1937-38-39.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

THIRTEENTH ANNUAL REPORT

OF THE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH,

FOR

YEAR 1938-39.

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COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

THIRTEENTH ANNUAL REPORT (FOR YEAR ENDED 30th JUNE, 1939).

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. *Laboratories.*—Satisfactory progress has been made in the arrangements for the erection of the National Standards Laboratory and the Aeronautical Research Laboratory.

As regards the former, the University of Sydney has made available a site for the laboratory in the grounds of the University. The preparation of working drawings by the Works Department is nearing completion, and tenders have already been invited for the foundations, which will be completed by about the end of September, 1939. Tenders for the remaining laboratory building will be invited early in October, 1939, and it is hoped that the building will be ready for occupation by June, 1940. The laboratory will be organized into three main sections, viz., Metrology, Electrotechnology and Physics. An officer has been appointed to take charge of each of these three sections, and the three officers concerned have been sent abroad to make arrangements for the placing of orders for the necessary standards and comparating apparatus. They will spend most of their time at the National Physical Laboratory, Teddington, which has kindly undertaken to render assistance and to provide accommodation. In addition, three graduates—one for each section—have been sent abroad to undergo special courses of training at the National Physical Laboratory. Besides providing for the work of the three sections, laboratory accommodation and facilities will be available in the building for research on physical problems connected with secondary industries.

The Aeronautical Research Laboratory is to be erected at Fisherman's Bend, Melbourne, on a site leased from the Victorian Government. The total area leased is about 10 acres, which will permit also of the erection of a Chemical Laboratory for investigations into problems affecting secondary industries. Tenders have been invited for the erection of the first part of the laboratory buildings, comprising an administrative block, special laboratories, and workshops. It is hoped that the erection and equipment of these parts of the building will be completed by about February, 1940. Orders have been placed for most of the necessary equipment, and plans for the wind tunnel and balance are in course of preparation. Mr. L. P. Coombes, the Officer-in-Charge, began duties with the Council in January, 1939, and officers have already been appointed to take charge of three sections, viz., Aerodynamics; Structure and Materials; and Engine and Fuel Tests.

Reference was made in the last report to the New South Wales State Government's action in making an area available at Port Hacking, 18 miles south of Sydney, for the purposes of the Council's Fisheries Section. During the year under review, the erection and equipment of a laboratory on this site were completed. Use will be made of other facilities on the site in the form of a tidal pool for storing live fish, a concrete tank above sea level, and a small laboratory building formerly used by the State fisheries authorities. The research motor vessel *Warreen*, which was placed in commission in May, 1938, has successfully carried out its first full year of deep-sea investigation covering approximately 30,000 miles.

As a result of resolutions passed by the Australian Agricultural Council at its meeting in Perth in 1938, funds have been provided for the erection by the Council of a Fruit Juice Laboratory adjacent to the laboratory at Homebush of the Council's Section of Food Preservation and Transport. The preparation of the plans for the laboratory is nearing completion, and orders have already been placed for most of the necessary equipment.

In the Forest Products Division at South Melbourne, a new laboratory building has been completed and equipped for experimental work on pulp and paper, the necessary funds having been provided by pulp and paper manufacturers in Australia. The first objective of the work is to formulate standard methods of test for pulp and paper. A building for a new section, viz.,

the Plywood and Veneer Section, has been completed and the laboratory part of the building has been equipped; the remaining part will house a large plywood lathe for which funds (£1,250) have been generously provided by Mr. Russell Grimwade.

Additions to the laboratory building of the Citricultural Research Station, Griffith, in the Murrumbidgee Irrigation Area, are nearing completion and will relieve the congestion which has existed for some years past in the laboratories established in 1924.

In the last Report, reference was made to the grant by the Australian Wool Board for capital expenditure on the improvement of the property at Cunnamulla, comprising 40,000 acres, made available to the Council at a nominal rental by the Queensland Government for the purposes of an experimental sheep station. The erection of the necessary residences, shearing shed, laboratory, fencing, &c. has been completed, and work is now in progress on the sheep blowfly and other problems of the pastoral industry. Arrangements are being made for the station to be used also as a centre for work on pasture grasses for the drier regions of the Commonwealth.

Experience has shown that the area at Berwick, Victoria, which has been rented for the work on mastitis in dairy cows, is not now quite adequate as a field station. Moreover, it would be unsuitable for other work of the Division of Animal Health and Nutrition. The whole position has recently been greatly improved by the purchase of a property at Werribee about 20 miles from the Division's Parkville Laboratory. The area is 117 acres and irrigable. The new property will undoubtedly prove a valuable asset to the Division in the future.

In connexion with the Council's building programme, and particularly in view of the design and erection of the National Standards Laboratory in Sydney and the Aeronautical Research Laboratory in Melbourne, it was decided to transfer an officer with suitable architectural experience from the Division of Forests Products to the Head Office of the Council. For the time being, he is engaged on the design and equipment of these two laboratories and one or two other smaller erections, and acts as adviser with respect to special designs, fittings, &c., which the Council needs for its work. He is also devoting some time to the collection of general information on building research.

3. *Photographs of Laboratories and Map.*—A new feature of this Report is the inclusion of photographs of a number of the Council's laboratories. The work of the Council is now carried out in many parts of the Commonwealth. The locations of the more important laboratories and field stations are shown on the accompanying map.

4. *Dairy Products Research.*—In accordance with a recommendation made some years ago by the Standing Committee on Agriculture, it had been hoped to initiate investigations into problems of Australia-wide significance to the dairying industry, more particularly on the dairy products side. The desired facilities were not available until early in 1939 when the Victorian State Department of Agriculture established a School of Dairy Technology and Dairy Science at its State Research Farm, Werribee. Associated with this School are laboratories and an experimental butter and cheese factory with extensive modern plant and equipment. On being approached the Department readily agreed to provide facilities for co-operative work. An officer of the Council who has had extensive experience in dairy products work in Great Britain, Australia and New Zealand has accordingly been transferred to Werribee where he will make an early commencement on a programme of investigations.

5. *Work in Western Australia.*—Of late years, the Council has seen the need for increased work in Western Australia on problems of national concern and of particular interest to the West. Efforts to make a commencement, however, have been complicated by the lack of adequate laboratory accommodation in the State. That position has now been changed by the State authorities assisting the University of Western Australia to establish an Institute of Agriculture in its grounds. The way has thus become clear for the Council to honour an undertaking it gave some time ago to provide the services of investigators if the State could provide accommodation. A programme of co-operative work has been adopted by the State Department of Agriculture, the University, and the Council. It has been agreed that the most promising lines of research are in the fields of agrostology, animal nutrition, and soils. Following a visit from a senior officer of the Council's Division of Plant Industry, work is in progress on certain agrostological problems; details of this co-operative effort are given in Section II. The services of an officer have also been made available in Western Australia to assist one of the Department of Agriculture's veterinary officers in investigations on the animal nutrition side.

6. *Information Section.*—In the last Annual Report, reference was made to the decision to establish an Information Section. During the year 1938–39, four officers were appointed to the staff of the Section, which has provided a most useful service, not only in furnishing information in response to inquiries received from manufacturers and others, but also in the preparation of summaries of information, bibliographies, &c., for the use of the Executive

Committee, other committees, and members of the staff of the Council. An important feature of the work of the Section is the provision, in response to inquiries, of photographic copies of articles appearing in scientific journals.

7. *Finance.*—The total expenditure of the Council during the financial year 1938–39 was £274,728, of which no less than £77,685 was contributed from sources other than the Commonwealth Treasury. The Council regards with gratification the action taken in this way by the various contributing bodies and the confidence which is thus expressed in the work of the Council. It is unique—at any rate in the records of Australia—for any Governmental institution to derive so large a part of its funds from contributions by industry. Among the many contributions received, reference may be made to those of the Australian Pastoral Research Trust; the New South Wales Water Conservation and Irrigation Commission; the Commonwealth Bank; the Australian Wool Board; the Australian Meat Board; the Australian Dairy Cattle Research Association; the Dried Fruits Control Board; the Mildura, Irymple, Red Cliffs and Aurora (Dried Fruits) Packing Companies; and pulp and paper manufacturers. A complete list of the contributions is given in a later part of this report.

Under the provisions of the *Science and Industry Research Appropriation Act* 1938, a Science and Industry Capital Trust Account was established, and a sum of £250,000 was appropriated to the credit of that account. The Act provided that the moneys standing to the credit of the account should be applied for the construction and equipment of laboratories and other buildings for the purpose of scientific and industrial investigations by the Council for Scientific and Industrial Research. The major part of the money will be expended on the National Standards Laboratory and the Aeronautical Research Laboratory. In addition, the cost of the Fisheries Laboratory, the new field station at Werribee for the Division of Animal Health and Nutrition, and new office accommodation at the Council's Head Office premises, is to be borne from the moneys in the account.

8. *Amendment to Act.*—During the year the Council's Act was amended by the *Science and Industry Research Act* 1939 to allow of the Vice-Chairman as well as the Chairman of each State Committee being a member of the Council. It is intended to use this provision for the greater representation of secondary industries on the Council in view of the Government's decision to extend the work in that direction.

The amending Act also included a provision to facilitate the employment of casual labour by allowing the Council to employ such people for periods of not more than twelve months without obtaining prior approval from the Minister.

II. PLANT INVESTIGATIONS.

1. *General.*—The significance of pastures to Australia is illustrated by the fact that approximately one-quarter of our national wealth is derived, directly or indirectly, from them. So it is that the Council engages in investigations of important pasture and stock problems. The Division of Plant Industry has, for some years, been actively engaged in the introduction of exotic pasture plants which are subjected to trial, after quarantine, in order to determine their worth as components of pastures in one climatic zone or another. In particular, efforts are being made to supply suitable plants for semi-arid country, legumes for monsoonal country, and soil binding plants to retain land against the forces of erosion. The Division is also engaged in the work of selecting improved strains of pasture plants and in that of synthesizing types. As noted in the report for 1936–37, work had not then begun in the extremely important field of pasture management, despite the belief that management methods may materially modify the pasture type for good or ill. The Australian Wool Board is well aware of the basic importance of investigations into problems of management, especially as they affect wool and the welfare of sheep. The Board recently made its interest effective by allotting £2,000 to initiate such investigations, and Dr. J. Griffiths Davies has been appointed to undertake the work.

The year closes with the resignation of Dr. G. A. Currie on his appointment as Hackett Professor of Agriculture in the University of Western Australia; since 1934, he has been in charge of weeds investigations jointly in this Division and that of Economic Entomology.

Once again during July the officers concerned with tobacco problems in both Commonwealth and States met in conference, on this occasion in Canberra. The opportunity was taken to review the programme of work and to consider the industry as a whole from the point of view of production. In addition to the preparation of progress reports for exchange between officers, it was arranged to collate information on a quarterly basis for publication in "Tobacco Intelligence" by the Imperial Economic Committee.

The survey of potato problems, which was commenced at the suggestion of the Standing Committee on Agriculture and referred to in the last report, is nearing completion, and it is expected to be submitted to the Committee in August, 1939.

A conference of officers engaged in seed-testing was held in Sydney in November, 1938; the methods in use were reviewed with the aim of achieving the greatest possible uniformity. Such technical conferences are of the utmost value, not only to the officers engaged in the actual work of seed-testing, but also to the States and the seeds traders.

2. *Plant Introduction.*—(i) *General.*—During the year, 433 additional plants were introduced, the total to the 30th June, 1939, now being 6,686 from 68 countries. The work of testing introductions on a satisfactory scale calls for trials over a wide range of seasons and conditions and is obviously long-dated. The first requisite is that the plants come through quarantine. After that, such introductions as pasture plants for drier areas or for erosion control may be used by pastoralists who are interested in co-operating with the Council for Scientific and Industrial Research in this work; these trials are usually on a small scale because seed stocks are limited. The position is different for cereal grains, as seed of these introductions is issued only to official plant breeders in the Departments of Agriculture or Universities and Colleges for possible use in crossing work. None is issued to farmers direct.

Among introduced wheats, four, which originated in Crete and Syria (but were received from England and New Zealand), gave high yields (over 40 bushels per acre) in tests over four years (1935–38) at Duntroon. Another, which originated in Portugal, was obtained from New Zealand and gave high yields. As "S 617" in New Zealand, it has emerged from exhaustive tests as a superior spring wheat under the name of "Tainui" and has been distributed extensively for culture throughout the province of Canterbury. The three leading wheats in the Duntroon tests are white in colour.

With average yields ranging from 53.5 to 52.0 bushels, "Swedish Gold M.A.C.R. 32" and four other barleys outyielded Trabut (check), which yielded 51.7 bushels, in a four year (1933, 1935–37) test of 27 introduced barleys. "Peruvian M.A.C. 305", with 51.7 bushels, ranked seventh and in malting tests proved to be of special interest in this connexion. In another test of 46 introduced barleys, mainly from Russia, high average yields over the 1937–38 period were obtained. The two leading barleys (C.P.I. 6478—*Hordeum vulgare* var. *pallidum* and C.P.I. 6486—*H. vulgare* var. *parallelum*) yielded 62.7 and 60.1 bushels per acre, respectively.

Upwards of 100 forage plants, mainly grasses, in rows, remained leafy and green throughout the record dry and hot season of 1938–39. Outstanding grasses in this respect included *Bouteloua curtipendula, Sporobolus airoides, Sporobolus Wrightii,* and *Panicum obtusum.* A number were quick to recover after the drought; among these were *Agropyron cristatum, Bromus inermis, Agropyron intermedium,* and *Brachypodium phoenicoides.*

Of the introductions which exhibited the most outstanding growth in autumn (early May), the most prominent were certain introduced strains of *Phalaris stenoptera, P. coerulescens, P. arundinacea, Agropyron cristatum, Bromus inermis, Dactylis glomerata, Hilaria mutica, Elymus junceus, Festuca Mairei,* and *Trifolium pratense.*

Some 70 strains of 33 grasses and thirteen legumes gave very promising growth in winter. Outstandingly good winter growers were *Phalaris stenoptera, P. coerulescens, P. arundinacea, Festuca Mairei, Bromus unioloides, B. marginatus, B. arduennensis, B. polyanthus, B. coloratus, B. macrostachyus, B. racemosus* var. *commutatus, B. macranthes,* strains of *Dactylis glomerata, Arrhenatherum erianthum,* hairy Peruvian lucerne, smooth Peruvian lucerne, and Bolivian lucerne.

Grasses under observation at Black Mountain for arresting soil erosion, which have proved their ability to hold the soil and to withstand prolonged drought, are the introduced *Elymus angustus, Elymus pseudoagropyron, Elymus multicaulis, Elymus giganteus, Bromus inermis,* and *Agropyron ramosum. Calamagrostis epigeios* (Chee grass) is soil-binding and salt-tolerating.

(ii) *Tests at Lawes, Queensland.*—The early part of the growing season at Lawes was unusually dry, while greatly improved conditions obtained towards the end of the season resulting in striking growth in many introduced plants at that time of the year.

The work during the past year has been concerned very largely with the further testing and evaluation of species previously selected as promising types. Much time has been devoted to the problem of developing suitable grass-legume mixtures for sub-tropical pastures. Ten legumes and two mixtures of legumes were combined with four grasses and studied in 48 plots. The most successful legumes were lucerne, annual Lespedezas, and *Phaseolus semi-erectus,* in combination with *Brachiaria brizantha, Panicum maximum,* Rhodes grass, and *Phalaris bulbosa.*

In plot studies with promising grasses, the average yield from *Brachiaria brizantha, Panicum maximum* (selection), and *Dichanthium* sp. was more than double that obtained from Rhodes grass. Other outstanding grasses in these plots were *Urochloa pullulans* and *Paspalum scrobiculatum.* The last-named was very palatable.

Trials of promising species on subsidiary areas in southern Queensland have been continued during the year. At Caboolture (Coastal Belt) the grasses *Paspalum scrobiculatum, Dichanthium* sp., *Digitaria valida,* and *Brachiaria dictyoneura* have shown the greatest promise. At Brookstead (Darling Downs) the most promising grasses under test were *Agropyron intermedium, Brachypodium*

phoenicoides, *Ehrharta erecta*, and *Sehima nervosa*, which showed up well as winter-growing species. At Surat (Maranoa) species of *Digitaria* were among the most promising introductions. The introduced legume *Phaseolus semi-erectus* has spread rapidly there and gives indications of being an outstanding pasture species.

In a trial of new grasses at Lawes, *Paspalum levae*, *P. stramineum*, and *P. cilitifolium* appeared to be quite promising. Older introductions at Lawes which have been classified as promising pasture plants include the following :—

(*a*) *Grasses.—Brachiaria brizantha*, *Panicum maximum* (selection), *Paspalum scrobiculatum*, *Urochloa pullulans*, *Dichanthium* sp., *Digitaria valida*, *Brachiaria dictyoneura*, *Eragrostis superba*, *Urochloa trichopus*, *Urochloa bolbodes*, *Sehima nervosa*, *Digitaria pentzii*, *Digitaria milanjiana*, *Digitaria setivalva*, *Paspalum plicatulum*, *Phalaris stenoptera*, *Agropyron intermedium*, *Brachypodium phoenicoides*, *Iseilema laxum*, *Cynodon dactylon*, *Sporobolus virginicus*.

(*b*) *Legumes.—Phaseolus semi-erectus*, *Lespedeza striata*, *Lespedeza stipulacea*, *Crotalaria usaramoensis*, *Crotalaria goreensis*, *Lespedeza daurica*, *Lespedeza juncea*, *Alysicarpus rugosus*, *Medicago hispida*.

(*c*) *Legumes for Green Manure and Cover Crops.—Glycine javanica*, *Dolichos lablab* *Dolichos debilis*, *Stizolobium atterimum*, *Stizolobium pachylobium*, *Phaseolus ricciardianus*, *Phaseolus radiatus*, *Phaseolus trinervius*, *Canavalia ensiformis*, *Sesbania paulensis*, Brabham cowpea, Iron cowpea, *Crotalaria usaramoensis*, *Crotalaria goreensis*.

A number of soybeans were subjected to test during the year, and seventeen have been classified as likely to be useful sorts.

Ten introduced grasses, in various stages of development, were cut and fed to fifteen months old heifers. Palatability was determined by use of systematic notes based on preferences and forage consumed. The following species proved the most palatable, in the order of final average percentage score :—*Paspalum scrobiculatum*, *Urochloa pullulans*, *Dichanthium* sp., *Sporobolus virginicus*, *Brachiaria dictyoneura*, *Brachiaria brizantha*.

(iii) *Tests at Fitzroyvale, Central Queensland*, have shown the following groups of introductions to be the most successful over three seasons (1936–39) :—

(*a*) (Tufted, ascending grasses which on the whole constitute excellent fodder grasses). *Panicum maximum* (purple-top Guinea), *P. maximum* (Common Guinea), *P. maximum* var. *trichoglume*, *Urochloa bolbodes*.

(*b*) (Semi-ascending to ascending tufted grasses of medium height which tend to form a " sole " more readily than those of the previous group). *Cenchrus ciliaris*, *Melinis minutiflora*, *Brachiaria brizantha*, *Brachiaria decumbens*, *Urochloa mosambicensis*.

(*c*) (A group with surface-rooting stolons). *Andropogon annulatus*, *Andropogon pertusus*, *Amphilophis glabra*, *Chloris gayana* (Kenya No. 1, Kenya No. 2 and Kafue (2), Rhodes grass—6585, 6586, 6606, 6561).

(*d*) (A group with surface-rooting stolons but producing little seed, necessitating vegetative propagation). *Brachiaria dictyoneura* and *Digitaria milanjiana*.

(*e*) (Leguminous components of proposed pasture swards which have produced exceptionally vigorous growth with seasonal summer rains). *Stylosanthes guyannensis* and *Arachis prostrata*.

The outstanding grasses over the four seasons of the year at Fitzroyvale are *Urochloa mosambicensis*, purple-top Guinea (*Panicum maximum*), *Brachiaria brizantha*, *Cenchrus ciliaris*, and the four strains of *Chloris gayana*.

Sixty-six plots of the above-mentioned grasses, with and without the legume *Stylosanthes guyannensis*, were laid down to determine, following establishment, their reaction to grazing.

Legumes which have shown up as possible pasture legumes include the following :—*Stylosanthes guyannensis* (the most outstanding and regarded as a tropical legume of very great potential pasture value) and *Arachis prostrata*. Others being investigated for pasture value are *Centrosema pubescens*, *Pueraria hirsuta*, *Glycine javanica*, *Meibomia discolor*, and *Arachis nhambiquara*. The most outstanding legumes for use as green manure include *Stizolobium atterimum*, *Stizolobium* sp., *Stizolobium pachylobium*, *Stizolobium deeringianum*, *Dolichos lablab*, and *Dolichos debilis*. Legumes useful for preventing soil erosion under tropical conditions are *Indigofera endecaphylla* and *Pueraria hirsuta*.

(iv) During 1938–39, seed representing 486 introduced plants was distributed for testing throughout Australia. In certain cases, however, the same introduction was sent to different States. During the year, seed of 86 introductions was supplied to other sections of the Division

of Plant Industry, making a total of 483 introduced plants so supplied during the past four and a half years. Seed of 194 species and varieties, representing 26 native and naturalized plants and 168 introductions (C.P.I.) were sent outside Australia during 1938–39.

(v) *Other Tests.*—Despite adverse climatic conditions which obtained during the greater part of the year, a number of introductions were successfully established in plots laid down in the Wagga, Bathurst, Orange, Glen Innes, Maitland, and Narrabri districts of New South Wales. It is too early yet to enable any conclusions to be drawn. Replies to a questionnaire distributed in June, 1938, indicated encouraging results with introductions being tried in all States and the Northern Territory. These include representatives of those listed in previous paragraphs of this Report.

(vi) *Sward studies* were carried out at Duntroon during the year on sixteen introduced grasses, seeded alone and with another grass, and with and without subterranean clover. These showed, from the data so far available, that *Bromus arduennensis* (C.P.I. 2382) was easily the best-yielding grass, succeeded in the order of yield by *Festuca elatior* (1144), *Agropyron cristatum* (1296), and *Phalaris tuberosa* (one of the checks). Other high-yielding grasses included *Festuca Mairei* (1499) seeded with *Agropyron intermedium* (1358), *Agropyron intermedium* (1358) and *Bromus inermis* (1297). The addition of subterranean clover increased the productivity, but in certain cases, as with the grasses *Festuca elatior* (1144) and *Bromus inermis* (1297), the accompanying clover seemed to exert a depressing influence.

Data on persistency, as determined by average percentage ground cover, so far show that *Phalaris stenoptera* (1305) with *Bromus inermis* (1297) are the most persistent, followed, in the order mentioned, by *Phalaris stenoptera* (1305), *Festuca elatior* (1144), *Agropyron cristatum* (6507), *Phalaris tuberosa*, *Bromus arduennensis* (2382), and *Dactylis glomerata* var. *hispanica* (2145).

Observations so far made of palatability to sheep have revealed that *Bromus* spp. are the most palatable, followed by strains of *Agropyron cristatum*, *Agropyron intermedium*, *Phalaris stenoptera*, and *Dactylis glomerata*, in the order named.

(vii) Germination studies were made on seeds of varying age of strains of *Festuca elatior*, *F. arundinacea*, *Poa bulbosa*, *Ph. arundinacea*, *Dactylis glomerata*, *Agropyron cristatum*, *A. elongatum*, *Brachypodium sylvaticum*, and *Briza subaristata*. They indicated that seed ten weeks, fifteen months, and 27 months old varied little in rate and final percentage germination at low temperatures. Pre-soaking increased the rate of germination of older seed, and the effect lasted for some months. In general, alternating temperatures, such as obtain in the field, increase the percentage germination.

Chemical analyses were made of a number of grasses at the flowering stage, and the uronic acid content, used as measure of drought resistance capacity, was determined.

3. *Pasture Plant Breeding.*—(i) *At Canberra.*—The extended and severe drought which was experienced during the past summer seriously interfered with the breeding work, and, combined with insect attack, destroyed practically all of the white clover plants. Other species resisted the conditions, and useful data on these were obtained. With both cocksfoot and *Bromus*, selections of different types of plants have been made, grouped, and planted in isolation for seed production. Investigations with the naturally occurring wallaby grasses (*Danthonia* spp.) have been commenced. The programme with the annual legumes has been continued, and selections from last year's material have been sown in small plots for comparative purposes.

(ii) *At Lawes, Queensland.*—The pasture plant breeding investigations at Lawes, being undertaken co-operatively with the Department of Public Instruction and the Department of Agriculture and Stock, are now in their third year. Work has been concentrated on lucerne, Rhodes grass, and *Phalaris* spp., but some preliminary work has been done with Mitchell grasses. The outstanding problem with lucerne appears to be one of survival, for after three years only 25 per cent. of the plants remained healthy, half of the remainder being dead and the other half infected with witches'-broom. The main causes of the loss appear to be witches'-broom, various wilts, flooding or extended wet periods, and grazing. Selections of various types have been made and grouped for seed production. Isolation plots of selections of *Phalaris* have been established and some seed obtained. Rhodes grass shows considerable variation, particularly in fineness of stem—a hopeful indication of improved strains being obtained. Six isolation plots have been sown for seed production.

(iii) *At Moss Vale, New South Wales.*—The pasture plant breeding work being conducted on the property of Sir Norman Kater at Moss Vale is now in its third year. The severity of the climatic conditions during last summer enabled important observations to be made on the reaction of the plants to such conditions. From the thousands of plants under test, some selections have been made and the material passed on to the second stage of the programme.

4. *Pasture Investigations.*—(i) *In Western Australia.*—In November, 1938, the Senior Agrostologist made a pasture survey of the south-western division of Western Australia. His subsequent recommendations were adopted and, in March, 1939, an officer was appointed to undertake the programme of investigations he outlined. This officer is stationed at the new University Institute of Agriculture, Crawley; and the closest co-operation with the University, the State Department of Agriculture, and representative graziers and business houses is being maintained throughout. Experimental work has been initiated on the following problems:—

(*a*) The elucidation of the trouble locally termed "stalling" of subterranean clover. This is the gradual recession in the yield of the clover, generally accompanied by the rapid entry of weeds into the sward.

(*b*) The possibility of extending the range of the leguminous species now available and the search for other legumes to supplement them.

(*c*) Detailed examination of the life-history, morphology, and agrostology of *Ehrharta calycina* (perennial veldt grass) and of *Lupinus varius* (blue lupin). Both of these species are imperfectly known, but both are extremely promising herbage species for the light soils so prevalent in Western Australia.

The field experiments are principally concerned with the determination of pasture species suited to the sheep country receiving from 17 to 25 inches of annual rainfall, and the search for suitable associate grasses to combine with subterranean clover, with a view to the prevention of the entry of undesirable weeds. Experimental plots have been laid down at several centres, viz., "Cranmore Park", Walebing (annual rainfall 17½ inches); "Glentromie", New Norcia (21 inches); Chittering (34 inches); York (18 inches); "Kendon", Midland Junction (34 inches); Williams (22 inches); Kojonup (21 inches). Wherever possible, the plots have been sown on clean fallow. Records of the establishment, yield, and botanical composition are being taken by sampling, and the plots are grazed by sheep.

The Western Australian work is being assisted by the University, which is providing the services of three post-graduate students, each of whom is concerned with a special project dealing with some phase of the general programme. Their special studies relate, *inter alia*, to the life-history, morphology, and variation in *Ehrharta calycina*; the life-history, seed yield, and variation in *Lupinus varius* and its allied species; the effect of growing subterranean clover and blue lupin on the fertility status of the light sands of the coastal belt.

(ii) *At Canberra.*—The improvement of pastures within the Australian Capital Territory and the allied environments of the Southern Tablelands is being regarded from two aspects:—(*a*) the improvement of existing pastures without ploughing; and (*b*) the use of sown pastures on land that is either under the plough or capable of being ploughed.

Increasing the range of superior herbage species capable of being introduced by surface cultivation alone, or the encouragement of the better endemic species by control of the grazing animal and the use of suitable artificial fertilizers, will form the basis of one attack on the problem of pasture improvement. A preliminary test has been made into the possibility of introducing into the swards, by surface cultivation alone or in combination with phosphates, certain selected grasses and legumes. These include some of the commoner commercial pasture species, as well as certain of the most valuable of the aliens brought in and tested by the Division's Plant Introduction Section.

On the fallowed land, work on the following three projects has been commenced:—

(*a*) A comparison of a representative range of grasses and legumes as simple grass-legume swards—and again including several introductions.

(*b*) In conjunction with the Department of Agriculture of New South Wales, a strain trial of the commercially more important species of herbage plants has been planted.

(*c*) Twenty-two acres of a mixture of *Phalaris tuberosa*, cocksfoot, subterranean clover, and lucerne has been established.

This pasture will be subjected to the following grazing treatments in its second and subsequent years:—(1) continuous grazing; (2) rotational grazing on a monthly basis; and (3) rotational grazing on a bi-monthly basis. The trial is designed to give information on the effect of continuous and rotational grazing by sheep on the yield and botanical composition of the sward, and the effects on the live weight, wool production, and parasitic infection of merino wethers. The co-operation of the Division of Animal Health and Nutrition has been enlisted in the work on wool yields and quality and in the investigation of the parasitic infection of the grazing sheep.

(iii) *Survey of Pasture Problems in Southern Queensland.*—During May and early June, 1939, a survey of the pasture problems of southern Queensland was made. The area covered embraced the Darling Downs, the Maranoa and Warrego districts, and included much land cleared of prickly pear within recent years. A report on the findings, together with recommendations for the investigation of certain of the problems encountered, is in course of preparation.

In May, 1939, an officer was appointed to carry out certain agrostological work in co-operation with the Division of Animal Health and Nutrition. Close collaboration is being maintained between the two Divisions, and visits have been made to several experimental centres in which animal problems are being investigated, with a view to rendering assistance in the agrostological problems arising in the course of the work on animal health. Advantage is to be taken of the research facilities existing at " Gilruth Plains," (Queensland), and the McMaster Field Station (New South Wales) in the development of the research programme in sheep pastures.

5. *Fruit Investigations.*—Investigations have been continued on the following subjects :—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 conditions (Griffith, New South Wales).

(i) *In Tasmania.*—Experiments and observations on fruit of the 1938 harvest confirmed previous findings in respect to the relationships that exist between the seasonal climate, fruit size and maturity, soil type, storage temperatures, delay in storage, and fruit physiology, and the incidence of various storage disorders. On the basis of tests on samples of the 1939 crop taken in January and February, and the seasonal climatic conditions, forecasts of the probable storage qualities of the main commercial varieties were made this year. It has been possible to make such forecasts with reasonable accuracy during the past several seasons ; they provide a most useful guide for planning picking programmes and storage schedules that will minimize wastage. Variation in apple maturity due to the climatic differences which exist between five fruit-growing centres in Tasmania was found to be no greater than the variation which may occur in one centre by reason of differences in soil type and cultural treatment, &c.

