this scheme has been modified by numerous small volcanic ash and basaltic intrusions. An extensive system of drainage of the flats has been installed and is controlled by the South-eastern Drainage Board.

The soils of the ranges are the principal centre for forest activities, and some of the soils concerned are not suited to other agricultural development. Associated with the flat areas and on the transition from range to flat are a number of soil types of widely different kind, but mostly of value for pasture purposes and in some cases for pines also. All these soils seem capable of greatly increased production under pasture of rye-grass, cocksfoot, *Phalaris*, and strawberry, white, and subterranean clovers, which it appears can all be used to advantage with a top-dressing of superphosphate. The situation has arisen of the pine tree coming into competition with grazing pasture as a commercial crop, and the soil survey serves a useful purpose in providing a soil type basis for assessing the value of the land for any particular purpose. From the survey a rating of the probable production capacity of timber from pines or under pasture in terms of sheep per acre can be made.

The spreading of the survey in the future over a widening circle from the present well investigated 450 square miles through the better rainfall country (more than 20 inches) in the south-eastern districts, affords a worthy objective for subsequent study.

(ii) *Murray Valley Irrigation Area.—Cobram District, Victoria.*—This survey continued through most of the year and now totals 250 square miles, comprising the complete parishes of Boosey, Katamatite, Cobram, Yarroweyah, Strathmerton, and Naringaningalook in the County of Moira, Victoria. There is considerable variation in the nature of the soils and in their respective values for irrigation purposes. Since the water available permits an allotment of a water right for only one acre in four of each holding, the design of farms often involves proper selection of sites for irrigation. Soil survey work is keeping ahead of channel construction so that soil maps and data are available to the State Department of Agriculture and the State Rivers and Water Supply Commission in Victoria who are collaborating in the work. The surveys are proceeding.

(iii) *Cressy District, Northern Tasmania.*—In 1936, the Tasmanian Department of Agriculture asked for soil surveys of two small areas at Illawarra and Maitland near Longford in northern central Tasmania. These surveys were used as a basis for field trials on subterranean clover pastures which are of an unsatisfactory type in this Cressy-Longford district. The affected soils extend as far west as Westbury.

Following field and pot experiments by the Department of Agriculture and the small surveys with additional laboratory investigation by the Soil Division, it was decided to cover all the affected area with a soil survey, and this was begun in January, 1940. The area lies in the angle formed by the lake, S. Esk, and Meander Rivers and covers approximately 140 square miles. This survey will serve to delineate the affected soils, provide a basis for extension work on the results of experiments which have already yielded valuable data, and will assist in the evaluation of different lower situated lands for possible irrigation development. The Cressy Experiment Farm lies within the area. Approximately 100 square miles have been covered this year.

(iv) *Waikerie Irrigation Area, South Australia.*—The field survey and laboratory study of the soils of this settlement have been completed. This unit of 5,000 acres completes the survey of the chain of irrigated horticultural settlements in the Murray Valley in Victoria, New South Wales, and South Australia. The soils conform largely to those Mallee types previously encountered, but the area is distinguished by the large proportion of sandy rises and the very stony nature of considerable sections. An attempt was made to define the incidence of certain tree deficiency diseases in relation to some soil types.

(v) *Yudnapinna Station Survey, South Australia.*—Some detailed soil and ecological studies were carried out on part of the Yudnapinna Station, 60 miles north-west of Port Augusta, to serve as a basis for observations on soil erosion and plant regeneration by the Waite Institute, Adelaide. An area of 25 square miles was studied in detail and classified as to soils and plant associations. It was felt that collaboration with agronomists of the Waite Institute to develop the soil aspect might make the study of the conservation of soil and vegetation in low rainfall country more complete. In July, 1940, further assistance will be given in providing a background of soil information and ecological data for the agronomic work to be undertaken subsequently.

(vi) *Kangaroo Island, South Australia.—Reconnaissance Survey.*—A rapid reconnaissance survey was made of the virgin areas of Kangaroo Island with a view to studying the variation within soil groups and the general distribution of the groups. A closer examination was made of 5,000 acres on which experimental work on legume establishment had proceeded during the previous year (*see* (3) Soil Microbiology). The soils were classified according to native vegetation

associations. A number of representative samples were collected and analysed. The possibility of developing these poor soils in a high rainfall zone opens up an important problem for South Australia. The soil work covers the first stage in the attack.

Cotton Soils in Queensland.—In April, 1940, an officer was seconded from the Division to the Research Division of the Queensland Department of Agriculture and Stock specifically to deal with soil investigations in cotton growing. A rapid preliminary inspection was made of certain areas under or proposed for cotton in the Callide and Dawson Valleys. A plan has been drawn up for an examination of certain portions of these districts, particularly with a view to using irrigation water on them as a supplement to rainfall for the cotton crop. This work is under the direction of the Queensland Department of Agriculture and Stock, the Soils Division acting only in an advisory capacity.

Aerial Photography.—The use of aerial photographs has become standard practice for field use by the soil survey section wherever practicable. The accuracy gained and additional speed made possible by the photographs makes them worth while, apart from such desirable features as being a record of present land use and providing base maps where land survey data are incomplete. It is current practice now to use the photographs for direct mapping in the field. During the past year the Wakool Area of 500,000 acres in New South Wales was flown for the Division by the Royal Australian Air Force, and prints are available for beginning this survey in July, 1940. A set of prints from earlier aerial photographs of part of northern Tasmania has been used for the Cressy survey with particular aptness in checking base maps. A small area of 25 square miles and several strip flights were photographed on Yudnapinna Station, South Australia, where work on soil erosion studies is under way in conjunction with the Waite Institute.

3. *Soil Microbiology.*—Investigations in soil microbiology have progressed along the lines previously indicated. An endeavour is being made to clarify some of the fundamental principles which govern the efficiency of the *Rhizobium*—host plant association. The influence of the host plant has proved to be of paramount importance in the occurrence of ineffective nodulation. The three separate species of *Rhizobium* associated with the *Medicago-Melilotus*, the *Trifolium*, and the *Vicia-Pisum-Lathyrus* groups have received particular attention, and highly effective strains for the common pasture or crop legumes within these groups have been isolated and are being maintained. Adaptation or mutation of strains is being studied, and also the influence of specific bacteriophage. Strains of *Rhizobium* which will infect the Lima bean have at last been isolated, the soil material on this occasion coming from overseas fields which had produced Lima bean crops. The technique of drying cultures under vacuum for storage has been successfully adopted. The possibilities of employing the technique for the production of field cultures are being investigated. The protective action of various colloids, factors influencing viability of dried materials, and the efficiency of various methods of seed transmission are the main features being studied.

In the field of practical application of seed inoculation, close contact has been maintained with farmers engaged in developing poor soils. The problem is not merely one of introducing effective nitrogen fixing-bacteria, but largely of defining the soil conditions necessary for bacterial activity and the successful growth and maturation of pioneer legumes. On Kangaroo Island these have proved to be exceptionally complicated, and a programme of field experiments has been adopted in order to assist in the definition of the problems involved in the development of agriculture on these soils in their raw condition.

4. *Laboratory Investigations.*—Detailed analyses have been made of soil samples collected from various localities, including 24 from the Territory of New Guinea, 65 from the Northern Territory, and 22 from the Callide Valley of Queensland. A number of samples collected during expeditions and surveys in the more arid parts of Australia have also been examined. Samples associated with soil surveys in the south-east of South Australia, on Kangaroo Island, and in the Waikerie Irrigation Area have also been analysed. The examination of samples collected during surveys in Victoria has been undertaken by the State Chemical Laboratories in Melbourne.

Interest has been maintained during the year in soil deficiencies in minor elements such as copper, zinc, and boron. A new area subject to copper deficiency has been noted on Kangaroo Island in connexion with investigations on the inoculation of legumes, and, in co-operation with the Department of Agriculture of South Australia, a study is proceeding of an area at McLaren Flat, South Australia, suspected of deficiencies in boron, manganese, and possibly zinc. A survey is being made of South Australian conditions generally by the examination for these minor elements of samples of oat plants collected from a wide range of centres. The oat plant is selected as being particularly responsive to variations in the fertility status of the soils concerned.

Modern methods for the examination of soil clays now include the use of X-ray diffraction technique. An opportunity was taken by an officer of the Division during study leave in the University of California, to establish some of the facts relating to the mineralogical character of a representative range of colloidal clays separated from Australian soils.

A number of soil types defined in the soil surveys are now known to possess a high fixing power for phosphate and in consequence to present special problems in the use of fertilizers. Methods are being developed which will enable this "fixing power" of the soil to be assessed, and field and pot experiments have been conducted with such soils in an endeavour to develop practical methods of overcoming the difficulties involved. A study is being made of rapid methods for the determination of silica, iron, and alumina in colloidal clays working with semi-micro methods.

The regular use of the spectrograph for the examination of soils and plant materials has been continued. The information required was mainly of a qualitative character. Much attention has been devoted to the determination of working conditions essential for quantitative results, and the necessary auxiliary equipment is being obtained and built up in the light of this experience.

Liaison during the year has been maintained with the Engineering and Water Supply Department of South Australia, and investigations in soil physics have been continued having a bearing on the design of a drainage system for the Berri and Barmera Irrigation settlements in South Australia.

VI. IRRIGATION SETTLEMENT INVESTIGATIONS.

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

1. *General.*—The Commonwealth Research Station is situated on the Sturt Highway, 10 miles from Mildura, on the main road from Mildura to Adelaide, within the group of irrigation settlements popularly known as the Mildura district. The main industry of these districts is the production of dried fruits, and the work of the Station is chiefly directed towards the viticultural, irrigation, fruit processing, and soil preservation problems associated with the dried fruits industry.

The results of the investigations are applicable generally to all settlements in the Murray Valley from Mypolonga in South Australia to Woorinen in Victoria, and are supplemented by investigations in other centres where such extensions are necessitated by local conditions.

The normal seasonal development of the annual growth on a vine, including the development of the fruit buds, has been established by observations over a number of years. Recently, the Advisory Committee of the Merbein Station requested that in any year of seasonal abnormality, special maturation studies be carried out and the results of the investigations given to settlers. Such studies have now been necessary for two successive years, the first year (1938–39) being characterized by excessive summer heat, and the following year (1939–40) by cool weather and delayed maturation. Important seasonal work, including the final pre-harvest irrigation, and the commencement of picking, are influenced by the maturation rate; the quality of the dried product is also affected. The results are expressed as curves showing the growth of the shoot and the berries, and the sugar rise and acidity fall of the grape juices. By such data, the rate and end point of maturation can be accurately determined. There has not previously been any single instance where the result of investigations at Merbein have been so quickly and completely incorporated in commercial routine. At the 1939 harvest, maturation studies indicated that harvest should be brought forward, and in 1940, that harvest should be delayed. The commercial advantage following the 1938–39 investigations was so marked that in 1940 the date of harvest and the attendant operations in practically all settlements was based on the results of the maturity studies.

The experience of the Station, in devising and adjusting the various dipping solutions used in drying grapes, has proved of great value with the advent of the war. For instance, it was found necessary to conserve supplies of potash, owing to the cessation of supplies from overseas. By the use of a wetter, potassium linoleate, it was found possible to dip grapes effectively with reduced quantities of potash, the wetter giving more efficient drainage and greater uniformity in the results. Solutions containing the soluble portions of vine ash were also used, and the extent to which potash could be conserved by adulteration with caustic soda and carbonate of soda was examined. The position now is that the industry can carry on its operations with the reduced supplies of potash available.

Similarly, cotton seed oil has now been successfully incorporated in the dips in lieu of olive oil, the supply of which is restricted. Another important innovation is a dried fruit wash—a casein paraffin emulsion with potassium oleate, which effectively reconditions sticky fruit, and gives it the freedom desired in pressed packs. The use of this emulsion has enabled satisfactory marketing of damaged berries which formerly had a low value owing to massing and sticking after final processing.

In the present year (1940), it is expected that reclamation mains for agricultural drainage will be completed in the group of settlements known as the Mildura district, having been commenced about six years ago. This marks a very significant change in the history of Australian irrigation, in that soil wastage, universally associated with irrigation, has been arrested, the stage

has been reached where successful reclamation is bringing wasted lands back into production, and the effective producing area within these settlements is increasing. The total cost of the drainage mains for an area of some 30,000 acres is £600,000, to which is added approximately an equal cost for the internal drains which are now partly or wholly constructed within the growers' holdings. This gives a capital cost of £40 per acre for the whole area, and is justified commercially by the intensity of the production, the mean population of the Mildura district now being one person to 1.3 acres. It is fitting that the Mildura district, as the oldest organized irrigation district in Australia, should be the first to undertake the preservation of its soils, and it is pleasing to note that organized reclamation is radiating outwards from Mildura to nearby settlements. At present, there is an awakening interest in soil preservation in all the principal irrigation districts in Australia. Special investigations were carried out by the Council in connexion with the planning and fitting of the drainage schemes.

Other viticultural investigations, including the relation between the quantity of fruiting wood and the yield, and the application of fertilizers, have now reached the stage where the results are being prepared for publication.

2. *Co-operation.*—There is a close co-operation with other branches of the Council, particularly the Division of Soils, which has rendered continuous assistance in the planning of soil, irrigation, and drainage investigations dealing with the plants. A very pleasing basis of co-operation with State officers engaged on similar work has evolved, and joint investigations are being carried out in several centres with State officers dealing with irrigation and horticultural problems. It is a pleasure to acknowledge again the assistance rendered by primary producers' organizations in the various dried fruit centres, where facilities for field investigations have been made available to any extent desired.

3. *Drainage Investigations.*—The work on the salt field at the Station established the principles of salt movement in Mallee land with the advent of irrigation. Present investigations deal with the application of these principles and are designed to give information respecting the planning of internal drains. The soil surveys carried out by the Division of Soils have mapped and described the principal soil types in the irrigation horticultural settlements on the Murray River. The drainage reactions of these principal soil types are now being examined. These investigations are supplying information in regard to the optimum depth and spacing of internal agricultural drains, and are carried out on various sites which are typical of the principal soil types.

Internal drainage in most of the settlements has reached the stage where a wide selection of sites and methods of drainage on private holdings is available, and it has been found possible to secure considerable variation in the depth and spacing of the drains. In some settlements, and for some soil types, it has been necessary to adopt the more arduous procedure of constructing experimental drains, or their equivalent, and providing a temporary outfall for the outflow of drainage waters. Measurements include the quantity of irrigation water applied, the run-off, and the rate of fall of the free water in the spaces between the drains. By means of close observation points (approximately ten feet), the lateral influence of the drain may be determined with considerable accuracy. Attention has first been given to the settlements in which systematic arrangements have been made for the disposal of drainage waters, and for these settlements, tables showing the optimum depth and spacing of drains for the main soil types have been prepared, and are being used by the land owners. A distinction has been made in regard to the intensity of drainage required, as drainage for reclamation warrants closer spacing than drainage for soil preservation. Plant surveys, indicating the rate of recovery of productivity, have been found very useful in all reclamation studies.

The staff of the Station is also assisting in the preliminary investigations in areas not yet reclaimed. The design of a drainage system for any settlement is dependent on the environment, including soil types of the area concerned, and is also influenced by the crops grown. Preliminary investigations include studies of the occurrence and fluctuation of soil water and of the free water of the sub-soil; the definition of the areas which will respond to agricultural drainage; and the type of drainage suited to the particular district.

4. *Irrigation Investigations.*—Studies of the method and duration of irrigation for economical and adequate watering of the various soil types have been continued on a number of sites. The information obtained indicates considerable wastage under present practices, associated in some settlements with a deterioration in productivity. The results for major soil types have been published, and at present the investigations are being extended to include larger scale investigations of the possibility of reorganization on a community basis. These studies are being carried out on the Cardross section of the Red Cliffs settlement. More intensive irrigation investigations, incidental to studies of internal drainage, are also in progress. The general result of the investigations has been an improvement, brought about by co-operation with the irrigation authorities, in the service of the community settlements. It has been found possible by a study of the spacing of the irrigation furrows and of the wetted profiles following irrigation,

to define the minimum efficient applications. Structural alteration in the irrigation channels, and in the layout, are necessary for any decided advance in general efficiency in the majority of the settlements.

5. *Viticulture.*—Viticultural studies have been extended to include alterations of the existing trellis, so as to permit a greater range of pruning methods. Results to date have shown that, with the traditional trellising systems where the trellis wires are in one vertical plane, high yields are frequently associated with a massing of bunches, which is unfavorable to their development and renders them more liable to damage in unfavorable seasons. Improvement has been obtained by the overhead trellis, as adopted in Western Australia for fresh grapes, and with the T-piece trellis, which permits parallel trellising of the fruiting wood on sultanas and currants.

The investigations carried on during the year were designed to note the effect of varying quantities of fruiting wood, in heavy yielding vineyards, on standard and T-piece trellis. The results to date show that with increased quantities of fruiting wood, a higher yield of fresh fruit is obtained. This, however, is offset by decreased sugar content, poorer quality, and also processing difficulties. From these experiments, it has been possible to determine, within practical limits, the number of canes for optimum results in yield and quality. This optimum necessarily varies with the producing environment, including such factors as the cultural practices, soil type, and the general health of the vines.

On the Station itself, more elaborate forms of trellising have been erected, some of which are based on designs seen in other countries. The establishment of the vines on these structures will take some time, and areas have been reserved at the Station for continuation.

The T-piece trellis has shown to advantage by allowing fuller and more uniform maturation of the fruit, with less massing. The latter feature decreases damage in bad weather.

6. *Fertilizer Trials.*—Fertilizer trials continue to show that, of the various plant foods, nitrogen is the limiting factor in yield, under the present nitrogen status of Murray Valley soils, which may be regarded as being in need of improvement. Nitrogen is obtained through the medium of leguminous cover crops, and also by the application of nitrogenous fertilizers. In most cases, cover crops do not provide sufficient nitrogen, and a supplementary dressing of sulphate of ammonia or blood and bone manure is applied. The use of green manure crops has a value in addition to its nitrogen content in maintaining soil structure. Phosphatic fertilizers have shown no measurable effect on vine yield ; the use of blood and bone manures is therefore expensive compared with sulphate of ammonia as a source of nitrogen. It is recognized that, where soil fertility is at a high level, the use of cover crops alone will suffice, but that in general the use of sulphate of ammonia in addition to the cover crop gives a payable increase in yield.

The effect of nitrogen in any form is to increase the number of bunches without depressing the bunch size, maturation, or quality, to any appreciable extent. As is to be expected, increased yields tend to depress maturity levels and quality, but the extent of this depression is much less than is generally recognized. Thus in a year when quality is high, nitrogen causes a reduction of less than one half of a Crown grade, while in a year when quality is low, the difference is negligible.

Analysis of the dried fruit shows that while heavy dressings of phosphatic fertilizers, in the form of superphosphate or of bone dust, have no effect on yield, increased phosphate content of the fruit occurs. In the case of potash, which has shown no effect on yield, there is no change in potash content of the fruit. The position is rather that those treatments that improve yield, such as green manure and sulphate of ammonia, increase the acidity of the fruit and therefore the potash content. This is due to the fact that acid in vine fruits is in the form of potassium hydrogen tartrate or cream of tartar.

Measurements of the nitrogen content of the soil and of various portions of the vine show that whereas nitrate nitrogen varies enormously throughout the year, total nitrogen remains constant. The roots and main framework of the vine do not alter in nitrogen content, but there is a considerable seasonal change in the nitrogen content of the annual growth.

7. *Fruit Processing.*—The special investigations in fruit processing are being continued. Further progress has been made in the study of the reactions of the dipping solutions, and additional information has been obtained regarding the parts played in the drying process by the oil, potash, caustic soda, and soaps or other wetting agents. Since the outbreak of war, investigations have been carried out on possible substitutes for potash, such as ash obtained from vine prunings and other sources, and various sodium salts. In regard to supplies of oil, it is pleasing to report that as a result of work carried out during the past few years, Australian cotton-seed oil is successfully replacing imported olive oil for dipping purposes. Further investigations of the keeping qualities of dried fruit produced by various dipping procedures have been carried out, and have shown, among other things, that soil conditions, manurial treatment, and maturity, also have a marked effect on quality.

Pest control in the dried fruits industry remains comparatively satisfactory, but new fumigants are being examined from time to time with a view to their possible use with dried fruit.

8. *Financial Assistance.*—Financial assistance to the Station has been well maintained by various organizations. Annual grants are made by the Australian Dried Fruits Control Board, the Mildura Packers' Association, the Nyah-Woorinen Research Committee, the Curlwaa and Coomealla Horticultural Advisory Committee, and the Red Cliffs Research Committee. The State Rivers and Water Supply Commission, Victoria, supplies irrigation water to the Station, and various local officers assist in the investigations. Contributions for the year totalled approximately £3,000. The major portion is allocated for investigations of general interest to the dried fruits industry, with minor amounts for investigations of local problems in the contributing districts.

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

1. *General.*—The Irrigation Research Station at Griffith was established in 1924. It has 90 acres of irrigable land, 30 acres of which are planted up, and it is provided with good laboratory facilities. The object of its investigations is the elucidation of cultural problems associated with irrigation culture, and, as such, many of its investigations are concerned with the soil. Under irrigation conditions the effects of climate are largely controlled, as the incidence of rainfall is relatively unimportant. The result is that the soil becomes relatively more important. The permeability of the soil largely determines the irrigation technique, and irrigation methods used on one soil type would be quite unsuited to those of another type. A proper understanding of the soil in relation to irrigation is necessary to avoid evils of water-logging and salt accumulation.

The New South Wales Water Conservation and Irrigation Commission co-operated in the establishment of the Station and maintains an active interest in it, contributing £1,500 per annum towards the working expenses and providing the land and water. Very helpful contact is also maintained with the Griffith Producers Co-operative Co. Ltd., who have provided cool storage facilities for citrus preservation investigations. During the past year, the Water Conservation and Irrigation Commission, the Department of Agriculture, the Rural Bank (all of New South Wales), and the Leeton Co-operative Cannery Ltd. have co-operated in an important orchard survey.

New laboratory extensions were opened by Mr. H. K. Nock, M.P. on 3rd October, 1939.

2. *Orchard Survey.*—After a prolonged drought, 5 inches of rain fell in March, 1939, followed a little later by 7 inches in April. The year's rainfall was 26 inches compared with an average of 15.7 inches. The incessant rain caused prolonged waterlogging of the soil during the winter. Besides this the very heavy nature of the rain caused widespread floods. In the middle of April, 3 inches of rain fell within 4½ hours, resulting in floods. Floods had also been caused by a heavy fall in March, when the rice fields were draining and the drains were full. The result of the waterlogging and floods was widespread damage to fruit trees. The Irrigation Research Extension Committee (*see* Appendix) resolved that the problem presented be investigated by carrying out a comprehensive survey, which is now in progress.

The objects of the survey are—

(*a*) To obtain accurate statistics of the number of trees of each variety and each age on the M.I.A. and the proportion of healthy and unthrifty trees (through causes other than the 1939 floods) and also the numbers killed or injured by the 1939 floods. This information is necessary in order to forecast future production, and is required by canneries, packing houses, and financial institutions.

(*b*) To determine the effects on the health, yield, and sizes of trees and vines, of the different cultural and irrigation methods practised, the fertilizers used, and the soil types and aspects that occur; in other words to find out as much as possible from past experience.

(*c*) To obtain maps and other data that will be of use in investigations in the field.

The survey consists of three phases—

(1) An aerial survey of the horticultural area of the M.I.A. Aerial maps of every orchard and vineyard were made to the scale of two chains to the inch. From these, the number, size, and health of the trees are determined, and other relevant features, such as ditches and general layout, noted.

(2) A ground survey that uses the aerial survey as a basis to collect information not given by the aerial photograph, such as age of trees, fertilizers used, tillage methods.