Experiments were continued on storage in artificial atmospheres. Liability to brown heart and alcoholic poisoning increased with carbon dioxide concentration and the maturity of the fruit, but decreased with temperature over the range 33° F. to 44° F. in the varieties Sturmer and French Crab. Experiments failed to comfirm the overseas reputation of Tasman Pride for high susceptibility to alcoholic poisoning. Results have also failed to confirm, for Tasmanian varieties, overseas findings on the value of pre-storage carbon dioxide treatment as a means of reducing low temperature breakdown ; the incidence of Jonathan spot was increased, and the method proved dangerous with varieties susceptible to brown heart.

No further results have been obtained in connexion with the control of field disorders.

(ii) *In Queensland.*—An account of the rootstock problem and plan of the experiments at Stanthorpe was published in the Council's Journal of May, 1938. Investigations this year were continued along the lines there described. In the propagation trials, apple stocks which have yielded more than 95 per cent. of rooted shoots from stool beds over a period of three years include Malling Nos. I., II., XII., and XVI.; Merton Nos. 779, 789, and 793; Ivory's Double Vigour Northern Spy; and seven local selections. Merton No. 788 and one local selection averaged about 60 per cent. rooted shoots per stool. Woolly aphis infestation in the propagating beds was again heavy on the Malling stocks and on S.4.

The root systems of 28 own-rooted varieties have been examined. The differences found between varieties were very great. For instance, the weight of roots expressed as a percentage of the weight of shoots averaged 23.9 in Allsopp's Early, 30.2 in Delicious, 54.3 in McIntosh Red, 71.4 in Stewart's Seedling, and 103.1 in Milton. The root systems of almost all the varieties were shallow ; the most deeply penetrating roots were those of Jonathan.

The varieties Packham's Triumph, Beurré, Hardy, and Winter Cole have been added to the range of scion varieties being tried on Malling pear stock selections. Other work described in last year's Report has been continued.

(iii) *In Irrigation Areas.*—Work has been commenced on problems associated with the maintenance of health and vigour in citrus trees on the Murrumbidgee Irrigation Area. As it is considered that the almost universal use in that area of the rough lemon, or at least, unsuitable strains of rough lemon, may be a factor contributing to the prevalence of unthrifty or short-lived orange trees, an investigation of the stock-scion relationships of citrus is being undertaken. Material of varieties which have proved most satisfactory as rootstocks for citrus in trials overseas (California, India, Egypt, &c.) is being imported. It is also proposed to survey local areas and to select rootstock material for propagation and subsequent trial from trees which are at least 25 years old and show no signs of declining thriftiness. Studies of the shoot and root growth of orange trees under the various conditions of soil and cultural treatment which obtain on the area

are also in progress. The object of these studies is not merely to determine whether certain conditions are favorable or unfavorable to satisfactory growth and development in citrus, but also to obtain information regarding the precise effect of various environmental conditions upon shoot and root growth.

Every spring a small percentage of scattered vines in the irrigation areas fail to resume growth in the spring; they are found to be dead and to exhibit characteristic symptoms at the base of the stem. Attempts to account for this condition are in progress. It is probably of non-parasitic origin. A microscopical examination of buds from sultana vines in the Murray River Irrigation Settlements made during May, 1939, showed that the abnormally hot summer of the past season had not adversely affected fruit-bud formation. Provided normal conditions prevail during the coming season, an excellent sultana harvest should be obtained.

The progress of other investigations in citrus and vine problems is recorded under the respective reports from the Commonwealth Research Stations at Merbein and Griffith.

(iv) *Tour Abroad.*—In a visit to overseas fruit-growing areas and research institutions, Dr. C. Barnard, Senior Officer in Horticultural Investigations, paid particular attention to problems of citrus and vine-growing in California and South Africa, and to apple problems in Eastern United States of America, Canada, and England. Information regarding the most recent methods of attack on fruit-growing problems was obtained. In the belief that a number of the problems in some Australian areas are primarily due to the cultivation of deciduous fruits under climatic conditions which are not ideally suited to their optimum development, a special study was made of the distribution of fruit varieties in relation to climate in the countries visited, and of the disorders which are associated with the cultivation of these fruits under unsuitable conditions of soil and climate.

6. *Wheat Investigations.*—(i) *Flag Smut.*—The discovery of early symptoms of this disease a few days after the coleoptiles appeared above ground was reported a few years ago. As all varieties of wheat showed the symptoms, it was concluded that wheat varieties that are popularly regarded as resistant developed resistance to the progress of the disease after infection. Using a refrigerating unit, the experiments are being repeated in order to determine whether there are any differences in susceptibility to infection at lower temperatures than those used in the early experiments. As the work is being done continuously, the influence of variation of temperature and other environmental conditions after germination is also being observed.

(ii) *Root Rot of Wheat.*—In co-operation with the Department of Agriculture of South Australia, the Waite Institute, and Messrs. Pearson and Sanders, of Yeelanna and Lowaldie, respectively, experiments have been planned for a period of five years with the object of obtaining information on the probable effect of (*a*) fallowing (*b*) methods of tillage, (*c*) pasture and other rotations in the incidence and control of take-all of wheat. An experiment to test the effect of additions of zinc sulphate, copper sulphate, iron sulphate, and gypsum was made on Mr. Sanders's farm, but the results were inconclusive, this being due in part to general failure of the crops consequent on drought. At Canberra, white heads were obtained in experiments in which excessive amounts of potassium salts and of ground magnesite were added to the soil. If these results are confirmed during the coming season, there will be some justification for the present tentative view that white heads in the field are sometimes due to physiological factors.

Experiments on the role of root rotting organisms are being continued. Great variation in the pathogenicity of eight single-spore cultures from the same ascus has been noted. The effects of the degree of compactness of the seed-bed, of depth of sowing, and of cutting back the plants have also been further investigated. Improvements have been made in methods of isolation of one of the organisms, and a short paper on this and some other aspects of the problem is to be prepared for publication soon.

(iii) *Yield.*—The investigation on the analysis of yield has been continued. Of 100 varieties tested at Canberra, the following are the best on the basis of their average yield over the past four seasons:—Carlisle (60 bushels per acre), Caliph (56), Bobin (56), Mallar (55), Exquisite (53), Morley (53), Canberra (51). A study of the growth of ten varieties throughout the season indicated that characters associated with yield began to differ between varieties from earing time onwards, and that the period prior to this, provided reasonable growth had occurred, was unimportant from this point of view. There was no significant difference in growth rate as measured by dry-weight increase.

7. *Tobacco Investigations.*—Under the terms of the Commonwealth grant of £20,000 per annum for the five-year period 1934–38 inclusive, the Council has conducted research on diseases and smoking quality, and the States have been responsible for demonstration and field services to growers. A further grant of £15,000 for 1939, reducing to £10,000 in 1943, has been provided for a continuation of the work. The existing co-operation between States, and between the States and the Commonwealth, has been maintained by a conference of tobacco officers, by the

half-yearly exchange of progress reports, by the quarterly exchange of information required by the Imperial Economic Committee for its publication *Tobacco Intelligence*, and by joint work in the determination of smoking quality.

(i) *Diseases.*—Seed-bed experiments on the control of downy mildew were made at Myrtleford (Victoria) and at Canberra. An investigation of downy mildew in fields in north-eastern Victoria was begun, and the work on yellow dwarf was also continued in Victoria. Tobacco disease surveys were made in Victoria, New South Wales, southern and northern Queensland. The control of downy mildew in seed-beds by benzol vapours has been uniformly successful in all States. In north Queensland, the adoption by growers of the methods recommended for the control of Cercospora leafspot has resulted in this disease being reduced from major to very minor importance. The worst recorded outbreak of yellow dwarf occurred this year, many fields in Victoria being abandoned on account of it.

(*a*) *Downy Mildew.*—Seed-bed experiments involving the use of benzol, paradichlorbenzene, and cuprous oxide spray in conjunction with various cover treatments were made at Myrtleford and Canberra. The results of both the spray and the paradichlorbenzene treatments were unsatisfactory. The nightly use of a evaporation surface of benzol equal to one-hundredth of the seed-bed area, together with wetting of the seed-bed covers, gave very satisfactory results, and it is recommended to growers. Shirlan compounds and alum-lead acetate were satisfactory as cover dressings. Work was begun on the epidemiology and methods of control of downy mildew in the field, but abnormally dry weather prevented the appearance of the disease until very late in the season.

(*b*) *Yellow Dwarf.*—The investigation of the occurrence and spread of this virus disease was continued in Victoria. The data suggest transmission by insects, but tests at Shepparton gave inconclusive results with three insects that commonly occur in diseased field crops. The disease has been transmitted, by grafting, to a number of plants belonging to the family Solanaceae.

(ii) *Disease Resistance.*—This work, commenced in 1934, was continued in seed-beds at Canberra, and in the field at Briagolong (Victoria). Most of the 420 seed samples of *Nicotiana* spp., mainly *N. tabacum*, received for testing, together with seed of crosses made in previous seasons, were sown at Canberra and later transplanted at Briagolong. So far, no useful resistance has been exhibited in seed-bed tests, and in the field this season many plants and rows of plants were completely destroyed by downy mildew. Seed of many of the plants, both heavily and lightly diseased, is being procured to determine whether they are genetically different. The variety Dungowan, which is usually considered to be resistant to downy mildew after transplanting, was affected as badly as other varieties that growers regard as susceptible.

(iii) *Chemical Investigations.*—The difficulties associated with the determination of definite chemical constituents of tobacco leaf and their connexion with smoking quality, have led to a modification in the method of approach to the problem of evaluation of tobacco by chemical tests. More attention is now being given to the selection of reagents that will react with groups of constituents. It has been found that some tests tend to separate tobaccos suitable for cigarettes from those suitable for use in pipe mixtures, while others, it is hoped, will enable a numerical value to be determined for such factors as strength and quality. A range of good, usable tobaccos has been tested, and further work is expected to establish consistent points of difference between a good and an indifferent product.

(iv) *Physiological Studies.*—This work is concerned with the developmental physiology of the tobacco plant as a whole, and of the individual leaves, special attention being given to the changing composition of the leaf as it approaches the stage of ripeness. By the use of different soils, fertilizers, and water supply, comparative data were obtained on the influence of these factors on the plant and to a lesser extent on smoking quality. It is apparent that the bad quality sometimes produced in certain areas cannot be due to soil alone, but must result from a combination of adverse climatic factors with the soil conditions and especially with low water supply.

(v) *Smoking Tests.*—Tobacco leaf samples representative of the crop produced in all States during 1937–38 have been received, as well as a number of samples for special tests; 168 samples have been cut, made into cigarettes, and forwarded to all States for smoking tests. A review of the smoking test results for 1934–1937 as compared with those for 1928–1930 shows that the percentage of leaf suitable for cigarettes, fine-cut and good medium pipe tobacco has increased from 21 to 60 of the total leaf produced. Fair medium pipe tobaccos have moved from 22 per cent. to 14 per cent., good heavy tobaccos from 18 to 9, and poor smoking tobacco has declined from 38 to 17. If the samples forwarded are representative of the crop, there has been a marked improvement in the smoking quality of Australian tobacco during the last few years.

8. *Potato Problems.*—(i) *Virus Diseases.*—Studies of the nature of the virus diseases of Australian potatoes have been continued during the year. The principal disease-producing viruses being known, the next step is to find out the reaction of each one on the varieties of potato commonly grown in Australia. This work is now approaching completion.

The prevalence of a particular virus disease in the field is found to be correlated with the variety grown and the severity with which the variety reacts to infection. Viruses producing the mildest symptoms are most widely dispersed in the field; the presence everywhere of latent or X-type viruses is an example of this. The viruses doing most damage are those that cause comparatively mild symptoms on the foilage, and decrease the yield of infected plants by 20 to 80 per cent. but seldom prevent the formation of tubers. Often those that cause least damage to the potato crop produce a fatal disease when infection occurs, and prevent, almost or entirely, the formation of tubers. Potatoes under field conditions are resistant to this type of disease. The mechanism of resistance in the potato is possibly like that of a wheat resistant to rust; the local reaction to inoculation is so violent that a belt of tissue around the inoculation point is killed and prevents the virus from gaining access to the rest of the plant.

Work is being continued on strains of the latent or X-type viruses with the idea of testing the suggestion that potatoes inoculated with a mild strain of a virus are immune to infection by a severe strain.

(ii) *Survey of Problems.*—One of the officers of the Division has been engaged on a survey of the problems of the potato industry in collaboration with the Department of Commerce and the State Departments of Agriculture. The information gathered during the visits to the potato-growing areas of the various States in the 1937–38 season and subsequently, has been collated and summaries of conclusions and recommendations have been prepared for the Standing Committee on Agriculture.

9. *Vegetable Fibre Investigations.*—These are in the initial stages and are mainly concerned at present with flax (*Linum usitatissimum*). Strains of high yielding flax developing good fibre are being sought and tested. Fifteen strains are being grown at the time of reporting, and a study is in progress to determine the effects of fertilizer components on yield and fibre quality. Another aim of these investigations is to study other fibre plants, particularly such as are already growing here or may readily do so and which may be used as substitute for flax under certain conditions.

10. *Diseases of Pine Trees—Needle Fusion.*—The results obtained up to the end of 1938 were published as Pamphlet 89. During 1939, it was observed that 70 per cent. of 89 diseased *Pinus taeda* and *P. caribea* treated with borax showed a reduction or complete absence of needle fusion symptoms in the growth made during the first season after treatment. The corresponding figure for 23 trees treated with superphosphate was 26 per cent., and 16 per cent. of 102 untreated controls spontaneously developed signs of recovery. It is expected that the trees treated with superphosphate will show more marked signs of response at a later date. In spite of the reduction in severity of needle fusion symptoms, there was little if any increase in the vegetative vigour of the trees responding to borax treatments. In more extensive experiments recently begun, the effect of broadcasting phosphorus and boron compounds over measured areas, instead of applying them to individual diseased trees, is being tested.

The percentages of trees affected with needle fusion showed a decrease last season in all the untreated plots under observation, except in one plot of *P. caribea* where growth was extremely poor. Determinations of acid-soluble P_2O_5 in numerous soil-samples from poor coastal plantations gave very low figures in all cases. The P_2O_5 contents of samples from different sites within a given plantation varied considerably, but there was no evidence that the amount of needle fusion was correlated with these variations. The same applied to loss on ignition. The results of grafting experiments suggest that certain individuals may be genetically much more susceptible to needle fusion than others, although the disease cannot be attributed entirely to genetic factors.

11. *Diseases of Peas.*—Under the conditions prevailing in Tasmania during the year, root rot or take-all of peas was less serious than usual. In co-operation with the Tasmanian Department of Agriculture, field experiments on the effect of fertilizers were made at the Experimental Farm at Cressy. The plots to which superphosphate was added gave very much better yields than those that received other major and minor elements. The addition of copper sulphate, zinc sulphate, and borax at 12 lb. per acre noticeably depressed the yields. The experiments are being repeated.

III. ENTOMOLOGICAL PROBLEMS.

1. *General.*—Steady progress has been made in the investigations of the Division of Economic Entomology along the lines of attack outlined in last year's report. It is pleasing to record the successful introduction and establishment of some parasites of insect pests and of

the one insect introduced to attack the weed lantana. During recent years, improved methods of controlling the common household pests, silver-fish, meat ants, and small black ants, have been developed.

In 1938, Dr. A. J. Nicholson, Chief of the Division, visited the United States of America, Canada, England, Europe, and South Africa to inquire into recent developments in entomological research. He represented the Commonwealth at the Seventh International Entomological Conference in Berlin, and at the Fifth International Locust Conference in Brussels.

Last year, the Australian Agricultural Council passed a resolution urging the intensification of investigations into grasshopper problems and suggested a conference of entomologists representing the Council for Scientific and Industrial Research, the Waite Institute, and the State Departments of Agriculture. The conference was held in Melbourne during July and surveyed all aspects of the problem. It recommended, among other things, additions to the Council's staff working on the problem, the extension of the system of State information services, and the standardization of nomenclature. The conference also endorsed the existing arrangement of co-operation and division of grasshopper research problems between the Division of Economic Entomology and the Waite Institute.

2. *Noxious Weeds.*—These investigations, which are shared jointly by the Divisions of Plant Industry and Economic Entomology are described in a separate section (IV.) of this report.

3. *Sheep Blowfly Investigations.*—(i) *General.*—During the year, attention has been concentrated chiefly on the three main problems outlined in last year's report, namely, the study of attractants and repellents, investigation of poisons, and examinations of dressings. In addition, the study of field strikes in the experimental flock has been continued, and a return has been made to more basic work in physiological studies of the maggot.

(ii) *The Experimental Flock.*—Complete records of strike incidence have now been kept for six years, and a considerable mass of statistical data has been obtained. Much of it has not yet been completely analysed, but some of the more outstanding points may be mentioned—

(*a*) The average annual number of breech strikes per 100 sheep has been 108, which is a fair indication of the amount of strike that may be expected in an unprotected flock. That strike in well managed commercial flocks rarely exceeds a quarter of this amount is an indication of the effectiveness of the protective measures already available.

(*b*) The three conformation classes, A, B, and C, have shown well-marked differences in strike incidence consistently every year, but the extent of these differences has been reduced by the development of a dressing which has prolonged the interval between strikes in sheep of the more susceptible groups.

(*c*) Polwarth ewes are less susceptible to breech strike than plain breeched, A class, pure Merino ewes.

(*d*) The effects of the Mules operation are permanent, as judged by conformation and strike incidence in a small group of treated ewes observed over a period of four years since operation.

(*e*) The incidence of fleece rot is closely correlated with age, being only significant, in the seasons under consideration, in the lambs and occasionally in the two-tooths.

(iii) *The Study of Attractants and Repellents.*—Examination of the conditions which make the sheep attractive to the fly have been continued, with two objects: firstly, to check and extend the work reported last year; and secondly, to develop, if possible, a more reliable method of testing repellents. The results obtained may be summarized briefly in the following terms:—

(*a*) More accurate experiments have shown that there is a gradation of attractiveness with age, lambs being most attractive and aged sheep least, but there is no significant difference between ewes and wethers.

(*b*) A comparison between the untreated breech and artificial attractants showed that alcoholic indole on the sheep was as attractive as a stained and wet, moderately susceptible breech, but decidedly less than a scouring or struck breech. A point of general interest was that scouring made the breech of wethers as attractive as that of urine-soiled ewes.

(*c*) A method has been developed of studying repellents by smearing them on the fleece around artificially attractive areas. The method appears promising, and tests have been carried out with a series of supposed repellents. So far, two, oil of citronella and a crude preparation of sandalwood oil, have been found to be worthy of further investigation.

(iv) *Physiological Studies.*—Last year, the cultivation of maggots on simple artificial media was described. The basal limits of nutritional materials have been determined, and an enriched medium, containing supplementary protein, has also been developed. This enriched medium has proved particularly useful in the examination of poisons, for it was found that maggots are more sensitive to toxic agencies when on a low plane of nutrition than when they have a liberal supply of easily assimilable food, such as is available, for example, when they are developing on sheep. The results of this work have been published as the Council's Pamphlet 90.

Mention was also made last year of the fact that the reaction of the gut contents varied in different parts from moderately alkaline to very acid. This work has been completed, and it has been found that, in the maggot of *Lucilia cuprina* and several other species, the reaction of the crop is the same as that of the food, the anterior part of the midgut is faintly alkaline, its middle section strongly acid, its posterior part weakly to distinctly alkaline, and the hindgut distinctly alkaline. The reaction in the gut of the adults is similar, except that the anterior midgut and the hindgut are faintly acid. These observations may have considerable practical significance.

Studies of mineral absorption have also been commenced. In the maggot, it was found that iron is absorbed and stored by a narrow band of cells in the acid section of the midgut. These cells are apparently able to regulate uptake to the requirements of the insect, for they concentrate iron from a medium containing little of it, but do not take up an excess from an iron-rich medium. Later in development, the storage function is shared by certain cells in the body cavity, and in the newly emerged adult there is no iron in the midgut, although it appears again when the fly has fed on iron-containing material. The reserve iron is drawn on by the tissues for the synthesis of highly complex molecules, and analyses have shown that approximately half the iron in the egg and larva is in this complex, physiologically active form. It was also found that the total iron content is proportional to the dry body weight at different stages of development and on different diets.

It has recently been shown that copper is also absorbed in the acid section of the midgut. Should this phenomenon prove to be general, it may lead to the solution of a considerable practical difficulty, for it should not be difficult to incorporate a poison, such as arsenic, in a dressing in a form which can be absorbed by the acid midgut but which would be insoluble, and harmless to the sheep, in the relatively alkaline conditions of strike wounds.

(v) *Toxicity Studies.*—The results of some of this work were reported last year; its objects are to devise simple and accurate methods of assessing the potency of poisons, to determine which poisons are most likely to be useful in prevention and treatment of strike, to discover the mechanism by which different poisons produce their effects, and, if possible, to establish principles which may be useful in applying poisons generally.

Stomach poisons were incorporated in the artificial media described above, and two methods were developed for general use in assessing their potency. The first is to determine the minimum dose of poison which will inhibit the growth of newly hatched maggots; and by this method the compounds of arsenic and selenium stand out as the most potent. The second method is to determine the speed at which maggots are killed by particular concentrations of the poisons; and in these tests some of the organic poisons, particularly nicotine, rank highest. The result has been the grading of a considerable number of poisons by both methods. A third method used was to determine the minimum time required for maggots to ingest a lethal dose of poison from a medium containing a given concentration. This method has so far only been used with arsenic, but it also gives promise of a definite field of usefulness, and it seems likely that poisons will come to be defined by a series of characteristics, which can be found easily and quickly in the laboratory, and which will indicate their probable value for particular purposes in the field.

A study of various compounds of arsenic has shown that there is great variation in their toxicity, the most remarkable difference being between calcium arsenite, which was the most toxic of the compounds tested, and calcium arsenate, which was the least. These differences cannot be fully explained by differences between the compounds in content of arsenic, toxicity of the basic radicle, or accessibility to the maggot, and they are being investigated further.

In the study of contact toxicity, full-grown maggots were used, and the first step was to devise methods of exposing them to the toxic liquid under standard conditions. This was followed by an examination of the effects on the mortality curve produced by varying concentration, time of exposure, temperature, &c. These variations were found generally to influence the position, rather than the form, of the curve, and it was found also that, when several toxic liquids were compared under different conditions, their order of relative toxicity remained the same. A survey of various contact poisons showed that solvents of fats and waxes are particularly toxic to *L. cuprina*, that the contact toxicity value of essential oils is correlated with their content of carvone and carvacrol, and that tar distillate fractions increase in toxicity with volatility and tar acid content.

(vi) *Dressings.*—A survey of proprietary and other dressings has been continued, each being tested for effect on the skin of the sheep and toxicity to maggots, and, if sufficiently promising, for immediate and late effects on strike wounds, protective value against restrike, and repellency. During the year, fifteen compounded dressings were examined, as well as various eucalyptus oils, Tagetes oil, tar fractions, and miscellaneous preparations. None proved to be thoroughly satisfactory.

4. *Buffalo-fly* (*Lyperosia exigua*).—Two small consignments of the predatory beetle *Hister coenosus* were obtained from the West Indies during the year, but all were dead on arrival. An attempt is now being made to find some satisfactory method of transporting this insect.

5. *Blood Parasites of Cattle.*—Pure strains of the protozoan parasites and the virus of ephemeral fever have been maintained at Canberra throughout the year. As in the past, supplies of *Anaplasma centrale* have been sent to Queensland for vaccine purposes as required.

6. *Cattle Ticks* (*Boophilus microplus*).—Further examinations of Australian larval ticks have been made, but no parasite has been found. Enquiries made in America last year indicated that the parasitic wasp *Hunterellus hookeri* is of no real importance in controlling cattle ticks.

7. *Stickfast Fleas of Rabbits.*—Two species of stickfast fleas (*Echidnophaga myrmecobii* and *E. perilis*), which infest rabbits in Australia, have been investigated in collaboration with the Division of Animal Health and Nutrition, in the hope that they might prove useful in transmitting the virus of rabbit myxomatosis. The life-history was worked out, and satisfactory methods were developed for breeding the fleas in large numbers in artificial cultures. Further work on them is described later.

8. *Orchard and Fruit Pests.*—(i) *Oriental Peach Moth* (*Cydia molesta*).—In the spring of 1938, there was a high initial population, and the moths emerged nine days earlier than has been previously recorded in the Goulburn Valley. Although the number of moths increased in the first generation, there was a marked decrease in abundance in the second and third generations during the heat waves in January and February. During the hot, dry conditions, very few young succulent twigs were produced on the peach trees, so that the larvae were unable to find a suitable habitat and died. After the drought broke the moth population increased, and the resulting larvae attacked quinces, which were the only suitable fruit available at that time. In the heavy crop of late peaches, infestation was very low. In the circumscribed district in the Murrumbidgee Irrigation Areas, where peach moth was present during the 1937–38 season, no moths were seen in the spring of 1938 and trapping was discontinued at the end of that season.

A careful study of the life cycle and habits of *Cydia molesta* and their relation to the growing peach trees has shown that there is little prospect of ever being able to control this pest by means of sprays. This conclusion is supported by field tests. Sprays, which laboratory experiments showed were excellent, completely failed in the field. The only possible explanation of these contradictory results is that the sprays failed to reach a high proportion of the peach moth larvae on the trees, no doubt owing to the special habits of both moths and larvae. Extensive experiments with the use of sprays against *C. molesta* in the United States of America have given equally disappointing results. No further work on the use of sprays against this pest will be carried out, but attention is being concentrated on establishing the American parasite *Macrocentrus ancylivorus* in large numbers. At the end of the 1937–38 season, a good number of parasites were recovered from certain orchards, but the unusually hot dry conditions of last season prevented further increase in their numbers, and more parasites will be introduced from the United States of America next spring. During the past season, much attention has been given to developing a satisfactory method of breeding the parasites under laboratory conditions in Australia.

(ii) *Codling Moth* (*Cydia pomonella*).—The work on insecticides has been continued in an endeavour to overcome the arsenic residue problem by the adaption of organic compounds, both synthetic and natural. Substitution derivatives of phenothiazine were prepared, and it was shown that these did not undergo atmospheric oxidation and blackening, which is the main disadvantage of phenothiazine as an insecticide when it is applied in districts with sunny and hot summers. Tests showed that these compounds were less toxic than the original material, and the results were confirmed by more exhaustive trials carried out about the same time by the United States of America Department of Agriculture. Owing to these unfavorable results, and to the fact that the makers of the compound are trying to achieve the same results by different means, the work on phenothiazine as an insecticide has been discontinued.

Attempts to reduce the tenacity of the bentonite, which is used to prolong the toxic period of a nicotine spray, have not been successful. Inert substances which have been tested must be added to the spray in relatively large quantities before appreciable reduction in tenacity occurs.

The study of fixed nicotine compounds has raised the question of the production of nicotine in Australia. A survey has been made of the possible sources, and of the extent to which they are at present utilized. The possibility of raising a crop of a species of tobacco plant

(*Nicotiana rustica*), which is known to be rich in nicotine, was regarded as uneconomic, in view of the work entailed in raising any tobacco crop. The question of similar alkaloids which occur in plants which are not of the genus *Nicotiana* is being further investigated by the Plant Introduction Section of the Division of Plant Industry. At present the only possible source of nicotine is waste from the tobacco industry. The scrap from tobacco factories is at present being almost completely utilized for the production of nicotine concentrates or nicotine dusts, but less than one-third of Australian requirements of the former are being met. The waste on the tobacco farms, however, is used to a negligible extent. A survey of the waste available in the tobacco-growing area in north-east Victoria was accordingly made. The waste consists of the leaf and stem which is scrapped during curing and grading, the material rejected by all buyers, and the stalk and unpicked leaf left in the field at the end of the season. The nicotine content of these sources was found by analysis of samples, and, from the results and estimates of amounts of material available in normal years, it was estimated that the district could produce from one-third to one-half of the present Australian nicotine requirements, without in any way interfering with the tobacco production. The utilization of this potential supply of nicotine is very dependent upon a cheap and simple method of extraction, which could be carried out in a factory in the growing district. Methods of extraction have, therefore, been studied, and certain conditions which govern extraction by various processes have been defined with more detail than is available in the literature on the subject. While a new method has not yet been devised, it is expected that the information obtained will be of material assistance, should any firm commence extraction of nicotine from the tobacco grower's waste.

9. *Field Crop and Pasture Pests.*—(i) *Locust Investigations.*—(*a*) *General.*—As the result of recommendations about nomenclature made at the conference of State Departments of Agriculture, the Waite Institute, and Council officers last year, *Chortoicetes terminifera* will now be known as the Australian plague locust and *Austroicetes cruciata* as the small plague grasshopper. Work on the analysis of information received through the New South Wales Locust Information Service has been continued, and co-operation with the Meteorological Bureau is throwing some light on the climatic factors influencing the course of outbreaks. Other investigations have been largely subordinated to this work, but further advances have been made in our knowledge of the ecology of the outbreak centres and of the systematics of the injurious species.

(*b*) *Systematics.*—The study of the difficult genera *Chortoicetes* and *Austroicetes* has been continued, and specimens have been identified at various times for the States and the Waite Institute.

(*c*) *Information Services.*—As a consequence of the recommendations of the Locust Conference, the arrangement with the New South Wales Department of Agriculture, whereby the Department's Stock Inspectors constitute a Locust Information Service, has been placed on a permanent footing. The reports submitted by these officers in the form of monthly maps of swarm movements, have formed the basis of the greater part of the year's work, and have led to results of considerable interest and importance. The Queensland Department of Agriculture and Stock has been approached with a view to establishing a similar Information Service in that State. This will provide data on several other species besides *Chortoicetes*, and will add to the meagre knowledge of their distribution and habits. Regular reports are not necessary from other States: the arrangement is that information will be passed on to the Council as it is received.

(*d*) *Detailed Analysis of Recent Outbreaks of Chortoicetes.*—Data on the location, stage of development, and movements of swarms during 1937–39 (provided by the New South Wales Information Service) have been analysed and correlated with climatic data. The spread of the infestation from month to month, and the areas occupied by one, two, and three generations, respectively, have been mapped. The dates of first appearance of each generation in different parts of the State have been studied, and lines have been mapped along which hatching occurred on the same dates. The climatic conditions of the two seasons have been represented on the same maps as the locust swarms, using the mean monthly maximum temperature as the index of temperature, and Meyer's ratio, calculated from the mean monthly precipitation and the mean monthly saturation deficit, as the index of soil moisture.

It has been found that hatching and the subsequent development of the hoppers will take place only in regions where the mean Meyer ratio during the period of development reaches a value of about two. Even the dates of hatching and of the subsequent life-history events are closely determined by the prevailing conditions of temperature and moisture. Development is most rapid under conditions of high temperature and adequate moisture. It is retarded or stopped if either temperature or humidity is deficient. The interest of these observations is that they have been made in terms of ordinary meteorological records, and thus offer a much better prospect of ultimate prediction than would similar observations in the laboratory which are difficult to apply in the field unless special records of the laboratory type are available from the field.

Three annual generations are produced only in regions in which sufficiently favorable conditions of temperature and moisture persist throughout the season. These conditions can be defined, and the regions mapped. This is of some importance, since it is known that the occurrence of three annual generations is one of the factors concerned in causing outbreaks.