(3) A statistical study of the results. This involves the entering of the data in a suitable way on census forms and statistical analysis of the data. The latter analysis of the data is being carried out by the Biometrics Section. The data entered on the census forms obtained from the aerial photograph includes the crop, variety, health, size of trees, number of trees (of each class). That obtained from the ground survey includes age of trees, method of irrigation, traction power used, depth of tillage, type of tillage, amounts of nitrogenous potassic, phosphoric, and organic manures used, and whether the land was flooded or not during the 1939 floods, and yields. Data obtained from other records and sources include the aspect (from contour maps), the soil (from soil maps of the soil survey), frequency of irrigation and amount of irrigation water used, and average water table (records of the Water Conservation and Irrigation Commission).

The work forms a co-operative effort. The work of compilation of data and entering on cards is carried out by the staff of the Research Station, and the statistical analysis is being done by the Biometrics Section as mentioned. The Council, the New South Wales Water Conservation and Irrigation Commission, the Department of Agriculture, the Rural Bank, and the Leeton Co-operative Cannery Ltd. are providing the finances for the aerial survey, stationery, and much of the temporary staff made necessary. The Council, the Commission, and Department have also made available the services of their officers to assist in the ground survey.

3. *Field Experiments.*—The original field experiments planted up in 1924 have yielded results of considerable value, which have largely been put into practice by the irrigation community. However, since the original fields were laid out, further problems have emerged, and the need for further field experiments has been felt for some time. It is desirable to test in practice ideas that have evolved from laboratory and small plot investigations. It is also necessary to determine the interactions between treatments previously found to be desirable and newer treatments under investigation.

The serious problem of soil deterioration due to loss of structure, compacting, and puddling, that was not apparent in the early days of the settlement needs investigation. Thus the possibility of sod culture of orchards as a means of preventing this soil deterioration needs study. Not only this but its relation to the nitrogen status of the soil and irrigation requirements of the orchard would have to be considered. These are only isolated examples of the type of problem involved. It is intended to plant up a complex field experiment of a factorial design to investigate various irrigation, drainage, fertilizer and soil amendment, sub-soiling and sod, and stock and scion treatments and their interactions. At present the necessary nursery stock is being raised and the land is being prepared.

4. *Irrigation Investigations.*—As described more fully in previous reports, irrigation investigations at the Griffith Station deal chiefly with the following :—

(*a*) The irrigation characteristics of soil types classified in the soil survey of the Murrumbidgee Irrigation Areas, especially the rate and extent of water infiltration under various conditions of soil moisture content, cultivation, &c.

(*b*) The most suitable systems of irrigation in relation to various soil and slope conditions, for example, the relative suitability of spray, contour check, furrow, and border systems.

(*c*) The basis for correct irrigation layout, and the technique for applying suitable quantities of water with sufficient evenness, for example, the choice of a suitable flow rate in relation to slope and length of run for soil type groups classified chiefly by infiltration rate.

The investigation of the irrigation characteristics of the Murrumbidgee soil types involves a study of the morphology of these highly structured soils. This has indicated that structure, in addition to its effect in water penetration, may be closely associated with root development and plant nutrition.

During the year, the Station has actively co-operated with settlers and various Government Departments in meeting the serious problems set by the abnormally wet winter of 1939. The Seepage and Water-logging Committee, representative of the Leeton Fruit Growers' Co-operative Society, the New South Wales Department of Agriculture, the New South Wales Water Conservation and Irrigation Commission, and the Research Station, continued its investigation of seriously affected farms and reported on problems of excess soil moisture. Recommendations were made regarding irrigation methods, surface drainage, and associated measures for research, extension work, and finance.

To co-ordinate an attack on excess soil moisture and related problems, the Irrigation Research Extension Committee was formed in October, 1939, comprising representatives of the Department of Agriculture, the Irrigation Commission, and the Station. In April, 1940, the Rural Bank of New South Wales appointed representatives. The immediate programme has been the orchard survey of the irrigation areas reported above. Sufficient progress has been made to indicate that before the 1940-41 irrigation season all necessary data will be available for the most effective operation of the Committee's extension work programme. This includes the preparation of farmers' bulletins, the formation of local groups for field demonstration and discussion, and publicity campaigns through the usual press, radio, and other channels. The Committee has also interested itself in the provision of adequate research and extension staffs for the areas.

The greater attention being paid to this co-operative work called for additional assistance in the irrigation research side of the Station's work. An assistant research officer was appointed for this purpose in April, 1940. During the year, most attention has been concentrated on the orchard survey. Data being collected on irrigation practices and difficulties on every orchard on the Areas will allow irrigation research to be directed to the most important problems. Further work has been carried out on the irrigation field being developed at Farm 466. This is now equipped with automatic electric control gear to regulate the flow of water in furrow and border irrigation experiments.

5. *Plant Nutrition.*—Investigations into the role of organic matter in plant nutrition have been continued by means of pot experiments and field trials. Field experiments have shown the marked response of citrus trees and other plants to leguminous green manure and farmyard manure under local conditions, and investigations now in progress are designed to determine the reason for this response. Undoubtedly the role of nitrogen is important but is not the only factor concerned.

It has been noted that there are certain areas in which good stands of tick beans cannot be obtained, and these areas are consistently the same each year. Preliminary observations show that the good spots are more calcareous with a good structure, while the poor spots are non-calcareous and are very impermeable. This suggests that the problem is one of permeability and its relation to the structure of the soil. Chemical and mechanical treatments were tried, and it was found that digging to a depth of 12 inches completely overcame the trouble. The importance of this is that it gives a clue to the loss of fertility of many irrigated soils and the consequent decline and dying back of fruit trees—particularly citrus. Investigations are continuing to follow up this lead.

6. *Salt Studies.*—As stated in previous reports, it has been found that with certain local soils in which salt accumulation at the surface commonly occurs in practice, the movement of salt from below to the surface is too limited to be of practical importance even where a water table is held only half a metre from the surface. This appears to make certain theories as to salt accumulation untenable. The problem is of great practical importance, and work is continuing to determine under what conditions salt accumulations occur on these soil types, and if possible to follow the migration of the salt through the soil. It is commonly observed that soil that has been mixed up (such as in rabbit warrens or where large trees are grubbed out) tends to become saline, and this type of salt accumulation is being investigated in particular.

7. *Pasture Investigations.*—Plots have been established to determine the most efficient irrigation methods for summer and winter pastures, and to determine the relative merits of summer and winter pastures with a view of ascertaining how to obtain the greatest value of pasture for the least expenditure in water. In the experiment, 144 one-hundredth acre plots have been established, and each plot will be watered separately by means of a pipe reticulation which will enable adequate control and measurement of the irrigation water. The investigation is being conducted in co-operation with the Division of Plant Industry which will carry out the agrostological side of the work.

8. *Citrus Preservation.*—Semi-commercial trials of processing and handling methods were conducted and included the use of borax baths and wax emulsions for use in marketing Navel and Valencia oranges with particular attention to the New Zealand market. Experimentally treated fruit was sent to New Zealand for examination at that end, and comparable treatments were stored at Griffith.

9. *Botanical Studies.*—Growth studies, root studies, citrus stock investigations, and inarching experiments carried out at the Station are reported under the Horticultural Section of the Division of Plant Industry.

VII. FOREST PRODUCTS INVESTIGATIONS.

1. *General.*—The outstanding feature of the year's work of the Division of Forest Products has been the gradual changing over of the normal research programme to work directly or indirectly connected with defence. In one field of work, the full time of a greatly enlarged staff working in two shifts has been devoted to defence activities, and gradually other researches which have no direct application to the present critical position have been dropped and work of more urgent need commenced. With few exceptions, the staff, which now numbers more than 100, is usefully employed on such work.

2. *Timber Mechanics.*—The outbreak of war necessitated a complete revision of the programme of this Section, and intensive work on the use of wood in aeroplanes was initiated. This work has been developed along three main lines and has now displaced most of the previously planned investigations. The Handbook of Structural Timber Design, which contains tabulated data on the strength and other properties of Australian timbers prepared in a form suitable for engineers and architects, &c. was issued in September, 1939. The demand for the book has been exceptionally heavy, the edition of 6,000 copies being almost exhausted, thus indicating its necessity. Donations totalling £650 were made towards the cost of this publication by various timber interests and users.

(i) *Properties of Australian Timbers suitable for Aircraft.*—A number of Australian timbers are known to have properties which would make them suitable for use in aeroplanes, but lack of detailed information on their properties has restricted their use. This position is being remedied with the utmost speed. About one dozen species considered sufficiently satisfactory to warrant intensive testing have been selected and the actual testing commenced. For this work, timber from at least 30 trees of each species is required, the necessary trees being selected in the bush by officers of the Division. It is very gratifying to report the wholehearted support and co-operation of the sawmillers in the various districts, whose help has been of the utmost value. Testing has proceeded sufficiently far to enable tentative specifications to be prepared for several timbers, and already hoop pine has been shown to be suitable for use in aircraft construction, its strength-weight ratio being about the same as spruce. Considerable commercial supplies of suitable quality are readily available. Reconnaissance tests of a number of other species of timber are being made by the Division of Wood Technology of the New South Wales Forestry Commission, and any of these which are promising will be intensively investigated by the Division of Forests Products.

(ii) *Properties of Aircraft Plywood made from Australian Timbers.*—The testing of Australian plywood is being actively carried out with the object of recommending substitutes for the imported birch and maple plywood. Close collaboration with the Section of Veneering and Gluing is being maintained. Four species of timber have been tested but only one, namely, northern silver ash, has proved at all promising. Further extensive tests on this species are now in progress. The value of scented satinwood has been increased due to changes in methods of plywood fabrication.

(iii) *Design of Box Spars.*—In collaboration with the Division of Aeronautics, a systematic series of tests is being made into methods of design of wooden box spars. To date, a satisfactory testing procedure has been developed, and systematic testing, which has already yielded valuable results, is in progress.

(iv) *Other Investigations.*—The study of steam bending of Australian timbers has been considerably advanced. Other investigations include systematic mechanical tests on jarrah, tests of the load-carrying capacity of split-ring connectors, the relationship between the mechanical properties of a timber and its silvicultural treatment, studies of stresses in trees and creep in timber beams, and tests of coach screws, built up columns, and old bridge girders.

3. *Preservation, Veneering, and Gluing.*—Consequent on the transfer of Mr. Cummins, Officer-in-Charge of Preservation, to the Information Section in April, 1940, the Sections of Preservation and of Veneering and Gluing were combined.

(i) *Field Investigations.*—Many of the routine field inspections were postponed, and as many of the tests are fairly well advanced it is proposed to reduce them as far as possible. The results of the inspections made closely follow the results reported last year, except that decay or termite attack has progressed in the untreated material, while some of the test pieces that had been given the less effective treatments are showing further signs of deterioration.

(ii) *Preservatives.*—Work was commenced in January, 1940, on a comprehensive investigation of Australian creosote oils from the aspect of their use as wood preservatives. A preliminary survey has been made of the nature of the oils produced by various processes, and tests of the toxicity of the various fractions and some of the common constituents of the oils commenced. This work has been financed by a grant of £800 per annum from the Tar Distillers Association.

(iii) *Fireproofing.*—Tests have been made on the fireproofing of Australian and certain imported timbers required for various defence purposes. The tests have been completed, treating schedules developed, and a treating plant has been designed and erected by a commercial firm in New South Wales.

(iv) *Timber Pathology.*—Investigations of various decays and stains in Australian timbers were made in the early part of the year. Tests were also initiated on the natural durability of Australian timber. Most of this work has now been temporarily abandoned and the officers concerned transferred to other work of a defence character.

(v) *Lyctus Investigation.*—The boric acid treatment of veneers to prevent Lyctus attack has now been in commercial use for nearly two years with entirely satisfactory results. A number of factories have installed treating plants, and many millions of square feet of sapwood veneer, which was previously discarded and burnt, have been treated and used without the receipt of a single complaint. The method of boric acid treatment has been extended to boards; the experimental tests have been very satisfactory. It is hoped to apply the results to commercial practice during the coming year.

(vi) *Veneering and Gluing.*—The laboratory has been greatly extended and provision made for a veneer drying room. The Coe rotary veneer lathe donated by Mr. Russell Grimwade has been installed together with the necessary equipment and also a small hot press for artificial resin adhesives. The work has been mainly confined to the use of Australian plywood for aircraft purposes, the Section working in close collaboration with the Timber Mechanics Section. A considerable amount of work has also been done on the testing of glues including animal, casein, and various artificial resin types. In connexion with the preparation of Australian specifications for glue and for casein, various tests have been made and the results incorporated in the draft standards which were prepared.

4. *Timber Physics.*—The fundamental work previously undertaken by this Section has been almost entirely abandoned, and co-operative work has been undertaken with other Sections on investigations of immediate importance. Because of the possible need for developing quick drying schedules for aircraft timbers, a comprehensive investigation of the effects of various kiln temperatures on the strength properties of timbers has been commenced, and already results of direct importance have been obtained. As well as high temperatures, the effect of low temperatures such as occur at high elevations, have also been studied. A special testing machine has been designed and is now being constructed. In regard to plywood for aircraft, the Section is responsible for determining the density and the dimensional changes due to changes in moisture content.

General assistance has been given in connexion with drying and shrinkage problems, the design and construction of constant humidity and temperature rooms, and the drying of flax. Some work has also been done on "improved" wood, the effect of silvicultural treatment on physical properties, and salt seasoning.

5. *Timber Seasoning.*—The experimental kilns have been largely used for the drying of the test material required for the aircraft work. This section has taken over the air and kiln drying of all such material and is also co-operating in the investigation on the effect of high temperatures on the strength properties of timber. The normal services of advice to industry, the supply of plans of kilns and drying rooms, and the correspondence courses in timber seasoning have been continued throughout the year.

6. *Utilization.*—The demand for information on Australian timbers, requests for substitutes and problems attendant on the development of the war have made large demands on the Section. In addition, staff has been supplied to assist in the collection of the material required for the aircraft investigation.

(i) *Survey and Advisory Work.*—Co-operation has been effected between the Section and various Government Departments, and officers of the Division have acted on Committees entrusted with the assessment of existing timber resources and supplies, the forecast of probable effects of the war, and the formulation of steps necessary to ensure the maintenance of essential supplies. By means of visits and circular letters, additional information on the properties and uses of timber has been obtained and included in the general records. These records of production, stocks and consumption of species, products and timber used, and firms engaged in producing or manufacturing activities have been constantly used. Inquiries received involved such items as timber suitable for agricultural machinery, air-raid shelters, ammunition boxes, battery separators, bearings, boats, cases, cooling towers, dunnage, handles, hat moulds, match boxes, mine timbers, railway coachwork, rifle and gun stocks, textile rollers, and X-ray screens.

(ii) *Grading of Australian Timbers and Preparation of Standards.*—Considerable progress has been made in the revision of provincial standards and in the preparation of several new specifications. The main work has been the revision of draft standard No. 02 "Nomenclature of Australian Timber" and the preparation of a draft specification for structural timbers.

Other specifications dealt with included doors, milled flooring, milled lining and weatherboards, green dressing quality sawn timber, and the determination of the moisture content of timber.

(iii) *Substitution of Australian for Imported Timbers.*—There has been a very active demand for advice on the availability and properties of local timbers as substitutes for imported timbers. Recommendations have been made for substitutes for ash, aspen, balsa wood, baltic timbers, Borneo whitewood, boxwood, Douglas fir, hemlock, Manchurian oak, persimmon, pitch pine, yellow pine, redwood, sugar pine, and teak. The substitution of certain of these timbers has involved changes in manufacturing procedure, and advice in this regard has been given, particularly in relation to the substitution of Australian hardwoods for case material, previously manufactured from hemlock and other softwoods.

(iv) *General.*—A number of manufacturing processes were especially investigated including the production of woodwool, wood flour, charcoal, and smoker's pipes. Statements on some of these processes were prepared and circulated. Especial attention has been given to the Monthly News Bulletin and articles of special interest and significance included. In the laboratory an apparatus for generating electrical energy at high frequency was designed and installed, and experiments made on the gluing up of large thicknesses of wood using heat reactive resin glues. These were highly successful, but the commercial development of the process has been temporarily abandoned.

7. *Wood Chemistry.*—(i) *Chemistry.*—Fundamental studies of certain aspects of wood chemistry and of pulp evaluation and paper testing methods, all of which are of importance to the Australian pulp and paper industry, have continued to be the main lines of investigation. Particular attention has been given to methods for the determination and isolation of the total carbohydrate fraction in wood. It has been concluded that no single method may be used to obtain this fraction free from impurities. After chlorination using chlorine water, the use of which has been shown to ensure minimum attack on the carbohydrate material, basic solutions of two main types, namely, (*a*) alcoholic solutions of ethanolamine, ammonia, and sodium hydroxide, and (*b*) aqueous solutions of ammonia, sodium hydroxide, and sodium carbonate are used. Most of the variables involved have been studied at length and reports are in the course of preparation. It seems that it is impossible to isolate the total carbohydrate fraction quantitatively and without impurities.

With the object of studying the material (other than lignin) present in the impure total carbohydrate fraction and which binds the fibre elements together, methods of fractionating the total carbohydrate material have been investigated. After a fairly extensive survey it was found that successive extractions with 82 per cent. dioxan, cold water, and cold 0.053 per cent. sodium hydroxide provide fractions which are amenable to investigation. Various materials were found in the extracts, and it was considered that the fibre-cementing material was mainly present in the sodium hydroxide extract. Evidence from this investigation and earlier work indicates that the cementing material is probably a non-carbohydrate and most probably a phenolic or acidic body. The mechanism of the mild alkaline extraction of wood has been studied using alkaline pre-treatments ranging from $N/_{300}$ to $N/_{2}$. This work has revealed very interesting information on the general problem and also supplied further data on the nature of the fibre-cementing material. A considerable amount of further work is planned along both lines.

(ii) *Paper Pulp.*—Investigations in connexion with pulp evaluation have to date been confined to the operation of the Lampen mill and, in particular, to the effect of mill speed on the degree of replication and the beating performance. Four types of pulp, namely, coniferous kraft, eucalypt kraft, coniferous sulphite, and bleached eucalypt soda pulp have been used with the mill operating at 250 and 300 r.p.m. Replication is satisfactory at either speed when beating kraft pulps, most satisfactory at 250 r.p.m. for coniferous sulphite, and not entirely satisfactory at either speed for eucalypt soda pulp unless the beating periods are very brief. The higher speed with kraft pulps has been found to cause the more rapid development of fibrillation, swelling, and some damage to the fibres. If a universal speed is to be adopted, then it appears necessary to operate the Lampen mill at 250 r.p.m. which would involve a departure from the standard conditions laid down by the Pulp Evaluation Committee of the Papermakers' Association of Great Britain. Accordingly, a study of the trend of and significance between the beating effects at the two speeds is being made and has been concluded in respect to eucalypt kraft. Various minor investigations associated with the pulp evaluation work have arisen and the necessary data have been obtained.

An important problem in pulp investigations is that of storage of the reference pulps and the possible effect of bacteria on the strength properties of these pulps. Studies indicated that beta-naphthol, formalin, santobrite, and zinc hydrosulphite may be used in economical quantities which are lethal to bacteria. Zinc hydrosulphite only, has a significant deleterious effect on the initial properties of the pulp. None of the treatments used could arrest the loss in tearing strength sustained by a eucalypt pulp within a week or two of its manufacture, and it appears that this loss is due to agencies other than bacteria.

Where a pulp mill handles wood from a variety of species and ages, it is difficult, on account of the varying chemical composition of the wood, to so control the cooking conditions that the lignin content of the prepared pulp is constant. Variation in the lignin content and the permanganate number of the pulp introduces difficulties in the control of the bleaching operations. Recent work has indicated that there is a correlation between the alkali consumption of the wood at 100° C. and the lignin content of the pulp obtained under standardized cooking conditions. Work with kraft pulp has been carried out and will be extended to cover soda pulp using wood of various species and ages. The work is of definite value in plant control and the correlation discovered is a step in the direction of providing a quick method of wood assay.

8. *Wood Structure.*—The co-operative scheme between the Wood Structure Section, the Commonwealth Forestry Bureau, and the various State forest services has been continued, and each of the co-operating bodies has received 417 slides of Australian and other timbers, 178 notched identification cards ready for use in the card sorting scheme of classification, and six reports dealing with special matters of wood identification. A successful meeting of Australian wood anatomists was held in Melbourne in August, 1939.

(i) *Anatomical Studies.*—This work has been continued and the results for the Australian Lauraceae have been published. The examination of the Australian Proteaceae has been completed, and, as opportunity offers, the results will be prepared for publication.

(ii) *Identification.*—Considerable success has attended the work initiated on several groups of closely related eucalypt timbers. Methods for the identification of timbers in the two groups (*a*) *E. regnans*, *E. obliqua*, and *E. gigantea*, and (*b*) *E. marginata*, *E. diversicolor*, *E. saligna*, *E. grandis*, *E. resinifera*, *E. longifolia*, and *E. botryoides* have been completed, and the work has been extended to other groups of timber. The results of the examinations made have been referred to specially designed punch cards.

A study of wood from two species of the genus *Callitris*, namely, *C. glauca* and *C. calcarata*, showed that there were no microscopical differences between them. Differences in odour and the occurrence of crystals of guaijol on the freshly cut surface are not specific, but are useful criteria in the absence of more exact differences.

The card sorting scheme has been extended in regard to both coniferous woods and hardwoods and to simplify the identification of unknown hardwoods, family (or sub-family or group) cards have been prepared. These have proved of considerable value in the preliminary investigations of unknown samples.

(iii) *Structure in Relation to Properties.*—Since the outbreak of war, an examination has been made of the structure of the various specimens used by the Timber Mechanics Section in its special aircraft investigations. In the case of hoop and bunya pine, reference discs from every test specimen have been examined in detail to determine the presence of compression wood or minute compression failures. To date, 1,100 discs have been examined as well as pieces of wood from 110 toughness specimens and from 356 tension specimens. The results of the examinations will be correlated directly with the results of the mechanical tests, and thus the exact effect of the various defects on the strength of the timbers will be determined.

Microscopic and fibre examinations have been made of beams which had been subjected to long time loading tests by the Timber Mechanics Section. These examinations indicated that long time loading resulted in the formation and distribution of minute failures throughout the compression side of the wood and that such failures seriously affect the mechanical properties of the beam.

(iv) *General.*—The Section co-operated with the Section of Chemistry in regard to the nature of the non-lignin bonding material of the fibres and the effect of beating in the Lampen mill on the four pulp types tested. In the latter case microscopic examinations were aimed at determining the relation between fibre structure and beating and photographic records were made at the various stages in the experiment. Resulting from the increased activities in the Information Section at the Council's Head Office, the photographic work has markedly increased, and considerable time is now devoted to the photographic copying of technical articles.

9. *Flax.*—Considerable further experience has been gained during the past year in flax research problems in the laboratory and in the application of research to the flax mills. It was originally proposed to increase the Australian flax acreage from 2,000 to 4,000 acres ; the recent decision to increase the area under flax to 21,000 acres during the coming year has affected the normal programme of work. Special studies have been made of the water retting process, and the sensitivity of the electrometric method for the determination of the endpoint of a bacterial ret has been further increased. Investigations have also been made into the question of artificially drying the flax straw and the effect of yield of line fibre due to methods of handling. Some tests of the suitability of various country waters and the disposal of retting effluents have been concluded.

Further research has been carried out on chemical retting. Complete chemical analyses have been made of unretted flax straw, and of straw fibre retted by bacterial and chemical means. The chemical compositions of the fibre so prepared were remarkably similar, and, using the chemical methods already developed, a fibre, comparable in chemical composition and general properties to bacterial retted fibre, can be obtained. Further systematic investigations are necessary, but these have had to be temporarily postponed so that special attention can be given to the many problems associated with the largely expanded flax acreage.

VIII. FOOD PRESERVATION INVESTIGATIONS.

1. *General.*—Owing to the outbreak of war, some changes have had to be made in the various research programmes of the Division of Food Preservation and Transport, although it has been possible to continue most of the major investigations in progress last year. The extensive investigations of the carriage of meat and fruit on shipboard have had to be abandoned. Several new investigations likely to yield results of considerable economic importance in war-time have been commenced. It seems likely that the amount of work of this nature will materially increase in the near future, and that, in consequence, several " long-term " investigations of a fundamental character will either have to be temporarily abandoned or will proceed only when opportunity offers.

The new fruit products laboratory, adjacent to the main laboratory at Homebush (New South Wales), was opened early in 1940, and already it has been possible to carry out a wide range of investigations on the production of pure apple, grape, pineapple, tomato, and prune juices and on general food canning problems. While the equipment was designed primarily for experimental purposes, nevertheless the type and layout conforms closely to the best industrial practice and, as such, has served as a " model ". Owing to the great increase in the amount of chemical work for the general fish preservation studies, a small extension to the main laboratory has been built for its accommodation.

Among the more important results obtained during the year is the definition of the effects of various detergent solutions on the rate of loss of weight from oranges during storage. As opportunity offers, the results are being tested on a commercial scale in citrus packing sheds, and it appears likely that they will be of considerable importance in retarding the loss of external physical condition, or appearance, of the fruit during export overseas, particularly to New Zealand.

Work has also been continued on the effects of the application to citrus fruits, and more recently pome fruit, of thin waxy and other coatings. For citrus fruits, there are a number of coatings which are effective in greatly retarding loss of weight without increasing the rate of onset of wastage, but, for pome fruits, the results so far obtained have been rather conflicting, and further intensive work is now in progress.

It is very pleasing to record that, through Professor Eric Ashby, the services of several members of the staff of the Botany Department of the University of Sydney have been made available for co-operative studies on physiological and mycological aspects of the handling and storage of fruit. The association of the two bodies is proving particularly valuable and has enabled much more intensive work to be undertaken than would otherwise have been possible with the Division's small staff. In the studies on the production of pure grape juices, it was necessary to test the suitability of a wide range of varieties. The Council has been fortunate, therefore, in securing the co-operation of the Roseworthy (South Australia) Agricultural College in undertaking these investigations which have now been commenced by the oenological staff of the College.

A considerable part of the investigators' time has been occupied by the carrying out of several scientific surveys of meat-works and other food processing plants, by giving technical assistance to several new industries, and by answering a wide range of inquiries, particularly relating to problems of the production of pure fruit juices and cordials, the drying of foodstuffs, and the quick freezing of fish, fruits, and vegetables.

Substantial financial assistance for the investigations was again received from many sources, notably the Australian Meat Board, the Sydney Metropolitan Meat Industry Commissioner, the Queensland Meat Industry Board, and the Egg Producers' Council. The purchase of some specialized equipment for fruit products investigations has been made possible by generous donations from many firms interested in fruit juice production.

2. *Meat Investigations.*—(i) *At the Brisbane Laboratory.*—(*a*) *Physical Studies.*—A considerable amount of the activity in this laboratory in the past twelve months has been devoted to studies on the precise control of the physical conditions of circulating air in storage spaces, at temperatures below the freezing point of water. While this work has been done mainly in connexion with the " bloom " problem in chilled beef, the results achieved are applicable to refrigeration problems in general where accurate controls are necessary. Studies in the chilled

beef field have indicated that a very precise control of aqueous vapour tension of the refrigerated air is necessary. To satisfy this need, a very full study has been made of the factors concerned, several of which were almost unsuspected. As a result, much special apparatus has been designed, including a constant-pressure water evaporator, which enables high relative humidities at temperatures below the freezing point of water to be maintained constant to a probable value of $\pm \frac{1}{2}$ per cent. Time has also been given to the difficult problem of the measurement of relative humidity, with results which have considerably improved the accuracy with which this measurement is usually made.

To achieve the satisfactory control of water-vapour tension, it was necessary to stabilize the temperature of the circulating brine. No apparatus working on a commercial liquid ammonia line was available which would do what was required. Following extensive experimentation on the automatic control of the liquid ammonia, apparatus was designed and installed which is holding brine temperatures constant to $\pm$ 0.25°C., and often within narrower limits.

(*b*) *Studies on Fat Storage.*—The work on the storage of beef fat, having chiefly as its objective the prevention of the frequent loss of yellow pigmentation, has produced some striking results. A series of fat samples cut from the one piece of back fat, and stored in desiccators in which definite vapour tensions have been maintained corresponding to relative humidities ranging from 70 per cent. to 99.3 per cent. have shown that, for certain vapour tensions, a very rapid disappearance of the normal yellow pigmentation occurs. This effect becomes so much less at other vapour tensions that, for one specific value, fat stored for 100 days has been indistinguishable from freshly-chilled back fat. Similar samples, after 300 days' storage, were still definitely yellowish as contrasted with the customary bleached appearance. More fundamental aspects as to the nature of this pigment degeneration are now being subjected to quantitative investigation. The exceptionally satisfactory nature of the early results of this work, and the very narrow range of vapour tensions over which satisfactory maintenance of pigmentation has been achieved, have been largely responsible for the physical studies mentioned above. The apparatus designed as a result of those studies achieves, from an engineering point of view, the precision of control which these experiments on pigmentation and water vapour tension indicate as necessary.

(*c*) *Shipboard Studies on Stowage and Wraps.*—That the nature of the stow of beef in a chilled beef storage space on board ship is quite an important factor in influencing bloom has been fairly well established. While better controlled work is possible in land storage, ship storage affords special opportunities not capable of reproduction on land unless a scale model of a ship's storage space is available. Consequently, this phase of the problem was actively pursued by shipboard experiments supplementary to those of the land storage type. The work on types of stow and wraps, commenced early in 1939 and having as its chief objective the study of the influence on weight loss and bloom of tight versus loose stowage and of methods of wrapping the beef, was continued in the early part of the year under review. Three carefully designed experimental shipments were made, but were abandoned owing to the freezing of all chilled beef afloat at the outbreak of war.

(*d*) *Chilled Beef Surveys.*—Several surveys of new meat-works chilling rooms have been carried out in order to rectify faults in installation and to enable them to conform with the stringent conditions laid down by the Council's investigators. Work was also carried out in order to find preventive measures for the long-standing problem of sour odours in the neck furrow of chilled crops. It has been shown that the trouble is due to inefficient sterilization of the neck plugs used to absorb blood and serum oozing from the cut veins during the cooling of the beef.

(*e*) *Studies on Meat-wrapping Materials.*—The value of certain proprietary rubber latex bags in protecting frozen meat from undue loss of water, which may result in loss of colour and "freezer burn", has been tested with quarters of beef, pork legs, and ox livers and kidneys. Such covers, when remaining intact, gave almost complete restriction of water loss from the meat and retention of normal colour, but they lacked adequate mechanical strength when unprotected at low temperatures. Studies are also being made of materials which may be suitable for making watertight containers for packaging special boneless cuts of frozen beef.

(ii) *At the Sydney Laboratory.*—(*a*) *The Use of Ozone in the Ripening of Meat.*—A critical examination of the use of ozone as a constituent of the storage atmosphere for beef held at + 5° C. for the purpose of ripening, has indicated that the effect of ozone in prolonging the storage life of the beef is dependent largely on the surface moisture content of the meat. In the case of experimental muscle slices, contaminated with pure strains of bacteria known to contribute largely to the spoilage of beef at chilling temperatures in Australian meat-works, and stored at + 5° in an atmosphere containing 5 parts per 1,000,000 of ozone, there is little or no extension of storage life with moisture contents down to 180 per cent. (on a dry-weight basis), but there may be an increase of 30 per cent. in storage life with moisture contents below 150 per cent. (fresh muscle contains approximately 300 per cent. water on a dry-weight basis). These results

cannot be referred directly to the surface moisture contents of beef cuts, since the rate of bacterial growth is greater for a given surface moisture content on a beef cut than on a thin slice of muscle. Experimental work on large pieces of meat is, therefore, to be carried out in a constant humidity chamber.

It has also been found that ozone, in the concentration used, namely, 5 parts per 1,000,000 which is the minimum concentration giving an extension of storage life at + 5° C., induces a readily detectable and highly unpleasant rancidity in the beef-fat. Since this off-taste appears within a period of three to four days, which is not a sufficient period for ripening, it is the real limiting factor and renders it unlikely that ozone will find an application in the ripening of meat.

It is probable that inadequate control of the factor of surface moisture content is the cause of discrepancies in the findings of overseas workers on the usefulness of ozone in chilled meat storage. Thus, while the results of the present investigation indicate little or no future for ozone in this field, they have proved valuable in giving authoritative data on this controversial subject.

(*b*) *Storage Disorders of Frozen Lamb Livers.*—Frozen lamb livers may exhibit on arrival in Great Britain certain storage disorders which are generally accompanied by high fat content. Lamb livers of known fat content have been placed in frozen storage in an attempt to reproduce these disorders and to relate them to the fat content of the liver. It is possible to select the livers of high fat content immediately after slaughter by means of their pale colour; the possibility of eliminating such livers from the export trade is being considered.

(*c*) *Canning Investigations.*—From time to time, problems brought forward by meat canners have been investigated, notably in connexion with black staining of canned meats and their containers. It is apparent that many of the tinplate lacquers in use are unsuitable for meat products, and an attempt is being made, in co-operation with local lacquer manufacturers, to develop a suitable general purpose lacquer for meat cans.

3. *Preservation of Fish.*—(i) *Freezing and Cold Storage of Fish.*—Two large-scale experiments with deep-sea flathead have been completed, and the results subjected to statistical analysis from which the following general conclusions have been drawn.

(*a*) *Denaturation of muscle proteins*, as measured by their reduced solubility in 1.0 M sodium chloride, was evident with increasing time of storage at all temperatures, but the method was not sufficiently sensitive to differentiate between widely different treatments.

Further experiments are being undertaken to define the fundamental nature of this change and to assess its relationship with the deterioration shown by increasing " dryness " and " toughness " of the frozen fish when subsequently cooked.

(*b*) " *Drip* ".—The loss of drip became progressively greater with increasing time of freezing between 15 minutes and 40 hours in the " critical zone ", 0° to − 5°C. Total drip increased with time in the frozen state at all temperatures of storage, the relative increase being greatest with the most rapidly frozen fish.

(*c*) *Changes in Fats.*—The onset of rancidity in the fats was indicated by the development of " fishy " and " tallowy " flavours particularly in the brown subcutaneous areas of relatively high fat content. " Fishy " flavours were detectable before any measurable increase in peroxide values, while the " tallowy " flavours appeared only when the peroxide values were relatively high. The factors affecting the development of peroxides were the period on ice prior to freezing and the temperatures and time of storage.

(*d*) *Palatability of Cooked Fish.*—The opinions of members of the panel who tasted samples of the steamed fish showed that the consistency or texture depreciated with decreasing rates of freezing and with increasing temperature and time of storage. While it is probable that these changes are bound up with alterations in the structural myosin fraction of the muscle proteins, it has not been found possible to use the salt-solubility level as a direct measure of the altered consistency.

The rate of development of off-flavours in the lateral streaks increased with lengthening of the period on ice prior to freezing, and also with increasing temperature and time of frozen storage. Peroxide values provided only an approximate quantitative index of " tallowy " rancidity and no measure of the so-called " fishiness ". Generally, the limits of storage life were determined by development of off-flavours in the streak areas, such deterioration being regarded as more objectionable than the changes in consistency. Nevertheless, the subcutaneous layers were frequently badly spoiled while the deeper and less oily areas remained unchanged.

As judged by their effects on palatability, the order of importance of the various factors, apart from the time in store, is temperature of storage, period on ice prior to freezing, and rate of freezing.

(ii) *Cold Storage of Smoked Fish.*—The storage life of smoked mullet and Australian salmon held at various temperatures has been determined by palatability tests and measurement of the rate of development of peroxides. The detection of off-flavours was rendered difficult

owing to the masking effect of the smoke constituents, but all observers could detect off-flavours at peroxide values of about 20 (1 g. extracted oil = 20 ml. $N/_{500}$ sodium thiosulphate). This value was recorded in approximately four months at − 12°C. but was not reached in eight months at − 30°C. Experiments with smoked fish held at 0° C. have indicated that the storage life, measured both by development of peroxides and freedom from microbial attack, is extended by increasing the loss of water from the tissues during curing and smoking.

(iii) *The Effect of Antioxidants on the Development of Rancidity.*—Because of the prime importance of rancidity of the fats in the storage of fish, the possibility of using antioxidants has been considered. The effectiveness of extracts of oat flour has been tested on whole and filleted fish which were dipped prior to freezing and periodically examined during storage for off-flavours and peroxide development. While the formation of peroxide was retarded to some extent by the treatment, there was no appreciable extension of storage life (at − 12° and − 20°C.) as measured by the development of off-flavours. More data will be required before any definite conclusions can be drawn.

4. *Egg Investigations.*—(i) *General.*—Studies of various factors in the production, handling, and storage, which may affect the rate of onset of microbial spoilage in eggs exported overseas, have been continued in each mainland State under the joint auspices of the Council and the Egg Producers' Council. The Division of Food Preservation and Transport has again been responsible for organizing the investigations carried out partly by State investigation groups on which the Council is represented and partly by the Division's officers. From the extensive data now available, several significant results have appeared, but these will need further confirmation before it will be possible to draw any valid conclusions. An account of the work carried out solely by the Division's officers is given in the following paragraphs and in the report of the Physics Section.

(ii) *Experimental Shipment to England.*—An experimental shipment was examined in London by the Division's liaison officer and Mr. C. F. Anderson of the South Australian Department of Agriculture. It consisted of cases of eggs of first-class export quality and other cases containing eggs which, while edible, exhibited certain faults in internal quality, their export being thereby debarred. Examinations shortly after discharge from the ship and also after two weeks at room temperature showed that, while the eggs conforming to the export standards remained in excellent condition, those possessing slight internal defects at the time of shipment from Australia showed a considerable amount of wastage from bacterial rotting. This experiment gives additional evidence for the maintenance of the existing strict standards of inspection of all eggs submitted for export.

(iii) *Bacteriological Investigations.*—This work is of rather an exploratory nature, as there are many variables to be considered in any research on the mechanism and prevention of bacterial infection of eggs. A survey has been made of the types of organisms predominating in typical "rots" occurring in eggs produced in Queensland, New South Wales, Victoria, and South Australia during the 1938–39 export season. The pathogenicity of 30 organisms, representative of the 250 organisms which were classified, was determined by inoculation of portion of a culture into fresh eggs and, after storage of these eggs, classification of the organisms re-isolated from the "rots" produced. Pure cultures have been obtained of the organisms predominating in the different types of "rots" occurring in experimental eggs used in the Victorian investigation group's experiments of the 1939–40 export season.

If it could be proved that the susceptibility to infection of the eggs laid by one bird varies at different intervals after laying, this would, as well as throwing some light on the mechanism of infection, have a practical application in suggesting that there is an optimum interval of time which should be allowed to elapse between the laying and washing of eggs. Work on this aspect is in progress.

Feeding of a culture of the organism to the birds and inoculation of a culture of the organism into the oviduct of the birds will also be carried out with a view to determining the natural method of infection of an egg. It is also intended to determine if eggs contain organisms at a very short interval after laying and, if so, the proportion of eggs which are not sterile and the type of organisms present.

The predominant organisms have been isolated from "rots" which, on Victorian egg floors, are known as "gassy" eggs, and which usually cause a good deal of trouble during the hotter summer months. The pathogenicity of these organisms, which are of similar types, has been proved.

5. *Fruit Handling and Storage Investigations.*—(i) *Citrus Fruits.*—(*a*) *General.*—The investigations have been continued in Sydney, Griffith, Melbourne, and Adelaide under the auspices of the Citrus Preservation Technical Committee on which the Council and the Departments of Agriculture of New South Wales, Victoria, and South Australia are represented. The main lines of investigation being carried out in the four centres are now as follows :—(1) Fundamental experiments designed to discover the nature and causes of the rind lesions appearing when the

fruit is stored at low temperatures. (2) Critical studies of the effects of various "sweating" treatments. (3) Pathological studies to determine whether some forms of rind lesions have a parasitic origin; also, critical studies of the factors governing the onset of septoria spotting in oranges. (4) Studies of the processing of citrus fruits with a view to reduction of mould wastage and an improvement in the external physical condition of the fruit.

(*b*) *Investigations at Sydney in co-operation with the New South Wales Department of Agriculture.*—The effect of various fungicidal treatments on mould wastage in Washington Navel and Valencia oranges has been further investigated; borax and Shirlan W.S. reduced wastage from *Penicillium*. The effect of various emulsions of wax, oil, and shellac on water loss is being studied, and further experiments are being planned to determine the effect of wax emulsions on wastage. Experiments on the control of storage spot wastage by preliminary high temperature sweating treatments have indicated that the effect of sweating is closely related to weight loss, but sweating to 3 per cent. moisture loss at 90°F. has been more effective than sweating to the same loss at 70°F. It is not certain whether this is due to the higher rate of evaporation at 90° F., or to a direct temperature effect, or whether both factors contributed to the result. The effect of sweating is being investigated in more detail this year, and the relation between the amount of storage spot which develops in cool storage and the moisture content of the rind at the time of storage is also being determined.

Experiments with Emperor mandarins have further confirmed previous findings that firm fruit is of better keeping quality than puffy fruit. Wastage caused by *Penicillium* attack was decreased by washing the fruit with borax and Shirlan W.S. solutions.

(*c*) *Investigations at Melbourne in co-operation with the Victorian Department of Agriculture.*—Experiments over several years on Victorian-grown Washington Navel and Valencia oranges have given strong evidence that a storage temperature of 42°F. is generally the most satisfactory in avoiding excessive development of mould and storage spot. This conclusion is not necessarily applicable to the storage of oranges grown in other regions in Australia, and more data will have to be obtained before it will be possible to make a general recommendation covering all Australian-grown fruit. Apart from the storage temperature, careful handling and the avoidance of late picking (after mid-July for Washington Navels) are the main factors in keeping mould wastage at a minimum. The incidence of storage spot is generally less when the fruit is "sweated" after picking in the orchard before handling. Brytene emulsions have had no appreciable effect on the development of wastage. It is possible that "sweating" at high temperatures (70° to 110° F.) may have a more definite effect on spotting, and this is being investigated during the present season.

(ii) *Other Fruits—at Sydney in co-operation with the New South Wales Department of Agriculture and at Melbourne in co-operation with the Victorian Department of Agriculture.*—(*a*) *Apples—At Sydney.*—The control of bitter pit in immature Granny Smith apples by pre-treatment with ethylene has again been demonstrated this year. This finding is of importance, as bitter pit is the main form of wastage in the early shipments overseas of Australian apples.

Experiments with Jonathan apples have indicated that the date of picking may be more important than the ground colour of the fruit at the time of picking, as, of four pickings made at Batlow at weekly intervals without regard to ground colour, only the second picking stored satisfactorily. Each picking contained fruits ranging from green to yellow in colour, but the first picking developed bitter pit and the third and fourth pickings breakdown, soft scald, Jonathan spot, and mould. Storage at 37° F. for six to eight weeks prior to storage at 32° F. completely controlled soft scald. Storage at 37°F. in an atmosphere of 16 per cent. oxygen and 5 per cent. carbon dioxide completely controlled soft scald and Jonathan spot in all pickings, but it increased wastage and breakdown in the later pickings. As ventilation is more restricted in gas storage than in air storage, the possibility of superficial scald developing is greater, and it is advisable to use oiled wraps under gas storage conditions.

The use of gas storage for Granny Smith, Delicious, and Democrat apples did not result in any marked improvement in storage behaviour, but further investigations are in progress. The effect of soil and tree dressings of boron on storage behaviour indicated that wastage was increased by a 4 lb. soil dressing and 1 per cent. spray, but was not affected by a 1 lb. soil dressing or 0.25 per cent. spray.

In view of the restricted overseas export of apples and the possibility of long term storage, investigations are now mainly concentrated on determining the optimum picking maturity for storage and the optimum conditions of temperature of storage and composition of the storage atmosphere.

Studies are also being made of the effects on apples of the application of more than 50 different protective coatings. These coatings are being made up from various oils, waxes, and shellac mixed in various properties. The effects on the rate of moisture loss and on wastage are being investigated at temperatures in the range 32° to 70° F.

At Melbourne.—The conditions governing the storage of Jonathan apples have been fairly well defined as a result of several years' work. Soft scald can be controlled by storing at 36° F. until the end of April, 34° during May, and 32° F. subsequently. Jonathan spot (where serious) can be controlled by the use of an atmosphere containing 5 per cent. carbon dioxide. Satisfactory control of breakdown, however, has not yet been obtained; it is being further investigated.

Last season the effect of storage temperature on nine other varieties (e.g., Delicious, Stewart, Granny Smith, King Cole, Cleopatra, Rome Beauty, London Pippin, Democrat, and Yates) was investigated. The King Cole variety reacted similarly to the Jonathan, being liable to soft scald at 32° F. None of the other varieties exhibited any signs of low temperature injury, but gave the best results at 32° F. The varieties Delicious, Stewart, Granny Smith, Cleopatra, and Rome Beauty were liable to superficial scald, which was controlled by the use of oil wraps.

In the Granny Smith variety a further season's experiments have confirmed the result that bitter pit can be almost completely controlled by picking the apples sufficiently mature and storing immediately at 32° to 34°F. It was found that the development of bitter pit was much less in apples picked at the end of April than those picked at the beginning. Even in the more mature apples, however, there was considerable development of bitter pit if the fruit was not stored immediately but left at outside temperatures for several days; if stored immediately the more mature apples remained practically free from bitter pit up to October. This work is being repeated during the present season, partly with a view to obtaining more fundamental information on bitter pit and the influence of temperature on its development.

Gas storage of ten varieties of apples by the method of reduced ventilation resulted in a retardation of colouring and softening, more particularly in the culinary varieties (those picked green). Contrary to the findings in Sydney, the best results were obtained with Granny Smith and Stewart varieties. The maximum effect was only obtained in the atmosphere 10 per cent. carbon dioxide, 11 per cent. oxygen. As this atmosphere proved somewhat injurious for many varieties, the experiments this season are being carried out using atmospheres containing only 5 per cent. of carbon dioxide, but with the oxygen reduced to 10 per cent. and 5 per cent.

(*b*) *Pears—At Sydney.*—The application of boron as soil and tree dressings had neither harmful nor beneficial effects on the storage life of the fruit. The results of gas storage have confirmed previous findings with Victorian-grown fruit that an atmosphere of 16 per cent. oxygen and 5 per cent. carbon dioxide increases the storage life at 32° F. by approximately 50 per cent. The various disorders which occur during storage and ripening have been closely studied, and the type of disorder varies with variety, locality in which the fruit is grown, and length of time the fruit has been in store. The use of protective coatings for retarding respiration and prolonging the storage life is being investigated. The possibility of extending the canning season by cool storage and gas storage is being studied in conjunction with a large firm of canners; tests have been carried out with the Golden Queen peach and the William pear.

At Melbourne.—The experiments on gas storage of pears are being continued during the present season. The storage life of W.B.C. and Bosc pears at 32° F. has generally been increased from about three months in air to six months in 10 per cent. carbon dioxide (by reduced ventilation). However, these varieties are not very promising for long storage, as other varieties such as Packham, Winter Cole, Josephine, and Winter Nelis have a storage life of five to six months at 32° F. in air. The increase of the storage life of the W.B.C. variety makes possible a considerable extension of the canning period, which will probably be of considerable importance with further expansion of the industry.

Experiments conducted in some detail with the W.B.C. and Bosc varieties have shown conclusively that continuous gas storage gives far better results than gas storage before or after a period of air storage. This finding is strikingly shown in the following table for W.B.C. pears.

Storage life at 32° F. (months).	First Picking.	Second Picking.
Air	2½	2
Ten per cent. carbon dioxide	7	5
Air six weeks, then 10 per cent. carbon dioxide	3½	2½
Ten per cent. carbon dioxide two months, then air	3½	3½
Ten per cent. carbon dioxide four months, then air	5	5

The W.B.C. pears that were held initially for six weeks in air at 32° F. were particularly liable to injury by carbon dioxide during subsequent gas storage; they developed skin spotting and "brown heart".