The direction of flight of swarms is usually such as to bring them into regions of higher humidity. This is probably connected with the direction of the prevailing wind in a manner which is not yet understood.

(*e*) *The Periodicity of Outbreaks of Chortoicetes.*—A study of past outbreaks in relation to climatic cycles has shown that outbreaks tend to reach their maximum in years of exceptional summer rainfall, and to be absent or mild in years of low rainfall. This is not surprising, in view of what has been reported above regarding the moisture conditions necessary for hatching and for the development of three annual generations. In general, it would be anticipated that the longer the period, and the wider the area over which the Meyer ratio exceeds two in a particular season, the more likely would it be that an outbreak would occur in that or the following season. We are still far from being able to predict outbreaks, but the possibility has been brought distinctly nearer by these investigations.

(*f*) *Ecology of the Outbreak Centres.*—This important subject has not been neglected, but the work has reached a stage where continuous investigations in the field are required, and these will be undertaken by an additional officer next season.

(*g*) *Experimental Work in the Laboratory.*—This work together with the study of phases, has been postponed until the work on other aspects of the problem is further advanced.

(ii) *Underground Grass Grub* (*Oncopera spp.*).—Last summer, at Leongatha (Victoria), eggs were collected from the earliest grass grub moths and scattered thickly over specially selected areas. Later when parasitic flies (*Hexamera* spp.) were received from New Zealand some were liberated in cages over the prepared areas and other were allowed to fly freely. This year's liberation was the most promising one yet made ; some of the flies were seen still flying around two weeks after liberation.

The life-history of another parasite of grass grubs, *Alomya debellator*, is being studied in England, and next season a consignment of this parasite will be sent to Australia.

(iii) *Red-legged Earth Mite* (*Halotydeus destructor*).—Work on this problem in Western Australia was planned to see if any modification of farm and pasture management would reduce the population of mites. Experiments showed that clean fallow does destroy the mites by starvation, but the beneficial effects are only of short duration in new pastures sown after clean fallow. The insects readily invade a new pasture in which they find conditions particularly favorable for their rapid multiplication. There is some evidence that heavy grazing of pastures in late autumn and winter reduces the number of mites present. Last year there was evidence to suggest that sulphate of ammonia increased the susceptibility of oats to mite attack and so a study was made of the effects of different fertilizers. No treatment was found which reduced mite attack. Cape weed appears to favour mite development.

Tests were made of the susceptibility to mite attack of fifteen different strains of subterranean clover. Of the late strains, Bass showed least damage and Tallarook also showed less damage than the average. Of the mid-season strains, Merino showed less damage than the others, whilst of the early strains Dwalganup and Springhurst were least damaged and Bacchus Marsh showed particularly severe attack. The three strains Tallarook, Nangeela, and Bacchus Marsh, which were beside one another in the plots, constitute a series showing increasing susceptibility to the mite. These results cannot at present be accepted as conclusive. Further observations were made on the way in which mites survive the hot dry summer months. During this period the eggs have specially thick resistant walls and are enclosed within the dead bodies of the mites.

(iv) *Shelter Bag Moth* (*Ochrogaster contraria*).—In the course of the investigations on this pest, it has been shown that many small and medium-sized Boree trees supposedly killed as the result of defoliation by the bag moth caterpillars have actually been killed by *Cerambycid* root borers. Parasites and predators attack the egg, caterpillar, and pupal stages of the bag moth, and these natural enemies are numerous and fairly effective in the field. A study of methods of mechanical control of this pest has been continued and the most efficient and simple method appears to be to collect egg bags by hand in December when they are small and non-irritant. Four other methods of direct control were tested.

(v) *Cabbage Moth* (*Plutella maculipennis*).—About 1,000 cocoons of the parasites *Angitia fenestralis* and *A. cerophaga* were obtained from New Zealand. A culture of these parasites was reared in the insectary, and several batches have been liberated in New South Wales, Victoria, and South Australia.

(vi) *Pea Weevil* (*Bruchus pisorum*).—This pest is serious in Western Australia where it attacks both garden and field peas. In some places the infestation has been so severe that it is unprofitable to grow field peas for seed production. Arrangements have been made to import the parasite *Triaspis thoracicus* which was found in France by officers of the United States of America Department of Agriculture.

10. *Termite* (*White Ant*) *Investigations*.—During the year, special attention has been given to the problem of direct control. Previous experiments had been confined largely to the control of mound colonies of *Eutermes exitiosus*; the results provided useful information on the relative efficiency of the various substances tested, among which the arsenicals, and particularly white arsenic, proved outstanding. In most instances of termite attack on buildings and timber structures, it is difficult or impossible to find the nest of the colony doing the damage, and thus control must depend on the treatment of the working galleries and the dissemination of the poison through the colony by the social habits of the insects. Laboratory and field experiments have disclosed at least some of the reasons, apart from their higher toxicity, for the superiority of arsenicals over fluosilicates (which have been recommended for termite control because they are less dangerous to man), and have shown that the destruction of a colony of soil-dwelling termites can be brought about by the introduction of small quantities of poison dust into the working galleries. Further experiments have been initiated in the hope that they will throw some light on the factors affecting the dissemination of poisons through a termite colony.

Routine examinations of the various field tests in progress were carried out, but no new series of treated timber samples were installed around mounds during the year. In the laboratory, tests were made to determine the resistance to termite attack of two or three special materials, regarding which information was required by a Government Department, prior to deciding whether or not they could safely be used in termite-infested areas. A series of standard laboratory colony tests has also been started to assess the anti-termitic properties of the chlorinated naphthalenes. These substances seem likely to be of considerable practical value for the treatment of manufactured building materials, such as fibre boards, and of fabric used for the covering of cables, &c., which have to be protected against termite attack, their insolubility in water being a decided advantage where leaching is likely to occur. It was found that the anti-termitic value increased with the number of substituted chlorine atoms, there being a marked difference between the di-chlor and the penta-chlor compounds.

Very little is known about the conditions necessary for the successful foundation of new colonies, particularly in soil-dwelling termites. Experiments were therefore established with a number of species, including *Coptotermes acinaciformis* (the most important pest termite in Australia), *Rhinotermes intermedius*, and *Porotermes adamsoni* (an important forest pest). Less difficulty was experienced in breeding the insects than had been anticipated, and some rather unexpected results have been obtained. In all the species studied, including these well known as sound-wood eaters, colony-founding pairs evinced a marked preference for decayed wood; even those of soil-dwelling forms mostly failed to find their way to wood that was completely buried in soil; and none survived if exposed to a relative humidity of 80 per cent. as they apparently required a saturated or almost saturated atmosphere.

The systematic revision of the Australian termites, mentioned in previous reports, has progressed satisfactorily, and now covers, in draft form, ten of the twelve genera represented in this country. The results, when completed and published, should fill the need for an authoritative reference work on this important group of insects. A more general publication, giving information on the distribution, habits, and economic significance of the better known species, is being prepared for publication.

11. *Pine Chermes* (*Pineus spp*).—The work on the control of this pest by means of parasites was complicated this year by the abnormally high temperatures experienced in Canberra in January. This hot weather considerably reduced the amount of host material available to the imported parasites. Three different parasites were introduced and liberated in pine plantations within the Australian Capital Territory. (i) *Leucopis obscura*, a European species which has been successfully introduced into Canada, (ii) *Leucopis artifacies* from California, and (iii) *Exochomus quadripustulatus* from England.

12. *Oak Aphis* (*Myzocallis annulata*).—The parasite *Aphelinus flavus* was successfully introduced from England, and a good colony was bred in the insectary at Canberra for liberation in the field. During the year this parasite was found on oak aphis in the Canberra district. As this parasite and another, *Trioxys aceris*, have also been found in Tasmania, no further parasites of oak aphis will be introduced from England at present.

13. *Oak Scale* (*Asterolecanium variolosum*).—The parasite *Habrolepis dalmanni* which was introduced and liberated last year has become established in Canberra and was sufficiently abundant locally to enable small consignments to be collected and sent to Victoria and New South Wales for liberation in those States.

14. *Greenhouse White Fly* (*Trialeurodes vaporarium*).—The introduced parasite *Encarsia formosa* has so successfully controlled this pest that no further requests for the parasite have been received during the past year.

15. *Green Vegetable Bug* (*Nezara viridula*).—The egg parasite (*Microphanurus basalis*) of this bug was obtained from the New South Wales Department of Agriculture and a stock bred in the insectary. From this source, about 1,600 parasites were liberated in Canberra where the vegetable bug appeared for the first time in 1937–38.

16. *Meat Ants* (*Iridomyrmex detectus*).—The results of previous experiments to determine the best method of destroying colonies of the meat ant, *I. detectus* Sm., have been published in the Council's Journal (Vol. 12, No. 2, May, 1939). Numerous treatments carried out during the year, using either carbon bisulphide or calcium cyanide, have confirmed the efficacy of these two fumigants for the control of this species of ant.

17. *Small House Ants* (*Technomyrmex albipes*).—Investigations into poison baits for the control of the common black house ant, *Technomyrmex albipes* Sm., have been continued, and it has been demonstrated that a very weak solution of sodium arsenite in sugar and water is effective. The importance of the low concentration of the poison (the bait contains only .06 per cent. sodium arsenite) is that the attractiveness of the syrup is unimpaired, and death does not occur before the foraging workers have had an opportunity of returning to the nest and distributing some of the poison to other members of the colony and to the larvae. A similar bait has been found effective against the introduced *Tapinoma megalocephala* Fab., which has recently appeared in pest numbers in certain localities. A container of a type more suitable than that previously used and recommended for setting out the baits has been designed.

18. *Garden Snails.*—The Meta, bran baits recommended for use against snails and slugs have proved to be very successful in Canberra. No further liberations of *Lampyris noctiluca* have been made.

19. *Systematic and General Entomology.*—About 900 specimens have been added to the museum this year. As in past years, numbers of insects have been identified for individual workers and institutions in Australia and abroad, and advice or practical assistance in treating pests has been given in response to various inquiries.

20. *Beneficial Insects Sent Overseas.*—This work, which is the most practical way by which the help received from overseas institutions can be reciprocated, has been continued. During the past year, beneficial insects have been sent to New Zealand, Norfolk Island, and Java.

IV. WEEDS INVESTIGATIONS.

1. *General.*—(i) *Co-operation.*—During the year, continued co-operation with officers of the New South Wales Department of Agriculture, through the Weeds Co-ordination Committee, has resulted in good progress with skeleton weed and St. John's wort control. In Victoria the Weeds Committee, consisting of officers of the State Departments of Lands and Agriculture, and a representative of the Council met a number of times and is arranging an extensive programme of work for the control of hoary cress. A Council officer was present with the South Australian Weeds Committee at one of its meetings when it was decided to engage on further co-operative work on Cape tulip. In Queensland, co-operation has continued with the State Department of Agriculture and Stock in mint weed work, and with the Prickly Pear Board on Noogoora burr, but a State weeds committee has not functioned yet. In each of the other States, no suitable opportunity for a meeting of the local Weeds Committee has presented itself.

(ii) *Insect Control of Weeds.*—Although early hopes that insects might solve many of Australia's weed problems besides that of prickly pear have not so far been realized, encouraging signs that the lantana bug may help to control lantana are to be seen at Atherton (Queensland) where the bugs have multiplied exceedingly and have begun to damage the bushes. Work is being continued with St. John's wort, Noogoora burr, lantana, and other weeds, until it can be decided whether they can or cannot be controlled by insects.

(ii) *Control by Cultural Methods.*—An expansion of experiments has taken place to control weeds by rotation of crop and other cultural methods. Rotations of crops which may lead to the control of mint weed on the Darling Downs and nut grass in the Lockyer Valley (Queensland) are being tried, and control of skeleton weed by cultural methods has been continued in the Riverina (New South Wales). Good progress has been made already in this field, and the results contribute to the well-being of agriculture in the districts concerned. In Victoria, similar work on hoary cress is projected.

(iii) *Weed Poisons.*—Experience has shown that application of large doses of poisonous chemicals for soil sterilization may be successful under a wide variety of conditions, but that application of chemicals in a spray to the leaves requires many favorable conditions for greatest

efficiency. The water deficit of the plant at the time of spraying is one of the most important factors in determining the efficacy of the spray; the conditions which influence this deficit are being investigated.

(iv) *Weeds of Pastures.*—In areas blessed with good winter rainfall, suitable improved pastures can be laid down, and if suitably top-dressed and not over-grazed, they will keep out weeds.

In semi-arid regions of summer rainfall where improved pastures are not yet feasible, the density of weeds in natural pastures may be influenced only by management. Experiments are being continued at St. George (Queensland), to see if a reduction of the grazing rate will permit an improvement in the pasture cover and a consequent diminution in the amount of galvanized burr present.

(v) *Life History Studies.*—The life history studies of weeds have been continued in the greenhouse, and those already completed have been valuable in giving information about the stage of growth at which the weed is most vulnerable to chemicals. They show also at which stage the weed grows most rapidly and consequently at what stage its competition with the crop will be most severe. St. John's wort and nut grass are the weeds under study at present.

(vi) *Field Work.*—Owing to the extension of co-operation with different bodies, it has been possible to extend field work during the year. At present, field work is being carried out as follows:—

In *New South Wales.*—Skeleton weed, St. John's wort, lantana, blackberry.
Queensland.—Noogoora burr, nut grass, mint weed, galvanized burr, lantana.
Victoria.—St. John's wort, ragwort.
South Australia.—Cape tulip.
Western Australia.—Wild turnip.

(vii) *Weeds of Irrigated Areas.*—By continuing the cutting treatments developed as a result of research, and patrolling the channels to destroy seedlings, the New South Wales Water Conservation and Irrigation Commission has cleared the pest plant, bulrush or cumbungi, from hundreds of miles of the irrigation channels in the Griffith and Leeton areas. A solution of this bulrush problem having been found, the investigator is now studying the problem of the control of giant water reed.

2. *Entomological Control.*—(i) *St. John's Wort* (*Hypericum perforatum*).—The insects sent from England to attack St. John's wort in Australia have not become established in this country, so work in England has been decreased, while work in the south of France, where different insects are available, has been increased.

Chrysolina geminata.—After tests had shown that this beetle from the south of France is harmless to economic plants, a small number were liberated in the field near Bright. The destructive bushfires of January swept over the liberation site and the insects perished, but further liberations will be made in the coming season. This species has a better chance to survive than those liberated previously, because it aestivates during the dry hot summer and breeds during autumn, winter, and spring.

Anaitis plagiata.—All liberations of this moth so far have been unsuccessful, owing to the caterpillars being attacked and destroyed by ants. A number of larvae were liberated in March, 1939, but they do not appear to have survived. Shipments of this insect will be discontinued if no success follows liberations this season.

Agrilus hyperici.—Large consignments of roots containing larvae of this stem and root boring beetle have been received in Canberra from Lavandou, the Council's station in the south of France. All tests are completed, and the adults emerging from the root material will be liberated in the field in the spring of 1939.

Zeuxidiplosis giardiana.—Growing plants of St. John's wort bearing galls containing larvae of this gall-midge were brought to Australia in a Wardian cage during the year. Unfortunately, the plants and the insects had died en route. Efforts are being made to bring the insect to Australia by air, because its short life and extreme delicacy make it difficult to transport by any other means.

(ii) *Noogoora burr* (*Xanthium pungens*).—During the year, the bulk of the work on insects of Noogoora burr has been carried out by the staff of the Prickly Pear Board under the arrangement for co-operation which has been in existence for three years.

Euaresta aequalis.—Burrs infested with the larvae of this seed fly were shipped from America to Sherwood (Queensland) direct, and the flies emerging were liberated in the field. In certain areas in the field, a generation of flies has bred out from burrs on which adults had been liberated in the previous year. This gives promise that the seed fly will be adapted to the burr in Australia and will become established here.

In America, the Council's officer is still seconded to the Prickly Pear Board station at Uvalde working on burr insects in collaboration with the staff there. In India, an officer of the Prickly Pear Board has made a survey of burr-infested areas in an effort to find insects destructive to burrs there. Two beetles, which bore in the stems of burrs and kill the plants, show promise : one is the larva of a Cerambycid, *Sybra* sp., and the other beetle is as yet unidentified.

Further work has been carried out on *Dectes spinosus*, *Baris* spp., *Mecas saturnina*, and *Ataxia hubbardi*, but very extensive tests are considered necessary to ensure that these insects are harmless to economic plants before liberating them. These tests are in progress.

(iii) *Lantana* (*Lantana camara*).—The lantana bug, *Teleonemia scrupulosa* Stal. (*Teleonemia lantanae* Distant), has persisted at Fairy Bower, Rockhampton, and has spread somewhat during the year. At Atherton, a colony of bugs released in November, 1936, has increased to vast numbers over an area of about 24 acres, and in that area has caused considerable destruction of foliage. It remains to be seen whether the large numbers of bugs will persist and increase. and whether the damage they cause will injure the bushes permanently. Officers of the Queensland Department of Agriculture and Stock are now distributing the bugs from the Atherton centre to different parts of coastal north Queensland. Consignments of bugs sent to Norfolk Island have apparently failed to become established there.

(iv) *Ragwort* (*Senecio jacobaea*).—The moth *Tyria jacobaeae* has failed to become established in Victoria on ragwort, chiefly through predatory attacks on the larvae by adults of the scorpion fly, *Harpobittacus* sp., so consideration is now being given to the fly *Pegohylemyia seneciella*, the larvae of which infest the flowers. This insect is giving promise of being useful in New Zealand, where it is being tried ; if its usefulness is proved, it will be tried in Australia.

(v) *Nut Grass* (*Cyperus rotundus*).—So far, trial consignments from Hawaii of the insects *Bactra truculenta* and *Athesapeuta cyperi* have been too small to establish tests in the insectaries. It may be necessary to arrange for an officer to visit Hawaii before success in transporting the insects in sufficient numbers to Australia can be achieved.

3. *Chemical, Cultural, and other Forms of Control.*—(i) *Skeleton Weed* (*Chondrilla juncea*).—Studies carried out at Wagga for the control of this weed by chemicals have shown that, short of complete soil sterilization, there are as yet no means of completely eradicating skeleton weed by poisons in a single season. Under certain conditions of water deficit in the plants, however, sprays containing a low concentration of arsenic will penetrate into the roots and kill them up to a depth of 3 feet. Work aimed at finding the best conditions under which to apply sprays and the best sprays to use is being continued. In the experiment to determine from what depth shoots can grow to the surface after being cut, it was found that a number of plants reached the surface from 3 feet under the surface, and one plant was near the surface and would probably have reached it from a depth of 4 feet. Continuous cultivation every three weeks reduced the weed to negligible proportions in two years.

(ii) *Nut Grass* (*Cyperus rotundus*).—The life-history series carried out in the greenhouse has shown that, from a single parent corm planted at the beginning of the summer growing season, as many as 77 new corms may be produced by the end of that season. Crop rotation experiments have been continued at Lawes (Queensland), and a minor investigation has been started to find out why maize cob ashes spread on nut grass areas will sometimes give a measure of control.

(iii) *Cape Tulip* (*Homeria collina*).—It appeared from work done in previous years that the time of flowering and of formation of new corms in the greenhouse at Canberra did not correspond with the times in the field. Samples of corms sent by Mr. Hawker of South Australia showed that the formation of new corms in the field began two months before new corms were formed in the greenhouse. The time of application of sprays has therefore to be adjusted to that time. During the present year, the chlorates were most effective in killing the cape tulip plants, but no spray caused eradication in one season. Further experiments are now being designed to test sprays over a number of seasons to kill the weed in rough ground where cultivation is not practicable.

(iv) *St. John's Wort* (*Hypericum perforatum*).—The plots laid down to pasture at Tumbarumba (New South Wales) have shown that a mixture of perennial rye grass, cocksfoot, and subterranean clover, established in a clean fallow and well top-dressed with superphosphate, leads to the control of St. John's wort in a season. Amongst weed-killers, the chlorates are preferable to arsenic in the district, because arsenic kills all surface growth and inhibits it for some months after heavy application, whereas chlorate is quickly washed out of the surface soil and allows other plants to recover readily.

(v) *Galvanized Burr* (*Bassia Birchii*).—This is the second year of the controlled grazing experiment to control galvanized burr in the St. George district (Queensland). In the areas which have been more lightly grazed than is usual for the district, there is evidence of the reappearance of valuable pasture grasses and also of greater bulk of those already present. In

the controlled areas, sheep were in better condition than those outside and gave about 3 lb. per head more wool of better quality. Further information about the weed itself has been obtained, and extensive samples of vegetation were taken in October to arrive at a satisfactory sampling technique for semi-arid pastures. Areas of different soil types have been mapped so that plant succession resulting from controlled grazing on each soil type may be followed.

(vi) *Bulrush* (*Typha* spp.).—The clearing of channels by the method of cutting outlined in last year's report has been continued, so that most of the channels which were very heavily infested have been cleaned. Pot experiments with bulrush are nearing completion and should provide further data concerning the number and frequency of cuttings required to kill the plant growing in various depths of water. Germination studies have shown that there is little hope of devising a practicable method of preventing seedling germination in drains.

So successful has been the control of *Typha* by the cutting method that the investigator is now paying attention to another problem, viz., the control of giant water reed (*Phragmites communis*). Much of this work will be carried out in Victoria. To date, field experiments have been carried out with a limited number of foliage sprays, soil sterilants, and cutting treatments. Sodium chlorate in 5 per cent. solution is promising as a foliage spray, and possibly will be effective as a sterilant when applied at the rate of 8 cwt. per acre. Arsenic, though sterilizing surface soils and preventing the growth of all other plants on the plot, does not greatly reduce the density of *Phragmites*. It is too early to estimate the effectiveness of cutting treatments.

(vii) *Mint Weed* (*Salvia reflexa*).—Experiments have been started in the Pittsworth district, Darling Downs, on land made available for the purpose by the Shire Council, for the control of mint weed, by weed-killers, competing plants, and cultural methods. With the co-operation of the Shire Council the cultivation trial has been started, but extreme heat in the spring of 1938 prevented the competing plants trials from being established. The plant can readily be killed, in situations where the use of poisons is appropriate, by sodium chloride or arsenic pentoxide. An area of stock route heavily infested by the weed was fenced off from stock in 1938, but so far no appreciable change in the vegetable cover has become apparent.

4. *Physiological Investigations.*—(i) *Studies in Penetration of Poisons.*—With a view to improving the entry of poisons into plants, investigations have been carried out to ascertain the relationship between certain physical properties of translocated sprays and their rate of penetration into leaves. This had involved a study of the wetting ability of a spray. Under certain conditions, the rate of penetration is an important factor affecting the behaviour of a spray; the addition of wetters to dilute sulphuric acid (an important penetrating agent) was found to influence its rate of penetration. Certain wetters decreased its rate of penetration, while sodium lauryl sulphate considerably increased its rate of penetration. An increase of concentration of sodium lauryl sulphate beyond 0.025 per cent. had no additional effect.

(ii) *Volume of Spray Retained.*—The volume of spray retained on a leaf is another factor which, under certain conditions, may influence the efficiency of a spray. The volume retained can be increased by raising the viscosity of the spray liquid, and various substances have been tried for their ability to increase the viscosity of solutions of sulphuric acid and ammonium thiocyanate. Gelatine and silicic acid were unsatisfactory, and, while starch and gum arabic offered promise, they were discarded in favour of sucrose and gum tragacanth. Sucrose greatly decreased the rate of penetration of sulphuric acid, while gum tragacanth had no effect. Further trials, therefore, were restricted to gum tragacanth. The addition of galvene and/or arsenic pentoxide to sulphuric acid with gum tragacanth had no effect on the rate of penetration.

(iii) *Field Experiments with Skeleton Weed.*—A number of additional field experiments on skeleton weed have been carried out at Wagga, and it has been shown that the time of day at which a spray is applied has an important effect upon its efficiency of kill. Under the conditions of the experiment, the most efficient spray application was made at 5.15 p.m. It has been found that a greater depth of kill is observed when the roots of sprayed plants are excavated ten days after spraying than when excavated after four days. It is most likely that this difference in kill is due to slowness in action of the poison at the greater depths. A further toxicity experiment was carried out; the following is the order of potency of the various poisons tried (the arsenicals were used with ammonium thiocyanate as penetrating agent):—arsenic pentoxide plus wetter, arsenic pentoxide, arsenic trioxide, sodium chlorate, "Sinox", dimethyl arsinic acid, p-tolyl arsinic acid and o-carboxyphenyl arsonic acid or sodium methyl arsonate, and lastly o-tolyl-arsonic acid. The inclusion of triethanolamine in the spray to give a surface active compound with arsenic acid did not significantly increase the depth of kill. In the experiment to ascertain the optimum concentration of sulphuric acid for use in acid sodium arsenite sprays, the best results were obtained with 1.0 normal acid.

The important relationships existing between moisture deficit within the plant, evaporating power of the air, soil moisture, and the efficiency of kill of a translocated spray, have emphasized the need for rapid field methods for measuring the controlling factors. Suitable methods are being investigated.

The anatomy of the subterranean axis of skeleton weed has been studied, and it has been found that that portion of the axis growing upwards after the root has been killed back for some distance exhibits stem anatomy. This may be important in the control of the plant.

More detailed physico-chemical measurements of tissues of skeleton weed have been made, to ascertain under what conditions poisons act. pH and a few rH measurements have been made of actual tissues, instead of the sap, as previously.

(iv) *Chemical Control of Blackberry.*—Experiments have been initiated at Batlow to investigate the chemical control of blackberry. While results show that repeated applications of a poison are necessary to eradicate this weed, it can be said that so far the order of efficiency of the poisons tried is: (1) sodium chlorate or "Atlacide", (2) arsenic pentoxide, (3) acid sodium arsenite, (4) "Sinox". The experiment is being continued.

5. *Staff.*—During the year, Mr. A. B. Cashmore left the Section to take up a position in the Agrostology Section of the Division of Plant Industry. Mr. W. M. Willoughby was appointed to the Section as from 1st June to work at Lawes (Queensland), and Mr. T. Wilkinson was appointed as from 13th June to assist in chemical and physiological work.

V. ANIMAL HEALTH AND NUTRITION INVESTIGATIONS.

1. *General.*—During the year, the organization and general developmental work of the Division was brought to a stage which may be regarded as more or less mature.

Accommodation for the smaller and larger experimental animals at the Laboratory in Melbourne was provided, and some useful internal structural alterations were carried out at both the Nutrition Laboratory in Adelaide and the McMaster Laboratory in Sydney. Developmental work continued at both the McMaster Field Station and at the National Field Station "Gilruth Plains," and the position in both has been consolidated. Land on which a new field station or experimental farm is to be established in the Werribee district (Victoria) was purchased and will be placed under permanent irrigated pasture. Preliminary work on grading and the laying down of channels and drains was completed by the end of the financial year.

The nature of the work carried out in the three main centres of Sydney, Melbourne, and Adelaide, has not departed greatly from that carried out previously. In addition, co-operative work with the State Departments of Agriculture has been extended; this includes the appointment of an officer to assist with work in Western Australia. Co-operation with the Division of Economic Entomology has been maintained through the Veterinary Entomological Committee, and was established with the Division of Plant Industry through the Inter-divisional Committee for Agrostology. During the year the Australian Agricultural Council appointed a Committee on Animal Production for the purpose of correlating the work of the States and national organizations; officers of the Division are associated with the Committee.

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

2. *Animal Health Research Laboratory, Melbourne.*—(i) *General.*—The establishment of the laboratory in its present situation has been made possible by the generous co-operation of the University of Melbourne, and part of the research programme is being carried out in close association with Dr. H. E. Albiston, Director of the University Veterinary Research Institute.

(ii) *Pleuro-pneumonia in Cattle.*—Work described in the last report has shown that cattle vaccinated with culture vaccine at the tip of the tail develop a strong immunity to experimental pleuro-pneumonia (inhalation infection) for at least one year. To determine if the immunity will persist up to three years, a herd of 108 dairy heifers, mostly shorthorn crosses, has been established. Vaccinations were commenced on one group and will be carried out on other groups at intervals over the next three years, at the end of which the animals will be tested for immunity. In order to gather further information on the value, in the field, of the culture vaccine, this was prepared during the year, as previously, and supplied to the Queensland Department of Agriculture and Stock, which sent out questionnaires on the Division's behalf to all users of the vaccine. In this way a large body of information is being accumulated that makes it appear certain that the vaccine is an effective immunizing agent. To date sufficient vaccine to vaccinate over a million cattle has been issued. During the year the practice was continued of supplying laboratories in Victoria with standardized antigen for the complement fixation test.

(iii) *Entero-toxaemia.*—Work was continued generally on the lines indicated in the last report. Only a small number of soils were examined, and it was often not possible to demonstrate *Cl. welchii* Type D in samples from paddocks on which entero-toxaemia was known to occur.

Doubts on the reliability of the technique stimulated further work in this direction. Attempts to develop selectively bacteriostatic media, using such agents as copper salts, aniline dyes, Endo's medium, &c. for this organism have, however, not been successful, and the original method of isolating from liver piece broth enrichment cultures has not been improved upon. Some economy of time and material has been effected by sowing up to four suspected strains in the one tube of test medium. A claim in the literature that *Cl. welchii* Type D is unable to form epsilon toxin in the bodies of guinea-pigs was investigated and shown to be false; the toxin was demonstrated both directly and indirectly. Systematic search in entero-toxaemia material and soils failed to reveal the presence of any types of *Cl. welchii* other than Types A and D.

(iv) *Black Disease.*—The work on the antigenic analysis of various strains of *Cl. novyi* (*Cl. oedematiens*) from black disease and other conditions has been delayed through inability to obtain rabbits during the developmental phase, but is now nearing completion. During the comparative study of these strains, a phenomenon that has hitherto been overlooked or misinterpreted has been observed and studied, namely, the capacity for *Cl. novyi* to give rise to motile daughter colonies.

(v) *Caseous Lymphadenitis.*—Two antigenic fractions of *C. ovis* have been isolated, one a nucleo-protein, the other a polysaccharide. Preliminary work on the chemical nature of these has been carried out, but it has been found difficult to free the polysaccharide from inorganic material, mainly magnesium phosphate. A satisfactory method for the production of antibacterial sera of high titre has been elaborated and applied to ovine and equine strains; this has permitted a serological study of the relationship between these strains to be instituted. These studies were made as part of a programme of work on the establishment of reliable criteria for the differentiation of strains of *C. ovis* and partly in an effort to determine if improved methods in the production of a protective vaccine can be evolved.

(vi) *Bovine Haematuria.*—The gypsum top-dressing experiment at Mount Gambier has been concluded. It was commenced in July, 1933, and of the six animals in the non-gypsum control group, one died from redwater in December, 1936, two in February, 1937, one in May, 1938, and one in November, 1938. Of the six animals grazing on the gypsum top-dressed area, one died in April, 1939, and one in May, 1939. Another experiment was commenced on the same property to determine the protective value, if any, of an increase in organic sulphur in the diet. A farm at Mount Schanck, on which redwater was prevalent and which was top-dressed with gypsum in 1933, has remained free from redwater since being top-dressed.