For the Bosc variety it is possible that carbon dioxide injury could be serious in consignments exposed to carbon dioxide on shipboard after a period of air storage on land. Bosc pears kept at 32° F. either in air or 10 per cent. carbon dioxide for twenty-one weeks, and then ripened, were entirely free from disorders after a week at 60° F., but 100 per cent. of the pears kept for fourteen weeks in air followed by seven weeks in 10 per cent. carbon dioxide developed internal disorders.

The longer-keeping varieties Packham, Winter Cole, and Winter Nelis were investigated last season, and were found to have a storage life of ten, eleven, and twelve months respectively in 10 per cent. carbon dioxide. This offers possibilities for longer storage, but the results need confirmation; further work is being carried out during the present season.

Most of the work with pears has been carried out in atmospheres obtained by reduced ventilation. In the present season other atmospheres (e.g., 5 per cent. carbon dioxide, 10 per cent. oxygen; 10 per cent. carbon dioxide, 5 per cent. oxygen; and 5 per cent. carbon dioxide, 5 per cent. oxygen) are being included, and six varieties are being investigated at two stages of maturity.

The ripening of pears after storage has been given some attention. With most varieties ripening is either abnormal or too slow at Melbourne winter temperatures. A leading Victorian grower has built a ripening room and ripened pears at 65° F. during the winter with very encouraging results. However, it has been found that the varieties Packham and Josephine, although ripening perfectly at 65° F., do not colour well at this temperature. Satisfactory colouring was only obtained at 55° F. and below.

(*c*) *Plums.—At Sydney.*—Very satisfactory results have been obtained with the Santa Rosa, Federation, Angelina, and Grand Duke varieties, using as storage conditions 32° F. for three weeks and subsequently 45° F. The use of lower storage and ripening temperatures has been investigated, but the results have not been satisfactory. This year's experiments have confirmed previous findings that the life of the President variety is relatively short.

At Melbourne.—The experiments with plums in recent years have been directed towards determining the optimum conditions for shipment to England of the mature fruit (i.e., those picked well grown and partly coloured but still firm, giving a pressure test of 8 to 10 lb. with the U.S. Penetrometer). Such plums are likely to give the highest quality on subsequent ripening. It has been concluded that if such plums were held at 32° F. for not more than three weeks, and then held at 45° F. for slow ripening during the remainder of a six weeks' voyage, most varieties would be discharged nearly ripe but sound and of good quality; while, if held at 32° F. for the whole of the voyage, they would be discharged in a less forward condition but would develop internal disorders either during the voyage or shortly after discharge.

The modified conditions were tried in an experimental shipment in 1939, but as the London market reacted unfavorably to ripe plums it was advisable to ascertain whether the fruit could be held at 32° F. for longer than three weeks or transferred subsequently to a lower temperature in order to retard ripening. It was found, however, that a maximum period of three weeks at 32° F. and a minimum subsequent temperature of 45° F. marked the limits of safety with all the varieties investigated in the last season, with the possible exception of the Cole's Golden Gage and Greengage varieties. From three seasons' results it is expected that these conditions should be satisfactory for Santa Rosa, Satsuma, Narrabeen, King Billy, Jefferson, Cole's Golden Gage, Greengage, Golden Drop, President, and Grand Duke varieties. The Formosa, Wickson, and Diamond varieties could not even be carried under these conditions, as they will undergo deterioration if stored for more than two weeks at 32° F. Their export is, therefore, not recommended.

(*d*) *Peaches.—At Sydney.*—The storage life of the J. H. Hale variety picked at an immature stage has been considerably increased at 32° F. by delaying its cool storage after picking, by prestorage treatment with ethylene, and by storage in an atmosphere of 16 per cent. oxygen and 5 per cent. carbon dioxide. The storage life of this variety was very much longer at 30° F. than at 32° F.

At Melbourne.—Investigations over several years have centred around the problem of export to England. The storage life at 32° F. of the three varieties Smith's, Catherine Anne, and Late Crawford—which mature from late January to early February—has varied somewhat from year to year, but has always been at least five weeks. Experiments in past years suggested that this might be increased by gas storage, but the results have been too variable for commercial application. Only in the less mature peaches was the storage life increased by gas storage, while in the more mature fruit it was often decreased. It is almost impossible to obtain peaches commercially at an exact stage of maturity, as in hot weather they may soften in twenty-four hours. Further, in the present season, peaches were obtained from a different grower and no appreciable increase in the storage life has been obtained by gas storage.

The storage life of at least five weeks at 32° F. is obtained only if the peaches are subsequently ripened at 65° F. ; a temperature of 45° F., which would correspond approximately with market temperatures after discharge in England, is too low for satisfactory ripening of this fruit. Five weeks is just sufficient to allow shipment of peaches on the fastest ships, provided the fruit could be subsequently conditioned at 65° F. on discharge. This method, however, would allow no margin of safety in the case of delay in arrival of ships or delay in conditioning the fruit after discharge.

Following some interesting results obtained by Davies and his colleagues in South Africa, details of which were kindly given to the Council's investigators, similar studies here indicated that if peaches of these three varieties were held for two days at 65° F. or one day at 80° F. after picking, they still had a storage life at 32° F. of five weeks, but they could be subsequently ripened at 45° F. Conditioning before shipment is certainly much more practicable, as it merely involves leaving the fruit out for about a day in hot summer weather or two days in cool weather before loading or placing in cool store. The best results were obtained with peaches picked while still firm. Hence, peaches could be picked while still sufficiently firm to handle, and conditioned after packing. These results are, of course, based on only one season's results and they need confirmation.

It was also interesting to observe that the peaches conditioned before storage at 32° F. had a storage life about two weeks longer when subsequently ripened at 65° F. than those stored immediately.

(*e*) *Grapes.—At Melbourne.*—The chemical control of mould in grapes is being further investigated during the present season; the best results have been obtained by packing in cork treated with a mixture of iodine and potassium iodide. The use of cork treated with the sodium salt of o-phenylphenol and also with potassium metabisulphite is being investigated. As granulated cork is becoming scarce and expensive, the use of alternative packing materials is being tried. The paper-woodwool pack has resulted in considerable mould wastage in past years, but in present trials the addition of alum-bisulphite tablets (following South African practice) is checking mould satisfactorily. The use of sawdust as a packing material is also being investigated.

6. *Fruit Products Investigations.*—(i) *Apple Juice.*—These experiments were carried out with the co-operation of the Department of Agriculture of Tasmania, from which State portion of the fruit used was derived. Seven varieties were tested at three pickings representing early, mid, and tree-ripe maturity. All fruit was of standard grade and treated according to a selected schedule with the object of obtaining the widest possible experience during the current season. The general processing method adopted was as follows :—Cull, wash, mill, press, strain, deaerate, flash pasteurize, cool, and bulk-store. Glass carboys of six gallons capacity were used for bulk storage, and by rigid exclusion of air in the headspace the growth of moulds was suppressed. Clarification by the use of pectolytic enzymes was not included as a routine measure, sedimentation during storage being regarded as a suitable alternative. No attempt was made to adjust the sugar-acid balance, since blending from bulk is to be effected later.

Four apple varieties—Cleopatra, French Crab, Sturmer, and Scarlet—were obtained from Tasmania, and Jonathan, Granny Smith, and Delicious from New South Wales. With small lots of juice, the maceration process recommended for improvement in flavour intensity was tested. No appreciable differences were noted, though it is to be recognized that maceration is of value with certain varieties only. Satisfactory results were obtained when brilliant clarification was attempted by the use of Strasburger and Seitz Filters. Pre-treatment with commercial pectolytic enzymes was inconclusive, and it would appear from preliminary investigation that viscosity change is not a useful measure of the effectiveness of such treatment.

The apple juice investigations are still proceeding and have not yet reached the stage at which recommendations as to commercial procedure may be made. However, indications are that processing methods adopted overseas are likely, with slight modification, to give satisfactory results in Australia.

(ii) *Pineapple Juice.*—Investigations were extended to cover Smooth Cayenne and Common Rough varieties grown in north and south Queensland. The general processing procedure adopted in the previous year being found satisfactory, work was directed towards refinements of individual steps in the preservation method. It was found that while deaeration is essential with many fruit juices immediately preceding pasteurization, it is unnecessary in the case of pineapple juice and, in fact, contributes somewhat towards loss of flavour. Pasteurization at 173° F. was shown to be equally as effective as the higher temperature of 190° F. used hitherto.

Reports from abroad suggest that the incorporation of constituents from the peel of pineapples produces bitter flavour in the juice. This point has been thoroughly tested and found to be untrue where Australian fruits are in question. Moreover, the use of unpeeled fruit desirably heightens colour intensity in the product. Confirmatory tests of earlier work demonstrate the

necessity for rapid cooling of cans that have been filled with hot juice. When allowed to cool in air, cooked flavour developed to an appreciable degree. Finally, while work connected with the clarification of pineapple juice is not yet sufficiently advanced, it would appear tentatively that a cloudy juice is to be preferred.

(iii) *Citrus Juices.*—The production of high quality orange juice presents greater difficulties than other juices as yet studied in this laboratory. The development of bitter flavour and an off-flavour akin to that of marmalade are the chief faults. Both of these undesirable flavours may be produced by severe processing treatments or may develop slowly in store. For this reason the effective life of orange juice is limited and may be set at two to three months at atmospheric temperatures or approximately six months when held in cool store.

The usually accepted temperature of pasteurization of orange juice is of the order of 200° F. to 205° F. Reduction in temperature to 195° F. and 190° F. appeared to give an equally satisfactory product; however, the work will need to be repeated before a final conclusion can be reached.

Two methods of juice extraction were tested, viz., pressure on peeled fruit and burring of unpeeled cut halves. The former method was found to give added bitterness due to leaching of the albedo. The burring method is also disadvantageous in that a certain amount of aeration is involved. Nevertheless, burring followed by rapid deaeration was found to give the better result.

Four orange varieties were tested during the season. Washington Navels at all maturities gave juices that were markedly bitter and unpalatable. Excision of the navel has been suggested as a means of mitigating bitter flavour, but a number of tests in this direction were carried out without success. Owing to adverse seasonal conditions, insufficient fruit was available for effective work on Joppa and Parramatta orange varieties. Parramatta oranges were again shown to be eminently suitable for juice production and considerably superior to the Joppas. Valencia oranges were fully tested, and when picked at the correct maturity they yield a satisfactory product though somewhat inferior to that obtained from Parramattas.

One lot of Marsh Seedless grapefruit was converted to juice by expression of peeled fruit. The juice was somewhat bitter but nevertheless very palatable, the delicate fresh flavour being well retained. Work with lemons has not yet been attempted but will be included in the forthcoming season.

(iv) *Tomato Juice.*—Juices were obtained from three varieties of tomatoes gathered on two occasions. The effect of flash pasteurization as compared with holding pasteurization was tested, as also was the process of homogenization. Standard treatment consisted in scalding the fruit to an internal temperature of 170° F. after it had been soaked in water, washed, and graded. Juice was obtained from an expeller press, strained, adjusted with salt and sugar, deaerated, pasteurized, and canned. The most suitable of the varieties tested was the Marglobe, though Bonny Best also gave a palatable product. Break of Day blended with Marglobe was reasonably satisfactory but of itself could not be regarded as a suitable variety. No difference was noted between the two methods of pasteurization employed, while the effect of homogenization was immediately apparent in the smoothness of the juice. The latter process appeared to reduce the colour intensity slightly, but the otherwise undesirable effects reported from overseas were not apparent.

(v) *Prune Juice.*—Two varieties of prunes, viz., Robes and D'Agens, were used at the suggestion of the Dried Fruits Board of New South Wales, which provided the necessary fruit. Within the variety, three grades, medium, small, and cull, were tested using a modification of the well known battery diffusion method of extraction. The work is still proceeding, but has nevertheless arrived at a stage where it might safely be concluded that Robes are definitely superior to D'Agens for juice purposes. The former are well balanced in acid and sugar and possess a pleasant flavour which is carried over into the product. The D'Agens samples used were found to be deficient in acid and lacking in flavour. Culled Robes gave a juice that was little, if at all, inferior to that produced from good quality fruit.

(vi) *Grape Juice.*—One phase of this work consisted in the testing of a wide number of varieties for their suitability for conversion to juice, and these studies were appropriately located at the Roseworthy Agricultural College, South Australia. Investigations by the Division in Sydney were confined to processing technique. At Roseworthy, some 27 separate varieties were tested, and of these a number grown under irrigated and non-irrigated conditions were investigated.

Four varieties only were used at Homebush. The accepted processing procedures were varied, but little difference in the final product was noted. A suitable sequence of operations is as follows:—mill, press hot, strain, deaerate, flash pasteurize into carboys, store, siphon, centrifuge, clarify, deaerate, flash pasteurize, and can.

(vii) *Miscellaneous Fruit Products.*—Preliminary work has been carried out on the manufacture of fruit jellies and of milled apple pulp for culinary purposes. Fruit jellies prepared from fresh fruit juices by the addition of sugar, acid, and pectin and the application of heat were shown to be very acceptable owing to retention of true fruit flavour in the product. As far as is known, fruit jellies manufactured in this way have not yet been marketed in Australia.

Milled apple pulp was prepared by passing peeled and cored apples through a high speed grater mill and vacuum canning the milled apple, which is then sterilized by immersion for thirty minutes in boiling water. The object of the technique is to submit the apple to a minimum of processing in order to retain maximum flavour intensity. It is proposed to compare milled apple pulp with commercial brands of pie apple and with pie apple prepared at the Homebush laboratories. This work is still proceeding.

(viii) *Lacquer Investigation.*—The internal lacquering of tinplate cans has been further investigated. By small refinements in technique it has been found possible to reduce the tin content in fruit juices to an extremely low figure. Using locally manufactured lacquers and the spray method previously evolved, the protective coating was found to be resistant to all juices so far handled. An alternative method of lacquering whereby the can is filled with lacquer, inverted, and allowed to drain prior to stoving is now being investigated. It would appear that, in the case of either method, double coating is desirable. Preliminary work on lacquers designed to prevent staining in meat cans has been undertaken. So far the results have not been entirely satisfactory.

7. *Physics.*—(i) *General.*—As in previous years, a large proportion of the time of the Physics Section has been devoted to the maintenance and running of mechanical equipment, the design and construction of apparatus, the statistical analysis of experimental data, and the design of experiments and collaboration with other Sections of the laboratory on various problems.

(ii) *Evaporation of Water from Oranges.*—Wilting or " loss of condition " due to excess water loss sometimes results in considerable decrease in the market value of oranges in commercial handling, and work is being carried out to discover means of reducing this loss. The effect on the condition of the fruit of any given proportion of water lost varies to some extent with different samples of oranges, but these variations seem generally to be small. As a rule, wilting becomes quite obvious when the water loss from the oranges exceeds about 5 per cent. of the initial weight.

In most of the growing areas it is necessary to wash oranges before packing for market. This washing is usually done in the packing houses in specially designed machines incorporating baths of some detergent solution, scrubbing brushes, drying tunnels, polishing brushes, and mechanical graders. A bath containing a fungicidal solution such as borax, and a tank for the application of wax emulsion, are sometimes included. It has been found that most of the detergent and fungicidal solutions in common use cause large increases in the rate of evaporation of water from treated fruit. With some of the detergents this increase may exceed 100 per cent. Thorough rinsing with clean water will eliminate or at least greatly reduce the adverse effect of the detergent solutions when the oranges are carefully washed by hand, but it is by no means certain that rinsing would be equally effective in machine treatment. The effect of rinsing in machine handling is now being studied. It has been shown that one of the long chain sulphonate detergents which is available commercially in Australia is an efficient cleanser and has no appreciable effect on the rate of loss of water from oranges when used for washing by hand, but when it is used in one type of commercial machine there is some increase in the rate of evaporation from the oranges though much less than with the detergent formerly in use. Tests are now in progress to determine whether this is a direct effect of the scrubbing brushes or whether the detergent solution also plays a part. It is possible that most of the detergents now in use have considerable fungicidal value, so that more work is necessary before it can be stated whether or not the adoption of rinsing or a change to one of the newer detergents is advisable.

After washing, oranges are sometimes given a thin coating of a suitable wax to restrict evaporation and improve the appearance of the fruit. Several of the relevant processes have been tested and shown to cause a restriction of the rate of loss of water of the order of 40 per cent. Most of the experiments so far carried out have been with oranges stored in open trays, but some tests have been carried out with oranges packed in cases. It was found that the outer fruits in the cases always behaved in the same way as oranges in open trays, but in a cold store at 40° F. with a low rate of air circulation the rate of evaporation from inner fruits was low and almost unaffected by previous washing or waxing treatments. In cases of fruit stored at 70° F. with a fairly vigorous air circulation, the rate of evaporation from the inner oranges was less than from the outer fruits, but the effects of washing and waxing treatments were only slightly less than in the outer fruits. The proportion of Australian oranges which are held in cold storage between picking and marketing is not large, and even with cold-stored fruit the weight loss in storage is generally small compared with that during the remainder of the marketing period,

so that the experiments carried out so far indicate that the effects of washing and waxing treatments on oranges submitted to ordinary commercial handling will be slightly less than those observed under laboratory conditions. Further work on the effect of packing in cases is in progress.

(iii) *The Evaporation of Water from Eggs in Storage.*—It is desirable to keep the loss of water by evaporation from eggs in cold storage as low as possible, but, if the relative humidity of the air surrounding the eggs is too high, there is serious risk of mould attack. Work has been started in co-operation with the Egg Producers' Council to determine whether it is possible by simple means to reduce the water loss from eggs shipped to England, without introducing any appreciable risk of mould attack. A test has been carried out, using two of the standard packing materials, to estimate the effect of (*a*) equilibration of the packing material under the conditions of the storage room before packing the eggs, and (*b*) lining the cases with a treated paper which is fairly efficient in restricting the passage of water vapour but not so impermeable as a good quality waxed paper. Further tests will be carried out with other wrapping materials.

(iv) *Cooling of a Wet Body.*—Work on this problem has been continued, but it has not yet proceeded far enough to draw definite conclusions.

8. *Investigations by the Division's Liaison Officer in London.*—(i) *General.*—A considerable proportion of this officer's time has been occupied by inquiries originating in Australia and relating to such matters as equipment for the drying of foodstuffs, the production of pure fruit juices, materials for the packaging of dry and moist perishable foods, and the canning of fruits and vegetables. More recently, he has been able to keep the Division fully informed about the problems which are arising in Great Britain in war-time in the feeding of the civilian population and the fighting services. With the data so provided, it has been possible for the Division to give attention to several problems of immediate urgency.

(ii) *Examinations of Experimental and Commercial Shipments of Foodstuffs.*—During the year, the liaison officer has examined and reported on the out-turn and ripening of one small experimental shipment of Beurre Bosc pears forwarded from New South Wales and on a large number of consignments of this variety from commercial shipments. Previous studies had shown that while Australian Bosc pears usually arrived in England in a reasonably sound condition either they developed severe disorders before ripening (during marketing), or, if remaining free from disorders, they seldom ripened to a satisfactory degree of texture, flavour, and juiciness. The studies in the 1939 season have confirmed these findings, and have provided strong evidence for the contention that the Beurre Bosc variety is seldom suitable for export from Australia to Great Britain.

IX. FISHERIES INVESTIGATIONS.

1. *General.*—Progress has been made during the past year in the primary investigations of the Fisheries Division into the potentialities of the pelagic fisheries. It is considered to be established that from certain well-situated ports—of which a typical example is Eden on the southern New South Wales coast—fishing for tuna by trolling can be successfully carried on by small powered boats for several months in the year, and the establishment of canneries at or near these ports should now encourage the gradual growth of this type of fishing. Experiments are now being conducted in the capture of tuna by large-scale commercial methods. In the case of at least one tuna species (striped tuna), it has been shown that the live-bait method is successful. Experiments are continuing with various types of live bait on the other tuna species, and the occurrence of suitable bait fishes is receiving close attention.

The rapid growth of the salmon canning industry and its by-product meal and oil industry has involved the provision by the Fisheries Division of an advisory and analytical service, including experiments on methods of liver preservation and oil extraction. The possibilities of canning and fully utilizing other fish species are also receiving attention.

Aerial reconnaissance flights had unfortunately to be suspended owing to the national war emergency. Three officers of the Division have visited Western Australia at different periods during the past year in order to make preliminary observations on the occurrences of fish of potential value, e.g., tuna, salmon, and crayfish.

2. *Technological Section.*—Since the last report, two papers on the marketing of fresh fish in Australia have been submitted for publication. One of these, Pamphlet 93, has now been issued, while the other is in the press and deals with the bacteria isolated from fish muscle and other allied sources. It is concluded that the bacterial flora of spoiling fish muscle is essentially that of the sea-water in which the fish lives, and of the slime and gills of freshly caught fish. Boxes, tables, and other articles with which fish habitually come in contact are infected with these bacteria which live and multiply in their new habitat, thus reinfecting other fish which are brought into contact with them.

A number of the commoner fish have been canned in various ways, and it has been found possible to make very palatable packs of the following :—mullet, barracouta, bluefin tuna, striped tuna, bonito, kingfish, little tunny, and albacore. A report of this section of the work is being prepared for publication. It will contain a *résumé* of methods and results of overseas operations, and the information which has been obtained by experiment and discussion.

Some smoking experiments have been carried out, including the smoking of mullet as a substitute in the manufacture of bloater paste. It is the aim of the Division to indicate methods for the smoking and canning of Australian fishes to replace overseas fish should these become unobtainable.

3. *Tuna Investigations.*—The lines of inquiry pursued during the preceding year have been continued and extended in the period under review, namely, the study of the geographical distribution and movements of the Australian tunas, and the biological work on racial stocks, fluctuations, and feeding habits. The investigations have shown that there are nine species of tuna in Australian waters, of which at least six have commercial possibilities, though two (the southern bluefin and the striped tuna) must be regarded as the staples in any considerable canning industry. The status of others inhabiting northern Australian seas is still uncertain, owing to the fact that the research vessel has made no surveys there.

A publication dealing with the Australian tunas, and designed for the use of the fisherman and fish-processor, is now ready for the press ; it contains a digest in popular language of what has been learned so far, and, owing to the desirability of expanding the fishing industry for war-time needs, it is being published in advance of the scientific papers on which the data is based. The laboratory and ship investigations have been aided by the co-operation of the two commercial canneries which have operated during the year, and useful statistical data have been supplied. Valued help has also been given by sport fishermen and others interested in these fish, notably Mr. C. E. Wellings of Eden, and Mr. A. F. D'Ombrain of West Maitland, New South Wales. During the year, the *Warreen* has conducted tuna investigations from Mackay, Queensland, to south of Hobart, and one cruise has been made to South Australian waters. Investigators have also visited centres in Western Australia where tuna occur.

Achievements in practical fishing methods have not yet been as great as hoped for, but successful attempts with live anchovy bait have demonstrated that striped tuna can be caught in large quantity by this method. It is quite likely that southern bluefin can be taken similarly. For commercial needs of the moment, however, trolling from small boats is adequate, and this method of fishing should be eminently suitable on the south coast of New South Wales. Last season, one- and two-men craft were able to land an average of a hundred tuna in a half-day's fishing. Lack of conclusive results by the *Warreen* have been mainly due to difficulties in obtaining live bait. Concentrated effort is now being devoted to this problem.

4. *Clupeoid Fishes* (*Pilchards, Anchovies, Sprats, &c.*).—The principal lines of investigation followed in respect of these fishes continue to relate to distribution and size, though much work has also been done on chemistry and maturity, and some on age and race-differentiation. Most of the work has concerned species from the waters of south-eastern Australia.

(i) *Pilchard* (*Sardinops neopilchardus*).—Further research has confirmed the opinion held earlier that this fish is most conspicuous in the waters of New South Wales and southern Queensland in the late autumn, winter, and early spring, when it occurs in at least moderate abundance in surface shoals. The main concentrations of fish seem to occur off the southern and central sectors of the New South Wales coast in the autumn, the central and northern sectors in the winter, and the northern sector and the waters of southern Queensland in the spring, thus exhibiting a northerly movement as the season progresses. The oil content of the pilchards at this season is low, probably on account of the spawning or spent condition of the fish ; in the summer months, when the fish are sexually immature, the oil content is very much higher but unfortunately they are not so numerous at the surface at this time. The length of those so far measured averages about six inches, with a maximum of 8½ inches. The occurrence of surface shoals of spawning pilchards in South Australian waters during the summer and autumn has been confirmed. Little is known about other waters except that those of the east coast of Tasmania do not seem to be much, if at all, frequented by pilchards at any time.

(ii) *Anchovy* (*Engraulis Australis*).—There is little definite information to add to previous reports on this fish, except that there appears to be a well-marked spawning season during which the fish are numerous and sometimes form shoals, during spring and summer, on the southern coast of New South Wales. Anchovies often occur in bays and estuaries, as well as in the open sea, and have now been proved to be excellent live bait for striped tuna fishing.

(iii) *Other Species.*—The blue sprat (*Stolephorus robustus*), sandy sprat (*Hyperlophus vittatus*), and southern herring (*Harengula castelnaui*) are species of the bay and estuary waters, in which they seem to remain all the year round. The largest is the herring, which averages about five inches in length, and which seems to be particularly common in the northern regions of New South Wales and in southern Queensland, and to have commercial possibilities. Two

other species, the maray (*Etrumeus jacksoniensis*) and the sprat (*Clupea bassensis*), are still little known ; the latter, which seems to be principally a fish of Tasmanian waters, was abundant near Hobart in May, 1940. Fishing experiments for shoals of these fish in the open seas have not to date been particularly successful, though some fair catches have been made with lampara and drift-nets.

5. *Mullet Investigations.*—The mullet investigations are aimed at obtaining information on spawning (place and time), rearing grounds, migrations, growth rate and size at various ages, maturity, and racial composition of the stocks of the bullhead mullet, *Mugil dobula.*

Efforts at securing information on spawning have not yielded complete or conclusive results, but data obtained suggest that *M. dobula* spawns during early winter, at the entrance to the rivers, that the spawning is confined to the northern part of the area of distribution, and that the southern waters are stocked by movement southward, either as larvae or as older fish. It is reasonably certain that the larvae and young fish occupy the estuary during the first year, move further from the sea in the second year, and mature at the end of the third year, when they make a spawning migration in autumn and early winter.

Tagging operations have been continued, and sufficient returns have been secured to indicate that there is an extensive northward migration probably in echelon formation. This applies to *M. dobula* of all kinds (i.e., whether recognized as sea or river mullet). During the year, measurements and collection of scales have been continued in the market and the field. Representatives of practically all age groups have been secured from most places within the area of distribution on the eastern coast, and a fair quantity of data has been secured from Western Australia. It is anticipated that the analysis of these data will show whether or not the fishery may be considered depleted. Suggestions as to protection and control will be possible upon completion of these studies.

Whilst most of this work has been upon *M. dobula*, attention has been given to the other mullets and to other important species of the estuarine and coastal fishery, where these have been met in the course of field operations.

6. *Oyster Investigations.*—A survey has been made of the oyster industry of the eastern coast of Australia. It is apparent that increase in the production and sale of oysters in Australia is quite possible. Such increase would involve the use of ground at present not used, and improvement in methods in many instances. Problems to be solved include those of elimination of the effect of variations in spat fall, of acceleration of growth rate, of formation of good shell shape, of maintenance in good " condition ", and of the elimination of losses. Marketing problems relate to the establishment of grading, and to the improvements in methods of placing oysters on the market.

The problems of growth and conditions have been attacked by fundamental studies which comprise biometrical, biological, and chemical analyses of samples, with correlated hydrological work. In addition, extensive ecological observations have been made. Work has been done on the histology of the oyster as a basis for pathological and physiological studies. A kymographic apparatus has been set up in association with the constant temperature aquaria, with which experiments are being conducted on the effect on shell movements (and therefore on the welfare of the oysters) of variations in temperature, salinity, hydrogen ion concentration, &c. One hundred samples of normal oysters have been submitted to the above analysis, and it is proposed to use that analysis in association with histological and kymographic work in an approach to a study of " winter mortality ". An experimental lease has been established in George's River from which material for this work is to be obtained.

A " spatting " lease has been established in Port Hacking where experiments are being conducted on the efficacy of various materials in collecting spat. Data have been collected here on time and level of spat fall. Observations have been made also on occurrences of oyster larvae in plankton catches, and these results in relation to ecological observations may suggest developments in respect to materials, place, and time for spat catchment.

7. *Australian Salmon Investigations.*—With the rapid and valuable development of the canning and general utilization of this species in the south-eastern Australian region, a complete knowledge of life history, distribution, movements, and technology has become essential.

Studies so far made indicate that in the above area there are two distinct populations. One occupies the New South Wales coast southwards from about Sydney to Green Cape. This may be called the Eastern Group. The other, which may be termed the Southern Group, occupies the Victorian coast from approximately Mallacoota to Cape Otway, and is found also off north-east Tasmania and in Bass Strait. This tentative differentiation is based upon characteristic growth rates, and the marked difference in spawning season. Thus the bulk of the Eastern group appearing in the commercial catch range from 6 to 8 lb. in weight, appear to be from 6 to 8 years old, and spawn between January and April. The corresponding findings for the southern group are 4 to 6 lb., 7 to 9 years (indicating a much slower growth rate), and October to April. The line of demarcation between the two groups occurs about Cape Howe.

Experimental tagging of young salmon has been commenced in the Gippsland Lake region of Victoria.

Life history investigations have commenced. The areas of occurrence of young fish are being determined and examined and specimens of from $1\frac{1}{2}$ to 12 inches have been obtained. These, in order of increasing size, are known as " crackers ", " lumpy trout ", and " salmon trout ". It may thus be possible to discover the spawning grounds.

8. *Hydrological and Plankton Report.*—The investigations of the Hydrological Section during the year under review have been in the nature of an extension and amplification of the programme given in the previous year's report. Complexity of the problem, lack of previous investigations, and immensity of the area covered, make it impossible at this juncture to explain, on established hydrological concepts, the major problems of distribution. A great deal of hydrological data has, however, been accumulated, and sufficient is probably now available for correlating with the occurrence of certain types of plankton and the fixing of limits of tolerance of fish species, &c. The seasonal variations in the properties of the water masses at established stations along the coastline have now in most cases been completed, and a rough criterion of variation can now be established for major seasonal departures from this normal value. Considerable progress has been made in the characterization of the more southerly Australian waters by means of the species taken in plankton catches. Selection of indicator species is being made, these being types which are found only in unusually warm or cold water, and which are, therefore, useful in demonstrating unusual incursions of water of either type as the case may be.

X. AUSTRALIAN NATIONAL STANDARDS LABORATORY.

In the previous report, reference was made to the erection of this Laboratory in the grounds of the University of Sydney. During the year under review the work of erection was practically completed. The equipment for the Laboratory is now being assembled. Two of the three senior officers have now returned to Australia and other officers at the National Physical Laboratory in Great Britain are obtaining experience and equipment.

1. *Metrology Section.*—Equipment is on order that will enable the lengths of slip gauges which form the basis of control of modern factory production to be checked in terms of wavelength of light to an order of accuracy of one-millionth of an inch. Longer lengths will be controlled by end bars, of which the longest will be one yard. Equipment for the inter-comparison of such bars is due to arrive shortly. The Section, however, is already assisting in the checking of gauges used for munitions and general factory production in New South Wales and Queensland. Negotiations are in progress for the purchase of the Laboratory's standards of mass.

2. *Electrotechnology Section.*—The portion of the building reserved for this Section is not yet quite complete and thus it has not been possible to set out the equipment required for electrical testing in the various rooms. However, a number of urgent investigations in connexion with the defence programme have already been carried out, and others are in progress.

The development of the Section will commence with the setting up of equipment for direct current measurement, including the testing of standard cells and resistances and of auxiliary equipment such as direct current indicating instruments, potentiometers, Kelvin and Wheatstone bridges, resistance boxes and other similar apparatus. When this function of the Section is developed sufficiently it will then be possible to proceed with measurements at power frequencies, Such measurements will include the testing of alternating current indicating instruments, electricity meters, current and voltage transformers and dielectrics. Simultaneously, the testing of the magnetic properties of materials will also be developed. The next stage will be the installation of standard bridges and networks for measurements of inductance and capacity, and other measurements at audio frequencies. At a later stage, facilities will be available for testing at higher frequencies.

3. *Physics Section.*—The staff of this Section is still abroad, but its equipment is now being delivered. The maintenance of electrical standards of E.M.F. and resistance will ultimately be a function of the Section. It will also undertake the calibration of all varieties of thermometers and pyrometers and will be equipped to carry out investigational work on heat insulation, and work in connexion with spectrophotometry, optics, photometry, refractometry, X-ray technology, viscosity and hydrometry. Equipment has been provided for an optics workshop for the production of precision surfaces in glass.

4. *Section of Co-ordination of Testing.*—This section has been established for the purpose of bringing about uniformity of practice in Australian testing laboratories so that reasonably concordant test results may be ensured. The immediate programme is being confined to laboratories concerned with the mechanical testing of materials required for defence purposes.

XI. AERONAUTICAL INVESTIGATIONS.

1. *General.*—Substantial progress has been made in the establishment of the research laboratory for aeronautical and engine investigations. The site at Fishermen's Bend has been levelled and fenced and laid out to accommodate, not only the Division of Aeronautics, but the newly formed Division of Industrial Chemistry. Work on the site commenced in August, 1939, and three buildings were ready for occupation in April, 1940, namely, the administrative block, a workshop block of seven bays, and a power station. The wind tunnel building is under construction, while two engine test houses remain to be built.

The administrative block faces the frontage on Lorimer-street, and has been designed as a central feature with one wing. The symmetry of the building will be completed when the other wing is built to house the Division of Industrial Chemistry. Behind the administrative block, a road has been run down the centre of the site; the aeronautical buildings lie to the west of this road and adjacent to the aerodrome. This will allow a hangar to be built and flight tests to be carried out when such tests are needed. The land to the east of this road is available for the buildings of the Division of Industrial Chemistry. A narrow strip along the eastern boundary fence can be used for building a towing tank of length up to 1,000 feet, for tests of seaplane or ship models; if the ship-building industry in Australia expands, a need for such a tank may arise. In order to use economically such facilities as can be made common to both aeronautics and chemistry, library and clerical offices are to be shared, and expensive equipment such as mechanical testing machines, metallurgical equipment, and machine tools, will be operated for the joint benefit of both Divisions.

The establishment of the laboratory has been undertaken in order to assist in the development of an aircraft manufacturing industry in Australia. The building of an aeroplane is a complex engineering problem, and the rapid advances made in aeronautics have not allowed time for aeroplane designs to be stabilized, or for sufficient theoretical knowledge to be accumulated for the solution of many design problems. Extensive experimental facilities are therefore needed, and the energies of the small staff which has been collected have, up to now, been almost wholly directed to designing or procuring this equipment. Unfortunately the outbreak of war has seriously interfered with the delivery of the larger specialized plant. Machine tools for the workshops had been ordered well in advance, with the result that the shops are well equipped and are engaged in making apparatus and small items of equipment for laboratory use.

The work of the laboratory is divided under the four headings of aerodynamics, structures and materials, engines and fuels, and instruments; sections have been formed to deal with each type of problem.

2. *Aerodynamics Section.*—An officer experienced in aerodynamic research was appointed in England and arrived in Melbourne in July, 1939. With an assistant, he has been engaged on the design of the wind tunnel and other equipment for aerodynamic research; this class of equipment is too specialized to be obtained commercially, and must be specially designed and manufactured.

The design of the wind tunnel, aerodynamic balance, and associated instruments and equipment is now complete. Before placing any orders, a one-eighth scale model of the wind tunnel was constructed at the Engineering School of the University of Melbourne, and tests made to check the design. The aerodynamic efficiency obtained in these tests exceeded expectations, and showed that the design compared very favorably with those in other countries. Construction of the equipment is proceeding. The largest item, the welded steel shell of the wind tunnel, is being manufactured at an engineering works in Melbourne. Though this steel shell is very large, having overall dimensions of 105 feet long by 44 feet wide with a maximum cross section 14 feet high by 18 feet wide, very close manufacturing tolerances were specified and are actually being improved on by the manufacturer. The airscrew and 550 h.p. electric driving motor and control gear are being constructed in England. Delivery of these items will almost certainly be delayed. The aerodynamic balance to measure the forces and moments on the model subjected to the airstream in the tunnel is also being made by an engineering firm in Melbourne to the design of the staff of the Aerodynamics Section. Some of the specially designed manometers and pressure recorders for use in the operation of the tunnel are being constructed by the workshops of the Department of Natural Philosophy at Melbourne University.

In order to assist in the design of high speed military aircraft in Australia, experiments are being made on a new method of obtaining high air speeds with low turbulence in a wind tunnel of the type under construction. This method should enable speeds of about twice the normal tunnel speed, i.e., of about 400 m.p.h., to be obtained.

Since the experimental equipment will not be available for some time, Professor Burstall has very kindly placed at the disposal of the Council the wind tunnel belonging to the School of Engineering at Melbourne University. While this tunnel is smaller and of very much lower speed than that being built, it has enabled investigations of certain aerodynamic problems of immediate importance for the defence of Australia to be begun.

3. *Structures and Materials Section.*—(i) *General.*—The Officer-in-Charge of this Section, who commenced duty in September, has had considerable experience in aeroplane structural design in both England and Australia. After careful consideration of the testing equipment already available in Melbourne, and of the problems likely to require testing facilities, orders were placed early in October for two Universal testing machines, one of 60,000 lb. capacity, and one of 6,000 lb. capacity. As each machine has a dual range, this provides the equivalent of four machines of varying capacity. In addition, an impact testing machine, a hardness testing machine, and two rotating fatigue testing machines were ordered. All these have been received and installed with the exception of the large machine which is now expected from America. Additional equipment, including a small impact testing machine for wood specimens, is being made in the laboratory workshops.

In order to deal with the metallic materials used in aircraft construction, a metallurgist has been appointed to the Section, and commenced duty in March of this year. While awaiting delivery of the necessary equipment for his work, arrangements have been made for this officer to use the equipment available in the Department of Metallurgy of the University of Melbourne.

(ii) *Wood in Aircraft Construction.*—From the commencement of its activities, the Division has been co-operating with the Division of Forest Products in general investigations regarding the suitability of Australian timbers for aircraft construction. The importance of this work cannot be over-estimated at the present time, as the principal material used in modern aeroplane construction, aluminium alloy, is not produced in this country. Wood offers many possibilities for aeroplane construction, and can be used as solid timber, plywood, improved (i.e., laminated and compressed) wood, or as an adjunct to plastic materials. For the present, only the simpler uses as solid timber and plywood are being investigated. Even this simplified programme is complicated by the fact that at present no rational theory of the design of wood spars has been formulated, and present design methods involve empirical factors on which there is no unanimous agreement. The investigation has therefore been divided into two parts (*a*) the determination of the basic properties of selected timbers (this portion of the work is the concern of the Division of Forest Products); and (*b*) the formulation of a rational theory of design and the necessary experimental work to develop the theory. The work under both headings is well advanced, and the results, when available, will be immediately applicable in many aircraft production schemes. The work under (*a*) has also enabled provisional specifications to be drafted for three aircraft timbers.

(iii) *Materials Survey.*—In November, 1939, a survey of local sources of materials likely to be of use in aircraft construction was commenced, and a questionnaire was prepared for circulation round the metals industry. The issue of the questionnaire and the preliminary analysis of the returns was performed by a section of the Department of Supply and Development. The results of the questionnaire were quite satisfactory, and the information now at hand is being passed on to that section of the Aircraft Production Commission which is responsible for ensuring supplies of materials for the aircraft industry.

(iv) *Standards Association.*—In November, 1939, the Standards Association of Australia was requested by the Department of Defence Co-ordination to endeavour " to produce co-ordination between local specifications and British Standard and D.T.D. Specifications " for aircraft materials. The necessity for this co-ordination is very real. In Great Britain, a very large number of different aircraft materials are in use, these being covered by some 300 Air Ministry (D.T.D.) and British Standard Specifications. It is obviously undesirable, if not impossible, to manufacture this large range of materials in Australia, and the main object of the Standard Association's work has been to reduce the number of specifications in use to the very minimum that would satisfy the reasonable demands of the industry. This has involved a very large amount of labour in the examination and correlation of current specifications, and the problem was further complicated by the existence of certain local standards based on American practice.

Aircraft steels were first considered. The Special Committee on Aircraft Steels was formed; the officer-in-charge of the Structures and Materials Section is a member of it. He also acted as secretary of the Committee and was also a member of its Drafting Sub-committee. Several new specifications covering locally produced steels have been drafted, and a progress report has been prepared and published in conjunction with the Association. The same officer is also a member of two other Committees of the Association which were formed this year, namely, the Aircraft Materials Executive Committee and the Special Committee on Non-Ferrous Metals for Aircraft.

(v) *Properties of Steels.*—Arising out of the work of the Special Committee on Aircraft Steels, the Structures and Materials Section has undertaken two investigations into the properties of steels manufactured in Australia. In order to reduce the number of materials required to be manufactured and stocked in Australia for the construction and repair of aircraft, it was decided to recommend that only one type of steel tube be used in general. The opinion of the Committee was that this should be a chrome-molybdenum steel tube, but as there was a large number of aircraft in service incorporating manganese steel of the T.45 type, the repair of these structures raised the question of the strength of a combination of chrome-molybdenum steel tube and manganese steel tube welded together. An investigation involving tensile and fatigue tests and metallographic examination is now in progress to answer this question, and the results should be available shortly.

In the course of its deliberations the Special Committee found that certain important information required for the draft specifications covering locally produced steels was lacking. The Division undertook to obtain this information, and accordingly an extensive investigation into the properties of chrome-molybdenum and of pearlitic manganese steel bars has commenced.

4. *Engines and Fuels Section.*—In this Section, it is proposed to install apparatus for both complete testing and developmental work on aircraft engines. The officer-in-charge of this Section has, since taking up his duties in January, been principally occupied with the inquiries and investigations preliminary to the specification and ordering of equipment.

For type trials on complete engines, a large dynamometer test plant, suitable for engines of up to 2,000 horse-power, has been ordered from a manufacturer in England. This plant, with its cooling equipment, instruments, and other auxiliaries, will be erected in a partially sound-proof test-house. In order to make tests on air-cooled engines, a cooling fan driven by a 650 h.p. electric motor is included. This will deliver an air blast of 160 m.p.h. over the cylinders of the radial engine five feet in diameter. Developmental work and research investigation on aircraft engines are usually carried out on a single-cylinder unit. A unit of this kind suitable for work on the types of engines being made in Australia is to be built, and a 400 h.p. dynamometer plant for absorbing and measuring the power, together with the necessary instruments and other equipment, has been ordered in England. This plant also includes a cooling arrangement for air-cooled cylinders.

It is hoped that the activities of the Section will not be confined to aircraft engines, but will cover the whole field of the internal combustion engine—a field which is not within the scope of any existing government-owned laboratory in this country. To this end, a small dynamometer and test bed, suitable for testing engines of the automobile type and of powers up to 120 b.h.p., have been ordered. In addition a vehicle dynamometer, on semi-permanent loan from the Institution of Automotive Engineers (Australia), has been installed.

For the testing of motor spirits and Diesel engine fuels, a C.F.R. engine has been obtained and is being installed. This is the standard engine for determining the octane number of motor spirits and the cetane number of Diesel fuels. It is anticipated that this engine will be useful to government departments and other large purchasers of fuel in providing a check on the quality of petrol or Diesel oil supplied. It will also be used for research investigations on locally-produced fuels. Equipment is also being provided to carry out all the usual laboratory tests on motor spirits and lubricating oils.

Several research projects are under consideration, but it is not likely that work on them can proceed until the installation of equipment is complete and a larger staff is available. These investigations will be mainly directed towards the improvement of fuel economy, a subject of particularly great importance in Australia. As one item of this nature, investigations are being made of a rotary valve engine which has been invented locally. It is claimed that the rotary valve allows a higher compression ratio to be used without detonation, and thus achieves increased thermal efficiency, with its attendant reduction in fuel consumption. The staff is co-operating with the inventor in developing the engine in a form suitable for aircraft use. A small engine of this type is running in the laboratory and a larger one is to be constructed.

At the request of the Department of Supply and Development, the laying down of test requirements and testing procedure for producer gas vehicles was undertaken. The test schedules have been considered, and testing is to be supervised by a Committee of which the officer-in-charge of the Section is a member.

Advice has also been given to a number of persons concerning inventions of new types of engines and devices connected with the internal combustion engine.

5. *Instruments Section.*—Equipment for calibrating and testing aircraft instruments has been ordered and some items have been installed, including a master air speed indicator calibrator and a stroboscopic revolution counter calibrator. Other equipment is to be made in the laboratory workshops. An instrument maker has been appointed, and is receiving specialized training in the workshops of Australian National Airways. Before the laboratory building was completed, the Instruments Section was called upon to carry out tests on an electrical tachometer which had

been developed locally, and which it was proposed should be adopted by the Royal Australian Air Force. Since the laboratory and equipment were not available, it was necessary to borrow and improvise apparatus and to make use of the laboratories of the University of Melbourne. The instrument successfully passed the prescribed tests, and was found to be in some ways superior to the imported instrument.

No professional staff has yet been appointed to the Section, which is being supervised by the officer-in-charge of the Engines and Fuels Section.

6. *Training of Aeronautical Engineers.*—The Division has again afforded practical help to the University of Sydney by making available the services of Mr. Coombes and Dr. Patterson for periods of two and three weeks respectively. This action was taken at the request of the University authorities consequent on the delayed arrival in Australia of Professor A. V. Stephens, who has recently been appointed to the University Chair of Aeronautics. Dr. Woods has delivered a course of lectures on the internal combustion engine to engineering students at the University of Melbourne. The education of technical college students in aeronautics has also been proceeding under the direction of Mr. Wills at the Melbourne Technical College. These evening courses have been well attended by the drawing office staff of the Commonwealth Aircraft Corporation.

XII. INVESTIGATIONS IN INDUSTRIAL CHEMISTRY.

During the year, effect was given to yet another recommendation of the former Secondary Industries Testing and Research Committee, viz., that a research service be established to carry out technical investigations of value to the secondary industries. A Division of Industrial Chemistry has now been formed and placed under the charge of Dr. I. W. Wark. Before his appointment, Dr. Wark, who is a graduate of the Universities of Melbourne and London, was for many years engaged on fundamental research work in the fields of flotation and surface chemistry.

The Government has made an amount of £50,000 available to the Council for the erection and equipment of a Laboratory for the new Division alongside the Aeronautical Research Laboratory at Fishermen's Bend, Melbourne. Plans for the laboratory have been completed and a contract for the constructional work will be let at an early date.

The chief objectives of the new Division are five in number, viz., (i) to promote technical efficiency in industry, (ii) to stimulate new industries, (iii) to encourage the utilization of Australian raw materials, (iv) to encourage the replacement of imported materials by materials of Australian origin, and (v) to investigate the possibilities of industrial by-products. As a long-term policy, the Division will endeavour to play its part in bringing about a better balance than the existing one between Australian primary and secondary industries ; its short term-policy will be governed by national war needs.

It has been decided to organize the laboratory into five main sections, each in charge of a senior investigator. These sections are—(i) physical chemistry, (ii) organic chemistry, (iii) inorganic chemistry, (iv) analytical chemistry, and (v) chemical engineering. In other words, the laboratory will not be organized on a problem basis, but work on any particular problem will be undertaken by one or more of the above sections, each section looking into special aspects. Biochemical work will also be undertaken.

After an extensive survey of many different industries, it has been decided to concentrate, in the early years, on problems relating to non-metallic minerals and their utilization, metals and alloys, wool and other fibres, hides and leather, and dairy produce.

XIII. OTHER INVESTIGATIONS.

1. *Lubrication and Bearings.*—During the year, some work concerning lubrication and the construction of bearings was put in hand. It is believed that the results will be of considerable value in connexion with the growth of the Australian aeroplane engine industry. The work is being undertaken as a co-operative research with the University of Melbourne, and is under the direction of Dr. P. Bowden, formerly of the University of Cambridge. The Australian programme provides for a continuation of Dr. Bowden's previous studies at Cambridge and for the training of a research team, consisting of a chemist, an engineer, and two physicists, in the highly specialized technique necessary for work in this field.