On a farm in Gippsland similar observations, which were started in 1934, were continued. During the year the first suspicion of the occurrence of redwater appeared, four and a half years after the farm was top-dressed. In view of the somewhat promising results obtained at Mount Gambier, Mount Schanck, and Gippsland, a similar experiment involving top-dressing of the pasture with gypsum was commenced on a farm in the Western District of Victoria, where the disease appears to develop more rapidly than in other districts studied. Other aspects of the investigation were under study at the Nutrition Laboratory, Adelaide.

(vii) *Myxomatosis of Rabbits.*—The second colony experiment carried out in a wire-netted enclosure of 400 square yards, in which two well-established warrens existed, was concluded during the year. The colony was started in February, 1937, by introducing the disease into an established colony of 30 wild rabbits. Normal rabbits were added to the colony at the rate of twelve each week. Deaths in the colony were mainly due to myxomatosis, but pasteurellosis and coccidiosis were both introduced from time to time through latent infections in the introduced rabbits. In the end, myxomatosis was eradicated from the colony on account of the more lethal effect of the disease in animals already affected with coccidiosis. The effect of the dual infection was that rabbits died from infection by the virus of myxomatosis before the disease reached a stage at which it could be transmitted to in-contact rabbits. The experiment was, therefore, terminated. The experiment showed that a single introduction of the disease into a small colony of rabbits which was recruited by twelve introductions each week set up an epizootic which lasted for 78 weeks. The total number of rabbits introduced into the colony was 935. Of this number 610 were picked up dead of myxomatosis, 107 from other causes. The remainder died underground, and although the cause of death could not be determined it is believed that the majority died from myxomatosis. At the termination of the experiment, the animals remaining in the colony were tested and two were found to be resistant to myxomatosis. It is evident, therefore, that under similar conditions a small proportion of rabbits may contract a mild type of the disease from which they recover with a more or less permanent resistance against further infection. The experiment also showed that the virus used is of a fixed type and does not tend to lose its virulence or to become modified in other ways.

Observations were continued on Wardang Island in a netted area of approximately 90 acres. The first experiment, which was recorded in the last report, showed that myxomatosis did not tend to spread from one colony of rabbits to another under natural conditions when the

population was relatively sparse. Another experiment was started on 28th June, 1938. The population was dense at this time, and active breeding was proceeding. There were at the commencement approximately 1,000 adults in the enclosure and an unknown number of kittens. Scattered over the enclosure there were approximately 30 warrens each containing a larger or smaller colony of rabbits. In addition, many rabbits were living wholly above ground and sheltering in bushes and long grass. The disease was first introduced on 28th June, 1938, when 21 kittens and twelve adults were deliberately inoculated in their burrows, nine in all. Further inoculations were carried out between 31st July and 9th August, 1938, when in all an additional 168 kittens and 51 adults divided between ten burrows were inoculated. Still further inoculations were carried out between 30th November and 6th December, 1938, when 85 rabbits were caught at the drinking troughs and liberated after inoculation. In these ways a total of 337 rabbits were inoculated at four different periods. In all, 934 uninoculated rabbits were found dead of the disease. Food became scarce and hand feeding with oats was resorted to; the weather became hot and dry. Under these conditions 633 rabbits died from heat and shortage of feed combined. The experiment was terminated in January, 1939, when 1,078 rabbits remained in the enclosure and were destroyed by the use of poison. The observations showed that, in spite of widespread introduction, the disease failed to control the rabbit population in the enclosure. The cause of the failure appears to be the fact that rabbits wander away from their colonies as soon as the disease becomes manifest in them and they reach an infectious state. In this way the disease may actually disappear from a colony already infected and there is little or no spread from colony to colony.

It is possible that under natural conditions the spread of the disease may be assisted by an insect vector, such as a flea or a mosquito. This possibility is under consideration and the inquiries are being continued. In addition, the disease is under investigation in the laboratory from various general aspects. Also some consideration is being given to the resistance of the virus to drying under vacuum.

(viii) *Mastitis in Dairy Cattle.*—The year ended was the fourth since the investigation of mastitis was commenced by the building up of a herd for the study of the bacteriology of the udder and possible infections in this organ. Normal, healthy heifers, which had not previously lactated and which might, therefore, be regarded as being free from mastitis, were taken as the foundation stock. They were maintained under quarantine conditions, care being taken to prevent contact with any infected animal. During the first year when the number of animals in production was small, and when all were in the early stages of their first lactation, most of the quarters remained relatively free of bacteria, and in those cases where bacteria did appear they were of a non-pathogenic variety. Later, however, streptococci of the mastitis-producing type appeared, despite the conditions of quarantine, but, although invading or becoming established in the udders of certain of the animals, they failed to produce clinical mastitis. In fact, organisms other than streptococci occurred more frequently and proved to be more troublesome. The fluctuation in occurrence and numbers of these organisms was carefully watched and recorded in order to determine to what extent they might predispose to a subsequent streptococcal infection. With the passage of time the presence of streptococci within the udders of the herd became more frequent, although still no typical case of mastitis developed.

In the second year, when the number of cows in production was greater and a proportion of them were in their second lactations, both streptococcal and staphylococcal infections became more prevalent, and at the end of this period three clinical cases of streptococcal mastitis occurred.

The third year, as anticipated, provided a larger number of clinical cases of mastitis, twelve in all, four being due to streptococci and eight to other organisms. In two of the four streptococcal cases there occurred complete loss of function of the infected quarters for the remainder of the lactation period. These quarters returned to full function at the following lactation. The other animals in the herd possessed 187 functioning quarters. Of this number, 110 remained sterile, but seven yielded high streptococcal counts and 70 yielded high staphylococcal counts without any clinical evidence of mastitis.

In the fourth year, there was a marked increase in bacterial invasion of the udder. In all, 45 cases of clinical mastitis occurred; and the proportion of cases due to streptococci increased considerably, being 25 as against 20.

It has thus become evident (*a*) that mastitis can develop in a clean herd without the introduction of a case of the disease; (*b*) that once established in a herd the disease seems to occur more frequently with each successive lactation; (*c*) that the type of streptococcal mastitis experienced in the experimental herd differs in its course from that commonly described overseas, being more acute in onset but more temporary and less "damaging"; (*d*) that the invasion of the udder by streptococci does not necessarily cause mastitis, and it would appear that some other contributing factor must operate.

During the year, systematic blood examinations were made for the detection of animals infected with the organism of contagious abortion. By the end of the year it appeared that the disease, which made its appearance in the herd during the previous year, had been eradicated by the methods adopted.

Observations on a number of cows in their first lactation in the herd of the State Research Farm, Werribee, were concluded, and plans were formulated for the determination of the existing types of *Str. agalactiae* in representative herds in the metropolitan area of Melbourne.

(ix) *Toxaemic Jaundice.*—During the year, the investigation in co-operation with the University Veterinary Research Institute and the Victorian Department of Agriculture was concluded. The investigation was into the cause of death of sheep grazed on an irrigation area on which copper sulphate had been used for the control of the fluke snail and for the treatment of foot-rot in the sheep. It was proved beyond any reasonable doubt that the cause of death was due to copper poisoning which is characterized in sheep by a haemolytic jaundice.

The joint investigation into toxaemic jaundice of sheep in the Murray Valley, with which the New South Wales Department of Agriculture is also associated, was continued, although greatly hampered by abnormal seasonal conditions. After a long dry period, bountiful rains commenced in February, 1939, and pastures were restored. The disease became manifest in flocks in the north-east of Victoria and in the Riverina. The data collected from these outbreaks give further support to the hypothesis that the jaundice is associated with high storage values for copper in the liver which may be followed by sudden mobilization of copper in the blood stream leading to destruction of red blood cells and the accumulation of pigments in the tissues. The investigation is being continued.

(x) *Vealer Breeding.*—Opportunity was taken with the herd mentioned under (ii) to start observations to determine the economic practicability of producing "vealers" from shorthorn-cross dairy cows, as recommended by Dr. Hammond. Stud Aberdeen-Angus bulls are being used. Results will be available in three years' time.

(xi) *Onchocerca gibsoni.*—Attempts were made to develop a complement-fixation test for the diagnosis of infestation of cattle with *O. gibsoni*, the cause of worm nodules, but so far the results have not been encouraging.

(xii) *Contagious Abortion.*—Work carried out on the comparative values of the complement-fixation and agglutination tests for the diagnosis of contagious abortion demonstrated a slight superiority of the first. It frequently gives evidence of infection earlier than the second and detects a slightly larger number of infected animals.

(xiii) *Observations Centred in Queensland.*—(*a*) *Peg-leg.*—An experiment started in 1936 was continued on cattle to determine the preventive value of phosphatic supplements in the form of (*a*) dicalcium phosphate, (*b*) bone-flour, (*c*) monoammonium phosphate in the drinking water.

Earlier experiments between 1931 and 1935 had indicated that the disease, which is associated with abnormally low amounts of phosphorus in soils and pastures, was a manifestation of phosphorus insufficiency and could be prevented by the administration of phosphatic supplements. The present trial has been in progress for over two years. To date, it has become apparent that the disease has not been prevented by these means and that there is little significant difference in weight gains between the controls and the treated animals. The reason for the unpredicted trend of the results is not yet clear, but it appears likely now that, although hypophosphorosis is undoubtedly associated with peg-leg, it is not the only factor concerned. During the course of these trials, the animals have undergone two epidemics of ephemeral fever which have disturbed the experiments considerably and caused the deaths of some animals. The experiment will terminate during 1940, when the results will be finally assessed.

(*b*) *Anaplasmosis.*—Observations carried out in co-operation with officers of the Queensland Department of Agriculture and Stock stationed at Townsville, were continued during the year. Normal, uninoculated cattle have been kept tick-free in an enclosure in close association with others carrying the blood parasites of the tick fevers. Precautions have been taken to prevent the introduction of ticks by keeping a moat surrounding the enclosure clean and full of a lethal fluid, as well as feeding the animals on fodder produced in Victoria, a tick-free area. None of the normal, uninoculated animals has shown the presence of parasites in the blood, but towards the end of the year one of the inoculated animals showed the presence of *Anaplasma centrale* after a residence in the enclosure of two years eleven months. It is not possible to prove that the infection was conveyed by winged insects. The matter is still under investigation.

3. *The McMaster Animal Health Laboratory.*—(i) *Parasitological Investigations.*—(*a*) *The Effect of Administration of Iron, Copper, and Cobalt on Hæmonchosis.*—The experiments referred to in the last report were continued and brought to a conclusion in December, 1938. A complete analysis of all the results has still to be finalized, but it can be said that the administration of

these mineral supplements did not favorably influence the course of progressive hæmonchosis. Previous observations that " resistance " to hæmonchosis could be broken down by placing the sheep on a " poor " diet were confirmed during the course of the experiment.

(*b*) *Efficiency of Anthelmintics against Immature Hœmonchus contortus.*—It was announced in the last report that copper sulphate and carbon tetrachloride were virtually ineffective against the immature forms of this parasite. Further experiments carried out during the year have shown that mixtures of copper sulphate and sodium arsenite, or copper sulphate and nicotine sulphate, were only fairly efficient against immature Hæmonchus. These findings not only serve to explain the apparent failure of treatment in certain outbreaks but re-affirm the necessity for transferring sheep to spelled pasture and for repeated treatments.

(*c*) *The Effect of Nicotine Sulphate* (*as Black-leaf* 40) *on Hœmonchus contortus.*—It was suggested by certain overseas workers that nicotine sulphate might be more effective than copper sulphate in bringing about reflex closure of the œsophageal groove in sheep. Trials carried out at the abattoir did not support this view. In addition, sheep, heavily infested with *H. contortus*, were treated as follows :—Twelve were given nicotine sulphate (as black-leaf 40) by the mouth, with partial success in only four cases. Four sheep were given a similar dose into the rumen without success in any of them. Six sheep were given a similar dose by the mouth, immediately preceded by a dose of copper sulphate which was sufficient to induce closure of the groove but was too small in itself to have any anthelmintic effect—treatment in these sheep was highly effective in each case. It appears, therefore, that nicotine sulphate is effective only when it passes direct to the abomasum and that it does not, of itself, induce reflex closure of the œsophageal groove.

(*d*) *The Development of Resistance to Hœmonchus contortus.*—An attempt was made to determine at what stage of the parasites' development within the host the animal's resistance was manifest. Resistant sheep were dosed with infective larvae, and were killed later at various intervals. No developing worms were found in sheep killed six days and ten days after the administration of larvae, and no larvae were found in the faeces of the sheep during the three days following their administration. It appears, therefore, that so far as this species is concerned, the host's resistance overcomes the parasite before the sixth day of its existence in the alimentary tract.

(*e*) *Treatment of Trichostrongylosis.*—A large number of sheep have been treated against *Trichostrongylus* spp. Recently anthelmintics have been administered by injection direct into the abomasum, not as a practical measure, but with the object of ensuring that the drugs in high concentration will come into contact with the parasites. When a preliminary dose of copper sulphate is used, drugs given by mouth may in certain cases pass to the rumen in as many as 25 per cent. of animals. The use of drugs in emulsions is also under investigation. The results of these trials may be summarized as follows :—Oil of turpentine in tylose emulsion was not efficient. Oil of cheropodium in tylose emulsion was not efficient and produced toxic effects. Carbon bisulphide in tylose emulsion showed encouraging efficiency. Tetrachlorethylene (i) in tylose emulsion, (ii) in a compound emulsion recommended by Monnig, or (iii) mixed with liquid paraffin, showed useful efficiency. Black leaf 40 (40 per cent. nicotine sulphate) and pure nicotine sulphate gave disappointing results. A mixture of copper sulphate with black leaf 40 gave satisfactory efficiency. It appears that tetrachlorethylene is a useful anthelmintic against *Trichostrongylus* spp., provided it enters the abomasum direct. Whether the use of this drug in an emulsion will give more satisfactory results than as a simple solution in liquid paraffin is not yet certain.

(*f*) *The Effect on Trichostrongylosis of Licks Containing Tobacco.*—A proprietary tobacco preparation, containing about 10 per cent. of nicotine, was administered to sheep both in the form of a lick mixed with salt and to individual sheep by daily dosing with a spoon. By neither of these methods had the preparation any effect in checking the development of Trichostrongylosis. This serves to confirm previous findings that tobacco preparations in lick forms, even though the nicotine content may be relatively high, are of no value in the prevention or treatment of Trichostrongylosis.

(*g*) *Treatment of Oesophagostomiasis.*—The possible effect of purgation on the mechanical elimination of oesophagostomes from the colon of sheep was investigated. Sodium sulphate induced copious purgation but failed to remove the worms. Arecoline hydrobromide in doses varying 0.06 to 0.5 grains failed to purge the sheep, and the larger doses caused marked salivation and griping. Lentin (Merck) was used in a trial at Armidale and proved to be a very efficient purgative, but it failed to remove other than a very small proportion of the worms present; moreover, it caused the death of several sheep. It may be noted also that Lentin was quite ineffective against *H. contortus* and *Trichostrongylus* spp. Further trials with Monnig's copper arsenate-copper tartrate powder gave very inconsistent and generally unsatisfactory results. Towards the latter end of the year, trials were commenced with phenothiazine and highly promising results were obtained (*see* section (*j*) below).

(*h*) *Outbreak of Oesophagostomiasis at Mittagong, New South Wales.*—This was a severe outbreak in an area not previously considered to be subject to this disease, and its investigation gave much interesting and valuable information. The occurrence served to emphasize the need for a more detailed survey of the distribution of this parasite (and other helminths), and for further knowledge of the climatic and geographic conditions which favour the occurrence of oesophagostomiasis in districts other than those in which it is at present known to be endemic.

(*i*) *The Pathogenicity of Nematodirus Species in Sheep.*—The difficulty of procuring adequate supplies of infective larvae for this work has been overcome during the year through the discovery of a relatively simple method for separating nematodirus larvae from the larvae of other species of nematode present in the sheep from which faeces are obtained (particulars of the method are in the press). As a result it has been possible to infect groups of sheep respectively with massive and light doses of nematodirus larvae. Two sheep, which received doses of 2,000 to 5,000 larvae, died, but others receiving smaller doses are as yet unaffected. The work is continuing ; the present evidence suggests that it is only under conditions of relative malnutrition that these parasites are ever of serious consequence.

(*j*) *Anthelmintic Value of Phenothiazine.*—The observation in America that the larvae of the horn fly (*Lyperosia* sp.) failed to develop in the faeces of cattle which received a comparatively small dose of phenothiazine focussed attention upon it as a possibly valuable anthelmintic. Preliminary trials have shown that it is of great potential value in the treatment of oesophagostomiasis and is highly efficient against *H. contortus*. Work is now in progress to determine the effective dose rate, the most suitable methods of administration, and the various species of helminths in different animals against which it is of value. The drug has a number of features which make it peculiarly suitable as an anthelmintic for ruminants. It is cheap, tasteless, and relatively non-toxic, and there is good reason to believe that with suitable doses it may be effective against oesophagostomes even though it enters the rumen. Chemical methods are being evolved to enable the rate of passage of phenothiazine through the alimentary tract to be determined, so that the dosage may be calculated on a factual rather than an empirical basis. An account of preliminary trials of its efficacy against oesophagostomiasis and haemonchosis is in the press.

(*k*) *Studies on the Recovery of Parasite Larvae from Soils and Pastures.*—The need for some reliable method of determining the degree of infectivity of pastures which have been grazed by worm infested sheep, and more particularly the rate at which the infectivity of such pastures declines, is such that work on the problem has been carried on as intensively as possible throughout the year. No less than 29 different groups of experiments have been made, their main purpose being to discover a technique which will give consistent results under standardized conditions. Latterly, a method has been evolved which is a great advance on anything attained previously. It is hoped to confirm these results and to publish details of the method in the near future. Another phase of this work which promises interesting and potentially valuable information concerns the effects of light and moisture on the numbers of larvae present on grass blades. These experiments, however, are not yet far enough advanced for any conclusion to be drawn.

(*l*) *Parasitological Field Trial at F. D. McMaster Field Station.*—The purpose of this trial was to discover the effect on the worm burden of sheep grazing at the rates of three sheep to the acre and one and a half sheep to the acre on natural pasture. Unfortunately, the dry conditions prevailing during the course of the trial did not favour the development of heavy infestations. Nevertheless, the trial revealed certain points of interest. Most of the sheep developed a considerable degree of resistance to haemonchosis, but there was a significantly larger number which failed to become resistant among the groups stocked at the heavier rate. Whereas the group running at the rate of three sheep per acre grazed their paddock evenly, the group at one and a half per acre concentrated their attention to about one-third of their paddock, leaving the balance almost untouched ; thus while nominally running at one and a half per acre they were actually grazing at the rate of about five sheep per acre on selected areas. Areas that are selectively grazed by sheep in this manner may become " danger areas " from the point of view of parasitic infestation, and their significance can readily be overlooked on country which appears to be lightly stocked. This point requires stressing because, although it is a relatively common occurrence, pastoralists as a whole are not sufficiently aware of its significance. It serves also to emphasise the essential part which pasture management and sheep husbandry must play in the control of parasitic diseases.

(*m*) *Field Trial at " Frodsley," Tasmania.*—This trial, on the effect of continuous intensive grazing of improved pastures on the worm burden of sheep and of repeated drenching as a means of control, was commenced in February, 1938, with two groups of 80 Corriedale weaners, each group being maintained in rotation on four plots of five acres each. Complete records are being kept, and a detailed report will be published in due course. During the first year of the trial there was no significant difference in body weight or wool production between the drenched and undrenched groups. The degree of parasitic infestation has remained relatively low in both

groups throughout, but the graphed results of periodic faecal egg counts and larval cultures indicate that drenching has been beneficial in this respect. The sheep have now been mated, and it will be of considerable interest to note the effect of the strain of pregnancy and lactation on their apparent resistance to internal parasites. Hay is constantly available to both groups, and interesting data are accumulating concerning the amount consumed in relation to the state of the pastures. The sheep have now been on these plots continuously for sixteen months and are in excellent condition. The assistance which is being rendered in this trial by the owner, Mr. Keith Brodribb, and officers of the Tasmanian Department of Agriculture is greatly appreciated.

(*n*) *Parasitological Investigations at Armidale.*—(i) *Epidemiological Trials.*—Two epidemiological trials are under way, and weekly examination of faeces from sheep in these trials is being carried out to estimate the rise and fall in the numbers of different nematode species so that they may be correlated with the seasonal and meteorological conditions. The trials will be continued over several seasons. Up to the present they have indicated that there are two critical periods for internal parasitism of sheep; one of these occurs immediately following the cessation of frosts, when *Hæmonchus contortus* infestations increase rapidly. As this period in New England generally occurs a month or so before lambing, it indicates the necessity for adopting pre-lambing treatment of ewes in order to reduce the exposure to infestation among their progeny. The second critical period is at or about weaning time, when infestations with Trichostrongyles tend to increase, thus indicating the special need for treatment against these parasites prior to weaning. Interesting observations are being made on the survival in faeces of the eggs of the common species of nematodes of sheep, under varying conditions of climate. (ii) *Trial Concerning Control of Hæmonchus Infestation by Winter Treatment.*—It was thought possible that treatment during the winter months might go a long way towards eliminating trouble from haemonchosis during the spring, but this trial showed that, while the treatment greatly reduced the degree of infestation during winter, there was sufficient residual infestation to cause heavy infections when the warmer weather supervened. A repetition of the trial will be carried out during the present winter, but in this instance the experimental animals will be divided into two groups, one of which will be retained on the same pasture throughout, while the other is rotated at three-weekly intervals between two comparable pasture areas. It is believed that the combination of winter treatment and rotation may serve to reduce residual infestations to such an extent as to obviate heavy increases in infestation during the spring. (iii) *Winter Treatment of Oesophagostomiasis.*—The trial concerning eradication of oesophagostomiasis by winter treatment involved two groups of two-tooth wethers, one of which was treated twice during the winter of 1938 by the sodium arsenite enema method, the other being treated four times during the same period with the powder composed of copper arsenate, copper tartrate, and calcium hydroxide, which has been claimed to be effective in South Africa. A small group of control, untreated sheep was kept. The enema treatment proved more effective than the powder for the removal of *O. columbianum*, but it yet remains to be seen whether the reduction in the degree of parasitism which was brought about in this way has been sufficient to preclude a recurrence of heavy infestations during the present winter. (iv) *Eradication of Limnea brazieri (the Fluke Snail).*—Two trials are under way concerning the eradication of *Limnea brazieri* (the intermediate host of the liver fluke). Selected snail-infested swamp areas were carefully treated by spraying with copper sulphate in July-August, 1938, and have been inspected carefully at monthly intervals since then. To date, one area has remained free, but in the other some degree of re-infestation has taken place. Preliminary observations are now being made in conjunction with the zoologist of the University College, Armidale, to determine the breeding season of *Limnea brazieri* under the climatic conditions obtaining in New England, in order that the treatment of swamp areas may be carried out at the most favorable season for a complete kill of snails. (v) *Survey of Internal Parasitism of Sheep.*—In conjunction with the District Veterinary Officer of the New South Wales Department of Agriculture and the Inspectors of Stock throughout his district, a survey is being made of the occurrence of internal parasitism of sheep. All outbreaks which are reported are now being recorded, and their occurrence will be correlated, if possible, with seasonal and climatic conditions.

(ii) *Studies on Fleece Chemistry.*—Studies have been continued to determine the variations in the fleece constituents of normal sheep, which result from seasonal and nutritional changes and advancing age. In addition a collection of suitable samples has been made to study comparatively the fleeces of sheep which are very susceptible, and relatively insusceptible, to blowfly attack. The work so far accomplished has dealt with normal fleeces, and the estimations which have been carried out have concerned the wool fibre, wool wax, suint, and " dirt ".

(*a*) *The Wool Fibre.*—The production of wool fibre on different areas of the body is being estimated, and it is hoped that a method may be developed by which both the fleece weight and the scoured weight of the fleece of any animal can be calculated from a small sample. The yield of each fleece sample is being determined.

(*b*) *The Wool Wax.*—This is a complex mixture of substances, and over 70,000 tons of it are produced every year in the Australian clip; yet it is of so little value that the bulk of it is not recovered from the wool scouring liquors. Following studies concerning the production of wool wax on different areas of the body surface, and variations resulting from seasonal and other factors, a detailed chemical analysis of the wax and its several ingredients is now under way. The fact that some of the constituents of wool wax have unusual chemical characteristics which may give them an economic value, while others, such as cholesterol, would have a wide market if cheap methods for their recovery could be evolved, is not being overlooked.

(*c*) *The Suint.*—This is a complex mixture in which all the ingredients have not been identified, but an investigation into their composition is now proceeding. The total amount of suint produced in the Australian clip is about 20,000 tons annually. The only constituent yet known which has any potential value is potassium. About 10,000 tons of potassium carbonate could be recovered from the annual suint production of Australian sheep. Some studies to determine whether certain nitrogenous ingredients of the suint are produced by special skin structures have been commenced.

(*d*) *The "Dirt".*—Investigations have shown that there is a small amount of material which is of a protein nature in the fleece fraction commonly referred to as "dirt". Although present only in small amounts it may be of importance in connexion with susceptibility to blowfly strike, since it has been shown at Canberra to have some nutritive value for blowfly larvae.

(*e*) During the year a large number of fleece analyses have been carried out, and a series of 200 samples has been collected from sheep whose susceptibility to blowfly strike on the body and breech is known in detail. These now await analysis. Other samples have been taken to determine the effect of age and season on the fleece constituents. A mass of results from this work is now ready for collation and interpretation. A review of work on the chemistry of the fleece, including the earlier sections of the work at the McMaster Laboratory, has been prepared and now awaits publication.

(*f*) As a result of the fundamental studies which have now been made on the chemistry of the fleece and its constituents, two suggestions that may be of practical importance have been put forward. The first is that for the purpose of reducing the incidence of "fleece rot"—a condition predisposing to blowfly attack on the body—and to reduce the amount of "wasty tip"—a condition which is said to reduce the commercial value of the fleece considerably—emulsified oils should be sprayed along the back, which is the portion of the sheep most liable to be affected. Some oily dressings have been made and are being tested on sheep at Gilruth Plains and in Sydney. The second suggestion is that a number of substances should be tested as jetting agents, such as the salts of lead, copper, barium, and zinc. These salts, besides being toxic to maggots, would react with the suint and greatly reduce its marked ability to take up moisture from the atmosphere. They should thus have a drying effect upon the jetted area which would be inimical to the development of blowfly larvae.

(*g*) Throughout the greater part of the year, work has been proceeding in connexion with a new process to prevent shrinkage and felting of woollen goods, which was discovered by Messrs. M. R. Freney and M. Lipson. Tests carried out in the laboratory have given striking results, the degree to which shrinkage and felting is prevented comparing very favorably with that obtained by Hall's sulphurylchloride process.

(*h*) *Studies on the Physical Characteristics of Wool.*—The physicist recently appointed for this work commenced duty towards the end of April and since then has spent a good deal of time in familiarizing himself with the special techniques required, and in acquiring and devising suitable apparatus. Tests carried out on a yarn testing machine kindly made available by Carpet Manufacturers Ltd., Fivedock, have shown that yarns made from wool treated by the method mentioned above for rendering wool unshrinkable, are more extensible and have a slightly higher breaking strength than untreated yarns. Treated and untreated yarns have also been tested under an oscillating stress which simulates in some degree the sort of stress and strain that materials made from such yarns would incur. In these tests the treated yarns have always been superior to untreated yarns, resisting two or three times the number of stresses that will tear normal yarns. Studies of the breaking points of individual fibres are under way, and a machine for the purpose has been devised and built. It is found that wool fibres generally possess several weak points along their length and that the portions remaining after successive breaks show an increase in apparent strength. Treated fibres are not substantially stronger than untreated ones, which tends to support the tentative view that the greater resistance of treated yarns is due rather to increased friction between the fibres composing them than to increased strength of the fibres themselves.

(iii) *Studies in Wool Biology.*—Mr. H. B. Carter, Walter and Eliza Hall Research Fellow in Veterinary Science of the University of Sydney, has had the hospitality and facilities of the McMaster Laboratory during the year. He carried out intensive studies on the growth and development of the wool follicles from early foetal life onwards, making valuable progress in this work and also in studies of the relative density and distribution of wool over the body surface.

(iv) *Studies on the Blowfly Problem.*—(*a*) *The Mules Operation.*—The trial at "Dungalear" concerning the efficacy of this operation in reducing the incidence of crutch strike is still under way. The experimental sheep were shorn in August, 1938, and the results up to that date have been published in the Council's Journal. Briefly it may be said that the operation reduced the incidence of crutch strikes (including those of doubtful origin) to about one-thirteenth of the number incurred by the control group. On examining the few treated sheep which were struck on the crutch or breech it was found that nearly all required slight additional treatment. When this was carried out and the results were taken from the time these re-treatments were completed, it was found that the incidence among the treated sheep had been reduced to less than one-thirtieth of that among the controls. Advantage was taken of the data available at shearing time to assess the effect of fly strike on wool production and body weight. A full account will be published shortly; in this flock, the usual fly strike incidence reduced the wool clip by approximately 2.5 per cent. irrespective of wool lost when strikes were dressed in the paddock. Interesting data were also obtained to show that it is the size rather than the number of strikes which is of most significance, and that in assessing the inherent merits of plain and wrinkly sheep as wool producers, it is essential to consider only those sheep which have not been struck. The experimental group has now been mated, and a continuous record of strikes is being maintained so that information can be procured regarding the effect of fly strike on conception, lambing, and lactation. The great assistance given us in this trial by the Manager of "Dungalear," Mr. Makeig, and his staff is very much appreciated.

(*b*) *Experimental Blowfly Dressing.*—The dressing referred to in the last report has been tested under field conditions. The results show that it compares well in efficacy with the glycerine diboric dressing, but it has the advantages that it is a great deal cheaper and is easier to apply, since it soaks rapidly through the wool about the struck area. A full report of all trials is under consideration by the Inter-divisional Committee on Veterinary Entomology.

(v) *Investigations on Ecto-parasites of Sheep and Sheep Dipping.*—It was originally intended to carry out dipping trials simultaneously with studies of the habits and life-histories of the ecto-parasites which dipping is intended to control. A thorough review of the literature reveals the fact that the available information about the sheep tick (*Melophagus ovinus*) and those species of lice commonly found on sheep, is extremely scanty. It was also apparent that a soundly planned investigation of the problem could only be based on a proper knowledge of the parasites involved, and that, in consequence, entomological studies on sheep ticks and lice were first required. This work is time-consuming, because the sheep tick not only multiplies slowly but is very difficult to maintain alive under artificial conditions. It is probably for these reasons that previous investigators have abandoned their efforts. During the past few months, definite headway has been made, and latterly the New South Wales Department of Agriculture has helped materially by procuring certain supplies of tick pupae from Stock Inspectors. The following information has been obtained from the preliminary studies :—

(*a*) *Duration of the Pupal Stage.*—Observations have been made on pupae in the wool of living sheep and on others kept in the laboratory. Of 100 pupae used in the tests, 63 emerged, 59 coming out on the 19th to 22nd days, and the remaining four on the 24th day. These observations were carried out during February, March, and April, and of thirteen pupae which failed to emerge, eleven occurred in February (out of 32), whereas in March and April only two failed to emerge (out of 31). During February the weather was excessively hot, whereas it was cooler in March and April. These observations are being continued.

(*b*) *The Effect of Temperature and Humidity on Tick Pupae.*—Using groups of 56 pupae of mixed ages, and with no regulation of humidity, it was found that none emerged at 40° C.; two emerged during the first three days at 37° C. but none thereafter; at 30° C. and 20° C. nineteen and sixteen emerged, respectively, up to the 21st day, while at room temperature (15–22° C.) a total of 44 emerged, the last to come out being on the 32nd day. Thus constant temperatures as low as 30° C. and 20° C. without control of humidity, appear to have an adverse effect upon pupae, and while the number emerging at a room temperature of 15–22° C. was fairly satisfactory, the pupal stage lasted, in some cases, about ten days longer than had previously been recorded.

Another test was carried out using freshly deposited pupae and controlling both temperature and humidity. At 37° C. with 90 per cent. and 70 per cent. humidity, none emerged out of a total of 33 pupae exposed. At 30° C. and 90 per cent. humidity, only six emerged out of twenty, whereas at 30° C. and 70 per cent. humidity, twenty emerged out of 21, after the usual period of 19–22 days. If further observations confirm this result, 30° C. and 70 per cent. humidity can be adopted as the standard conditions for testing the viability of pupae in dipping trials, and also for hatching supplies of ticks for experimental purposes.

(*c*) *Sexual Maturity.*—Observations have shown that females, known to be from three to four days old when placed with males for 24 hours, are capable of being fertilized.

(*d*) *Length of the Gestation Period.*—Observations of some 50 females have shown that the interval between the depositing of successive pupae is generally seven days, and occasionally eight days. Only one pupae is deposited at a time, but a single act of copulation suffices for the production of several pupae. In one trial, three females produced four pupae each, at seven day intervals, without recourse to the male, and the pupae all hatched normally.

(*e*) *Longevity of Female Ticks.*—Considerable difficulty arises in assessing this, since ticks die in a few days if removed from the sheep, and if a number are placed on a clean sheep they tend to disappear. Attempts are being made to discover their fate ; a special cage has now been constructed for this work.

(*f*) *Migrations of the Tick upon the Sheep.*—Ticks move about considerably over the body and fleece of the sheep, and if any attempt is made to confine them to a given area, for purposes of observation, they soon die. The reason is obscure, and as a first step towards understanding it, the movements of a number of ticks on different sheep are being recorded. Most of the pupae are deposited on the underside of the neck in front of the brisket, though a few are found on other parts of the body. This latter point has a practical bearing inasmuch as the wool in front of the brisket is commonly left half an inch or more in length at shearing and, in consequence, many pupae which would be removed with the wool if they had occurred elsewhere on the body, are left attached to the lower neck wool on the sheep. Observations on these lines, and others of a similar type, are being continued throughout the year to note the effect of seasonal changes, and, on the information already obtained, laboratory tests of the effect on hatchability of pupae will be carried out with a variety of dipping reagents.

Before the need for these preliminary studies on the sheep tick was fully realized a number of chemical analyses of dipping fluids had been carried out. Their main purpose was to determine the rate at which arsenic is removed from arsenical dipping fluids by the fleeces of the sheep which pass through it, and also to select some suitable dipping fluid as a standard with which others could be compared.

The definite progress which has been made this year with regard to the Division's knowledge of the sheep tick is encouraging and will greatly facilitate further work on this important problem.

(vi) *Foot-rot Investigations.*—Investigations during the past year, both at the laboratory and in the field, have been devoted mainly to the study of the organism " K " which is the essential cause of the ordinary contagious type of foot-rot. Laboratory experiments have provided further information on the conditions most suitable for the growth of the organism in artificial culture and have clearly shown that the " K " organism should not be classed as one that is highly pathogenic for sheep. It produces no disease when introduced in large quantities into the blood stream of healthy sheep, and it has been possible to establish it artificially only on the feet and at the base of the horn of the head, by scarification and the application of infective material. The presence of bacteria, other than " K ", appears to assist " K " to become established in the tissues and thus cause foot-rot, and the role played by these other organisms is being studied. The development of the infection and the sequence of changes produced in the feet have been noted in small experimental plots at the McMaster Laboratory, and the results thus obtained have proved valuable when applied to field work. A comparison of strains of the " K " organism, gathered from three States, indicates that, although they all set up the same disease, they show certain differences which tend to lessen the hope of obtaining a vaccine which will be active against all strains. The results of preliminary experiments suggest that it may be very difficult, or perhaps impossible, to immunize sheep by any practicable method of vaccination.

For the greater part of the year, field work has been hampered by the drought which prevailed in New South Wales and Victoria. Nevertheless, sufficient reliable evidence has been obtained to support the contention that clean sheep placed on suitably spelled pastures will not develop the common contagious type of foot-rot, whether these be highly improved pastures under irrigation or dry farming methods. It has now been put into practice on several properties where the elimination of all carriers and spelling of pastures has led to complete freedom from the disease, while on other properties in the same districts, but where no such measures had been put into operation, foot-rot was as prevalent as usual when the seasonal conditions were suitable. More definite evidence regarding the time of survival on pastures of the organism " K " should soon be forthcoming, so that plans for eradication at all times of the year may then be evolved. Foot-rot re-appeared in areas which received adequate rain after a prolonged drought. This was due to renewed activity of infections in the feet of " carriers " and the purchase and introduction of sheep from other areas.

In districts where the rainfall was excessive another type of foot lameness (or foot-rot) became very prevalent. As a result of studies of this condition made in the autumn of 1939, it became apparent that much of the confusion that has arisen in the past with regard to the cause of foot-rot is due to the fact that, whereas the " K " type of contagious foot-rot is present to a greater or less degree every year in certain areas, seasons similar to the autumn of 1939 lead to the occurrence of many cases of pus formation under the horn of the hoof and about the coronet. This latter is not caused by the " K " organism but by one or more of the common pus producing bacteria. Both types of infection may co-exist on the same property, and it is readily understandable that in the past these two distinct diseases have often been regarded as different manifestations of a single disease.

(vii) *Studies on Pregnancy Toxaemia of Ewes.*—The experiments referred to in the last report concluded with lambing of the ewes in July-August, 1938. Attempts to induce typical pregnancy toxaemia were unsuccessful, but several cases of illness were caused in the groups subjected to low planes of nutrition. Considerable interest attaches to these results, since they have served to show that where pregnant ewes are undernourished, a condition may arise which could well be mistaken for pregnancy toxaemia. Moreover, it was shown by biochemical examination of the blood and urine of ewes throughout pregnancy, that the levels of blood non-protein nitrogen and sugar tend to fluctuate as parturition approaches. If the ewe is starved at this period, these fluctuations are accentuated and a ketosis occurs, not necessarily accompanied by symptoms of pregnancy toxaemia. It thus appears that the ketosis which has been regarded by many workers as the essential feature of pregnancy toxaemia may be merely incidental. Opportunities are being sought to study more typical outbreaks of the disease than were available last year, and work is proceeding in the laboratory on certain of the endocrine secretions and dietary abnormalities which, either singly or together, may give a clue to the true nature of the disease. The New South Wales Department of Agriculture will again assist by notifying the Division of suitable outbreaks for field observations, and the Victorian Department of Agriculture has kindly offered facilities at the State Research Farm, Werribee.

(viii) *Field Trials.*—(*a*) *Rugging.*—The trial at " Brae Springs " was terminated last shearing. The second year of the trial confirmed the fact that, under the conditions of moderate temperatures, light rainfall, and relative absence of dust and burrs which pertain in that locality, rugging was not an economic procedure. Another trial is under way at Saumarez, Armidale, and is being conducted in co-operation with the New South Wales Department of Agriculture. It aims to determine if rugging aged ewes assists them to withstand the rigorous winter conditions, and to bear and rear a lamb. One group is rugged throughout the year and the other for the winter months only. Another phase of this trial is the rugging of weaners and its possible effect on their general wellbeing and consequent ability to resist infestation with worms.

(*b*) *Caseous Lymphadenitis.*—Two of these trials were terminated during the year. The Wambrook trial included the use of rugging off shears and the placing of newly shorn sheep in paddocks which had been spelled and contained a good pasture cover to prevent soil contamination of shear cuts. The trial was terminated because the incidence of caseous lymphadenitis was somewhat low in both experimental groups and controls, and the dry conditions which prevailed were unsatisfactory. The trial at Hartwood also concerned the placing of newly shorn sheep in spelled paddocks with a good cover of pasture, but had to be abandoned because drought made it impossible to provide a suitable paddock. The trial of rugging off shears until shear cuts have healed, as a means of preventing infection, which was commenced at Murrundi in 1937, is still proceeding ; results will be available in 1940. The trial at " Noondoo ", of vaccination as a means of control, gave results which suggest that some measure of success was obtained.

(*c*) *The Effect of Grazing Superfine Woolled Sheep on Improved Pasture.*—The trial at " Merryville " was abandoned after the November shearing, the reasons being that drought conditions had prevailed over two seasons. The co-operative trial at " Valley Field ", Tasmania,

was conducted by the Tasmanian Department of Agriculture. The results of the first year's observations have been published by the Tasmanian Department, and were very similar to those obtained during the early stages of the " Merryville " trial previously reported.

4. *The F. D. McMaster Field Station.*—(i) *General.*—Progress has been made with the programme of establishing permanent improved pastures. Approximately 70 acres reached their second year and 50 are in their first year. Attention was given to sub-divisional fencing of approximately 1 mile in length, clearing of 40 acres of stumps, and conservation of fodder in the form of meadow hay, of which 77 tons were cut. Advice was received on afforestation and a programme of work was prepared. The Station was equipped with meteorological instruments for the collection of data essential in the experimental work. At the end of the year 856 sheep were on hand, 7 horses, and 27 heifers on loan to control rough grazing. The machinery shed was extended and an electric motor installed for shearing.

(ii) *Fertility of Sheep.*—A stage was reached in the experimental observations on the periodicity of oestrus in certain Australian Merino ewes and a cross-bred group which enabled publication of preliminary results. These continuous observations on four groups of sheep showed a well defined periodicity in the percentage number of ewes coming into heat which was distinctly seasonal. The results apply strictly to the locality of the field station. The investigation, including a study of the environmental factors associated with the periodicity, is being continued. Similar Merino ewe groups were established at Hughenden (Queensland), Cunnamulla (Queensland) and at Launceston (Tasmania). Dissimilar Merino sheep were grouped for observation at Burketown (Queensland) and Hughenden (Queensland). In addition, pure-bred groups from the Camden Park Estate Merino flock, the Austin Wanganella Peppin-bred Merino flock, the Walker Estate Border Leicester flock, the New South Wales Department of Agriculture's Wagga flock of Dorset Horned, and a cross-bred Border Leicester x Camden Merino group were placed under observation to determine any genetically controlled differences in occurrence or periodicity of oestrus. Further, in association with the Economic Branch of the Bank of New South Wales a questionnaire was sent to the Manager of every Branch of the Bank within the sheep breeding areas of Australia. This seeks information with regard to breeding practices in each locality.

(iii) *Inheritance of Colour in Sheep.*—From the co-opted flocks it was learned that, among 8,564 ewes, 7,371 lambs, of which 40 were noticeably coloured (0.5 per cent.), were dropped. The first experimental mating of the Station coloured flock resulted in 12 lambs. Their sire was wholly white. Notwithstanding that all the dams were coloured, wholly or in part, not one of the lambs showed coloured wool, and in all cases pigmentation was confined to their eyelids, ears, and hooves. A wholly black ram was mated in the autumn with white ewes, and the coloured ewe flock was mated with another white ram of Austin Wanganella blood. Among samples representing the wool shorn from the Station flock of 68 coloured sheep we were unable to find a homogeneous black specimen. Two classifications are necessary to arrange the samples, one with regard to heterogeneity and one with regard to intensity of colour, and each character has a wide range of variability.

(iv) *Inheritance of Wrinkling in Merino and Cross-bred Sheep.*—This investigation is planned to determine the specificity of genetic factors which give rise to wrinkling in any area and the change of fibre population which is inherently associated with the degree of general or local development of skin folding. Progeny are awaited from matings made (*a*) with excessively wrinkly Merino rams (3) of Tasmanian origin and Border Leicester ewes, and (*b*) with excessively wrinkly Merino ewes with the same rams.

(v) *Establishment of an Inbred Flock of Australian Merinos.*—The nucleus of a flock to be inbred to control genetic variability in critical experiments with small numbers of animals was secured. One hundred " Boonoke " stud ewes and one ram were mated. Among the progeny, fleece and other characters will be recorded and their inheritance investigated.

(vi) *Inheritance of Horns in Merino Sheep.*—Certain stud Merino breeders have discussed the advisability of establishing polled strains. Accordingly, an inquiry was commenced into the method of the inheritance of horns in sheep. For this purpose, the Station is indebted to Messrs. F. S. Falkiner & Co. for 50 polled ewes and a polled ram. These sheep are in the first filial generation and have been again mated.

(vii) *A Genetic Study of the Jersey Breed of Cattle in Australia.*—Unfortunately, with the present staff few opportunities have arisen for laboriously detailed abstracting. This investigation, therefore, was not particularly advanced during the year. The system of randomization has been worked out, and the first three sample volumes of the herd book have been abstracted for skeleton pedigrees.

(viii) *Zebu Hybridization.*—The experimental herds in Queensland were visited in July, 1938, and the third progress report was presented in August ; it includes additional observations, and shows that, broadly, the results after four and one-half years of breeding may be regarded as

highly promising. It has been demonstrated that the hybrids are very much better adapted to the northern environment than British breeds, that carcases carrying as high as 50 per cent. of Zebu blood compare favorably with those wholly British-bred animals reared under similar conditions, and that finished hybrid carcases can be produced approximately twelve months earlier than from British breeds at equal weights. The question of temperament, however, still remains a limiting factor to the general utilization of the hybrid, and its investigation is regarded as most important.

(ix) *Co-operative Work.*—In addition to the investigational work centred at the Station, assistance has been given to officers of the Division stationed at the McMaster Laboratory. For the purposes of an investigation into pregnancy toxaemia in ewes, 115 ewes were cared for on the Station, 90 sheep were maintained for parasitological observations, a lamb breeding flock to supply experimental lambs for parasitological work was maintained, sheep for periodic fleece sampling and dipping experiments were also maintained, and 150 ewes were mated in connexion with observations on the fertility of rams.

5. *The Animal Nutrition Laboratory, Adelaide.*—(i) *General.*—Additional accommodation for experimental animals and alterations to the laboratory were completed during the year. Through financial assistance from the Australian Wool Board, work concerned with nutritional principles of drought feeding and with the effects of nutrition on wool production was extended. A start was made on a comprehensive study of the comparative nutritional values of various grains which might be used for hand feeding sheep. A start was also made with a study on the influence of adverse nutritional environment during growth and development on the wool-producing propensity of the sheep.

(ii) *Phosphorus Metabolism of the Sheep.*—(*a*) *" Wambanumba," Young, New South Wales.*—The observations have extended over another year and still indicate that giving sheep an extra supply of phosphorus, equivalent to practically their total requirements, exerts no beneficial effects on their general health or productivity, in spite of the fact that the soils in this area contain a singularly small concentration of phosphorus. No significant difference has been observed to exist, over the total period of growth of the sheep, between the mean body weights of the group receiving extra phosphorus and the controls. The results of a detailed study of the fleeces taken at two consecutive shearings show that the wool production has been influenced neither in quality nor in quantity by the phosphatic supplement. Further, there was no significant difference observed between the number of lambs dropped by either group. The observations will be continued over a second period of gestation, and the growth of the second drop of lambs will be studied until they are weaned at six months of age. In order to render the series of observations more complete, an experiment was initiated to study the effects of a phosphatic supplement on the growth of young lambs confined to the more ideal nutritive conditions afforded by sown pastures.

(*b*) *Penola, South-east of South Australia.*—An investigation, similar to that conducted at Wambanumba, has been in progress at Penola since the experimental ewes were weaned in January, 1938. Observations over this period indicate that a considerable additional supply of phosphorus in the form of dicalcic phosphate exerts no significant effect on the growth rate or on the amount and quality of wool produced. The studies will be continued over a period of two consecutive matings.

(*c*) *Manuka, Winton, Western Queensland.*—The investigation of the effect of phosphatic licks that was undertaken at Manuka by the Australian Estates Company Ltd. in co-operation with and as part of the programme of trials conducted by the Nutrition Laboratory of the Division has been concluded after three years of observations. Over the whole of this period no significant benefit was observed to follow the procedure of offering phosphatic lick to the flock, although the sheep consumed it freely. Neither the growth rate nor the body weight of the flock receiving extra phosphorus differed significantly from that of the control flock run under the same conditions, in spite of the dry periods which imposed acute nutritional stress. At no time during the three years did the phosphatic supplement achieve an economic improvement, whether this be measured in terms of body weight, of wool quality or quantity, of the percentage of lambs marked, or of the subsequent development of lambs.

(*d*) *Laboratory Investigations.*—The results of a series of laboratory investigations into several aspects of the phosphorus metabolism of the sheep have now been collected for early publication.

(iii) *The Effects of Ingestion of Fluorine by Sheep.*—(*a*) *The Effects of Ingestion of Small Amounts of Fluorine over Long Periods.*—The investigation of the effects which supervene in sheep when their diet contains small quantities of fluorine for a considerable period had been concluded, and the results have been reported in Bulletin No. 121.

(*b*) *The Effects of Intermittent Ingestion of Fluorine.*—The body weight of the group of sheep which have received 120 mg. of fluorine per day in rock phosphate for periods of six months, interspersed by periods of the same duration during which no fluorine is fed, has remained the same as that of the control group. The teeth of the former animals, however, show the lesions associated with the early symptoms of chronic fluorosis.

(iv) *Supplementary and Drought Feeding.*—(*a*) *Comparative Value of Protein Concentrates.*—The study of the comparative capacity of proteins from different sources to supply the necessary substrate for wool growth has been continued. Providing the sheep is not in negative caloric balance, up to 12 per cent. of the ingested nitrogen is recovered as wool nitrogen at the lower intake levels when, as might be expected, the conversion is most efficient. Mixtures of lucerne and wheat proteins or of lucerne and yeast proteins are complementary, and the efficiency of conversion from such mixtures is higher than when any of these proteins are fed separately at comparable levels.

(*b*) *Energy Metabolism.*—The energy balances and wool growth of sheep that have been fed on diets consisting of lucerne in conjunction with wheat straw, and with cellulose, and of wheat, barley, and maize, respectively, have been investigated, and it has been observed that the energy metabolized for maintenance is less when grain is fed than it is when cellulose is the main source of energy. The original energy metabolism chamber has been reconstructed and the apparatus duplicated to deal with the extra determinations involved in the programme of drought feeding investigations.

(v) *Bovine Haematuria.*—The analytical and geochemical investigations in connexion with this disease have been continued. The field work for the year involved visits to Mount Gambier (South Australia) and Pomborneit (Victoria) for geochemical examination and the collection of samples of soil, fodder, and other relevant material. The geochemical aspects of the problem at Pomborneit have proved of exceptional interest, as they show, in intensified form, the characteristics which, in the majority of instances, appear to be typical of areas where haematuria vesicalis is enzootic. The fact that the development of haematuria in cows at Pomborneit appears to be more rapid than at the other localities studied may, therefore, be of some significance when taken in conjuction with the geochemical evidence. The apparently specific and preferential association of most areas of enzootic haematuria with certain regions of extrusive or scoriaceous volcanic rocks of basaltic facies has been the basis on which the geochemical investigations have been made. The chemical analysis of soils, pastures, and animal products have been augmented, as before, by the spectrographic examinations made by the Division of Soils.

The analytical work has been directed more especially towards a successive elimination from suspicion of certain elements which are apparently unusual components of the soils, pastures, and tissues from haematuria areas, and which might possibly be contributing factors in the cause of the disease. As the normal range of concentration of many of these rarer elements in biological materials is imperfectly known, progress has been necessarily slow. Barium and gallium, two apparently abnormal components of samples from haematuria areas, have, in this way, been successively eliminated as possible causes of haematuria. Tin and molybdenum, which spectrographic and chemical work have shown to be minor components of the biological samples from both Mount Gambier and Pomborneit, have been examined in some detail in a variety of samples, and this phase of the work is still in progress.

(vi) *Plant Proteins.*—The study of the chemical composition and nutritional value of plant proteins has been extended and has been supported further by the Animal Products Research Foundation of the University of Adelaide. Extracts containing practically all the nitrogen from samples of Wimmera ryegrass prepared by fine grinding and separation from the fibrous portions have proved to be poorly digested by rats which are utilized as the experimental animals. Attempts to get the whole of the protein in solution have hitherto met with only partial success, but more recent improvements in the methods have materially increased the recovery.

Dr. J. W. H. Lugg, a member of the staff of the Nutrition Laboratory, has spent two years' study leave working on the chemistry of plant proteins at the Imperial College of Science and Technology, London. His investigations took two main courses, namely, the extraction of proteins from plant materials, and the analysis of leaf proteins. Improvement was effected in the extraction of proteins from leaves, and samples were prepared from leaves of perennial ryegrass and of cocksfoot. It is now considered possible to obtain representative samples of relatively pure proteins from the fresh leaves of many, at least, of the fodder plants. Further analyses have confirmed earlier expectations that the whole protein of the leaves of mono-cotyledonous and di-cotyledonous plants is of much the same composition, irrespective of climatic and fertility conditions under which they develop or of the age of the plant. From the observations so far completed, the differences in amino acid composition of leaf proteins extracted by these methods from various orders and species among the angiosperms, appear to be relatively small, and, if such a generalization may be established, it would follow that the nutritional difference between

the leaf proteins should not be great. This implication is to be put to critical test as soon as the leaf proteins are separted in sufficient amount to allow the determination of the biological value by balance experiments with living animals.

(vii) *Physiological Studies: The Passage of Fluids through the Ruminant Stomachs.*—(*a*) *Studies in Deglutition in the Sheep.*—The study of the course taken when inbibed fluids pass through the complex fore-stomachs of the sheep, that was initiated in order to provide a rationale for the administration of drugs and vermifuge substances to sheep, has been continued. The investigations of the passage of fluids taken in the normal course of drinking have been extended to young lambs. It was observed that their reactions are similar to those of the older animals previously commented upon, in that the major proportion, and in most cases the whole, of water barium sulphate mixtures taken in this way passes to the fore-stomachs. This behaviour is unaffected either by isolating the lambs from the ewes or by preventing them from drinking water for some hours previous to the observations. Milk barium sulphate mixtures suckled from a bottle have been observed to pass to the abomasum even in sheep approaching maturity. Milk follows this course when suckled from the ewe.

Investigation of the influence of age on the path taken by water barium sulphate mixtures administered by gravity drenching has been continued until the animals have reached approximately three years of age, and it has been concluded that age has no uniform influence on the reflex. Some animals seemingly develop a tendency to pass to the fore-stomachs fluid administered in this way; other tend to pass most of it to the abomasum; while many of the animals tend to pass the whole of the drench to the abomasum. The reaction of individuals to gravity drenching has been observed not to be influenced by hunger, by thirst, by posture, by temperature of the mixture (between 4° C. and 40° C.), or by the rate of which the animal takes the liquid.

A study of the nature of the stimulus exerted by solutions of copper sulphate on the oesophageal groove reflex mechanism has been initiated. It would seem at this juncture that, providing the correct stimulus is applied, the mechanism which ensures the passage of fluids to the true stomach continues to function efficiently irrespective of the age of the sheep.

(viii) *Coast Disease.*—The determination that the progressive and fatal malady, coast disease, which affects sheep confined to the calcareous littoral, is due to a dual deficiency of cobalt and of copper in the fodder, has been reported upon previously. The experimental investigations have amply demonstrated that the malady may be controlled effectively and economically by supplying the animals with the lacking elements incorporated in salt licks, and the methods recommended by the Division are being widely applied with complete success in the seriously affected areas. By appropriate treatment of sheep suffering the dual deficiency, the syndrome of uncomplicated copper deficiency on the one hand, and of uncomplicated cobalt deficiency on the other, have been studied. Besides the littoral tracts where the dual deficiency occurs, preliminary investigations in the field have led to the recognition of certian areas where the well-being of ruminants is limited by a shortage of available cobalt in the fodder, and of others where a shortage of available copper is the only nutritional factor which affects the health of sheep. Methods for the more ready detection of areas where these deficiencies are incipient are being evolved prior to an extension to more comprehensive surveys of these limiting factors in the Australian sheep-raising areas.

(*a*) *Investigations at Robe, South-east of South Australia.*—Experiments concluded during the year have amply demonstrated the benefit derived from the administration of an amount of copper considerably greater than was at first considered necessary to overcome the deficiency of copper which accompanies the cobalt deficiency at this area. Trials still in progress have indicated that 5 mg. of copper per day, in conjunction with cobalt, ensure the continued health of sheep depastured continually on seriously affected country. A small group of sheep at this site have consumed 30 and 60 mg. of copper per head per day in a salt lick without showing any untoward symptoms. These observations will be continued to investigate further the possible danger associated with the continued ingestion of relatively large amounts of copper.

The possibility that cobalt administered at levels less than 1 mg. per day may effectively maintain sheep in continual good health while depastured on seriously affected tracts, is being investigated. Sheep receiving 0.1 mg. of cobalt per day, together with sufficient copper to fulfil their requirements of this element, have been mated; progress of the health of both the ewes and their lambs will be closely followed. Experiments initiated some years ago have demonstrated that there is no evidence of a nutritional deficiency of any element other than that of cobalt and of copper in sheep depastured continually on the affected littoral.

(*b*) *Ataxia.*—The occurrence of enzootic ataxia in lambs bred on much of the coasty country is, with little doubt, due to the copper deficiency which accompanies the cobalt deficiency of the pastures of these areas to more or less serious degree. Tracts where uncomplicated copper deficiency symptoms appear in grazing sheep have been recognized, and a preliminary survey

of these areas is being conducted by employing a species of oats which is extremely sensitive to low quantities of available copper in the soils as an indicator. Further breeding trials have been initiated at the Robe field station to study the separate effects of uncomplicated cobalt and copper deficiency on the health and development of lambs.

(*c*) *Cobalt and Copper Deficiency in Ruminants.*—A chemical method—for the estimation of minute amounts of cobalt—which is suitable for application to soils, to pastures, and to animal tissues, has been perfected in the Nutrition Laboratory and has provided a useful tool for the more ready detection of cobalt deficient areas and for the elucidation of the manner in which cobalt exerts its influences.

The underlying physiological mechanisms that are effected in ruminants which do not receive a more or less constant supply of cobalt in their diet are being investigated. For the purpose of assisting with these studies, Dr. Mary Cross elected a year ago to come from the Biochemical Laboratory, Cambridge, to investigate the effects of cobalt deficiency on the ability of isolated tissues to respire normally. She was supported for these studies by a scholarship awarded by the British Federation of University Women and has been a scientific guest in the laboratory for ten months. It has been observed that the oxygen uptake of liver, kidney, and brain slices from cobalt deficient sheep did not vary significantly from that of similar tissues from normal healthy control animals. The investigations are being continued with various substrates. The effect of cobalt deficiency on the partition of nitrogenous urinary constituents is being investigated.

(ix) *Agrostological Investigations.*—(*a*) *Sown Pastures and Cereals on Copper Deficient Soils.*—The investigations concerned with the establishment of sown pastures and of cereals on typical copper-deficient country have been continued. The application of 14 lb. of copper sulphate per acre has been observed to prevent the appearance of obvious copper deficiency symptoms in oats and in wheat, and to have resulted in a striking increase in the yield of both grain and straw. The yields were increased by increasing the quantity of copper dressing up to a maximum which was obtained between the 28 and 56 lb. per acre level. Quantities above this exerted no further effect. A significant further effect on the yield of grain was observed by superimposing a dressing of 1 cwt. of sulphate of potash on the higher levels of copper. When the dressings of copper sulphate were less than 56 lb. per acre, this latter effect was not apparent. The application of iron, manganese, and nitrogen at seeding, both in the presence and absence of copper and potash, exerted no effect on the yield of oats. Superphosphate applied at the level of 1 cwt. per acre had no effect on the yield of oats, but at the 2-cwt. per acre level it depressed the yield of grain. Late application in September-October of 56 lb. of copper sulphate per acre brought about a marked recovery of severely affected oats, and a good grain yield was obtained. Untreated plants remained affected and, in general, failed to head. In spite of the very pronounced effect of copper on the development and yield of wheat and oats in the field, the treated plants were not entirely normal in appearance and yield characteristics, and there is evidence of some other undetermined limiting factor. This latter is being further investigated.

A pasture of black medic and Wimmera rye-grass, sown in May, 1937, with 17 lb. of copper sulphate per acre, became well established and made vigorous growth during 1938. On an immediately adjacent area, a similar sown pasture which received no copper dressing has reverted entirely to natural species. Several perennial pasture species, viz., lucerne, cocksfoot, perennial ryegrass, *Phalaris tuberosa*, and Yorkshire fog, have shown great promise in these areas when dressed with copper, and a sward trial and several bulk pastures have been sown with selected mixtures.

Copper deficiency symptoms were observed in a number of species grown in pot cultures of Robe soil, and were overcome by the application of copper sulphate. Rye and a variety of oats from Europe (*Avena Strigosa*) were observed to posses a high resistance to the deficiency. Lucerne, tomato, and onion plants responded to copper treatment, but several other crops under pot culture conditions grew satisfactorily without treatment. Subterranean clover was grown successfully in pot cultures of this highly alkaline soil and showed an early response to the application of iron. A late significant response was obtained to the application of copper sulphate.

In order to determine the extent of the areas where the productivity is increased by the application of copper sulphate, a series of trials have been laid down in twenty centres where incipient copper deficiency symptoms in plants and animals have been suspected to occur.

(*b*) *Pasture Experiments at Clare.*—The results of these trials have been published in the Council's Journal, Volume 12, pages 145-150 (1939).

(*c*) *Pasture Experiments at Wambanumba.*—The investigations in relation to sulphur deficiency are being continued at this site where, in future, the studies will be carried out in collaboration with the Agrostology Section of the Division of Plant Industry.

6. *The National Field Station, "Gilruth Plains."*—At the beginning of the financial year, approximately half of the capital vote from the Australian Wool Board for permanent improvements on the Station had been expended. During the year the developmental work was completed. The Station is fully stocked with sheep, and at the end of the year was carrying about 4,400 breeding ewes and 1,800 ewe weaners. In addition, there was a small stud flock which serves for some of the experimental investigations which require closer observation of the animals. The summer rains were very late, but good falls were received in March and assured feed for some months. In spite of the fact that developmental work was only completed during the year, a start was made on experimental observations.

(i) *Fly Strike Observations.*—(*a*) *Dr. Watt's Treatment for Strike Prevention.*—The experiment was not completed, but observations failed to indicate that the treated sheep are less susceptible to strike than the untreated.

(*b*) *Manchester's Treatment for Blowfly Strike Prevention.*—This treatment was placed under investigation but it is too early to report upon results obtained.