Results obtained in the Cambridge work have an important bearing on the problems of lubrication and wear, particularly on the lubrication of metals under difficult conditions of high temperature, as, for example, in the case of piston rings and bearings of a modern high speed engine. They also provide a valuable guide in the selection of correct bearing metals for use under different practical conditions and the prevention of corrosion, scoring, and seizure of bearings. Determinations are also being made on the wear of engines operating on different designs of producer gas equipment. Not only will these investigations be of value in the

development of high speed engines, but, in the event of a shortage of lubricating oils, they will enable substitutes to be rapidly tested and their suitability for various applications to be readily determined.

2. *Commonwealth Prickly Pear Board.*—In the first main section of this report, it was mentioned that during the year under review the Commonwealth Prickly Pear Board had been disbanded after a very successful period of operation. The measures taken to follow up different aspects of prickly pear control were also outlined.

3. *Radio Research Board.*—The work of this Board has continued as in previous years with the co-operation of the Postmaster-General's Department and of the Universities of Melbourne and Sydney.

Early in the year it became evident that the Board would have to modify its research programme considerably owing to the outbreak of war, which called for the concentration of all possible effort on problems related more directly to Australia's defence requirements. With that end in view, some of the Board's staff have answered the call for physicists for other work. In consequence, in connexion with the Sydney work, experiments designed to investigate some of the complexing features of the ionosphere and its variations have been held in abeyance pending a return to more normal world conditions. Nevertheless, it has been possible to maintain the long-term series of observations of the equivalent-height and echo intensity of the reflective layers. For this purpose, the relevant transmitters and receivers have been re-designed, re-built, and rack-mounted, thus providing permanent, compact, and reliable units which can be operated with relatively little attention. Further examination has been made of the connexion between conditions in the ionosphere and meteorological conditions at the ground. This work has been extended to include the correlation of both these phenomena with terrestrial magnetic disturbances. A definite interdependence has been found.

The Sydney work continues to be greatly assisted by the co-operation of several allied investigators working in the University of Sydney, the Sydney Technical College, and the Solar Observatory, Mount Stromlo.

In Melbourne, following on the completion of the work on the reflection of atmospherics in the ionosphere, attention is being given to ultra high frequency work. The new programme has involved an investigation, using two distinct methods, of the refractive indices of various gases in the atmosphere for wave-lengths in the region of $2\frac{1}{2}$–5 metres.

4. *Mineragraphic Investigations.*—During the year, 22 investigations have been carried out into the mineral associations of the valuable minerals in ores, mill products, and residues submitted by mining companies and institutions. Each of these investigations was complete in itself, and directed to some specific problem, such as the mode of occurrence of gold in an ore, concentrate, or tailing, particularly in relation to gold losses during treatment; or to the association of metal-bearing minerals in an ore body or mill product. Nine of these investigations have determined the mineral association of ores which have been subjected to the ore dressing test referred to in the section (5) that follows.

One of the most interesting investigations concerned unusual coated gold from the New Cobar Mine, Cobar, New South Wales. This appeared in a table concentrate containing abundant pyrite and arsenopyrite, together with some galena, a little chalcopyrite, pyrrhotite, zinc blende, native bismuth, and gold. Though the concentrate contained 129 oz. of gold and 52 oz. of silver per ton, no free gold was to be observed on panning. Instead, a black product appeared at the head of the pan which proved on examination to be largely free gold coated with native bismuth or lead and bismuth sulphides or silver chloride.

A comprehensive examination was made of four mill products from the North Broken Hill Mine with the view to the determination of the variation of the valuable lead, zinc, and silver minerals, in different sizings of each product. By assuming that the grains in each sizing are of equal dimensions and by counting the different types of grains along equally spaced traverses across a polished section, a quantitative expression of the minerals was presented which reflected the variations in the lead, zinc, and silver assay values of each sizing of three products. A measure of the relative importance of free and composite grains in all sizings was thus obtained giving direct evidence of the effectiveness of the grinding units. Another problem concerned the identification of the lead minerals in a flotation concentrate from the Moonlight lease, Wiluna, assaying 0.66 per cent. lead. As lead minerals are heavy, a superpanner concentrate was prepared in order to increase the amounts of the lead minerals in the microscopical preparations. In this way two lead minerals were found, one being a lead sulphantimonide, jamesonite, and the other a copper lead sulphantimonide which may have been bournonite or a copper bearing jamesonite. A microscopical examination has also been completed of the copper ores of the Mount Oxide mine, Queensland. Chalcocite is the chief copper mineral below the oxidized zone and is largely a secondary replacement of primary pyrite. Primary copper sulphides are practically absent.

These mineragraphic investigations have been facilitated by contributions from a number of mining companies through the Australasian Institute of Mining and Metallurgy. The University of Melbourne has also assisted by granting the investigators laboratory accommodation in the Geology School.

5. *Ore-dressing Investigations.*—These co-operative investigations have been carried out in the laboratories of the Kalgoorlie School of Mines, the South Australian School of Mines and Industries, and the Metallurgy School of the University of Melbourne. With the sustained high price of gold the demand for investigations into the treatment of ores and metallurgical products continues and, judging from the comments received from those for whom work has been done, the investigations have played no small part in increasing the gold production of Australia. With modern technique quite a few mines, formerly closed down on account of ore-treatment difficulties, can now be profitably worked.

In Kalgoorlie, some 25 reports discussing work on different gold ores were issued. In Adelaide, as in previous years, examinations were made of ores and mineral products from other parts of Australia as well as from South Australia. The war has caused considerable interest in minerals such as fluorite, wolfram and scheelite, which are needed in the manufacture of munitions. In consequence, some investigations in these fields have been undertaken.

At the Melbourne Laboratory, there has been the customary large demand for routine work on gold projects. In addition, base metal ores of special importance in present-day war conditions have received attention. An investigation of note was carried out on ore from the All Nations Gold Mine, Bingara, New South Wales, in which a detailed investigation of the results of cyanidation and flotation versus flotation and cyanidation was made. Extensive work was also carried out on cupriferous gold ore from Kelsey Creek, North Queensland. Ore from a chromite deposit at Marlborough (Queensland) was studied with the object of producing a high-grade concentrate suitable for use in the steel industry. The ore is a difficult one to treat, but work is proceeding as Australia does not produce any high-grade chromite deposits and uses quite a considerable tonnage in her tanning industry alone. Scheelite bearing products from Barraba (New South Wales) received some attention and were found to be readily treatable by flotation. It is expected that the work will result in a flotation plant being installed at the mine.

6. *Standards Association of Australia**.—The record of the Association's work during the past year is a notable one, not by reason of comparison with work done in previous years so much as by the contribution made to Australia's war effort. The anticipations of the Council of the Association during the preceding year have been realized, and the Association has been called upon to undertake a considerable programme of work of the utmost importance to the production of munitions of all kinds. Of especial value has been the preparation of standard specifications for aircraft materials and components, based upon the specifications used by the British Air Ministry, but providing a simplified range of materials for Australian manufacture and, when such has been found to be necessary, modifying some of the requirements of the specifications to conform to Australian conditions as to raw materials and methods of production.

In addition to aircraft materials, such products as heavy textiles, ropes and cordages, and bolts suitable for automotive equipment have been dealt with. Accessory needs have also been met, such as the provision of specifications for suitable magazines for the storage of explosives. The need for conserving liquid fuel resources by the application of producer gas to automobiles has led to co-operative work with the Department of Supply and Development for the issue of specifications for gas producers and charcoal. The facilities available to the Association have been placed at the disposal of those responsible for developing Australian self-sufficiency, and have been utilized for the investigation of various technical matters concerning new fields of Australian manufacture.

The heavy burden imposed on the Association by these urgent tasks has created difficulties which have been accentuated by two factors. The first of these has been the seconding of the Chief Executive Officer for special duty with the National Standards Laboratory, and the request to the Association to release two experienced technical officers for duty with the Aircraft Production Commission. The second factor has been the inability of the Commonwealth Government to agree to make a supplementary grant to the Association to meet the financial commitments arising from the special war work undertaken. It has, therefore, only been possible to make a limited number of staff appointments to replace the officers who have been transferred, and the work of the Association current at the outbreak of war has of necessity had to be drastically curtailed. Some of this work is of the utmost importance in war-time in order to maintain general industrial efficiency, and as far as the restrictions in staff and finance permit such work is being

* This Association is an independent body which is financially supported by contributions from Governments and industries. The Council for Scientific and Industrial Research acts as the liaison body between the Association and its main contributor—the Commonwealth Government.

proceeded with. The problem of securing adequate financial support for work that is essential to the prosecution of munition manufacture in Australia will, however, have to be met in the coming year.

7. *Biometrical Section.*—The chief functions of the statistical staff are, first, to advise in the planning of experimental work, so that it can be designed to give the greatest efficiency and to supply an unbiased estimate of the experimental errors involved; secondly, to provide satisfactory means of reducing data to summary form; and, thirdly, to test the significance of experimental results, and thus safeguard the experimenter against drawing hasty conclusions that could be disproved if more data were available.

In the Division of Plant Industry, attention has been given to experiments on the control of hoary cress, St. John's wort, skeleton weed, water reed, and galvanized burr; investigations on the treatment and control of pastures have also been considered statistically, both from the point of view of design, and in the analysis of subsequent results. A report has been prepared on the statistical analyses of yellow dwarf counts in tobacco areas grown for experimental purposes by the Victorian Department of Agriculture. These analyses provide some indication of the incidence and spread of the disease. Other matters considered include the effect of *Ophiobolus graminis* on the development of wheat plants, effects of different treatments on needle fusion of pines, the relation of potato yield to seasonal rainfall, the influence of certain virus diseases on the form of potato tubers, and the planning and analysis of flax fibre variety experiments.

Arrangements have been made for the data of the Griffith horticultural survey to be statistically analysed at Canberra. The data will be transferred to Hollerith cards and the necessary sortings and tabulations will be made by the Bureau of Census and Statistics. From the tabulations there will be determined the distributions and mean ratings of health, size, and yield of crops grown on different soils and slopes and subjected to different manurial and cultural treatments. The effects of the 1939 flood will be given particular consideration. It is anticipated that the analysis will establish the differences in resistance of various crops in this area to waterlogging conditions, and the differences between soils in the damage done to trees under such conditions.

Statistical treatment has also been given to researches into the conditions governing grasshopper populations, subterranean clover mites, and trials of various repelling and attracting substances in their effect on blow-fly strike of sheep. Other work has concerned rabbit myxomatosis, mastitis, and parasitism in sheep. Finally, additions have been made to the staff of the Section in order to cope with the large volume of extra work involved in the working of two shifts by the Division of Forest Products in order to expedite its studies on the use of Australian timbers for aircraft.

XIV. INFORMATION SECTION.

1. *General.*—The functions of this Section, which were given in full in a previous report, are, briefly, the preparation of summaries of information for use by the Council or by outside industries; the dissemination of information through trade organizations; the preparation of articles explaining the objects and results of researches; the preparation of press statements; the editing and distribution of the Councils' publications; the preparation and collection of exhibits demonstrating the work of the Council; the provision of secretarial services to Committees of the Council; and the maintenance of the special records necessary for its particular purposes.

In the older more highly industrialized countries of Europe and America, information services, both governmental and private, have been the order of the day for some decades. Advice has lately reached Australia that yet another country—Italy—has now set up a National Centre for Technical Documentation as a branch of the Italian National Research Council (Il Consiglio Nazionale delle Ricerche) and the first of its functions is "to supply researchers, manufacturers, and any one requiring it with documentary material in the fields of engineering and industry". Banks in the United States of America have developed yet another variety of information service; it is designed to advise manufacturers as to the whereabouts of the product, material, machine, or process best suited to the complex needs of present-day production.

2. *Staff.*—The staff of the Section was increased during the year, and now consists of six people with training mainly on the chemical and physics sides; in addition, there is the former library staff of three, one of whom is a graduate on the botanical side.

3. *Requests for Information.*—During the year under review, the Section received such a volume of requests for technical information on the part of industry that it has been forced to concentrate on meeting this demand at the expense of the development of some of its other functions. This want on the part of industry was intensified with the outbreak of war and the consequent upset of supplies. Thus some manufacturers want to know how to produce materials

they can no longer import, others wish to know whether there are any Australian substitutes for materials they formerly brought into the country, and others again desire to have technical information concerning the establishment of an entirely new Australian production. At times much of this information is available from a study of the technical literature ; at other times much of it is known to Universities and other authorities who have at all times been most generous with their assistance.

The services of the Section have not been confined to private industry ; a considerable demand has come from Government Departments and other governmental and semi-governmental organizations. The Department of Supply and Development, for instance, is continually asking the Section for technical information in connexion with its work relating to the allocation of existing supplies of chemicals and to the local production of additional supplies.

During the year some 950 inquiries were dealt with ; an idea of their variety will be obtained from the following selection from them :—

(*a*) *Primary Industries.*—Liquorice, olives, sunflowers, Turkey rhubarb, pyrethrum, wattles (for wattle bark), carob trees, foxgloves (for digitalis), tung tree, ginger, marine fibre, grass-tree resin, ramie, wool scouring, soya beans, water purification, starlings, sericulture, algae in water, apple drying, and pineapple products.

(*b*) *Manufactures.*—Rennet, activated carbon, chrome magnesite bricks, luminous paints, chamois and glove leather, carbon electrodes, potato starch, iron oxide pigments, glycerine, citric acid, charcoal briquettes, egg albumen, abrasives, hydrogen peroxide, dextrose, rolled gold wire, synthetic camphor, vanillin, carbon black, gluten, mica condensers, thymol from eucalyptus oil, photo-electric cells, chlorates, hexachlorethane, furfural, dipicrylamine, acetone, glycol, cetyl alcohol, sodium ethoxide, carbon bisulphide, water resistant glues, lead coating steel, tinning cast iron, spark plug insulation, reclaimed rubber, substitutes for tinplate.

(*c*) *Industrial Minerals and Chemicals.*—Talc, osmiridium, tungsten ores, mica, tellurium, asbestos, tantalite, aluminium and iron phosphates, vermiculite, rutile, strontium and lithium salts, soda lime, potassium sulphate, metallic powders, Bayer process for alumina, anhydrous sodium sulphide, aluminium ore, magnesium trisilicate, sodium silicate, and hafnium.

(*d*) *Miscellaneous.*—Prevention of rancidity in fats, drying by infra-red radiation, reclaiming lubricating oil, dustproofing concrete floors, waterproofing canvas, leather, paper, green efflorescence of bricks, preservation of hessian, jute substitutes, micro-analytical methods for silver, wood distillation, carpet beetles, evaporation of water from dams, and dugong oil.

4. *Library.*—The Council's library taken as a whole is perhaps one of the most extensive scientific libraries in the Commonwealth. That portion of it maintained at the Council's Head Office serves as the main working tool of the Information Section and specializes particularly in the subjects of chemical technology, metallurgy, textiles, and other matters pertaining to the secondary industries. As in most libraries designed entirely for the technical and scientific reader, far more importance is placed on the collection of journals, periodicals, and occasional publications of research laboratories and Government Departments than on text books. Special attention is also given to the collection of indexing journals and bibliographies so that references on any matter that arises may be rapidly obtained. During the year, the resources of the library were considerably augmented by the addition of a number of periodicals, many of which were not previously available in Australia. The preparation of a catalogue of the technical journals held in the various private libraries of the Commonwealth was also undertaken. The various manufacturers owning these libraries afforded most helpful co-operation in this matter and freely gave details of their journals. The catalogue is maintained in card form at the Council's Head Office and is proving a useful adjunct to the Catalogue of Scientific Periodicals in the Public Libraries of Australia which was published some years ago, in indicating the whereabouts of any particular journal desired for consultation.

5. *Photographic Copying.*—The Section is experiencing an ever-growing demand for photographic copies of journal articles. Such copies are of particular value to technologists in a country like Australia where workers are often isolated and where access to some of the journals they desire to see is often difficult if not impossible. University and other investigators located in the less populous States are making a considerable use of these copies.

XV. FINANCIAL MATTERS, STAFF, AND PUBLICATIONS.

1. *Finance.*—The statement of expenditure from 1st July, 1939, to 30th June, 1940, is as follows :—

	£	£	£
(1) Salaries and contingencies	..	..	24,681*
(2) Remuneration of Chairman and Members of Council ..	..	..	2,379†
(3) Investigations—			
(i) Animal Problems—			
(*a*) Sheep diseases : foot-rot, black disease, preputial disease, caseous lymphadenitis, entero-toxaemia, pregnancy disease and equine navel ill (at Animal Health Laboratory, Parkville, Victoria) ..	..	6,355	
(*b*) Mastitis (Victoria)	4,471		
Less contribution from Australian Cattle Research Association and part Berwick Farm Revenue ..	4,471		
		..	
(*c*) Rabbit myxomatosis (at Animal Health Laboratory, Parkville, Victoria, and Wardang Island, South Australia) ..	..	437	
(*d*) Tick and tick fevers, pleuro-pneumonia, &c., (at Animal Health Laboratory, Parkville, Victoria, and Field Stations at Tooradin, Koo-Wee-Rup, Victoria, and Helenslee, Queensland)	5,943		
Less contributions from Queensland Government, part proceeds from sale of vaccine, and C.P.P. Revenue Fund	2,129		
		3,814	
(*e*) Haematuria (Victoria and South Australia)..	..	278	
(*f*) Toxaemic jaundice (at Animal Health Laboratory, Parkville, Victoria, and Field Station, Barooga, New South Wales) ..	1,362		
Less contributions from Toxaemic Jaundice Revenue Fund, Australian Wool Board and Australian Meat Board	1,262		
		100	
(*g*) Parasitology (at McMaster Laboratory, University of Sydney)	10,573		
Less contributions from George Aitken Pastoral Research Trust, University of Sydney, and Australian Wool Board..	1,685		
		8,888	
(*h*) Bacteriology (at McMaster Laboratory, University of Sydney)	2,267		
Less contributions from University of Sydney, George Aitken Pastoral Research Trust, and Australian Wool Board	570		
		1,697	
(*i*) Biochemical problems (at McMaster Laboratory, University of Sydney) ..	1,604		
Less contributions from Australian Wool Board..	840		
		764	

* 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*) Parasitology and genetics (at F. D. McMaster Field Station, St. Mary's, New South Wales	4,693		
Less contributions from Australian Wool Board, University of Sydney, and Infertility Revenue Fund ..	891		
		3,802	
(*k*) External parasites (at McMaster Laboratory, University of Sydney)	545		
Less contributions from Australian Wool Board..	389		
		156	
(*l*) Wool research (at McMaster Laboratory, University of Sydney)	1,524		
(*m*) Wool biology (at McMaster Laboratory, University of Sydney)	1,098		
Less contributions from Australian Wool Board..	1,098		
		..	
(*n*) National Field Station "Gilruth Plains", Cunnamulla, Queensland	4,228		
Less contributions by Australian Wool Board, Commonwealth Bank, George Aitken Pastoral Research Trust, and Station Revenue Account	4,228		
		..	
(*o*) Entero-toxaemia (braxy-like disease), Moora (Gingin) disease, ataxia in lambs, &c. (Western Australia)	..	475	
(*p*) Biochemical and Agrostological Studies (at Animal Nutrition Laboratory, Adelaide, and Field Stations, Robe, South Australia, and Wambanumba, New South Wales)..	12,279		
Less contributions from George Aitken Pastoral Research Trust and Nutrition Revenue Account ..	704		
		11,575	
(*q*) Feeding Experiments (at Waite Agricultural Research Institute, Glen Osmond, South Australia)	1,346		
Less contributions from George Aitken Pastoral Research Trust ..	100		
		1,246	
(*r*) Field Experiments on Mineral Supplements (at Field Stations, Wambanumba, New South Wales; Penola, South Australia; and Robe, South Australia)	1,394		
Less contributions from George Aitken Pastoral Research Trust ..	300		
		1,094	
(*s*) Drought feeding (at Animal Nutrition Laboratory, Adelaide)	1,297		
Less contributions from Australian Wool Board..	1,297		
(*t*) Nutrition and Wool Production (at Animal Nutrition Laboratory, Adelaide) ..	1,194		
Less contributions from Australian Wool Board..	1,194		

	£	£	£
(3) Investigations—*continued.*			
(i) Animal Problems—*continued.*			
(*u*) Suspense account		67	
(*v*) Central Office		4,189	
		46,461	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..		9,000	
			37,461
(ii) Plant Problems—Division of Plant Industry—			
(*a*) Central Laboratory—			
Annual	5,602		
Capital	435		
		6,037	
(*b*) Experimental plots		554	
(*c*) Plant pathology		3,900	
(*d*) Plant genetics		5,172	
(*e*) Herbarium		298	
(*f*) Fibre investigations		127	
(*g*) Experimental Farm, Duntroon		1,473	
(*h*) Plant introduction		3,791	
(*i*) Apple rootstocks, Stanthorpe, Queensland ..		1,054	
(*j*) Agrostology	7,782		
Less contributions from Australian Wool Board..	2,208		
		5,574	
(*k*) Fruit problems	3,267		
Less contributions from Victorian Central Citrus Association	100		
		3,167	
(*l*) Tobacco investigations	4,465		
Less contributions from Tobacco Trust Fund	4,465		
		..	
(*m*) Water weeds and hoary cress, Victoria ..	513		
Less contributions from New South Wales Conservation and Irrigation Commission, and Victorian State Rivers and Water Supply Commission	513		
(*n*) Suspense account		10	
			31,157
(iii) Entomological Problems—Division of Economic Entomology—			
(*a*) Central Laboratory—			
Annual	4,217		
Capital	345		
		4,562	
(*b*) Agricultural entomology and museum		1,788	
(*c*) Agricultural entomology (orchard and fruit pests)		108	
(*d*) Agricultural entomology (grasshopper investigations)		2,338	
(*e*) Agricultural entomology (red-legged earth mite)		446	
(*f*) Forest entomology		2,950	
(*g*) Noxious weeds		4,554	
(*h*) Insecticide investigations		346	
(*i*) Wheat infestation		65	

(3) Investigations—*continued.*	£	£	£
(iii) Entomological Problems—Division of Economic Entomology—*continued,*			
(*j*) Veterinary entomology	4,423		
Less contributions from George Aitken Pastoral Research Trust, Australian Wool Board, and Economic Entomology Revenue Account ..	179		
		4,244	
(*k*) Oriental peach moth	888		
Less contributions from Department of Agriculture, Victoria	888		
		..	
(*l*) Constant temperature chambers ..	30		
Less contributions from Sir MacPherson Robertson	30		
		..	
(*m*) Cotton investigations	382		
Less contributions from Ministry of Agriculture, Egypt	382		
		..	
(*n*) Suspense Account		544	
			21,945
(iv) Horticultural Problems of the Irrigation Settlements—			
Citricultural—			
(*a*) Research Station, Griffith—			
Salaries and incidentals	8,079		
Capital	4,578		
	12,657		
Less funds provided from Station Revenue	6,114		
	6,543		
Less contributions by New South Wales Water Conservation and Irrigation Commission ..	1,500		
		5,043	
Viticultural—			
(*b*) Research Station, Merbein—			
Salaries and incidentals	6,868		
Capital	558		
	7,426		
Less funds provided from Station Revenue	936		
	6,490		
Less contributions by Dried Fruits Control Board and Nyah-Woorinen Dried Fruits Enquiry Committee	1,560		
		4,930	
(*c*) Ripening, processing, &c. of vine fruits, Mildura District	902		
Less contributions by Irymple Packing Pty. Ltd., Mildura Co-op. Fruit Co., Red Cliffs Co-op. Fruit Co. Ltd., and Aurora Packing Pty. Ltd.	902		
		..	
			9,973