(*c*) *The Effect of Tail Length on Susceptibility to Strike.*—These observations were started, but it will be some months before the evidence is collected.

(*d*) *Dressings for Ewes at Lamb Marking.*—Observations were commenced to determine the efficacy or otherwise of dressings for lamb marking wounds. So far these have shown that, when flies are numerous, application of certain dressings to the wool surrounding the wound gives a definite degree of protection against strike. This investigation is being extended, and several types of dressings are being tried.

(*e*) *Conformation of Animals and Incidence of Strike.*—The whole of the stock on the property was systematically observed with regard to strike, and careful records were kept; they will later be examined in order to determine the effect of conformation of the animal and treatment in relation to strike and re-strike. No results can be expected from these observations until there is a sufficient mass of data which can be satisfactorily examined for significance.

(ii) *Fertility in Merino Ewes.*—Observations on the periodicity of oestrus were made at the Station, and these form part of the work that is centred at the McMaster Field Station. The object is to determine if the periodicity of oestrus in the Merino ewe is the same irrespective of climatic conditions. The observations will not be concluded for some time.

(iii) *Shearing of Lambs.*—An experiment was commenced in order to determine if anything is to be gained by shearing lambs at about four months of age and again as hoggets, rather than leaving them unshorn until the hogget shearing. Observations will be made on body weights, wool growth, and monetary returns.

7. *Investigations in Western Australia.*—Co-operation with the officers of the Western Australian Department of Agriculture was continued during the year. Towards the end of the year, a biochemist was appointed to assist in this co-operative work. Various stock diseases were under investigation, the most important being ataxia in lambs, "falling disease" of cattle, and Denmark "wasting disease".

8. *Investigations in Tasmania.*—Co-operative investigations have been continued with officers of the Department of Agriculture. The progress of the investigations has been dealt with under 3 (i) (*m*) and 3 (viii) (*c*).

VI. SOILS INVESTIGATIONS.

1. *General.*—The Division of Soils has its head-quarters at the Waite Agricultural Research Institute, about 4 miles from Adelaide, and is housed there in the Darling Laboratory and part of the Melrose Laboratory. The recently completed Ransom Mortlock Laboratory provides further accommodation for the Division. A considerable part of the Division's work is, of course, conducted in the field. As the production of wealth in Australia's pastoral, agricultural, and horticultural industries is dependent ultimately on the soil, the investigations of the Division, aiming at accurate knowledge which will permit of intelligent and economic methods of soil management, treatment, and improvement, are obviously matters which, in the interets of those great industries, cannot be neglected without serious consequences.

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

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

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

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

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

In pursuance of the policy of expansion owing to the increasing demand for soil surveys, two further field officers were added to the staff of the Division during the current year. Co-ordination with the Woods and Forests Department of South Australia during the survey of forest reserve and planted areas in the south-east of South Australia was maintained by an officer of that Department being seconded to the Division for active participation during the course of the field work.

Interest has been maintained, particularly from the microbiological aspect, in problems of soil fertility, notably those associated with large scale development of scrub and heath country. During the year, interest has widened over a greater number of areas in South Australia, and the principles involved will be capable of application throughout the poor soil areas in higher rainfall zones of the Commonwealth.

2. *Soil Surveys.*—During the year, intensive field work has been continued in South Australia and Victoria. An inspection was made of soil classification being conducted by officers of the Queensland Department of Agriculture and Stock concerned in the development of cotton growing.

The field work for the soil survey of 12,000 acres of horticultural land in the Red Cliffs Irrigation Settlement (Victoria) has been completed. This concludes an extensive series of soil survey operations in the Mildura district.

A soil survey of the area comprising the Murray Valley Irrigation Scheme near Yarrawonga (Victoria) is being undertaken in co-operation with the Victorian Department of Agriculture. A water right for irrigating one acre in four will be made available for this area, and the soil survey will provide a basis for selection of irrigation land. An area of 77,000 acres has already been covered by the survey.

At the request of the Engineering and Water Supply Department (South Australia) inquiries are being made concerning certain aspects of a proposed drainage scheme for Berri and Cobdogla Irrigation areas. The movement of drainage water through sand beds is being investigated.

In the south-east of South Australia the field work initiated in 1937 on the forest reserves was continued, and during the year Penola forest—27,000 acres—was surveyed. In addition the soil survey of the Hundred of Riddoch had been completed. This area involved pastoral and forest country, the latter portion being surveyed during the previous year's programme. Also, the survey of the Hundred of Hindmarsh involving similar conditions is almost completed. Aerial photography, which is being used extensively on these surveys, has been completed by the Royal Australian Air Force over an area of a further three Hundreds.

One of the Division's officers was seconded as botanist and pedologist to a scientific expedition to the desert country of Central Australia.

3. *Laboratory Investigations.*—Detailed analyses of a group of 120 soils from the Callide Valley cotton areas, the Northern Territory, and the Kimberleys (Western Australia) have been in progress for some months and are to be continued. These represent areas and soil types which have not previously been examined.

The Department of Agriculture, New Guinea, forwarded 40 samples of soils and guanos from various localities upon which advice was required. The results of these analyses were embodied in a report submitted to the Director of Agriculture at Rabaul. In addition, approximately 80 soils from all parts of South Australia have been examined for salt content and soil reaction.

Work is continuing on the investigation of soil profiles in relation to plant diseases. Soils from Canberra are being examined in the hope of elucidating local cases of low fertility. Similarly, a disease affecting fruit trees at McLaren Flat (South Australia), in which a soil deficiency is suspected, is being examined in conjunction with the Horticultural Branch of the Department of Agriculture.

A complete range of the fertilizers used in Australia is being investigated by the polarographic method of analysis, with the result that many striking differences in the content of trace elements have been revealed. This investigation has involved considerable time spent in developing experimental technique applicable to the analysis for traces of metals.

An officer of the Commonwealth Research Station at Merbein (Victoria) has been seconded to the Division to gain experience in methods for the examination of soils.

During the year a large spectrograph for more accurate work on trace elements was received. It was set up and calibrated for 35 elements.

Experimental work on 51 soils and on necessary photographic solutions was pursued. Qualitative estimations on a wide range of materials including chemical compounds, plant products and parts, animal parts and excreta, and fertilizers were made. Quantitative estimations were made on material from *P. radiata* and *P. muricata* from South Australia and New South Wales, orange leaves, and oats.

Investigations on arcing of soils, rates of volatilization of soil and plant ashes in the arc were commenced and in part completed.

Extensive general laboratory work has been done on samples from soil profiles collected during the course of the soil surveys on the Murray River and in the south-east of South Australia.

4. *Soil Microbiology.*—Investigations in soil microbiology have continued along the lines indicated in last year's report. An understanding of the Rhizobial strain—host plant relationship is of fundamental importance in the successful application of the seed inoculation technique in agricultural practice. The strain relationships of the *Medicago-Melilotus* group have received particular attention, in addition to the *Vicia-Pisum-Lathyrus* group. Whilst the extreme variations in effectiveness of strains which are related to host plant species may not be associated with the species of economic importance of the former group, the variations within the latter group appear to be very significant.

Another important aspect is the development of methods of seed or soil inoculation suited to the present extensive programmes of development such as are common in South Australia and Western Australia. The possibilities of using dry methods are being investigated.

Close contact with such developmental work is being maintained with the object of increasing the efficiency of fertility building programmes from the practical point of view. The problem is one of defining the soil conditions necessary for the efficient inoculation of pioneer legume plants, these conditions being at least as important as the introduction of effective nitrogen fixing bacteria with the seed.

VII. IRRIGATION SETTLEMENT INVESTIGATIONS.

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

1. *General.*—The Commonwealth Research Station is situated on the Sturt Highway, ten miles from Mildura, on the main road from Mildura to Adelaide. The work of the station is principally directed towards problems associated with the irrigation of the horticultural lands of the middle and lower Murray and the production and processing of the grapes grown in these areas. The station provides laboratory accommodation and other necessary facilities for the staff; and also a vineyard of approximately 36 acres, divided into experimental fields designed for the projects of the officers concerned, all of whom are engaged in investigations which include field work. Though the results of the investigations may apply generally to all settlements producing dried fruits, it has been found necessary, on account of variations in the soils, climate, and general producing environment, to extend the investigations to other Murray Valley settlements. Thus at present, the experimental plots for various purposes extend from all settlements on the Murray between Woorinen (Victoria) and Waikerie (South Australia), with minor interests in other irrigation areas.

Soil preservation and reclamation studies are proceeding steadily, and these investigations are closely associated with drainage and reclamation works in the various irrigation centres. The older irrigation areas in Australia have in most cases now reached the stage where the lands, having been irrigated for a number of years, show evidence of declining productivity. This decline was accepted until recent years as inevitable in irrigation settlements. More recently, however, as the causes of soil deterioration and the amelioration measures for correction have been more accurately defined by investigations, there has been an impetus in all States to consider drainage and other measures for soil improvement. In this respect, it is pleasing to record a very considerable measure of success in some of the irrigation settlements. Mildura, Red Cliffs, and Merbein, totalling 33,000 irrigated acres, are now provided practically throughout with drainage facilities, and there is very general evidence and recognition of the restoration and safeguarding of fertility resulting from these works. At the present time, reclamation is proceeding in the settlements of Nyah, Woorinen, and Kerang (Victoria); Coomealla (New South Wales); and Renmark, Berri, Barmera, and Waikerie (South Australia).

The part played by the station in these works is to examine and report on the extent and cause of soil wastage, and to investigate the responses of the affected areas to sub-surface or to surface drainage. Following such an examination, including a study of the crops grown, it is possible to suggest remedial measures and the type of drainage that will most economically and efficiently serve the district concerned. Throughout the work, including the planning of the various drainage schemes, the staff of the station is closely associated with the State Departments concerned, and with the various producers' organizations of the irrigation districts.

It has been found necessary to extend the viticultural investigations, as increased production, following intensification of irrigation and cultural practices and more systematic manuring, has apparently made the grapes more sensitive to damage in unfavorable seasons. A real problem arises from the fact that higher yields resulting from increased soil nitrogen are associated with depressed quality in the dried fruit and also with less resistance to wastage factors. At the present stage of the inquiry, it appears that yields can be increased by preserving more fruiting wood at pruning time and by additional applications of nitrogenous fertilizers. There is, however, a definite limit to which increases by these means are warranted, and in many seasons the increased yields do not compensate for the additional harvesting costs, greater liability to damage, and reduced quality. The present aim is to determine the fruiting potentialities of a vineyard in its environment, so as to produce the maximum yield consistent with satisfactory quality and proper maturation of the canes which carry the following crop. In the case of Zante currants, a more favorable season has given improved quality, and there is evidence that further improvements can be consolidated by alteration of the existing trellising and pruning methods and by judicious summer pruning. It is becoming evident that the traditional methods of trellising and training vines are being seriously challenged, and modifications so as to give a wider and more systematic distribution of the fruiting wood are rightly coming into vogue.

The work on fruit processing has been continued, and the reactions of the various dips and drying methods have been closely examined in reference to the class of fruit produced and the drying environment of the various districts.

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; and also with the Division of Plant Industry, in the initiation and carrying out of 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.*—(i) *General Principles.*—Loss of productivity of portions of irrigated settlements has been universally accepted as inevitable in past years and was viewed as a normal and expected occurrence. As experience aided by investigations gradually clarified the problem, and ameliorative measures for the prevention of wastage of irrigated lands and the misuse of irrigation water became known, this viewpoint changed. In Australia, and also in irrigated lands of other countries, the present conception is that the fertility of irrigated lands may be maintained, if suitable methods of irrigation management are followed. The principal factors contributing to the preservation and reclamation or irrigated lands are sub-surface and/or surface drainage, controlled applications of irrigation water, and the regular and successful growth of plants to use the soil water. The majority of soils irrigated in Australia have been productive in the early years, and soil wastage has developed subsequently, in portions of each area, with continued irrigation. The nature of other soil types, particularly the potentialities to salt development, is such that the success of irrigation is not assured. A soil survey to determine the possibilities of successful irrigation should be viewed as an essential preliminary before entering on any irrigation expansion. It is also essential for consideration of irrigation practices and for reclamation of existing settlements.

(ii) *Causes of Wastage.*—Excess water in the soil and sub-soil, coupled in some cases with the incidence of injurious salts, is the prime cause of soil deterioration in irrigated lands. It is possible but so far not practicable, by careful irrigation, to prevent the accumulation of salt in the surface layers where they do maximum injury to plant growth. Sufficient refinement in irrigation practice to give this result is rarely seen, and is certainly not represented on a community scale in any of the irrigated settlements. The furrow method of irrigation is general for the permeable soils of the River Murray irrigation settlements used for horticultural plants. This method is inevitably associated with accumulations of free sub-soil water, with the resultant soil wastage in many soil types. Surveys of the seasonal occurrence and fluctuations of free water have been made in all horticultural settlements on the Murray in South Australia, New South Wales, and Victoria, from Waikerie (South Australia) to Wooriner,

near Swan Hill (Victoria). Free water, associated with soil wastage, has been noted in all these settlements. This being so, it is an inevitable conclusion that agricultural drainage in the settlements under consideration is necessary for correction of conditions which have already been brought about; and further, that sufficient improvement in irrigation practice to obviate agricultural drainage is not considered practicable. In any case, in the older irrigation districts, drainage is necessary for correction of faulty soil conditions which have already arisen.

(iii) *Conditions not Requiring Agricultural Drainage.*—Conditions under which agricultural drainage is not warranted for irrigated lands do occur in Australia. Such cases are limited to soils of heavy texture which do not respond to sub-surface drainage. These conditions are represented in Victoria in the Kerang district (pasture lands) and at Woorinen (horticultural lands). Storm waters and excess irrigation waters penetrate these soils relatively slowly, and provision for surface drainage in these areas has been found necessary. It is probable also that the adoption of the spray method of irrigation would be successful in preventing soil wastage. This system involves pressure for application and is, therefore, costly. Its application is generally restricted to cases where the irrigation water is applied gravitationally and is then pumped on to the land by the occupier. The general estimate of the cost of irrigation in the few cases noted is that it would be at least doubled by the installation of the spray system.

(iv) *Preservation of Soil Fertility.*—Ameliorative measures, to offset the results of excess irrigation, comprise the following:—

(*a*) Controlled application of irrigation water.
(*b*) Establishment of economic plants for usage of applied water.
(*c*) Sub-surface drainage for light textured pervious soils; or
(*d*) Surface drainage for heavy textured relatively impervious soils.

The first three of these measures are, in general, applicable to the dried fruit areas on River Murray settlements. Controlled applications of irrigation water, to secure a nearer approach to the minimum efficient quantity, is warranted because it is cheaper, quite apart from the consideration that it tends to prevent soil wastage. The extent to which this is practicable is shown in the Berri area in recent years. Irrigations of 4 inches to 5 inches appear to represent the practical ideal minimum. Assuming 5 to 6 irrigations necessary each year, an annual usage of 25 to 30 acre inches may be considered necessary for horticultural properties on which cover crops are grown; and this minimum is now being approached.

The successful growth of a plant of economic value for usage of water applied by irrigation is a first principle. As wasted areas arise, accompanied by the destruction of the vegetation, any applied irrigation waters always tend to accumulate in the soil, and deterioration extends. Thus the arresting by reclamation of an affected area usually assists in preserving fertility on the adjoining lands. There are limits, however, to the ameliorative effects that can be obtained by the combination of controlled applications and the successful growth of plants; and the universal experience is that, ultimately, drainage is the only solution for lands adversely affected by irrigation waters.

(v) *Methods of Agricultural Drainage.*—The design of a drainage system for any irrigation settlement is intimately dependent on the environment of the area concerned. The soil type, the nature of the sub-soil texture, and the texture of the deep seated horizons, all have a bearing on the drainage design. A knowledge of the characteristics of these soil horizons, and their permeability to sub-soil water, may be considered an essential preliminary in drainage considerations. The principal systems of agricultural drainage applicable to irrigated lands of the Murray have accordingly been tabulated below. For clarity, external drainage, or the disposal of drainage waters, is separated from internal drainage, which involves the collection of the sub-soil waters within the holding.

(vi) *External Drainage for Discharge of Drainage Waters to Streams or Suitable Depressions.*—(*a*) Gravitationally through pipes or open cuts.

(*b*) Pumped for discharge in surface channels or shallow pipe lines.

(*c*) Discharged direct to a deep-seated pervious layer (say 40 to 150 feet) from which pumping may be ultimately necessary.

(vii) *Internal Systems for Collection of Drainage Waters.*—(*a*) Agricultural drain pipes, with pervious joints, usually laid at 4 feet to 7 feet deep.

(*b*) Natural drainage through a pervious sub-soil.

(*c*) Natural drainage through pervious layers relatively deep-seated.

(*d*) Internal open cut drains.

Existing combinations of these various external and internal systems in Australia are as follows:—

Mildura A.1.—Here water is collected in drains laid at 4 feet to 7 feet, and discharged to gravitational mains 6 feet to 30 feet deep.

Waikerie C.3.—The water is collected in a shaft or pit 16 feet to 20 feet deep, from pervious layers within this horizon, and discharged directly to a bore leading from the bottom of the shaft to a pervious limestone layer at 100 feet to 120 feet.

Barmera A.3.—The water is discharged direct from pervious layers underlying limestone strata, to a gravitational drainage main 5 feet to 25 feet deep.

Berri C.1.—At present, the deep-seated sand horizon is saturated in many parts of the settlement, and the effects of pumping from the sand drift are being investigated.

Renmark A.3.—An open cut drainage main has recently been made to a depth of about 9 feet to which internal drainage waters are discharged directly through pervious sub-soil layers.

(viii) *Internal Drainage.*—The facilities for investigation of the results of drainage are ample, as holdings on which the drains are constructed by the occupier are made available for this purpose. The optimum depth for drains is based mainly on the soil profile of major soil types, which have been described by the Division of Soils. The effects of the drains on the water table are mapped by noting the fluctuations of the free water surface at appropriate spacings between parallel drains. As a result of this work, it has been found possible to define, within fairly narrow limits, the appropriate depth and spacing of drains in the various soil types. The results show, as might be expected, that the sandy soils are best served with deep drains (up to 6 feet) with wide spacings (up to 90 feet). The loams require closer spacing (about 40 feet), and the more or less permeable layer on which the drains are placed is usually fairly shallow (at or about 4 feet). On some of the clay loams, and on the clay soils, the response to agricultural drainage is feeble, and the intensive drainage required may be uneconomical.

4. *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 the bunches 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-trellis. The T-trellis has so far shown to advantage. 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.

Fertilizer trials continue to show that of the various plant foods nitrogen is the chief limiting factor in yield, under the present nitrogen content of Murray Valley soils. Nitrogen is obtained through the medium of leguminous cover crops, and also by the application of artificial fertilizers. Increased yields due to nitrogen show decreased quality, as is the case with any practice that increases yield beyond certain limits. Grapes from plots manured with nitrogen show increased nitrogen content accompanied by other undesirable features. Results of phosphatic fertilizers reflect mainly as better growth of the cover crops. Though heavy dressings of phosphatic fertilizers are associated with increased phosphates in the fruits, no increases in the yield or in the general health of the vine have been noted. Potassic fertilizers have similarly given no increased yields, while adding to the potash content of the fruit.

Nitrogen studies have been deemed sufficiently important to warrant a special investigation. Measurements of soil nitrogen, and the nitrogen in the trunk, annual shoots, and leaves of the vine, are now made at regular intervals, in connexion with further studies of the relation between shoot growth, bud development, and bunch development.

5. *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 the parts played by the oil, potash, caustic soda, and soaps or other wetting agents, in the drying process, have been established. A chemical investigation of sultana "bloom" has also been carried out. The removal of the substance which consists of a mixture of waxes and a resin acid is essential for rapid drying of the fruit, and is brought about by the dipping solutions.

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, all have a marked effect on quality. Bleaching investigations have shown that, by treating sultanas with comparatively small amounts of sulphur dioxide, it is possible to bring about a marked improvement as regards the preservation of colour without

adversely affecting the flavour. Commercial use is now being made of these results. Investigations into the packing house treatment of rain damaged fruit have also been carried out, and a satisfactory oil emulsion wash for this class of fruit has been prepared.

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 fruits. The necessity for fumigation with ethyl formate at the packing point and for separating packed fruit from unprocessed fruit in the packing houses, has been established. The efficiency of toxic grease bands containing pyrethrum or organic thiocyanate to prevent the migration of larvae from unprocessed fruit has also been demonstrated.

6. *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, and the Curlwaa and Coomealla Horticultural Advisory 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. The object of its investigations is the elucidation of cultural problems associated with irrigation agriculture, and, as such, many of its investigations are concerned with the soil. When one considers that the effect of one of the main factors of plant life associated with the climate, viz., rainfall, is more or less controlled by the irrigationist, it is readily seen that the soil assumes relatively greater importance to the irrigation agriculturist than to the agriculturist who depends entirely on rainfall to supply the soil moisture. With the object of increasing the yield of irrigation crops and maintaining the health of permanent plantings, such as fruit trees, and maintaining the fertility of the soil, the researches at Griffith comprise studies of the nutrition of the plant, with special reference to its bearing on the health of the plant; investigations into the application of irrigation water to the soil, with which are associated studies of soil permeability and soil structure; studies of the root systems of plants; and other botanical studies concerned in the health of the plant. Certain other work of more general application, but for which the station is particularly suited, is also carried out, for example, investigations of cool storage of citrus and the analysis of river waters.

The New South Wales Water Conservation and Irrigation Commission contributes £1,500 per annum towards the working expenses of the Station, and 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 year, additions have been built to the laboratories; they have relieved the previous congestion.

2. *Plant Nutrition.*—Early studies reported in previous issues have shown that citrus trees respond to leguminous green manures. Repeated observations and experiments have shown that not only citrus trees but most plants respond to green manuring and farm yard manure, under the conditions of the district, and the same type of response is not obtained from inorganic ferilizers. Because of its obvious and very important practical importance, this effect of organic matter has received special investigation for a number of years. The problem has been studied both by pot experiments and by field trials with various test plants. With pot experiments, using ignited soil to which calcium phosphate has been added, the healthy growth of wheat is entirely dependent on the addition of suitable organic matter. In the early stages of growth, the amount of nitrogen added, whether organic or inorganic, is the predominating factor determining rate of growth. After about six weeks, however, cultures not receiving organic matter become yellow and ultimately die, regardless of the amount of inorganic nitrogen added. Water extracts of farmyard manure maintain a healthy growth. Similar effects are obtained when unignited sandy loam soil is used, but the effect is not so pronounced, apparently due to the organic matter in the soil. The problem is being further investigated in an attempt to discover what is added with the farmyard manure to cause the rather remarkable effect.

3. *Irrigation Investigations.*—The progress made in irrigation research has now enabled the past work to be reviewed in detail, and principles have been formulated for the design of new areas or the irrigation of existing farms. As a result, work has commenced on the lines indicated for secondary irrigation research, and more intensive extension work to apply irrigation research results to the farms on the Area is being organized in co-operation with settlers and the State authorities concerned.

Following on the fundamental research work, it has been possible to analyse systematically the chief factors controlling the amount and distribution of water applied by furrow or border irrigation, namely, soil type and tilth conditions, slope, length of run, and flow rate. The study of the interaction of these variables under control conditions has greatly simplified irrigation technique, and has provided a new method of approach to the problems of choosing suitable slopes and lengths of run in relation to soil when designing new areas, or in selecting suitable irrigation methods to meet existing conditions of farm lay-out.

These experiments have emphasized again that the control of the flow rate per furrow or border stands out as the most important single factor in irrigation management. There is often room for much improvement in the control of the flow rate, and investigations are in progress on methods of distributing water to furrows and borders. Various types of apparatus have been designed, and control devices developed in other countries are being used in field tests.

Most of the irrigation investigations have dealt with primary flow conditions—a constant flow at the entrance to the furrow cut off about the time it reaches the far end of the orchard bay. Under several combinations of factors such practice gives a satisfactory irrigation. Under other combinations there is need for secondary methods of varying flow and tillage conditions for securing more even soakage distribution. An area of about 12 acres has been laid out for studying, *inter alia*, these secondary methods of surface irrigation under various slope, flow, and length of run conditions. Soil samples have been taken and infiltration tests conducted on a chain grid over this area. The data obtained will enable the irrigation experiments to be carried out with rigid control of soil type and soil soakage conditions.

Work is being continued on the determination of factors controlling infiltration of water in soils. The infiltration rate and other soakage characteristics of major soil types are being studied in relation to relevant physical soil properties. The results indicate that these data will afford a quantitative basis for applying irrigation principles within the limits allowable in farm practice. A mathematical study of the infiltration and irrigation data indicates that there is a sound theoretical basis for relating infiltration rate with the various other factors in irrigation practice. With the development of a more standardized and controlled experimental technique, direct quantitative comparisons have become possible with similar work recently commenced in other countries.

To enable the results of the Station's irrigation work to become directly available to the settlers, a committee has been formed to co-ordinate research and extension. It consists of representatives of the New South Wales Department of Agriculture, the New South Wales Water Conservation and Irrigation Commission, and the Griffith Research Station. A group of farms has been selected as a project area on which the procedure to be followed in dealing with the wide range of soil types, crop, slope, and other conditions is being worked out in co-operation with the growers and research and extension officers.

The Research Station is represented on another committee which has been set up to investigate farms on which seepage or water-logging problems are of immediate concern. Several farms have been investigated, and, where necessary, an irrigation and reclamation programme has been put in operation.

4. *River Water Analysis.*—A start has been made in the analysis of waters from the various rivers and storage basins of the State. The object is to collect systematic data of the salt and silt content of the waters. The result will be valuable for hydrological and irrigation interests. To determine the best technique of sampling and analysis, the studies so far are of a preliminary nature. The work will be done in co-operation with the Water Conservation and Irrigation Commission of New South Wales, which will collect the samples and take records of river heights, rainfall on the catchments, inflows and outflows to storage basins, &c.

5. *Inarching of Citrus Trees.*—To determine the possibility of increasing the productivity and longevity of citrus trees by replacing the root systems by better stocks, inarching experiments are being carried out both on healthy and unthrifty trees, using both sweet orange and rough lemon stocks. In the case of unthrifty trees, other treatments, such as cutting back and the use of farmyard manure, are also being combined with the inarching.

The inarching consists of planting nursery trees beside the tree to be inarched and grafting the stem of the nursery tree into that of the established tree. Usually, four nursery trees are used for each established tree, one on every side of it. The roots of the inarches grow, and if successful they should gradually replace the root system of the established tree.

6. *Stock Selection.*—Seed from individual rough lemon, sweet orange, and sour orange trees are sown in the nursery bed, and studies are made on the seedlings produced with a view to selecting superior strains for use as stocks. In this work root grafts are also useful. Portions of roots from promising trees are grafted to various varieties of citrus stems, and the trees produced will be compared. This investigation is important, as there is strong evidence to show that a large part of the citrus plantings in Australia are not on the most suitable stock, and there

is reason to believe that it should not be difficult to select strains of rough lemon and sweet orange stock that will produce trees much superior to the average tree at present in the citrus orchards of the Commonwealth.

7. *Root Studies.*—Studies on the root system of plants are still progressing with especial reference to citrus roots. Three methods are used : (i) Sampling with a soil tube and washing out the roots. This method, which is quick and cheap, gives a good idea of the concentration of the absorbing roots in the different soil depths. (ii) Excavating the root system and mapping the roots. This method is expensive and time consuming, but is necessary for a true picture of the morphology, as distinct from the physiology, of the root system. (iii) The use of a soil window by which it is possible to study the growth of the roots at different soil depths at different seasons of the year. Its limitations, due to the presence of an artificial soil-glass interface, are obvious ; but it is the only method available for obtaining some of the desired data. From the three methods together it is possible to fill in the gaps of the complete picture of root morphology and physiology.

The root and stock work is now being carried on in co-operation with the horticultural section of the Division of Plant Industry.

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

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

10. *Pasture Plots.*—The pasture plots to form a local trial and demonstration of various grasses—clover mixtures and fertilizer dressings—have proved valuable in assisting the growing live-stock industries of the areas.

VIII. FOREST PRODUCTS INVESTIGATIONS.

1. *General.*—Marked developments have taken place in the work of the Division of Forest Products.

A new section for veneers and plywoods has been formed, and a new building containing suitable office and laboratory accommodation and a large workshop for the installation of machinery has been erected for the section. Practically the whole of the equipment for the section has been donated by various timber interests ; it was completed by a splendid gift of Mr. Russell Grimwade, C.M.G., who provided a sum of £1,250 for the purchase of an experimental Coe lathe, which is now on order.

Another important development has been the completion and equipment of a laboratory for experimental pulp and paper studies. One of the first studies to be carried out in this section will be a co-operative study with the three contributing companies into every aspect of the testing of pulp and paper, with a view to establishing standardized Australian practice and to correlating the results of tests with the properties of commercial paper.

A further important result of the year's work has been the preparation for publication of a Timber Handbook which, for the first time, provides engineers and architects with tabulated data on the strength properties of Australian timbers, in a form suited for the designer. It has taken a number of years to provide the experimental data required, and a large part of the year under review, to make the necessary calculations and arrange the tables. This publication is now in the printer's hands. A sum of £600 has been donated by various timber interests in all the States towards the cost of printing the Handbook.

The Lyctus, or powder post borer, has been under continuous study for some years because of the extensive commercial losses due to its activities. The use of boric acid has now been proved to be effective, and commercial plants erected in Queensland have proved to be very successful. The value of this single development is perhaps best shown by quoting a letter from the Hon. R. Pease, M.L.A., Minister for Lands and Forests in Queensland—

> It is some months now since you forwarded to the Director of Forests (Mr. V. Grenning) details of the method developed in your laboratories for the treatment of veneers with boric acid.
>
> Since then, I have observed the plant in operation at Brisbane Sawmills, Windsor, and I have been greatly impressed with the treatment. You have succeeded in making possible great economies for the timber industry and, as Minister for Lands, I desire to express my appreciation of this service and to remark on the satisfaction that it gives me to observe again how science is benefiting industry.
>
> I would like to congratulate you on a splendid piece of work.

The disastrous forest fires in Victoria led to a great deal of time being spent on the study of methods for salvaging as much as possible of the immense volume of fire-killed timber. Officers of the Division have co-operated extensively with officers of the Victorian Forest Commission and with a Committee set up by the Victorian Government to report on a salvage plan, which is in process of being implemented.

A satisfactory feature has been the appointment of additional staff to allow of the more rapid expansion of fundamental researches, which are of the utmost importance in preparing the way for future developments. The Division's early and most effective work was more in the application of existing knowledge to improve practice, but this must change if it is to continue to prove useful.

Contributions.—Contributions amounting to a total of £4,150 were received during the year; details are given in Section XIII., paragraph 2. In addition, several donations of material were received.

2. *Section of Timber Utilization.*—Progress in the Utilization Section for the year has been marked by an increase in the scope of problems dealt with. Inquiries increased to over 660, and a steady demand was made on the services of the Section by visitors and correspondents and in the internal working of the Division. Officers of the Section visited Queensland, New South Wales, Tasmania, and South Australia, in addition to maintaining activities in Victoria. Co-operation was continued with forestry authorities in all States in problems relating to improved utilization of their timbers, and advisory work extended through many parts of the Commonwealth. Information on Australian timbers for many military and naval requirements was given to the Defence Department. New work was initiated in relation to the salvage of fire-killed timbers, and notable expansion was made in projects on standard grading, wood manufacturing processes, surveys of utilization, electrical determination of moisture content, and extension service.