(3) Investigations—*continued.*	£	£	£
(v) Soil Problems—			
(*a*) Investigations at Waite Agricultural Research Institute, Glen Osmond, South Australia—			
Annual	10,895		
Capital	162		
		11,057	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	2,500		
		8,557	
(vi) Food Preservation and Transport—			
(*a*) Central Laboratory, Homebush, New South Wales—			
Annual	3,527		
Capital	198		
		3,725	
(*b*) Meat investigations, Homebush, New South Wales	1,050		
Less contributions by Australian Meat Board and Metropolitan Meat Industry Commissioner, New South Wales	1,048		
		2	
(*c*) Fish investigations, Homebush, New South Wales	1,981		
(*d*) Non-tropical fruits, Homebush, New South Wales	1,696		
Less contributions from New South Wales Department of Agriculture	1,000		
		696	
(*e*) Physics and Transport, Homebush, New South Wales	..	1,533	
(*f*) Citrus preservation	..	1,570	
(*g*) Meat investigations, Brisbane Abattoir ..	992		
Less contributions by Queensland Meat Industry Board	850		
		142	
(*h*) Egg investigations	1,032		
Less contributions from Egg Producers' Council	516		
		516	
(*i*) Non-tropical fruits, Melbourne	..	797	
(*j*) Fruit juice investigations, Homebush, New South Wales	2,656		
Less contributions from various contributors	24		
		2,632	
(*k*) Adviser on Food Preservation	..	182	
(*l*) Suspense Account	..	46	
		13,822	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	..	2,000	
			11,822

(3) Investigations—*continued.*	£	£	£
(vii) Forest Products—			
(*a*) Central Laboratory—			
Annual	10,466		
Capital	1,433		
		11,899	
(*b*) Seasoning	..	2,280	
(*c*) Preservation	..	1,444	
(*d*) Chemistry	2,640		
Less contributions from Australian Paper Manufacturers Limited, Associated Pulp and Paper Mills Ltd., and Australian Newsprint Mills Pty. Ltd.	1,500		
		1,140	
(*e*) Creosote investigations	356		
Less contributions from Tar Distillery Industry	356		
		..	
(*f*) Plant for Veneer laboratory	1,250		
Less contributions by Mr. Russell Grimwade	1,250		
		..	
(*g*) Aircraft timber investigations	2,589		
Less various contributions	80		
		2,509	
(*h*) Preservation of railway sleepers	17		
Less contribution by South Australian Railways	17		
		..	
(*i*) Wood structure	2,841		
Less contributions from Bureau of Forestry, Canberra, and Queensland, New South Wales, Victorian and Western Australian Forests Services	125		
		2,716	
(*j*) Mechanics	..	2,499	
(*k*) Utilization	..	1,909	
(*l*) Physics	..	1,067	
(*m*) Fibres..	..	974	
(*n*) Statistics and computing	..	185	
(*o*) Holocellulose investigations	..	179	
(*p*) Veneer and gluing	1,877		
Less various contributions	392		
		1,485	
(*q*) Suspense Account	..	177	
		30,463	
Less miscellaneous contributions ..	..	473	
		29,990	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..	..	1,500	
			28,490
(viii) Mining and Metallurgy—			
(*a*) Mineragraphic investigations	..	798	
Less contribution by Australasian Institute of Mining and Metallurgy	..	184	
			614

(3) Investigations—*continued.*	£	£	£
(ix) Radio Research—			
(*a*) Melbourne and Sydney Universities ..	4,991		
Less contributions by Postmaster-General's Department	3,724		
		1,267	
(*b*) Advisers on radio research	..	96	
		1,363	
(x) Information Service including Library	..	..	4,141
(xi) Gold Mining—			
(*a*) Mineragraphic investigations, Melbourne University	..	810	
(*b*) Ore-dressing, Melbourne University ..	..	1,275	
(*c*) Ore-dressing, South Australian School of Mines	..	860	
(*d*) Ore-dressing, Kalgoorlie School of Mines ..	..	178	
(*e*) Advisory Committee	..	206	
			3,329
(xii) Fisheries Investigations—			
(*a*) Administrative—			
Annual	5,008		
Capital	340		
		5,348	
(*b*) Marine biology	..	3,361	
(*c*) Marine bacteriology	..	658	
(*d*) Chemistry (including fish and by-product analyses) and hydrology	..	527	
(*e*) Investigations at sea	..	6,846	
(*f*) Fish liver oils investigations	..	65	
			16,805
(xiii) Apple and Pear Investigations—			
(*a*) Grants to States	..	4,521	
(*b*) Codling Moth	..	193	
(*c*) Experimental consignments of pears ..	..	107	
(*d*) Shipboard survey of brown-heart problem ..	..	*Cr.* 5	
		4,816	
Less contributions from Department of Commerce	..	4,816	
			..
(xiv) Aeronautical Research—			
(*a*) Administrative—			
Annual	3,884		
Capital	4,751		
		8,635	
(*b*) Wind tunnel investigations	..	760	
(*c*) Aircraft timber investigations	..	703	
(*d*) Structure and materials	..	622	
(*e*) Engine and fuels	..	266	
(*f*) Aerodynamics	..	193	
(*g*) Suspense Account	..	74	
			11,253
(xv) National Standards Laboratory—			
(*a*) Administrative—			
Annual	1,733		
Capital	379		
		2,112	
(*b*) Physics	..	1,670	
(*c*) Electrical	..	1,395	
(*d*) Metrology	..	2,010	
(*e*) Suspense Account	..	218	
(*f*) Testing Co-ordination	..	84	
			7,489

(3) Investigations—*continued.*	£	£	£
(xvi) Secondary Industry Research	..	..	3,291
(xvii) Training of Students—Secondary Industry Research	..	..	1,521
(xviii) Miscellaneous—			
(*a*) Producer Gas	..	513	
(*b*) Tomato Wilt	..	87	
(*c*) Mineral Deficiency in Pastures	..	926	
(*d*) Dairy Research	..	1,574	
(*e*) Statistical Section	..	1,232	
(*f*) Co-operative Primary Industry Research in Western Australia	..	75	
(*g*) Lubricants and Bearings	1,541		
Less contribution from University of Melbourne	234		
		1,307	
(*h*) Evaporation from Ponds	100		
Less contribution from Australian Wool Board..	100		
(*i*) Various	..	1,297	
			7,011
Total of Item 3—Investigations ..	..	..	206,222

2. *Contributions.*—The following statement shows the receipts and disbursements during the year 1939–40 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled " The Specific Purposes Trust Account " :—

	Receipts 1939–40 and balances brought forward from 1938–39.		Expenditure 1939–40.
	£		£
Commonwealth Bank (Animal Health and Nutrition, Horticultural, Food Preservation and Transport, Prickly Pear, and Forest Products Investigations)	16,300	..	15,500
Commonwealth Bank (Bee Investigations)	92	..	..
Postmaster-General's Department (Radio Research) ..	3,998	..	3,724
George Aitken Pastoral Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,000	..	2,000
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	1,500	..	1,500
New South Wales Water Conservation and Irrigation Commission (Cumbungi Investigations)	324	..	257
Victorian State Rivers and Water Supply Commission (Cumbungi Investigations)	349	..	257
Queensland Government (Animal Health Investigations—Cattle Research)	1,000	..	1,000
Australian Wool Board (Animal Health and Nutrition Investigations—Sheep Research)	9,645	..	9,163
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	184	..	184
Dried Fruits Control Board (Dried Fruits Investigations)	1,500	..	1,500
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)..	60	..	60
Australian Dairy Council (Wood Taint in Butter Investigations)	20	..	..
Queensland Meat Industry Board (Meat Investigations)	858	..	*858
Carried forward	37,830	..	36,003

* Includes £8 on account 1938–39 expenditure.

	Receipts 1939–40 and balances brought forward from 1938–39.	Expenditure 1939–40.
	£	£
Brought forward	37,830 ..	36,003
Sir MacPherson Robertson (Entomological Investigations)	30 ..	30
Ministry of Agriculture, Egypt—Cotton Investigations (Entomological Investigations)	523 ..	382
University of Sydney (Animal Health and Nutrition Investigations)	755 ..	755
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Nutrition Investigations) ..	95 ..	45
Revenue Fund—Mining and Metallurgy	3 ..	..
Revenue Fund—Contagious Pleuro-pneumonia Investigations (Animal Health and Nutrition Investigations)	344 ..	176
Revenue Fund—Oonoonba Research Station—Sale of Vaccine (Animal Health and Nutrition Investigations)	2,336 ..	953
Revenue Fund—Parkville Laboratory (Animal Health and Nutrition Investigations)	79 ..	..
Revenue Fund—Berwick Farm (Mastitis Investigations)	1,298 ..	1,298
Revenue Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations)	5,628 ..	3,273
Revenue Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations)	250 ..	..
Revenue Fund—Bacteriological Investigations (Animal Health and Nutrition Investigations)	23 ..	..
Revenue Fund—Parasitological Investigations (Animal Health and Nutrition Investigations)	59 ..	..
Revenue Fund—F. D. McMaster Field Station (Animal Health and Nutrition Investigations)	874 ..	395
Revenue Fund—Nutrition Laboratory (Animal Health and Nutrition Investigations)	425 ..	204
Revenue Fund—Toxaemic Jaundice Investigations, Barooga, New South Wales (Animal Health and Nutrition Investigations)	12 ..	1
Revenue Fund—Plant Industry Investigations ..	24 ..	..
Revenue Fund—Entomological Investigations ..	228 ..	100
Revenue Fund—Griffith Research Station (Citricultural Investigations)	7,446 ..	6,115
Revenue Fund—Merbein Research Station (Viticultural Investigations)	4,220 ..	936
Revenue Fund—Citrus Preservation Investigations ..	293 ..	..
Revenue Fund—Division of Food Preservation and Transport	42 ..	..
Revenue Fund—Egg Investigations, Egg Producers' Council (Division of Food Preservation and Transport)	20 ..	..
Revenue Fund—Ore-dressing Investigations.. ..	432 ..	..
Tobacco Trust Fund—Prime Minister's Department (Tobacco Investigations)	10,824 ..	4,464
New South Wales Department of Agriculture (Food Investigations)	1,000 ..	1,000
Australian Meat Board (Meat Investigations).. ..	524 ..	524
Australian Meat Board (Toxaemic Jaundice Investigations, Barooga, New South Wales)	626 ..	608
Metropolitan Meat Industry Commissioner of New South Wales (Food Investigations)	524 ..	524
Carried forward	76,767 ..	57,786

	Receipts 1939–40 and balances brought forward from 1938–39.	Expenditure 1939–40.
	£	£
Brought forward	76,767 ..	57,786
Department of Commerce (Apple and Pear Investigations)	5,368 ..	4,816
Mildura Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	228 ..	*226
Irymple Packing Company (Dried Vine Fruits Investigations, Merbein)	228 ..	226
Red Cliffs Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	228 ..	226
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	228 ..	226
Swallow & Ariell Limited (Dried Vine Fruits Investigations, Merbein)	1 ..	1
Aden Packing Company (Dried Vine Fruits Investigations, Merbein)	1 ..	1
Australian Dairy Cattle Research Association (Mastitis Investigations)	4,350 ..	†3,961
Department of Agriculture, Victoria (Oriental Peach Moth Investigations)	888 ..	888
Australian Paper Manufacturers Limited (Paper Pulp Investigations)	500 ..	500
Associated Pulp and Paper Mills Limited (Paper Pulp Investigations)	500 ..	500
Australian Newsprint Mills Pty. Ltd. (Paper Pulp Investigations)	500 ..	500
Russell Grimwade, Esq. (Forest Products Investigations)	1,250 ..	1,250
Bureau of Forestry, Canberra, and Forest Services of Queensland, Victoria, New South Wales, and Western Australia—Wood Structure (Forest Products Investigations)	125 ..	125
South Australian Railways (Treatment of Railway Sleepers)	17 ..	17
Tar Distillers Research Committee (Creosote Investigations)—Division of Forest Products	366 ..	356
Sundry Contributors (Forest Products Investigations)	1,485 ..	473
Forests Department, Western Australia—Division of Forest Products—Design Data Text Book ..	50 ..	50
Timber Development Association of Victoria—Division of Forest Products	100 ..	100
Western Australian Sawmillers' Association (Division of Forest Products—Design Data Text Book) ..	50 ..	50
Sydney and Suburban Timber Merchants' Association (Division of Forest Products—Design Data Text Book)	50 ..	50
Tasmanian Timber Organization Pty. Ltd. (Division of Forest Products—Design Data Text Book) ..	50 ..	50
Institution of Engineers, Australia (Division of Forest Products—Design Data Text Book)	50 ..	50
Plywood and Veneer Board (Queensland) (Division of Forest Products—Design Data Text Book) ..	50 ..	50
Land Administration Board, Queensland (Division of Forest Products—Design Data Text Book). ..	50 ..	50
Associated Country Sawmillers of New South Wales (Division of Forest Products—Design Data Text Book)	50 ..	50
Carried forward	93,530 ..	72,578

* Includes £6 on account of 1938–39 expenditure.
† Includes £788 on account of 1938–39 expenditure.

	Receipts 1939–40 and balances brought forward from 1938–39.	Expenditure 1939–40.
	£	£
Brought forward	93,530 ..	72,578
Queensland Timber Export Association (Division of Forest Products—Design Data Text Book) ..	25 ..	25
Brisbane Timber Merchants' Association (Division of Forest Products—Design Data Text Book) ..	25 ..	25
Queensland Timber Stabilization Board (Division of Forest Products—Design Data Text Book) ..	25 ..	25
Timber Development Association of South Australia (Division of Forest Products—Design Data Text Book)	25 ..	25
Murie & Co. Ltd. (Division of Forest Products—Design Data Text Book)	5 ..	5
Davie Bros., Tasmania (Division of Forest Products—Aircraft Timber Research)	14 ..	14
Brisbane Timber Merchants' Association (Division of Forest Products—Aircraft Timber Research) ..	50 ..	50
Britton Bros., Tasmania (Division of Forest Products—Aircraft Timber Research)	5 ..	5
K. D. Atkins Pty. Ltd. (Division of Forest Products—Aircraft Timber Research)	12 ..	12
Hardy's Pty. Ltd. (Division of Forest Products—Veneer and Gluing Work)	41 ..	30
Queensland Timber Export Association (Division of Forest Products—Veneer and Gluing Work) ..	50 ..	50
Plywood and Veneer Board, Queensland (Division of Forest Products—Veneer and Gluing Work) ..	250 ..	250
Ricketts & Thorp Ltd. (Division of Forest Products—Veneer and Gluing Work)	20 ..	20
G. L. Briggs & Son (Division of Forest Products—Veneer and Gluing Work)	5 ..	5
Veneer and Plywood Pty. Ltd. (Division of Forest Products—Veneer and Gluing Work)	10 ..	10
Plywood Manufacturing Co. Pty. Ltd. (Division of Forest Products—Veneer and Gluing Work) ..	11 ..	11
Beale & Co. Ltd. (Division of Forest Products—Veneer and Gluing Work)	5 ..	5
Brisbane Timber Merchants' Association (Division of Forest Products—Veneer and Gluing Work) ..	25 ..	11
O.T. Limited (Division of Food Preservation and Transport—Fruit Juice Investigations)	10 ..	10
Leeton Co-op. Cannery Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations) ..	25 ..	14
Batlow Packing House Co-op. Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations)	20 ..	..
Lewis Berger & Sons Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations) ..	25 ..	..
Egg Producers' Council (Division of Food Preservation and Transport—Egg Investigations)	752 ..	516
Egg Producers' Council (Watery Whites in Eggs) ..	2 ..	..
Sundry Contributors (Council for Scientific and Industrial Research Publications)	6 ..	..
Friction Research (University of Melbourne) ..	234 ..	234
Victorian Central Citrus Association (Citrus Problems) ..	100 ..	100
Amalgamated Textiles (Aust.) Ltd. (Division of Industrial Chemistry)	35 ..	..
	95,342 ..	74,030

3. *Staff.*—The following is a list of the staff of the Council as at the 30th June, 1940. The list does not include typists, laboratory assistants, and miscellaneous workers.

1. Head Office Staff.

Chief Executive Officer—Sir David Rivett, K.C.M.G., M.A., D.Sc., F.A.C.I.
Deputy Chief Executive Officer—A. E. V. Richardson, C.M.G., M.A., D.Sc.
Secretary—G. Lightfoot, M.A.
Assistant Secretary and Officer-in-Charge, Information Section—G. A. Cook, M.Sc. B.M.E., F.A.C.I.
Assistant Secretary (Finance and Supplies)—H. P. Breen, A.I.C.A.

Information Section—

J. E. Cummins, B.Sc., M.S., F.A.C.I.
F. G. Nicholls, M.Sc.
G. H. Payne, B.Sc., A.A.C.I.
N. C. Hancox, M.Sc., A.A.C.I.
Miss M. E. Hamilton, B.Sc.

Library—

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

Accounts, Stores—

Accountant—M. G. Grace, A.I.C.A.
D. J. Bryant.
R. W. Viney, A.I.C.A.
M. A. Elliott.
V. Leonard.
A. Patterson, A.F.I.A.
C. Munro.
J. Farey.
F. J. Whitty.
R. Bennett.
J. Bourne.
C. Garrow.
C. Cole.
K. Gamble.
J. Smithwick.

Orders and Transport—

J. M. Derum.
L. Graham.

Staff—

R. D. Elder.

Records—

P. Domec-Carre.
P. Knuckey.
R. McVilly, A.F.I.A.
F. Butler.
B. Gooley.
B. Gaynor.
M. Combe.
M. Reynolds.
D. Yarr.

Head Typist—

Miss B. Thomas.

Clerical Assistant to Chief Executive Officer—Miss A. Slattery, B.A.
Clerical Assistant to Chairman—Mrs. N. E. Roberts.
Clerical Assistant to Deputy Chief Executive Officer—Miss J. L. Thomas.
Clerk-in-Charge, Canberra—K. J. Prowse (acting).
Clerk, Division of Animal Health and Nutrition Head-quarters, Melbourne—J. Foley.
Local Clerical Officer, Sydney—H. H. Wilson.
Architect—W. R. Ferguson, B.E., A.R.A.I.A.

2. Secretaries of State Committees.

New South Wales—
Mrs. N. E. Roberts, 906 Culwulla Chambers, Castlereagh-street, Sydney.

Victoria—
G. A. Cook, M.Sc., B.M.E., F.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—
R. P. Roberts, B.Sc., Institute of Agriculture, University of Western Australia, Nedlands, Western Australia.

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 E. Mollison.

Pathology—
Senior Research Officer—H. R. Angell, O.B.E., B.Sc.Agr., M.S., Ph.D.
Research Officer—J. G. Bald, M.Agr.Sc., Ph.D.
Research Officer—W. V. Ludbrook, B.Agr.Sc., Ph.D.
Assistant Research Officer—N. H. White, M.Sc.
Assistant Research Officer—D. O. Norris, B.Sc.Agr.

Genetics—
Senior Research Officer—J. R. A. McMillan, D.Sc.Agr., M.S.
Assistant Research Officer—F. W. Hely, B.Sc.Agr.
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.Ed.

Horticultural and General Botany—
Senior Research Officer—C. Barnard, D.Sc.

Weeds Investigations—
Assistant Research Officer—C. G. Greenham, M.Sc.
Assistant Research Officer—T. Wilkinson, B.Sc.

Vegetable Fibre Investigations—
Assistant Research Officer—J. Calvert, D.Sc., F.L.S.

Agrostology—
Senior Research Officer—J. G. Davies, B.Sc., Ph.D.
Assistant Research Officer—R. Roe, B.Sc.Agr.
Assistant Research Officer—R. M. Moore, B.Sc.Agr.
Assistant Research Officer—N. Shaw, B.Sc.Agr.
Technical Officer—E. H. Kipps, B.Sc.

Tobacco Investigations—
Research Officer (pathology)—A. V. Hill, M.Agr.Sc.
Technical Officer (quality)—G. H. Marks.
Assistant Research Officer (pathology)—K. F. Plomley, B.Sc.Agr.
Technical Officer (genetics)—E. T. Bailey, B.Sc.

At University of Sydney—
Assistant Research Officer (chemistry and tobacco)—A. J. Tow, M.Sc.
Technical Officer (chemistry of tobacco)—Miss H. Moore, B.Sc.

At Waite Agricultural Research Institute—
Technical Officer in plant physiology (tobacco)—Miss J. McPherson, B.Sc.
Assistant in plant physiology (tobacco)—Miss M. Hogg.

At Moss Vale, New South Wales—
Assistant Research Officer (genetics)—K. L. Hills, B.Agr.Sc.

At Griffith, New South Wales—
Assistant Research Officer (horticultural physiology)—Miss J. Hearman, B.Sc., Ph.D.

At Queensland Agricultural High School and College, Lawes—
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)—W. M. Willoughby, 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 Melbourne—
Assistant Research Officer (weeds investigations)—R. W. Prunster, B.Sc. (Agric.).

At University of Tasmania, Hobart—
Assistant Research Officer (fruit investigations)—D. Martin, B.Sc.

At University of Western Australia, Perth—
Research Officer (agrostology)—A. B. Cashmore, M.Sc.
Assistant Research Officer (agrostology)—R. C. Rossiter, B.Sc.Agr.

5. Division of Economic Entomology.

At Canberra—

Administration—
Chief—A. J. Nicholson, D.Sc.
Librarian (half-time)—Miss E. Mollison.

Veterinary Entomology—
Principal Research Officer—I. M. Mackerras, B.Sc., M.B., Ch.M. (on military leave abroad).
Assistant Research Officer (blowfly investigations)—Mrs. M. J. Mackerras, M.Sc., M.B. (on leave).
Assistant Research Officer (blowfly investigations)—D. F. Waterhouse, M.Sc.
Assistant Research Officer (biochemist)—F. G. Lennox, M.Sc., A.I.C., A.A.C.I.
Technical Officer—D. L. Hall, Dip.Ag.

Forest Entomology—
Senior Research Officer—G. F. Hill.
Research Officer (termite investigations)—F. N. Ratcliffe, B.A.
Assistant Research Officer (termite investigations)—F. J. Gay, B.Sc., D.I.C.
Technical Officer (termite investigations)—T. Greaves.

Insecticide Investigations—
Assistant Research Officer—J. S. Fitzgerald, M.Sc., D.I.C., Ph.D.

Agricultural Entomology and Museum—
Assistant Research Officer—T. G. Campbell.
Assistant Research Officer (locust investigations)—K. H. L. Key, M.Sc., Ph.D., D.I.C.
Technical Officer (locust investigations)—D. A. C. Cameron, B.Sc.Agr.

At Warren, New South Wales—
Assistant Research Officer (locust investigations)—L. R. Clark, M.Sc.

At Mooroopna, Victoria—
Assistant Research Officer (peach moth investigations)—G. A. H. Helson, M.Sc.

At Katanning, Western Australia—
Assistant Research Officer (earth mite investigations)—K. R. Norris, M.Sc.

Weeds Investigations—

In India—
Research Officer—R. C. Mundell, B.Sc.

At Uvalde, Texas, United States of America—
Senior Research Officer—L. F. Hitchcock, M.Sc.
Assistant Research Officer—S. G. Kelly, M.S. (Agr.).

Abroad (formerly at Le Lavandou, France)—
Assistant Research Officer—F. Wilson.

6. Division of Animal Health and Nutrition.

At Animal Health Research Laboratory, Melbourne—
Chief—L. B. Bull, D.V.Sc.
Divisional Secretary—A. J. Vasey, B.Agr.Sc.
Chief Bacteriologist and Officer-in-charge—A. W. Turner, D.Sc., D.V.Sc.
Senior Research Officer (mastitis investigations)—D. Murnane, B.V.Sc.
Senior Research Officer (myxomatosis, bovine haematuria, caseous lymphadenitis)—C. G. Dickinson, B.V.Sc.
Senior Research Officer (pleuro-pneumonia, serological investigations)—A. D. Campbell, B.V.Sc.
Research Officer (immuno-chemistry)—A. T. Dann, M.Sc., A.A.C.I.
Assistant Research Officer (bacteriology, mastitis)—E. Munch-Petersen, M.Sc., Ph.B., M.I.F.
Assistant Research Officer (pleuro-pneumonia, toxaemic jaundice)—A. T. Dick, M.Sc.
Technical Officer—Miss C. E. Eales, B.Sc.
Technical Officer—Miss M. J. Monsborough, B.Sc.
Technical Officer—E. Wold.
Librarian—Miss B. H. Anderson, B.Sc. (part-time).

At F. D. McMaster Animal Health Laboratory, Sydney—
Officer-in-charge—D. A. Gill, M.R.C.V.S., D.V.S.M.
Principal Research Officer (bacteriology)—T. S. Gregory, B.V.Sc.
Senior Research Officer (parasitology)—H. McL. Gordon, B.V.Sc.
Senior Research Officer (biochemistry)—M. C. Franklin, M.Sc., Ph.D. (Cantab.), A.I.C.
Research Officer (parasitology)—G. Kauzal, D.V.Sc.
Research officer (bacteriology, foot-rot)—W. I. B. Beveridge, B.V.Sc.
Research Officer (field investigations, ectoparasites)—N. P. H. Graham, B.V.Sc.
Research Officer (chemistry of wool)—M. R. Freney, B.Sc.
Research Officer (wool biology)—H. B. Carter, B.V.Sc.
Assistant Research Officer (parasitology, field studies)—I. W. Montgomery B.V.Sc. (on military leave).
Assistant Research Officer (chemistry of dips)—A. R. M. Lipson, B.Sc.
Assistant Research Officer (parasitology)—L. K. Whitten, B.V.Sc.
Assistant Research Officer (physical testing of wool)—E. H. Mercer, B.Sc.
Assistant Research Officer (statistics)—Miss H. Newton Turner, B.Arch.
Technical Officer—E. Parrish.

At Animal Nutrition Laboratory, Adelaide—
Chief Nutrition Officer and Officer-in-Charge—H. R. Marston, F.A.C.I.
Secretary—J. Ward Walters.
Senior Research Officer (metabolism)—E. W. L. Lines, B.Sc.
Research Officer (chemistry)—R. G. Thomas, B.Sc.
Assistant Research Officer (ruminant physiology)—R. H. Watson, B.Sc.Agr.
Assistant Research Officer (biochemistry)—J. W. H. Lugg, D.Sc., F.I.C., A.A.C.I.
Assistant Research Officer (biochemistry)—S. T. Evans, B.Sc., A.A.C.I.
Assistant Research Officer (agrostology)—D. S. Riceman, B.Agr.Sc.
Assistant Research Officer (metabolism)—H. J. Lee, B.Sc.
Assistant Research Officer (biochemistry)—Frau Ella Flaum, D.Sc.Agric. (Budapest).
Technical Officer—J. D. O. Wilson.
Technical Officer—F. C. Farr.
Statistical Recorder—G. W. Bussell.

At Waite Agricultural Research Institute, Adelaide—
Assistant Research Officer (mineral requirements and field investigations)—A. W. Peirce, B.Sc., A.A.C.I.

At F. D. McMaster Field Station, Badgery's Creek, New South Wales—
Principal Research Officer and Officer-in-charge (animal genetics)—R. B. Kelley, D.V.Sc.
Assistant Research Officer (field investigations)—H. E. B. Shaw, B.V.Sc.
Technical Officer—C. R. Graham.

At National Field Station, "Gilruth Plains", Cunnamulla, Queensland—
Research Officer-in-charge—J. H. Riches, B.Sc.Agr., Ph.D.
Station Manager—M. G. Murdoch.

7. 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.

8. Division of Soils.

At Waite Agricultural Research Institute—
Chief—J. A. Prescott, D.Sc., A.A.C.I. (part-time).
Senior Research Officer (soil surveys)—J. K. Taylor, M.Sc., B.A.
Research Officer (soil surveys)—T. J. Marshall, M.Agr.Sc.
Research Officer (soil surveys)—C. G. Stephens, M.Sc., A.A.C.I.
Research Officer (soil chemistry)—J. S. Hosking, M.Sc., A.I.C., A.A.C.I.
Assistant Research Officer (soil chemistry)—A. Walkley, B.A., B.Sc., Ph.D. A.A.C.I.
Assistant Research Officer (spectrography)—A. C. Oertel, M.Sc.
Assistant Research Officer (microbiology)—T. H. Strong, B.Agr.Sc.
Assistant Research Officer (soil surveys)—J. G. Baldwin, B.Agr.Sc.
Assistant Research Officer (soil surveys)—G. D. Hubble, B.Agr.Sc. (seconded to the Queensland Department of Agriculture and Stock).
Assistant Research Officer (soil surveys and ecology)—R. L. Crocker, B.Sc.
Assistant Research Officer (soil surveys)—B. E. Butler, B.Agr.Sc.
Assistant Research Officer (soil surveys)—R. Smith, B.Agr.Sc.
Assistant Research Officer (soil surveys)—R. I. Herriot, B.Agr.Sc.
Assistant Research Officer (soil surveys)—R. G. Downes, M.Agr.Sc.
Assistant Research Officer (soil surveys)—E. J. Johnston, B.Agr.Sc.
Assistant Research Officer (soil surveys)—T. Langsford Smith, B.Sc.
Technical Officer (surveys and cartography)—P. D. Hooper.
Technical Assistant (soil chemistry)—H. R. Skewes.

9. Irrigation Settlement Problems.

At Irrigation 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., A.A.C.I.
Assistant Research Officer—R. R. Pennefather, B.Agr.Sc.
Assistant Research Officer—H. S. McKee, B.A., D.Phil., A.A.C.I.
Orchard Superintendent—B. H. Martin, H.D.A.

At Commonwealth Research Station, Merbein—
Officer-in-charge—A. V. Lyon, M.Agr.Sc.
Senior Research Officer (chemist)—E. C. Orton, B.Sc., A.I.C., A.A.C.I.
Assistant Research Officer (irrigation and viticulture)—D. V. Walters, M.Agr.Sc.
Assistant Research Officer (drainage)—A. L. Tisdall, M.Agr.Sc.
Assistant Research Officer (chemist)—P. Dixon, M.Sc.
Technical Officer—J. E. Giles.
Research Officer—A. C. Ingerson (part-time).
Research Officer—R. C. Polkinghorne (part-time).

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.) (on leave).
Librarian and Records Clerk—Miss M. I. Hulme.

Chemistry Section—
Officer-in-charge—W. E. Cohen, D.Sc., A.A.C.I.
Assistant Research Officer (chemist)—A. W. Mackney, M.Sc, A.A.C.I.
Assistant Research Officer (chemist)—Miss T. M. Reynolds, M.Sc., D.Phil., A.A.C.I.
Technical Officer—A. G. Charles, A.A.C.I.
Technical Officer—A. J. Watson, A.A.C.I.

Fibre Investigations—
Officer-in-charge—A. M. Munro, M.A. (Oxon.), A.I.C., F.C.S.
Assistant Research Officer—Miss J. F. Couchman, B.Sc.

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

Preservation Section—
Officer-in-Charge—S. F. Rust, B.Sc., M.S.
Assistant Research Officer—H. B. Wilson, B.Sc., A.A.C.I.
Assistant Research Officer—N. Tamblyn, M.Sc. (Agric.).
Creosote Research Officer—D. E. Bland, M.Sc., A.A.C.I. (co-operative investigation with Tar Distillers).

Wood Structure Section—
Officer-in-charge—H. E. Dadswell, M.Sc., A.A.C.I.
Assistant Research Officer—H. D. Ingle, B.For.Sc. (N.Z.)
Assistant Research Officer—Miss A. M. Eckersley, M.Sc.
Assistant Research Officer—Miss J. Ellis, B.Sc.

Photography—
Technical Officer—E. S. Smith.
Technical Officer—Miss A. M. Lightfoot.

Timber Mechanics Section—
Officer-in-Charge—I. Langlands, B.E.E., M.Mech.E., A.M.I.E.(Aust.).
Assistant Research Officer—R. S. T. Kingston, B.Sc., B.E.
Technical Officer—B. Whitington, B.Sc., B.E.
Technical Officer—A. L. Gunn.
Technical Officer—N. H. Kloot.

Timber Physics Section—
Officer-in-charge—W. L. Greenhill, M.E., Dip.Sc.
Assistant Research Officer—G. W. R. Ardley, M.Sc.

Timber Utilization Section—
Officer-in-Charge—R. F. Turnbull, B.E. (Hons.).
Assistant Research Officer—A. J. Thomas, Dip.For.
Assistant Research Officer—A. Gordon, B.Sc.
Technical Officer—A. Rosel.

Veneering and Gluing Section—
Officer-in-charge—S. F. Rust, B.Sc., M.S.
Assistant Research Officer—C. E. Dixon, M.Sc., A.A.S.E.
Technical Officer—R. Deeble.

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

11. Division of Food Preservation and Transport.

At State Abattoir, Sydney—
Chief—J. R. Vickery, M.Sc., Ph.D.

Physics Section—
Senior Research Officer—E. W. Hicks, B.A., B.Sc., A.A.C.I.
Assistant Research Officer—M. C. Taylor, M.Sc.

Fruit Storage Section—
Research Officer—S. A. Trout, M.Sc., Ph.D.
Technical Officer—P. R. Maguire.

Fruit Products Section—
Research Officer—L. J. Lynch, B.Sc.Agr.

Meat and Fish Storage Section—
Research Officer—W. A. Empey, B.V.Sc.
Assistant Research Officer—C. C. Kuchel, B.Sc., A.A.C.I.
Assistant Research Officer—J. F. Kefford, M.Sc., A.A.C.I.

At Government Cool Stores, Melbourne—
Research Officer (biochemist)—F. E. Huelin, B.Sc., Ph.D., A.A.C.I.

At Animal Health Research Laboratory, Melbourne—
Assistant Research Officer (bacteriologist)—Miss L. R. Alford, B.Sc.

At Brisbane Abattoir—
Assistant Research Officer (biophysicist)—A. R. Riddle, M.A., M.Sc.

At Fisheries Research Laboratory, Cronulla—
Technical Officer (fish curing and canning)—R. Allen.

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

12. Division of Fisheries.

At Port Hacking, Sydney—
Chief—H. Thompson, M.A., D.Sc.
Assistant Research Officer (bacteriologist)—E. J. Ferguson Wood, M.Sc., B.A.
Assistant Research Officer (biologist)—D. L. Serventy, B.Sc., Ph.D.
Assistant Research Officer (biologist)—G. L. Kesteven, B.Sc.
Assistant Research Officer (biologist)—M. Blackburn, M.Sc.
Assistant Research Officer (biologist)—A. Tubb, M.Sc.
Assistant Research Officer (chemist and hydrographer)—D. Rochford, B.Sc.
Assistant Research Officer (librarian and biologist)—Miss F. V. Murray, M.Sc.
Technical Officer—A. Proctor (laboratory).
Technical Officer—G. Clark (M.V. *Warreen*).
Technical Officer—Miss M. Stokes, B.Sc.
Clerk—W. J. Gillespie, A.F.I.A., A.A.I.S.
Master—M.V. *Warreen*—Captain A. Flett.

At Melbourne—
Fisheries Officer—S. Fowler.

13. Australian National Standards Laboratory.

Electro-technology Section—
D. M. Myers, B.E., D.Sc.

Metrology Section—
N. A. Esserman, B.Sc., A.Inst.P.

Physics Section—
G. H. Briggs, Ph.D., D.Sc.

14. Division of Aeronautics.

Chief—L. P. Coombes, B.Sc.
Senior Draughtsman—D. W. Eaton.
Draughtsman—F. Redlich.

Aerodynamics Section—
Officer-in-Charge—G. N. Patterson, B.Sc., M.A., Ph.D.
Assistant Research Officer—T. F. C. Lawrence, B.Sc., B.E.

Structures and Materials Section—
Officer-in-Charge—H. A. Wills, B.E.
Assistant Research Officer—J. B. Dance, B.Met.E.

Engines Section—
Officer-in-Charge—M. W. Woods, D.Phil., B.Sc., B.E.
Technical Officer—T. M. Spiers.

Instruments Section—
Technical Officer—A. N. A. Clowes.

Workshops—
Technical Officer—J. S. McLaren.

15. Division of Industrial Chemistry.

Chief Chemist—I. W. Wark, Ph.D., D.Sc., F.A.C.I.
Senior Research Officer—E. J. Drake.
Assistant Research Officer—K. E. Murray, B.Sc., A.A.C.I.

16. Radio Research.

At University of Melbourne—
Investigator—A. F. B. Nickson, M.Sc.

At University of Sydney—
Investigator—F. W. Wood, B.Sc.
Investigator—A. H. Mutton, B.E.

17. Ore-Dressing Investigations.

At University of Melbourne—
Investigator—J. G. Hart.

At School of Mines, Adelaide, South Australia—
Investigator—K. S. Blaskett, B.E.

18. Other Investigations.

Mineragraphic Investigations—
Investigator—F. L. Stillwell, D.Sc.
Research Officer—A. Edwards, B.Sc., Ph.D.

Biometrics—
At Canberra—
Research Officer (in charge of section)—Mrs. J. Calvert (Miss F. E. Allan), M.A., Dip.Ed.

At Melbourne—
Assistant Research Officer—Miss M. Barnard, M. A., B.Sc., Ph.D.

Dairy Products Investigations—
At Dairy College of Science and Technology, Werribee—
Investigator—W. J. Wiley, D.Sc., A.A.C.I.

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

(i) *Bulletins.*

No. 129.—Investigations on Chilled Beef. Part II.—Cooling and Storage in the Meatworks, by W. J. Scott, B.Agr.Sc., and J. R. Vickery, M.Sc., Ph.D.

No. 130.—Chemical Investigations on the Fleece of Sheep, by Martin R. Freney, B.Sc.

No. 131.—Black End and Anthracnose of the Banana with Special Reference to *Gloeosporium musarum* Cke. and Mass., by J. H. Simmonds, M.Sc., and R. S. Mitchell, M.Sc.Agr.

No. 132.—The Wood Anatomy of Some Australian Lauraceae with Methods for their Identification (Division of Forest Products—Technical Paper No. 34), by H. E. Dadswell, M.Sc., and Audrey M. Eckersley, M.Sc.

No. 133.—A Soil Survey of the Mildura Irrigation Settlement, Victoria, by F. Penman, M.Sc., G. D. Hubble, B.Agr.Sc., J. K. Taylor, B.A., M.Sc., and P. D. Hooper.

(ii) *Pamphlets.*

No. 91.—The Effect of Spacing and Time of Sowing on Yield and Yield Components of Wheat Varieties, by H. Fairfield Smith, B.Sc.(Agr.), M.S.A.

No. 92.—The Density of Australian Timbers. 2.—Air-dry and Basic Density Data for 172 Timbers (Division of Forest Products—Technical Paper No. 33), by W. L. Greenhill, M.E., Dip.Sc., and H. E. Dadswell, M.Sc.

No. 93.—Studies on the Marketing of Fresh Fish in Eastern Australia, Part 1.—Field Observations and Quantitative Bacterial Results. (Fisheries Section—Report No. 2), by E. J. Ferguson Wood, M.Sc., B.A.

No. 94.—Some Effects of Alkaline Reagents on Wool.
(1) Chemical Studies, with Special Reference to Felting and Shrinkage, by M. R. Freney, B.Sc., and M. Lipson, B.Sc.
(2) Preliminary Notes on the Physical Properties of Alkali-treated Wool, by E. H. Mercer, B.Sc., and M. R. Freney, B.Sc.

No. 95.—Australian Apples. A Guide to Picking for Export or Local Storage and to the Best Shipping Periods for Export Varieties. Compiled by W. M. Carne.
No. 96.—Further Investigations on Copper Deficiency in Plants in South Australia, by D. S. Riceman, B.Ag.Sc., C. M. Donald, B.Sc.Agr., and S. T. Evans, B.Sc.
No. 97.—The Shrinkage of Australian Timbers. 2.—Shrinkage Data for 170 Timbers (Division of Forest Products—Technical Paper No. 35), by W. L. Greenhill, M.E., Dip.Sc.
No. 98.—The Prevention and Treatment of Blowfly Strike in Sheep. Report No. 2, by the Joint Blowfly Committee.
No. 99.—Studies on Chemical Weed-killers with Special Reference to Skeleton Weed, by C. G. Greenham, M.Sc., G. A. Currie, D.Sc., B.Agr.Sc., and F. E. Allan, M.A.

(iii) *Trade Circulars.*

No. 45.—The Testing of Timber for Moisture Content.
No. 46.—The Air-seasoning of Timber.
No. 11.—(Revised Edition)—Wood Borers in Australia. Part 2.—Anobium or the Furniture Borer.
No. 25.—(Revised Edition)—Wood Borers in Australia. Part 3.—Pin Hole Borers.

(iv) *Food Preservation Circular.*

No. 3–P.—The Cooling of Export Chilled Beef.

(v) *Fisheries Circulars.*

No. 1.—Some Notes on the Smoking of Fish.
No. 2.—The Canning of Fish and Fish Products in Australia.

(vi) *Quarterly Journal.*

Vol. 12, No. 3, August, 1939.
Vol. 12, No. 4, November, 1939.
Vol. 13, No. 1, February, 1940.
Vol. 13, No. 2, May, 1940.

(vii) *Annual Report for the year ending 30th June,* 1939.

(viii) "*Handbook of Structural Timber Design.*"

XVI. 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 Commonwealth Bank (from its Rural Credits Development Fund), the Australian Wool Board, the Australian Meat Board, the George Aitken Pastoral Research Trust, the Australian 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. LIGHTFOOT, Secretary.

October, 1940.

APPENDIX.

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

COUNCIL (AS AT 30TH JUNE, 1940).

EXECUTIVE.

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

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Professor R. D. Watt, M.A., B.Sc. (New South Wales).
Russell Grimwade, C.B.E., B.Sc. F.A.C.I. (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.

N. K. S. Brodribb, O.B.E., F.I.C., A.A.C.I.
G. S. Colman, C.B.E.
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.

STATE COMMITTEES (AS AT 30TH JUNE, 1940).

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E. C. Andrews, B.A., F.G.S.
Professor E. Ashby, D.Sc.
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., F.L.S., F.Z.S.
Professor J. C. Earl, D.Sc., Ph.D., F.I.C., F.A.C.I.
W. R. Hebblewhite, B.E.
C. H. Hoskins.
The Hon. Sir Norman W. Kater, Kt., M.L.C., M.B., Ch.M.
F. Leverrier, K.C., B.A., B.Sc.
Sir Frederick McMaster, Kt.
J. Merrett.
J. Nangle, O.B.E., F.R.A.S.
R. J. Noble, B.Sc.(Agr.), M.Sc., Ph.D.
E. D. Ogilvie, B.A.
Professor J. D. Stewart, M.R.C.V.S., B.V.Sc.
F. J. Walker.
Lieut.-Col. H. F. White, C.M.G., D.S.O.

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W. Baragwanath.
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Sir Dalziel Kelly, Kt., LL.B.
Professor W. N. Kernot, B.C.E., M.Mech.E., M.Inst.C.E.
Emeritus-Professor Sir Thomas R. Lyle, M.A., D.Sc., F.R.S.
H. A. Mullett, B.Agr.Sc.
B. Perry, A.A.C.I.
F. J. Rae, B.A., B.Sc., B.Agr.Sc.
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P. H. Harper, B.A.
L. St.J. Jones.
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E. J. Casey, Commonwealth Dried Fruits Control Board.

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A. E. Cameron, Red Cliffs Settlement.
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W. Heaysman, Cardross Horticultural Society.
L. W. Andrew, Waikerie, South Australia.

O. Weste, Renmark, South Australia.
S. Heaysman, Coomealla, New South Wales.
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T. T. Morley, Griffith Producers' Co-operative Co. Ltd.
A. G. Enticknap, 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.
H. J. Williams, Leeton Co-operative Cannery Ltd.

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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.
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A. G. Strickland, M.Agr.Sc., Chief Horticultural Officer, Department of Agriculture, South Australia.
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C. G. Savage, Director of Fruit Culture, Department of Agriculture, New South Wales.
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Professor G. A. Currie, D.Sc., B.Agr.Sc., Institute of Agriculture, University of Western Australia, Crawley, Western Australia.
I. Thomas, Department of Agriculture, Western Australia.
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(*Formerly the Interdivisional Blowfly Committee ; its function is to co-ordinate certain activities of the Divisions of Economic Entomology and of Animal Health and Nutrition.*)

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D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Nutrition, C.S.I.R.

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F. J. Walker, Sydney.
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A. F. Dunbar, B.Sc., Melbourne Technical College.
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G. A. Cook, M.Sc., B.M.E., F.A.C.I., Council for Scientific and Industrial Research.
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F. J. Shea, Department of Supply and Development, Melbourne.
J. Storey, Aircraft Production Commission.
G. Lightfoot, M.A., Council for Scientific and Industrial Research.
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B.—COMMITTEES CONCERNING WORK IN WHICH THE COUNCIL IS CO-OPERATING.

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(*Of Australian Council of Agriculture.*)

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R. P. M. Short, Under-Secretary, Department of Agriculture and Stock, Queensland.
W. J. Spafford, Director, Department of Agriculture, South Australia.
L. St. J. Jones, Under-Secretary, Department of Agriculture, Western Australia.
H. C. Smith, Secretary, Department of Agriculture, Tasmania.
J. F. Murphy, Secretary, Department of Commerce, Canberra.
Sir George Julius, Kt., B.Sc., B.M.E.
Sir David Rivett, K.C.M.G., M.A., D.Sc.
A. E. V. Richardson, C.M.G., M.A., D.Sc. } Members of Executive Committee of C.S.I.R.

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Professor J. K. Murray, B.A., B.Sc.Agr., Queensland Department of Public Instruction.
C. W. Winders, B.Sc.Agr., Department of Agriculture and Stock, Brisbane.
J. R. A. McMillan, B.Agr.Sc., M.S., D.Sc. (with C. S. Christian, B.Sc.Agr., M.Sc., as deputy), C.S.I.R.
B. T. Dickson, B.A., Ph.D., C.S.I.R., *ex officio* member.
R. Veitch, B.Sc.Agr., B.Sc.For., F.R.E.S., Department of Agriculture and Stock, Brisbane.

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A. G. Strickland, M.Agr.Sc., Chief Horticultural Instructor, Department of Agriculture, South Australia.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein, Victoria.
A. C. Gordon, Superintendent for Irrigation, Lands Department, South Australia.
E. R. Laurie, Engineer for Irrigation, Engineering and Water Supply Department, South Australia.

CURLWAA AND COOMEALLA HORTICULTURAL ADVISORY COMMITTEE, NEW SOUTH WALES.

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Chairman*).
F. S. Barrett, Water Conservation and Irrigation Commission, New South Wales.
S. Colley, Rural Bank, New South Wales.
F. S. Oldham, Department of Agriculture, New South Wales.
W. Webley, Coomealla Settlers' Representative.
S. P. Taylor, Curlwaa Settlers' Representative.
A. L. Tisdall, Commonwealth Research Station, Merbein (*Secretary*).

WAKOOL DISTRICT RESEARCH COMMITTEE, NEW SOUTH WALES.

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Chairman*).
T. J. Marshall, M.Agr.Sc., Division of Soils, C.S.I.R.
J. B. Moore, Water Conservation and Irrigation Commission, New South Wales.
J. M. Arthur, Department of Agriculture, New South Wales.
F. Mathews, Rural Bank, New South Wales.
E. E. Ellis
H. J. Jackson } Representing Landholders (Wakool Irrigation Area).
R. Redfearn

ADVISORY COMMITTEE ON WATERLOGGING PROBLEMS.

(*This Committee was formed by the Leeton Fruit-growers' Co-operative Society to advise settlers in cases where they have some difficult irrigation problem.*)

F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission (*Chairman*).
C. G. Savage, Department of Agriculture, New South Wales.
A. G. Enticknap, Yenda Producers' Co-operative Society Ltd.
R. R. Pennefather, B.Agr.Sc., Irrigation Research Station, Griffith.

IRRIGATION RESEARCH EXTENSION COMMITTEE (MURRUMBIDGEE IRRIGATION AREAS).

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