(i) *Survey and Advisory Work on Forest Products.*—Through visits into the timber trade and correspondence, fresh information was collected concerning the properties and uses of timbers, particular attention being devoted to determining why certain woods are preferred for certain purposes. Systems for recording the information were considerably expanded. Several thousand cards are now in use showing the names of timbers, their uses and their producers, agents, and users; the manufacturers of timber products; the timbers used for various purposes; and price data and statistics on forest products. The systematized records have been most useful in advisory work, as was amply demonstrated during the year when they were the means of locating sources of supply of several thousands of tons of wood waste which a large manufacturing company put to an important commercial use. Inquiries received related to timbers suitable for agricultural implements, aircraft, archery, battery boxes, battery separators, boat building, boot lasts, brooms, brushware, carriage construction, cases, casks, charcoal, chemical sinks, church furniture, cross-arms, decking, dunnage, electrical transmission equipment, fishing rods, flooring for factories, dwellings, and halls, golf club heads, gun and rifle stocks, handsaw handles, instrument tables, match boxes, paper machine parts, pattern-making, pencils, piano parts, plywood, rulers, skating floors, skis, smokers' pipes, stockyards, springboards, tanks, tennis racquets, textile rollers, toys, trays, turnery, vats, veneers and walking sticks. Advice was also tendered on the properties and uses of over 30 different species.

(ii) *Grading Australian Timbers and Preparation of Standards.*—The secretarial work of the Timber Sectional Committee of the Standards Association of Australia was continued. New standards published by the Association during the year were:—A.S. No. 0.3—Milled Flooring, Part VI.—Cypress pine; 0.4—Milled Lining, Part III.—Hoop pine, bunya pine and kauri; 0.6—Plywood; 0.10, 11, and 14–43—Jarrah and karri.

Grading rules previously published by the Association in 1934 under one cover were revised and separate sets of grading rules for A.S. No. 0.3—Milled Flooring, A.S. No. 0.4—Milled Lining, and A.S. No. 0.5—Milled Weatherboard, embodying approved revisions and additional parts were issued in mimeographed form.

The outstanding feature of the year's work has been the completion of draft technical standard No. 0.2—Nomenclature of Australian Timbers. The aim of this publication is to standardize the trade names of timbers and so reduce the disabilities due to the existing confusion of names. It is also intended to link the standard trade names with a standard reference name of the botanical type that will remain unchanged despite any future splitting of species by botanists or changes of authorship under international botanical rules. Owing to the somewhat conflicting desires of different timber interests, the preparation has involved a tremendous amount of work, and a spirit of goodwill and a desire to compromise have been necessary for its completion. It is believed to be a substantial contribution to the solution of an old problem and should prove most valuable. It was issued by the Standards Association on 1st July, 1939, for public critical review.

In addition to the above, specifications have been drafted for structural timbers, mining timbers, and joinery stock. Two Trade Circulars on the selection of structural timber and the selection of plywood were issued.

(iii) *Building Construction in Australia.*—Liaison was maintained with the Timber Development Association and the Building Industry Congress. In connexion with the Association's timber housing campaign, data was assembled for inclusion in a statement which the Association submitted to the Victorian State Housing Commission, and assistance was given in the preparation for publication of the plans which were entered in its competition for timber house design. The Officer-in-charge of the Section continued to act on the Standards Committee of the Building Industry Congress which is framing model specifications for brick residences. The series of lectures on timber as a building material inaugurated last year in the University of Sydney were repeated during the year in Adelaide ; a large representation of the architectural profession attended. Publicity articles on wooden windows, and the priming of joinery were released in the Division's Monthly News Letter. General information on wood construction in Australia was prepared for the French Consul, a statement on building by-laws for the Comité International du Bois, and advice given to local inquirers on prefabricated construction, materials for rural housing, log cabin construction, air-raid precaution structures, the design of roofs and trusses, and flooring for a factory.

(iv) *The Design of Sawmills and Woodworking Plants.*—Data on portable power felling saws was forwarded to an inquirer. The performance of available saw-milling machines suitable for the conversion of softwoods was reviewed for interested millers. Preliminary sketches of plant layout were prepared for firms intending to commence sawmilling in hardwood forests. Suggestions *re* the equipment and layout of a core-stock plant were submitted. The layout of a polishing room was planned for a furniture manufacturer. Designs of sawdust burning units were distributed.

(v) *Manufacturing Processes.*—Advice was given in regard to various matters of interest to manufacturers ; these matters included the manufacture of fibre boards, wood-wool, charcoal for producer gas, flooring including parquetry, laminated products, the manufacture of brushware, the peeling of plantation timber, the elimination of tannin stains, wood distillation processes, pulping, the dyeing of sawdust, and the manufacture of emblems. Inquiries were conducted among firms engaged in the processing of copals and damars, and assistance rendered to merchants interested in finding markets for material from new sources. Digests of information on the requirements for manufacturing wood flour and sawdust briquettes were distributed.

3. *Wood Structure.*—The co-operative scheme between this Section, the Forest Services of New South Wales, Queensland, Victoria, and Western Australia, and the Commonwealth Forestry Bureau, has been successfully maintained. In the development of this project, each of the co-operating bodies has received 300 slides of Australian and other timbers, 30 photographs showing cross sections of various commercial timbers at ten magnifications, and 173 species identification cards, duly typed, notched, and ready for use in the card sorting schemes of identification. The scheme for use with coniferous woods was developed during the year, and for this purpose, 128 species of 24 genera of this group were examined macroscopically and microscopically and the features considered most useful in their identification suitably arranged on an 8-in. x 5-in. punched card.

(i) *Anatomical Studies.*—The work on the study of the anatomy of Australian timbers has been continued. The results for the Australian *Meliaceae* have been published as Bulletin 124, while the work on the Australian *Lauraceae* has been completed. In the latter investigation, 170 specimens of 6 genera and 34 species were examined ; the results are being prepared for publication. Further investigations along similar lines have included the examination of available specimens of the Australian *Proteaceae* (130 specimens of 16 genera and 36 species). Additional material is still being collected through the co-operation of the State Forest Services.

(ii) *Structure of the Cell Wall.*—During the year under review, it was possible to carry out numerous fundamental investigations related to the structure of the cell wall and the intercellular layer. The Australian paper industry has realized the value of such fundamental investigations in connexion with the utilization of Australian hardwoods for pulping. In the work carried out, close co-operation was maintained with the Section of Wood Chemistry since many of the problems were related to those of that Section, and since the methods of approach were partly chemical.

Methods for revealing the presence of cell-wall lignin have been developed, and, using these methods, many dicotyledonous timbers, both tropical and temperate, normal and compression wood of conifers, and many Australian timbers have been examined. The degree of secondary wall lignification as indicated in this manner has been correlated with that supposedly revealed by staining reactions ; there appeared to be a high degree of correlation between such staining indications of cell-wall lignification and the actual presence of cell-wall lignin. In addition, the

removal of lignin by various processes of delignification using thin cross sections was paralleled by a change in the staining reaction of the sections indicating loss of lignin. From these results, it would appear that staining reactions do have a definite value in indicating the presence of lignified tissue as claimed by the botanists. Other experiments, however, in which some change of the staining reactions of the cell-wall was detected after boiling with 0.08 per cent. sodium hydroxide or 3 per cent. sulphuric acid, which treatments did not remove lignin, indicated that staining reactions were not necessarily an indication of lignin itself, but rather of some lignin complex which could be readily modified by chemical treatment.

Using certain processes of delignification, it was possible to remove lignin from cross and radial sections of various species without causing maceration. In fact, the appearance of these sections after delignification was practically identical with that before even though approximately one-fifth of the dry weight of the material had been removed during the process. It was shown, however, that the non-lignin cementing material could be removed or modified sufficiently to cause maceration by treatment of delignified cross or radial sections with 0.08 per cent. sodium hydroxide. In the continuation of these experiments, radial sections of sufficient thickness to give free fibres were used, and it was shown with these sections that the non-lignin cementing material could be removed or modified prior to delignification by means of an alkaline pretreatment at boiling temperatures. A very satisfactory procedure for obtaining free fibres from radial sections of dicotyledonous woods (cut at 35 μ thickness) was found to be (*a*) pretreatment with boiling 0.053–0.08 per cent. sodium hydroxide, (*b*) chlorination with chlorine water, and (*c*) an alkaline wash with 0.08 per cent. sodium hydroxide with rapid stirring for a few minutes at room temperatures. Fibres separated in this way retained a high percentage of the furfural-yielding constituents originally present in the wood:

The exact nature of the non-lignin cementing material removed or modified by the alkaline treatment is not exactly known. Either the lignin or the non-lignin bonding materials can be removed separately without causing the fibres to fall apart and without altering the appearance of the section. Just what is the relation between them remains to be explored.

(iii) *Structure in Relation to Properties.*—In co-operation with the Section of Wood Preservation, the percentage pore area in various species of eucalypts has been determined in order to obtain some indication of the degree of penetration to be expected in the sapwood of these species where presumably the major part of the penetration occurs in the pores. In the examination of numerous specimens of American ash supplied to the Section of Timber Mechanics for test, it was found that by far the greatest degree of variance in toughness, namely, 52 per cent., could be accounted for by the variation in conditions of growth as revealed by the number of rings per inch. In the case of several brittle specimens (low toughness), broken fibres were isolated on maceration, indicating the presence of minute compression failures. A systematic survey of the structure of *Eucalyptus gigantea* in relation to certain properties of the timber has been commenced. The percentage of late-wood and the extent of brittle heart have been determined. More detailed examinations of the structure of the specimens actually used in toughness determinations are being carried out. In these and other lines of work, the Section of Wood Structure is attempting to correlate the properties of timbers with the gross and microscopic structure of the various specimens of such timbers available for examination.

(iv) *Identification.*—A total of 304 specimens was received for identification during the year. This compares with 470 for 1937–38 and 300 for 1936–37. The identification of timbers from the Mandated Territory of New Guinea and from Pacific Islands under British rule was handicapped considerably by the lack of authentic material from these regions.

(v) *General.*—The photographic work carried out for other Divisions and Sections of the Council has increased tremendously. Much of this increase is due to the further development of the photographic copying of published articles for the Information Section. During the year, the photographic work completed has reached a total of 3,235 prints, 10,374 enlargements, consisting mostly of enlarged copies of published articles or diagrams, 111 lantern slides, 5,826 Leica copy negatives, 544 plates, and 70 roll films. In addition, a number of positive film strips equivalent to 760 individual slides have been prepared.

4. *Section of Timber Seasoning.*—Work in this Section followed essentially the same general lines as that done in previous years, consisting of direct trade contact projects on the one hand, and of laboratory projects on the other. Of the work done under the latter class, practically all was of such a nature that the results were of immediate commercial application. This was in keeping with the policy, adopted several years ago, of transferring to the Timber Physics Section all fundamental studies relevant to seasoning; it is regarded as important that, for some time to come, the Seasoning Section should concentrate on work that will maintain close contact between the Division and the timber industry, and consolidate the advances that the Division has been able to promote in the practice of timber seasoning.

The issuing of plans of kilns and drying rooms was continued, and it is interesting to note that, of 522 drying and re-drying units for sawn timber, veneer, and plywood that are now operating in Australia, 283 have been built to plans supplied by this Section. The educational programme followed out comprised publication of articles and trade circulars, and the conduct of a correspondence course and of a course of lectures and practical work in timber seasoning.

Most of the laboratory work done was in connexion with the determination of kiln drying schedules, investigations with five species being carried out either to completion or in part. In addition, work was done on the drying of timber from immature trees of two species. Reports covering the results of these investigations were issued from time to time.

Other major projects on which work was done were the study of collapse, salt seasoning as applied to Australian timbers, and kiln design and construction. Under the last project, a wood-wool drier, which it is believed will be of considerable value to this small branch of the timber industry, was designed and given thorough trials. Details of this drier are to be published in the near future.

5. *Wood Chemistry and Pulp and Paper Investigations.*—Revision and development of methods for the analysis of woods and pulps has been the main problem on which the Section of Wood Chemistry has been engaged during the past twelve months. Experience with the existing analytical methods during the investigation of the pulping properties of trees of *E. sieberiana* indicated the need for a critical examination of some of the methods. In addition, observations made by the officer-in-charge while abroad showed, in many instances, where methods might be improved.

First and foremost, the problem of preparation of a wood sample for analysis has been carefully re-examined. For this work, the mild cutting action of the Wiley Laboratory Mill offered a method by which a wood sample might be prepared with the minimum loss during milling and without the production of unnecessarily large quantities of the finer fractions (100–). The mill, when used with *E. regnans*, consistently produced 50 to 55 per cent. of 60–80 material, and the 20 to 30 per cent. of 100–material did not contain a very large proportion of very fine wood powder such as was previously produced by the Christy and Norris impact mill. After a preliminary running-in period with flat-ground knives, it was possible to duplicate samples with respect to their proportions of the various particle sizes. Chemical examination of the various fractions showed that a piece of wood from the light-coloured, relatively extractive-free species was most accurately represented by the 60–80 or 80–100 fractions. The 100– fraction was also equally representative in some respects, but its cellulose content was lower on account of cellulose losses which occur during isolation from the finer fractions. There was no evidence of segregation of any constituent to the finer fractions. Subject to the realization that cellulose values would be slightly low, the 60– fraction from such woods could also be used. On the other hand, coloured woods which are rich in extraneous materials, such as *E. marginata*, may be truly represented only if the 60– material is used for analysis, that is, all of the wood must be included in the sample and no particle size fraction discarded. There is definite evidence that segregation of extraneous material to the finer fractions occurs when these woods are milled. Laboratory procedure has, therefore, been modified so as to use the 60–80 or 60– material from light-coloured woods and the 60- material only from the coloured woods.

The method for the determination of furfural-yielding substances in woods has been modified so that thiobarbituric acid is used as the precipitant for furfural. This reagent has been shown to be far more satisfactory than phloroglucinol when dealing with hardwoods. With softwoods, it is equally satisfactory providing precautions are taken to wash out the water-soluble condensation product which thiobarbituric acid forms with formaldehyde. The latter is produced by the lignin of softwoods during distillation with 12 per cent. hydrochloric acid. The condensation between thiobarbituric acid and furfural is accompanied by adsorption of some of the reagent by the precipitate. Providing that the precipitation is carried out under standardized conditions and at ordinary laboratory temperatures, a regression equation may be used to correct this adsorption. For ordinary wood analysis when the furfural is calculated as xylan and the values for the latter are used for purposes of comparison, the regression equation need not be used. The results of this investigation were published in the Council's Journal (November, 1938).

Variability in results obtained during the determination of Cross and Bevan cellulose have been very disconcerting at times. The errors have been shown to be largely mechanical and may be minimized by using smoother crucibles for the determination. Alundum crucibles (R.A. 98), even if smoothed by design or as the result of continued use, have been shown to be the main cause of variability in this determination. Alundum crucibles (R.A. 360) have proved to be very satisfactory when chlorine water is used as the chlorinating medium. The errors which occur when using R.A. 98 crucibles are due to retention of cellulose by the working

crucible, loss of cellulose through the pores of the crucible, and contamination of the cellulose by fine particles of alundum. The finer R.A. 360 crucibles minimize the first and third of these and eliminate the second altogether.

Chlorine water has been shown to be the most satisfactory chlorinating medium, because it enables control of temperature and time and ensures thorough contact between wood and chlorine. Celluloses prepared with chlorine water have been compared with those prepared with gaseous chlorine under careful control and with gaseous chlorine diluted with chilled air. It has been shown, in the case of woods such as *E. regnans*, that chlorine water cellulose has by far the lowest copper number and that it is the only product in which the alpha-cellulose content is determinable. The other products are too degraded to be filtered after treatment with mercerizing solution. The effects on the yield and quality of the cellulose of the quality of sodium sulphite used, of the care taken in washing the cellulose, and of alkaline pre-treatments have also been studied.

Attempts have been made to develop a suitable method for the isolation of the total carbohydrate fraction or holocellulose from woods. The method of Van Beckum and Ritter has been given a thorough trial, but some difficulty has been experienced in determining the point of complete delignification and in ensuring the complete removal of lignin without loss of carbohydrate. A number of alternative methods, all of which employ chlorine water as the chlorinating medium, have been tried. Cold ammoniacal alcohol, cold ethanolamine-alcohol, and cold very dilute aqueous sodium hydroxide have been used to dissolve chlor-lignin. With the first two, complete delignification without loss of carbohydrate may be attained under routine conditions. However, with both these reagents, a stable reaction product with carbohydrate is produced, and the final product does not strictly represent the carbohydrates or carbohydrate types as they existed in the wood. This objection also applies, even more seriously, to the method of Van Beckum and Ritter. Work on these methods is proceeding steadily, and it is hoped to have a routine method available very soon.

The effects and mechanism of mild alkaline pre-treatments on woods have received considerable attention. It has been established that very mild alkaline pre-treatments remove or modify the inter-cellular layer in such a manner that, when thin wood shavings so pre-treated are subjected to controlled forms of delignification, they separate into free fibres which retain most of the carbohydrate matter originally present in the wood. This interesting discovery has led to the development of a simplified soda-chlorine process for producing pulps rich in hemicelluloses from thin wood shavings. Some time has been spent in perfecting and testing this process, and a preliminary account of it was published in the Council's Journal (May, 1939). It is proposed to investigate the qualities of the pulp produced by means of this process.

A considerable amount of time has been devoted to setting up and testing equipment for pulp evaluation and paper testing. In addition, junior members of the staff have been trained in paper-making and paper-testing in preparation for an extensive investigation of the variables in beating procedure using the Lampen mill, 1½ lb. Niagara beater, and Clark Kollergang.

The results of an investigation of the pulping properties of samples from three trees of *E. sieberiana* have been published (Pamphlet 86), and the analysis of the wood and pulp samples from one tree of *E. sieberiana* has recently been completed using the revised methods of analysis.

6. *Section of Timber Mechanics.*—The number of individual tests made during the year was approximately 10,000 (exclusive of moisture content determinations, which are made on every specimen tested), thus constituting a record for the Section.

(i) *Strength Tests on Australian Timbers.*—The average results of the tests on karri, white cypress pine, and hoop pine were published, as was also a complete analysis of the results of the tests on radiata pine. Routine tests were made on spotted gum (air-dry), red tulip oak (air-dry), and jarrah (green).

(ii) *The Steam-Bending of Australian Timbers.*—During the year, attention was devoted mainly to the reconnaissance of the properties of Australian timbers in order to obtain some idea of their suitability for steam-bending. An article on the results of the tests on the first 31 species has been prepared for publication. No species tested so far is as good as imported ash (*Fraxinus* spp.) but the following timbers—spur mahogany (*Dysoxylum pettigrewianum*, Bail.), celery top pine, myrtle beech, southern sassafras, red tulip oak, radiata pine, Corsican pine (*Pinus laricio*), horizontal (*Anodopetalum biglandulosum*) and northern silky oak—have given very good results. These species are superior to such well known bending timbers as blackwood and silver ash and very much superior to karri and spotted gum. The latter two species, together with Queensland maple, could not be satisfactorily bent at 6 inches radius (1-in. thick material). A feature of the tests was the good results obtained with exotic pines, particularly radiata pine. These were all bent at high moisture contents; sufficient material was not available to check their bending qualities at lower moisture contents. Comprehensive tests have been carried out on karri, both in the green and dry condition, but the results have not been analysed.

(iii) *Tests on Split-ring Connectors.*—Tests on green ironbark were completed, also tests on jarrah and karri specimens that were made up two years previously and allowed to dry to about 18 per cent. moisture content. The tests on the dry specimens showed that, when the load is applied parallel to the grain, the strength of the joint is somewhat higher than the strength when green, but when the load is applied perpendicular to the grain, the strength after drying is 10 to 20 per cent. less than when green, apparently owing to the centre core failing during drying because of shrinkage. The tests are not complete, but tentative working loads have been drawn up and are being published in the Handbook of Structural Timber Design.

As mentioned in last year's report, a study is being made of the effectiveness of various treatments for protecting the connectors against corrosion caused by wood acids and moisture. Preliminary examination after the first twelve months indicate that the following coats have given the best results :—Galvanizing, aluminium paste in long oil varnish, Parkering, zinc dust in boiled linseed oil, and coke oven pitch and coal tar. Further examination will be made at the end of two and three years' exposure.

(iv) *Tests on Coach Screws.*—As stated in previous reports, experiments are being carried out at the request of the Standards Association of Australia on the relative efficiency of three types of coach screws. Tests on the holding power of the three types when driven into green messmate, stringybark, white stringybark, grey ironbark, have been completed, and the tests on the screws driven into green Douglas fir are about half finished. In every case, both the maximum torque required to drive the screw and the holding power have been determined. The analysis of the results of the tests so far carried out has shown that there is little difference in the holding power of the three types of screw.

(v) *The Sagging of Timber Beams.*—It was stated in last year's report that, as the result of preliminary tests, the decision was reached to use $3\frac{1}{4}$-in. square beams of green mountain ash having extreme fibre stresses varying from 2,000 to 6,000 lb. per square inch. Although the average modulus of rupture of the timber used was about 10,000 lb.-square inches, all the specimens loaded to 6,000 lb.-square inches and some of those loaded to 4,000 lb.-square inches, have failed in the twelve months during which the tests have been in progress. The amount of sagging varied with the stress, but, even in the case of the beams loaded to 2,000 lb.-square inches (i.e., the normal working stress), it was from two to four times the original deflection. In order to investigate the possibility of using models, which would permit of sufficient replication and efficient matching, geometrically similar quarter-scale specimens were cut from the same planks as the $3\frac{1}{4}$-in. square specimens. Unfortunately, the behaviour of the full scale and quarter-scale beams was quite different, the models sagging proportionally much less than the full scale beams during the first few weeks of loading.

(vi) *Relation between Silviculture and Properties.—Alpine ash* (*Euc. gigantea*).—In co-operation with the Commonwealth Forestry Bureau, samples of 100 trees of alpine ash from the Australian Capital Territory were collected to investigate the effect of such factors as density and rate of growth on the mechanical and physical properties. The tests on the properties of the green specimens have been completed and a summary of the results published. The only factor having any marked influence on the strength properties was the density, but there was no relation between density and shrinkage or density and incidence of collapse. Although the timber varies from three to sixteen rings per inch, there was no correlation between rate of growth and (*a*) static strength, (*b*) impact strength, (*c*) shrinkage, or (*d*) collapse.

(vii) *Stresses in Trees.*—Mathematical investigation has shown that the large stresses that undoubtedly exist at the centre of trees must be due to the layers of woods immediately adjacent to the bark being in longitudinal tension. No facilities were available for checking this experimentally, but recently published work by Jacobs of the Commonwealth Forestry Bureau, dealing with an experimental investigation into stresses in trees, confirmed the existence of such stresses. A theoretical investigation of the problem showed that, taking Jacob's figures, the longitudinal tension in the outside fibres must be of the order of 1,000 lb.-square inches. The theoretical treatment showed that in addition to longitudinal stresses, radial stresses must also be present and the existence of these radial stresses was demonstrated experimentally. Jacob's results are now being analysed for the purpose of developing a complete mathematical treatment of the problem.

(viii) *The Use of Wood for Aircraft.*—Most military aeroplanes are now built of metal, but, in times of emergency, it appears likely that it would be necessary to construct large numbers of planes built of Australian timbers. It has been decided that research work on wooden aeroplanes will be carried out by the Council's Aeronautical Research Laboratory and the Division working in co-operation. A list of Australian timbers that may prove suitable for aircraft work has now been prepared ; hoop pine appears to be one of the most promising species. A start has been made on research work in connexion with the design of wooden wing spars.

(ix) *Miscellaneous.*—A series of ten lectures on timber was given to students of the University of Melbourne during last academic year as part of the course in Civil Engineering, Part. I. Arrangements have been made to repeat the course during the present academic year. Short series of tests were made on the construction of boxes, the strength of old Douglas fir timber, the suitability of American ash for steam bending, the strength and stiffness of 2-in. thick bridge decking, the relative merits of different methods of bundling flooring, and the strength of built-up columns.

7. *Section of Wood Preservation.*—On account of the shortage of staff, it has been necessary during the past year to postpone the inspection of certain field tests and also to eliminate some of the projects indicated in the programme of work. This curtailment of work was due chiefly to the transfer of two officers from the Section, to the appointment of another to a travelling scholarship, and to the continued demand for assistance by the timber using authorities. On account of the disastrous bushfires in Victoria, work on an extensive investigation of the value of some of the so-called less durable timbers of Victoria has been postponed.

(i) *Field Investigations.*—The results being obtained from the various pole-testing sites are still being examined with interest by the various pole-using authorities. The oldest comprehensive test sites are at Belgrave and Benalla, where poles treated by various methods have now been in service for periods of from four and one-half to five and one-half years. It has been demonstrated that creosote oil brush treatment over sapwood or truewood, plus puddling of the soil with half a gallon of creosote oil, gives protection against both termites and decay to small *E. obliqua* poles for a period of at least two years. Untreated poles during the same period were attacked by decay and or termites. Investigations are now being made into the value of using larger quantities of creosote oil for puddling and into the value of different methods of puddling. The State Electricity Commission of Victoria has adopted puddling as standard practice for certain poles and has developed a special technique. Poles charred over sapwood, sprayed with creosote, and the soil puddled are showing signs of decay in the sapwood. Desapped poles similarly treated are sound after four and one-half to five and one-half years, during which time they have been re-sprayed with creosote and the soil re-puddled. Round, unsapped, creosote-impregnated poles are all sound.

In previous reports, mention has been made of the development of decay in *E. obliqua* poles at Belgrave and Benalla, which were treated with A. H. bandages (containing Tanalith U). In 1933, a number of poles of *E. corymbosa* were fitted with bandages and installed in North Queensland. After six years' service, only 10 per cent. of the treated poles have been attacked by termites, whereas in all the untreated poles, considerable termite attack has occurred, 10 per cent. of the untreated poles having been renewed. The difference in results between the different test sites is probably due mainly to the test localities. Decay does not appear to be a factor in the Queensland test.

It appears probable that the setting of untreated sleepers of durable timbers into ballast already infected by decay organisms from the previously existing sleepers may considerably reduce the service life obtainable. General field evidence tends to confirm this opinion. A field test has, therefore, been commenced in Western Australia in which 74 untreated, sound, jarrah sleepers and 76 creosote brush-treated sleepers were installed in track, replacing untreated jarrah sleepers the majority of which had been in service for about 29 years.

At the request of a large mining company, an inspection of their mine was made and a report prepared on the question of timber preservation and utilization. This report indicated particularly that considerable savings were possible by the adoption of better practices both in regard to treatment of the timbers, the grades and species of timbers used, and the methods of construction.

(ii) *Treatability of Timbers.*—It has been noted that the amount of creosote oil absorbed by the sapwood of Australian timbers varies considerably within the species and also between different species. The penetration of the oil appears to be wholly confined, at least in some species, to the pores. Where this is so and the percentage of pore area is small, it appears that it may be impracticable, even under severe treatment conditions, to obtain a snfficiently high absorption and even penetration to ensure reasonable protection against decay, &c. An investigation of the structure of the sapwood in relation to the penetration and absorption of creosote oil has been commenced. Preliminary work, in co-operation with the Wood Structure Section, has been confined to developing suitable methods for the determination of pore volume. In five species tested, the mean percentage pore area has been found to vary from 14.2 to 22.4, while the range within a species varied as much as from 5.2 per cent. to 34.0 per cent. The actual extent and significance of this sample variation has not yet been determined and the work is being continued.

(iii) *Preservation Processes.*—In January, 1936, a number of standing partly-decayed poles were treated by the oxy-acetylene scouring and charring process, alternate poles in the line being left untreated for comparison. Recently, for physical reasons, four of the treated and three of the untreated poles were removed. The ground line portion of each of the poles was cut into discs, and these submitted to macroscopical and pathological examination. No wood-destroying fungi were isolated from the treated pole sections, and there was no evidence of decay on the surface of checks or immediately below the charred area. The untreated poles contained slight decay, particularly on the surfaces of checks, but except for their size would have given service for some further years. This preliminary examination, however, indicates that the oxy-acetylene scouring and charring process on Class 1 durability poles prevents reinfection for a period of approximately three years at least, without the necessity of re-spraying with creosote oil. Creosote oil was still present in the charred wood.

(iv) *Preservatives.*—Service tests have been continued on a large number of preservatives which have been impregnated into *E. regnans* and *P. radiata* truewood and *E. regnans* sapling billets. Work has not been in progress snfficiently long to allow of definite conclusions being drawn. Further field tests have been made in regard to the formation of a brownish, resin-like compound which forms on the surface of creosote-impregnated sapwood. This deposit appears to be characteristic of Australian vertical retort creosote oils and has not apparently been observed overseas. A detailed study of Australian creosote oil as a wood preservative is of considerable urgency.

In co-operation with the Sydney Harbour Trust, a preliminary investigation was made to determine the rate of leaching and change in composition of creosote oil, when impregnated into wood immersed in sea water. Comparative tests were made with similarly treated material exposed to evaporation under inside conditions. The results indicate a fairly fast rate of loss of the portions of the creosote distilling below 230° C., the loss being very similar under sea water or exposed to moderate air conditions. Immersion in sea water indicates a slight decrease in tar acids, while increased exposure to the air apparently results in an increase. The cause of this variation is unknown.

(v) *Timber Pathology.*—The investigation of decay in jarrah was continued at the University of Western Australia in co-operation with the Western Australia Forests Department until February, 1939, when the work was transferred to Melbourne. Previous work had been concerned with the more fundamental aspects of identification, mode and range of occurrence, relative importance, &c., of the various heart rots of the living tree, together with a study of the causal fungi. During the past year, the investigation was extended to include decays of jarrah in service, with particular emphasis on the problem of determining which of the various decays of the living tree are likely to continue during the service life of the converted timber. It was at first believed that an extensive cultural study of jarrah which had decayed under different service conditions would discriminate between those heart rots which continue and those which are of no further importance. This method, however, proved unsatisfactory and a series of field tests were eventually installed. In these field tests, several hundred specimens containing measured and charted areas of the principal pathological defects of the living tree were installed—some partly and some completely buried—in three test sites selected as representing different types of service environment. Concurrently, an investigation has been commenced to determine the viability of the various heart rot fungi of jarrah during and after air seasoning.

The investigation of decay of jarrah in service indicated that, under moist conditions, *Coniophora cerebella* is most frequently the destructive agent. It is of interest to record the fact that this fungus has been found attacking the living tree, in which quite extensive rot may be produced. A decay of jarrah and many other local and imported timbers characterized by abundant longitudinal penetration of the fibre walls, parallel to the long axes of the fibres and either vertical or helical, was further investigated. This type of rot, with its extremely characteristic hyphal penetration, was found to be caused by a non-basidiomycete fungus. The investigation of "pencilling" in jarrah and certain other eucalypts caused by the fungus *Fistulina hepatica* has been continued. In no case has evidence been obtained of typical rot being produced by this fungus.

The taxonomy of the fungus associated with "heart" in young trees of *E. regnans* and referred to as *Gonytrichum caesium* in the previous report has been determined by the Imperial Mycological Institute as a species of *Gonytrichum* Nees (*Cadophora* Lagerberg and Melin) and not specificially as *G. caesium.* A number of cultures were added to the standard collection of fungi, the collection being revised and re-arranged.

(vi) *Lyctus Investigations.*—The laboratory investigations continued from the previous year indicated that boric acid in low concentrations rendered susceptible sapwood immune to Lyctus attack. The lethal concentration was found to be about 0.12 per cent. of boric acid (calculated on the oven-dry weight of the wood). Tests of the rate of diffusion of boric acid

into green veneer showed that adequate absorption and penetration could be obtained, when using hot solutions, the time factor being relatively short. Details for commercial treatment were developed and a plant erected on a plywood mill at Brisbane. A total of about 100,000 square feet of sapwood veneer of different species and of different thicknesses was treated and tests made of the absorptions and penetrations obtained. From these results, commercial treatment schedules were developed; they have been published and distributed to the veneer and plywood industry. Treated veneer can be satisfactorily glued with casein but not with Tego film. The colour of the wood and its subsequent finishing are not affected. The treatment of timber in various thicknesses is now being investigated using boric acid.

The effect, on Lyctus attack, of adding various chemicals to the glue, has been investigated for three-sixteenth-inch plywood. None of the chemicals tested have retarded Lyctus development. Further tests are being continued.

In addition to Lyctus control by means of impregnation of the sapwood with chemicals, studies have been made of starch depletion by means of various methods of log seasoning, controlled kiln seasoning, and resorption in the tree. The first two methods do not appear, from the results obtained, to be of practical value under Australian conditions, and no further work is planned. Starch resorption, by means of top bark ringing of the tree, offers the greatest possibility of control from the economic standpoint, particularly in regard to timbers containing a relatively narrow sapwood and used mainly for general building and joinery purposes. A detailed working plan has, therefore, been prepared and circulated to the various Forest Services concerned. In Queensland, work already carried out by the Queensland Forest Service has indicated that starch resorption is relatively rapid in *E. maculata*, and further detailed work is being undertaken. In Victoria, tests have been postponed owing to the recent bushfires. It was found that defoliation of the trees by fire definitely affected the starch content of the sapwood, due to the subsequent development of epicormic buds on the trunks of trees, thus resulting in "feathering." Until the crown of the tree recovers, and the shoots on the bole die-off, starch resorption studies in conjunction with top bark ringing will not be possible in any of the readily available timber areas, all of which were affected by the fires.

(vii) *Termite Investigations.*—In co-operation with the Division of Economic Entomology, a survey was made of the nature and extent of termite damage in Adelaide. Various methods of treatment, some of them of doubtful value, if any, have been used by the local builders to reduce the possibility of damage. Termite attack has not been arrested, and even the use of termite-resistant timbers has not been satisfactory. The estimated annual damage is at least £40,000, so that there appeared definite justification for the use of termite-proof construction. A special trade circular was, therefore, prepared giving full details of the method advocated, and a demonstration of the method was made, using a residence in course of construction. The demonstration created marked interest and was attended by about 300 members of the building industry in Adelaide. The cost of installation of the termite-proof construction using standard factory-produced termite shields of galvanized iron was determined to be from about 1 to 1.5 per cent. of the total building cost.

(viii) *Salvaging of Fire-killed Timber.*—The disastrous fires which occurred in Victoria in January, 1939, killed large areas of virgin forest. It has been estimated by the Forests Commission that the volume of timber so killed exceeds 2,000 million super. feet in the round. All of this timber is of low durability and represents the normal cutting for a period of about fifteen years. The salvaging of as much of this timber as possible is a national necessity, and the Division of Forest Products has assisted in the development of suggested methods of treatment.

In co-operation with the Utilization Section, a field study was first undertaken to determine the significance of the probable factors which would cause deterioration of the fire-killed timber. Previous fires of 1926 and 1932, which were, however, restricted in size, had resulted in the killing of substantial areas of similar type forest, and salvage operations had been conducted on these areas. These operations consisted merely of felling the trees and arranging to convert as much of the salvage-felled material in as short a time as possible. Areas of this salvage-felled material were available for examination, which revealed that the main causes of deterioration were pin-hole borers and physical degrade such as checking and splitting. By comparison, decay was of minor significance. As a result of the studies made, recommendations were prepared to give protection to the timber under varying conditions. The cases considered were (*a*) salvage-felled trees lying at the stump, (*b*) logs hauled to extraction lines, (*c*) logs hauled to dumps and stored in the dry condition, (*d*) logs hauled to dumps and stored under water sprays to keep them continuously damp, and (*e*) logs submerged in fresh water.

A study of the incidence and nature of the pin-hole borer damage present in previous fire-killed material showed this to be due to both Platypodid and Lymexylonid borers. No specific information is available on the life-histories and taxonomy of the species of both groups

of insects, and recommendations were made to the Forests Commission to appoint a forest entomologist to undertake this investigation as an essential factor in the development and carrying out of salvage operations. It is very pleasing to note that this recommendation has been carried into effect and that an entomologist will shortly be appointed.

(ix) *Miscellaneous.*—As in previous years, numerous inquiries were received on various aspects of wood preservation, the total number being 461. A curious and previously unrecorded type of damage to treated wood pipe was investigated by the Section. It was found that the inside of the wooden staves had been attacked by what appears to be Dryopid beetle larvae for a distance of about 1 mile from the intake of the pipe, the water being from a fresh-water mountain stream. In a period of six years, the beetle larvae had reduced the thickness of the hardwood staves from three-quarters of an inch to a thin shell. Their attack ceased when the pressure head on the pipe increased to about 75 feet. The beetle larvae have been kept alive under water for nearly eight months without completing their life cycle. Recommendations involving chlorine treatment of the affected section were made.

8. *Section of Veneering and Gluing.*—This Section was established in July, 1938. All the plant for experimental production of veneers and plywoods has been obtained, except the Coe lathe, reference to which has been made previously. Seventy-five visits to various plants in New South Wales and Victoria have been paid by officers of the Section, and 260 inquiries have been dealt with.

(i) *Gluing Characteristics of Australian Timbers.*—Supplies of timber from 54 species were obtained and prepared for test. The gluing characteristics of North Queensland kauri, hoop pine, canary ash, and silver ash with four types of casein glue, two animal glues, and soya bean glue have been determined.

(ii) *Testing of Glues.*—Practically all the proprietary casein glues on the market have been tested to determine whether they conform to British Standard Specification 3V2. With one exception (a liquid glue), they proved satisfactory. A number of cases of glue failure have been examined and reported on. Tests to show the rate of setting and joint shear strength obtained with a number of casein glues were carried out. These indicated clearly the advantages of using the quick-setting adhesives developed for use in conjunction with the vacuum veneering process. Trials with a patent thermo-setting glue with an animal glue base are practically completed. They indicate that this thermo-setting adhesive can be used over a wide range of conditions to give very strong joints in a very short time under pressure. No trouble is experienced with the staining of face veneers. British Standard methods for the determination of the moisture content and keeping quality of animal glue were tested out. It is intended to incorporate these clauses in the Australian Standard Specification for joiners' glue.

(iii) *Veneering of Australian and Imported Timbers.*—Some co-operative work has been carried out with a Victorian company in the experimental slicing and peeling of mountain ash; good results were obtained. Logs will need to be carefully selected to avoid gum pockets if this industry is to succeed.

(iv) *Re-drying of Glued-up Stock.*—Three re-drying rooms have been designed and installed in factories during the year. Two others are in the course of construction. Investigations were carried out at factories to determine re-drying schedules for various classes of stock. Other miscellaneous investigations included the manufacture of textile rollers from Tego-bonded Australian timbers, the stability of solid core doors, the resistance to flame penetration of fire-proofed veneer doors, the bleaching of timbers, the manufacture of flush doors, and the type of sodium silicate best suited for plywood adhesives.

As the veneer and plywood industry is comparatively new in Australia, it is felt that the greatest present need is accurate information on the methods of manufacture. For this reason, six articles have been contributed to trade journals and ten to the Division's *Monthly News Letter*. In addition, two trade circulars have been issued.

9. *Section of Timber Physics.*—For the first few years, the Timber Physics Section was concerned largely with establishing methods of determining various physical properties of timber and with the obtaining of information on these properties for Australian species. A great deal of routine testing has been involved, as the number of different species that must be considered is in the vicinity of 200 and, for each species, it is desirable to have material from at least five different trees. While work of this nature must still go on, sufficient information is now available in some cases to warrant the publication of results, and the analysing and tabulating of this information is proceeding. Density data for 172 timbers and electrical moisture meter correction figures for 140 timbers have recently been prepared for publication, and shrinkage data for nearly 200 species will be available shortly.

More and more of the work of the Section is now being devoted to fundamental studies, and it is in this connexion that the value is most felt of the recent visit abroad of the Officer-in-Charge. The cordial reception accorded at the overseas forest products laboratories

has made it possible to benefit by their experience and at the same time to co-ordinate our work with theirs so as to avoid unnecessary repetition or overlapping. Several new avenues for promising investigations have become apparent, and already a start has been made on some of this new work. Good progress should be made during the coming year as an additional officer has recently been appointed to the staff of the Section.

As part of the general study of the relation between silvicultural treatment and properties, investigation is being made into the variation in density and shrinkage from pith to bark in young trees. Sixty trees of hoop pine, 85 trees of blackbutt, and 4 trees of radiata pine have already been tested. It is frequently found that the material in the immediate vicinity of the pith has unusual properties ; for instance, with radiata pine, the material within a radius of about 3 inches of the pith has an abnormally large longitudinal shrinkage, while the values are quite normal outside this area.

Work on the fundamental investigation of shrinkage was continued at the Forest Products Research Laboratory, Princes Risborough, mainly in connexion with the occurrence of shrinkage hysteresis. The results obtained indicate an hysteresis in shrinking and swelling with moisture content change only at moisture contents above about 20 per cent. Further studies have been commenced on longitudinal shrinkage with the object of determining the effect of tangential and radial drying stresses on this property.

Public interest in electrical moisture meters has definitely been maintained during the year, and moisture meters are now being manufactured in Australia by three independent firms. Considerable work on electrical moisture meters was carried out during the year by the Utilization Section. This work, amongst other things, included the development of the Moisture Tester, an instrument of the capacity type, which definitely enters a field not covered by resistance-type meters in that it will measure moisture contents down to zero. This Moisture Tester has been calibrated by the Timber Physics Section for a number of different species. Work on the application of electrical moisture meters to glued stock such as plywood has been continued. It appears that resin glues have very little, if any, effect on meter readings, whereas large errors may be introduced when casein glue has been used.

Work carried out last year to establish equilibrium moisture content curves for a number of Australian species was later found to be subject to considerable inaccuracy due to the method used for measuring the relative humidity of the air. This was the wet and dry bulb arrangement which in its usual form is definitely unsatisfactory in confined spaces such as the conditioning chamber employed for this work. A second series of tests has now been completed using an improved type of dew-point apparatus for measuring the humidity. In this apparatus a silver mirror is cooled by circulating water and the dew deposition indicated by the change in reflected light falling on a photo-electric cell. This has given very satisfactory results, and a progress report on the work has been prepared.

Work has been continued on the fundamental study of collapse mainly in relation to the mechanism of reconditioning. Apparatus has been designed and obtained for investigating the permeability of hardwoods, and it is hoped that results obtained with this equipment will throw further light on the phenomenon of collapse by correlating the incidence of collapse with the dimensions of the inter-communicating passages between the wood cells.

The Officer-in-Charge of the Timber Physics Section attended the Annual Conference of the Timber Utilization Department of the Comité International du Bois at Brussels last September as the official Australian delegate. Many valuable contacts were made and a paper was presented at the conference entitled " Recent Investigations of the Shrinkage of Wood."

10. *Flax Investigations.*—The work in this Section has developed very satisfactorily, and considerable experience has been gained in retting by the Duplex and Courtrai systems. This has rendered possible advice to a commercial plant in the actual detailed control of its retting. It has been shown that Australian-grown flax straw can produce good quality fibre, and it is understood that this year the area under flax in Victoria is to be increased from 1,000 to 2,000 acres. In order to facilitate the work a small scutching machine has been built. Previously it has been necessary to take the retted flax to the factory at Colac for this treatment.

It has been part of the work of the Section to endeavour to develop a chemical method of retting. This, if successful, would lead to a great saving in time of retting, and further, would give much more uniform results as the whole process could be standardized and controlled. Existing methods depend upon a partial breakdown of the straw by bacterial action, and this from its nature is incapable of close control and must give variable products.

Methods which produce flax of high quality in six hours' retting instead of as many days have now been devised by the Division. The quality of the product has been checked by independent evaluation by experts, and it has proved to be higher in value than that produced by tank retting. It is felt that larger scale tests are essential before details of this process are

released ; these tests are now in progress. It is felt that a definite step has been taken towards putting this very old industry, which has for centuries been conducted on purely empirical lines, on a definite scientific basis.

Behind any scientific process must be as complete an understanding as possible of each step. To provide this knowledge, chemical studies of retting are being carried out. In the first place, studies have been made of the chemical changes occurring during various stages of a tank ret. It is hoped by these studies to find what constituents of the straw are being attacked and in what order. Similar studies on chemically retted straw are projected for the coming year. Problems of the drying of retted straw, the treatment of effiuents from factories, and of methods of indicating the end of a ret, are also being studied.

IX. FOOD PRESERVATION INVESTIGATIONS.

1. *General.*—Several new investigations have been commenced at the laboratory of the Council's Section of Food Preservation and Transport, Homebush Bay, Sydney. They include studies on the freezing and storage of filleted fish, the "ripening" of beef cuts, and the production and canning of pure citrus and pineapple juices. Some preliminary investigations on the smoking of fish have also been commenced with the co-operation of the Council's Fisheries Section.

At the request of the Australian Agricultural Council, steps have recently been taken to extend the scope of the work on fruit juices to include those from apples, tomatoes, and grapes. Extensions of the existing laboratory at Homebush Bay are required in order to cope adequately with these new investigations, and it is expected that building operations will commence early in the next financial year.

A partial re-construction and a general overhaul of the cold rooms at the Council's Brisbane Abattoir Laboratory have been rendered possible by the generous support of the Queensland Meat Industry Board. The old rooms are now well equipped with precise temperature and humidity control to enable accurate studies to be carried out on the problem of the loss of "bloom" from chilled beef during storage.

In June, 1939, the Officer-in-charge of the Section returned to Australia after a visit to Great Britain and South Africa. He was able to renew valuable contacts with colleagues in various food research laboratories, to discuss general policy and specific plans for further investigations on the overseas transport of foodstuffs, to investigate the out-turn in England of various classes of meat and fruit, and to make many inquiries relating to the production and canning of pure fruit juices. He has furnished the Council with several reports on the results of his inquiries, and action will probably soon be taken to implement several of his recommendations concerning further work on problems of the overseas transport of foodstuffs.

2. *Meat Investigations.*—(i) *Chilled Beef Investigations (Brisbane).*—(*a*) *General.*—The Council's laboratory at the Brisbane abattoir is now devoted mainly to studies of the loss of "bloom" in chilled beef, but, from time to time, microbiological work is being carried out on the reduction and control of micro-flora acquired in the meatworks and the ships' cargo spaces. Surveys have also been made of the physical conditions in several meatworks' chilling rooms. It is pleasing to record that the conditions for the preparation and cooling of beef laid down by the Council are being actively and successfully applied in most Australian meatworks exporting chilled beef, and a considerable part of the investigator's time has been occupied by consultations with meatworks' officials in connexion with the installation of improved equipment and technique. During the year, detailed results of the work on microbial contamination acquired in the meatworks have been published as one of the Council's Bulletins (No. 126), and a further Bulletin dealing with the conditions to be maintained during cooling and storage of the beef in the meatworks is now in the press.

(*b*) *Pigment Changes during the Storage of Beef Fat.*—Further small-scale experiments on the changes taking place in fat pigments, as a function of the water-vapour tension of the surrounding air, are being carried out. These studies are now being extended to semi-commercial scale storage trials with quarters of beef.

(*c*) *General Storage Experiments.*—Three storage experiments have been conducted subsequent to the re-modelling of the Council's experimental chambers, and they were planned chiefly to obtain information concerning the conditions under which "staining" of the fatty tissues at the areas of contact between the suspended quarters may occur. The data to be obtained from such experiments are of considerable importance in connexion with the stowage of quarters on shipboard, where "contact staining" may often be very severe.

(*d*) *Shipboard Studies on Stowage.*—A series of shipboard experiments have been commenced in order to study the influence on " bloom " of the degree of tightness of the stowage. These experiments are part of a wider scheme for the study of the physical conditions obtaining within large stacks of chilled beef quarters, and they are being carried out with the co-operation of the British Food Investigation Board and the shipowners.

(ii) *Investigations at Homebush.*—A study of the use of ozone as a preservative in the ripening or conditioning of beef cuts has been commenced. So many contradictory statements have been made on the value of ozone for this purpose, that a carefully controlled investigation of the question seems to be necessary, to find out whether it is possible to use concentrations high enough to retard the growth of micro-organisms very considerably without causing undesirable changes in the colour of the beef or off-flavours in the fat. The concentrations of ozone which have been recommended for this purpose are very low (of the order of five parts per million), and it is difficult to measure such small quantities. Consequently, a critical study of possible methods of analysis was necessary as a first step in this work. A satisfactory micro-method using potassium iodide has now been developed.

Small scale experiments with slices of beef muscle stored at 41° F. have now been started. Sterile slices are sprayed with suspensions of selected strains of bacteria to give various initial contaminations, and are being studied in storage in atmospheres containing various concentrations of ozone. The strains of bacteria used were shown in earlier work to be capable of relatively fast growth on beef at chilling temperatures and to be among those most frequently present on the surface of beef prepared in Australian meatworks. These experiments are still in the early stages, so that no opinion can yet be given as to the real value of ozone in the conditioning of beef.

3. *Fruit Storage Investigations.*—(i) *Citrus Fruits.*—(*a*) *Report of Citrus Research Officer.*—During the year a special effort was made to clarify the position with respect to the etiological factors of storage spot, in an endeavour to substitute rational pre-storage and storage treatments for the empirical methods hitherto adopted. The greater part of the work was carried out in South Australia, where it was shown that at least one of the organisms frequently associated with lesions of storage spot exists as a latent infection in the rind of oranges prior to storage. Investigations are still proceeding. One other point of interest that emerges simultaneously from citrus work at Griffith and Adelaide, is the recognition of the existence of an over-riding " physiological factor " at the time of picking. To this factor is attributed a certain inconsistency in storage results in fruit subjected to sweating and other treatments designed to mitigate storage spot wastage.

A survey of wastage in Australian oranges and mandarins in New Zealand was completed. Special attention was paid to the individual effects of handling, transport, and storage. Wastage was found to be considerable, despite the comparatively short time interval from producer to consumer. Concern was occasioned by general deterioration in condition, due to excessive loss of moisture from the fruit. From an examination of individual lines of oranges, the influence of packing shed treatment on mould wastage was emphasized. In this connexion, recommendations have been made; if adopted, they should result in marked improvement and thereby assist in stabilizing the export trade.

The question of the loss of the external physical condition of the fruit, or wilting as it is often termed, has already received consideration from an experimental viewpoint. Oranges from the Murrumbidgee Irrigation Area, treated with a wax coating to restrict evaporation, and untreated controls, were forwarded to Auckland for storage and examination by officers of the New Zealand Department of Scientific and Industrial Research. A report favouring the wax treatment was subsequently received. A more comprehensive series of experimental shipments of Washington Navels from Victoria is now in course of progress. Comparison is to be made of normal and improved packing shed methods, and fungicidal and evaporation-restriction treatments have been included, the whole forming a factorial design capable of biometrical interpretation.

(*b*) *Investigations at Homebush in co-operation with the New South Wales Department of Agriculture.*—The effect of maturity of the fruit at the time of picking, preliminary sweating treatments, temperature of storage, and various washing and waxing treatments on wastage in Washington Navel and Valencia late oranges from the Gosford area has been investigated. The effect of the temperature of storage varied with the maturity of the fruit at the time of picking, conditions prior to picking, and the type of wastage. A temperature of 50° F. appears to be the most satisfactory for fruit which is susceptible to storage spot, but mould is best controlled by a temperature of 37° to 40° F. Mould wastage is usually greatest in pickings following heavy rain. Preliminary sweating at high temperatures of the order of 70° to 90° F. generally reduces wastage from storage spot and mould, but the effect varies from year to year, from grove to grove, and with maturity and conditions prior to picking.

An attempt was made in this year's experiments to differentiate between the effect of moisture loss and the direct effect of exposure to the relatively high sweating temperatures. The results indicate that moisture loss has a definite effect, but the temperature treatment is also of importance. Further experiments will be necessary to confirm this. In one lot of fruit there was a critical moisture loss of 3 to 4 per cent., beyond which increased water loss led to greater wastage. There are indications that the critical value will vary with a number of factors.

Wastage in Valencia late oranges from Penicillium attack and storage spot was decreased by treating the fruit with a wax emulsion and by using diphenyl wraps. Treatment with borax resulted in less mould wastage in Washington Navel oranges but greater wastage from storage spot. Experiments with Valencia late oranges have confirmed results of previous investigations in New South Wales that fruit harvested in December can be stored and marketed in sound condition in March.

The association between fungi and storage spot lesions has been investigated. Organisms of three types, viz. :—*Colletotrichum*, *Alternaria*, and *Fusarium* were found in some button lesions of readily visible size, but only on rare occasions were these fungi isolated from lateral lesions. Moreover, the number of sterile button lesions was in most cases very much greater than that which was infected.

Emperor Mandarins were picked from two groves in the Hawkesbury River district in mid-June and stored at 37°, 40°, and 45° F. Wastage was least at 40° F. and greatest at 45° F. after seven weeks' storage, and was decreased by preliminary washing treatment with 1 per cent. caustic soda or with 8 per cent. borax. Borax gave better results than soda with clipped fruit, but the results were reversed with pulled fruit. There was more wastage in pulled than in clipped fruit, and the firm type of mandarin kept much better than the larger, softer, and more puffy type.

(c) *Investigations (Melbourne) in co-operation with the Victorian Department of Agriculture.*—Further work with Washington Navel and Late Valencia oranges has demonstrated the increase in wastage brought about by commercial grading and packing as compared with careful handling by Departmental officers. There was more wastage in the later picking, and the effect of commercial handling was more marked. The use of waxed wraps and the practice of clipping the oranges from the tree gave a slight reduction in wastage. Preliminary sweating at 70° F. before storage did not affect the wastage. Last season's results with Washington Navels showed no significant variation in wastage with temperature of storage over the range 40° to 50° F., while the Late Valencia oranges gave more wastage at the higher temperatures in the range 36° to 45° F.

(ii) *Other Fruits.*—(a) *Investigations at Homebush in co-operation with the New South Wales Department of Agriculture.—Apples.*—The effects of maturity at picking time, district, application of boron to the tree and to the soil, delayed storage, and temperature of storage are being studied with Jonathan, Delicious, Democrat, and Granny Smith apples. Storage at 36° F. prior to storage at 32° F. which has given good results in experiments conducted in Victoria, is being compared with continuous storage at 34° F., and the effect of storage in an atmosphere of 5 per cent. CO_2 and 16 per cent. O_2 is being investigated on a semi-commercial scale. Preliminary treatment with ethylene was effective in controlling bitter pit in early Granny Smith apples which contained little starch at picking time, but it was not effective when abundant starch was present.

Pears.—The various factors associated with wastage in many varieties of pears from several pear-growing districts in New South Wales are being investigated. Photographic records of the various disorders, accompanied by full descriptions, are being compiled with the object of clarifying the present unsatisfactory nomenclature of non-parasitic disorders in pears. The effects of the application of boron to the tree and to the soil on the storage behaviour of various varieties of pears and storage in an atmosphere of 5 per cent. CO_2 and 16 per cent. O_2 on a semi-commercial scale, are being studied, but the results are not yet available. An experimental shipment of pears from Griffith and Orange was sent to England for detailed examination. The effect of delaying the cooling of these pears has been investigated in land storage experiments.

Peaches.—The effects of maturity at picking time, storage temperature, and gas storage have been investigated with various varieties of dessert and canning peaches. The storage life at 32° F. was relatively short in most varieties obtained in the 1938–39 season. The best results were obtained with the Phillips Cling, a canning variety which ripened to a good quality at 65° F. and 55° F. but not at 45° F. after five weeks' storage at 32° F. No extension of storage life of any of the varieties was obtained by the use of an atmosphere containing 5 per cent. of carbon dioxide and 16 per cent. of oxygen.

Plums.—The storage life of the Willson variety was only three weeks at 32° F., and this is probably the reason why serious wastage has occurred in shipments of this variety to the East. This variety did not ripen at 45° F. A storage life of nine weeks was obtained with the Santa Rosa variety by storing it at 32° F. for two weeks prior to storage at 45° F. This variety ripened normally at 45° and 55° F. but not at higher temperatures. Fruits which were fully coloured but firm at picking time developed the best quality on ripening. A small sample of Ophir plums gave very satisfactory results at 32° F. when subsequently ripened at 65° F. Favorable comment has been received regarding the condition of this variety on arrival in England. The storage life of the Grand Duke and President varieties at 32° F. was six and four weeks respectively, when the fruit was subsequently ripened at 55° and 65° F. As these varieties usually arrive in England in an injected condition under the present method of carriage at 32° F., they can only be used there for culinary purposes. Cooking tests were, therefore, carried out, and it was found that the injected and discoloured appearance was not evident after cooking, provided the fruit had been stored not longer than two weeks after the first appearance of symptoms of " over-storage ".

Tomatoes.—The effects of storage temperature, preliminary waxing treatments, and gas storage on the storage behaviour of late season tomatoes are being investigated.

(*b*) *Investigations in Melbourne in co-operation with Victorian Department of Agriculture.*—*Peaches.*—Further investigations on peaches picked at two stages of maturity have not shown any very consistent relation between maturity and storage life, i.e., when stored at 32° F. in air and ripened at 60° F., the softer apparently more mature peaches have given practically the same storage life as the less mature ones. But maturity appears to have a marked effect on the reaction of the fruit in gas storage, the storage life of immature or semi-mature peaches being increased by gas storage (using 5 to 10 per cent. of carbon dioxide), while the life of more mature peaches is either unaffected or decreased by gas storage. To obtain peaches sufficiently immature for gas storage, there would generally be some sacrifice of flavour, particularly in the earlier varieties. Satisfactory ripening of peaches has been obtained consistently only at 55° F. and above, but in isolated cases peaches have ripened satisfactorily at 45° to 50° F. The use of wraps treated with diphenyl and o-phenylphenol for the control of brown rot was investigated. Some control was obtained with the Catherine Anne and Late Crawford varieties, but o-phenylphenol tended partially to scald the fruit.

Plums.—With many varieties the storage life at 32° F. was only about four and a half weeks, but subsequent ripening at 45° F. enabled the fruit to be kept for several weeks longer at this temperature. The Cole's Golden Gage variety, however, could be kept for as long as 9 to 10 weeks at 32° F. In four varieties, gas storage resulted in a slight increase in the life of fruit of the first maturity only. In the other four varieties, gas storage markedly decreased the storage life of both maturities. As the best results with mature plums have been obtained by keeping them for not more than a month at 32° F. and then transferring them to 45° F., an experimental shipment on these lines was arranged by the Victorian Fruit Marketing Association in conjunction with the Fruit Export Handling Committee. About 1,800 cases were carried for two weeks at 32° F. (allowing for two weeks in cool store before shipment), and the temperature of the chamber was then raised to 45° F. According to reports from London, a large proportion of these plums ripened normally while corresponding plums carried at 32° F. throughout the voyage failed to ripen but became brown and mealy. This superiority, however, was not reflected in the market prices, as the experimental plums appeared riper and were not acceptable to buyers.

Pears.—The conclusion that gas storage can increase the storage life of less mature fruit but may have the reverse effect with more mature fruit, has also been drawn from experiments with pears. Unlike peaches and plums, pears can be picked when quite hard and green and ripened with excellent flavour; and gas storage (using 5 and 10 per cent. of carbon dioxide) has increased the storage life at 32° F. by about 50 per cent. when applied immediately after picking. However, if the pears are allowed to reach a more advanced stage of colour in air storage before being placed in gas storage, core breakdown may be increased, and " brown heart," a special form of carbon dioxide injury, may occur. Such a result was obtained with Bosc and Josephine pears last season by storing at 32° F. and removing them from air to 10 per cent. CO_2 three months after picking. A similar result is being obtained in the present season by removing Williams Bon Chretien pears from air to gas storage six weeks after picking.

A Victorian canning factory has, for several years, stored Williams Bon Chretien pears at 32° F. before canning. In the present season, the maximum storage life of three months in air at 32° F. was found insufficient to cope with the canning programme, and several thousand cases of pears were stored in a gas-tight chamber. With the chamber half full, the carbon dioxide content could only be held at 2.5 per cent. As the crop was light in the current season, canning was completed earlier than usual, and the bulk of the gas-stores pears were canned early in April

after about eleven weeks' storage. However, a small sample was sent to the Government Cool Stores and retained at 32° F. in 2.5 per cent. CO_2. The pears have now been held for a total period of twenty weeks, and are still ripening satisfactorily.

Grapes.—Experiments have been continued on the storage of grapes (Waltham Cross and Ohanez) packed in cork treated with various chemicals—iodine, sulphur, iodoform, diphenyl, and o-phenylphenol—for the control of mould. The most promising results have been obtained with iodine, notwithstanding the fact that a slight tainting of the fruit occurs.

Apples.—Further work with Jonathan apples has confirmed the previous conclusion that, for prolonged storage, it is best to store at 32° F. with an initial holding period at a temperature a few degrees higher to minimize the development of soft scald and breakdown. The following conditions have been recommended for cool stores—36° F. until the end of April, then 34° F. until the end of May and thereafter at 32° F.

Delayed storage at atmospheric temperatures (55° to 65° F.) only results in loss of quality and cannot be relied on for the control of soft scald and breakdown, as a maximum development after a certain period of delay often occurs, and it would be impossible to say whether such delay would increase or decrease scald in any particular sample. It has been shown that the presence of 5 per cent. carbon dioxide in the storage atmosphere prevents the development of Jonathan spot and reduces mould, but it is still uncertain whether it has any significant effect on breakdown.

Experiments have been conducted with Granny Smith, Delicious, and Stewart apples which are liable to superficial scald. Delayed storage at 45°, 55°, and 65° F. did not result in any consistent control, but this was effected by the use of oil wraps. Storage in an atmosphere containing 5 per cent. of carbon dioxide reduced mould attack but resulted in an increase of superficial scald when plain wraps were used. The apples in oil wraps developed no scald even in gas storage. Indications have been obtained that delayed storage increases the development of bitter pit in Granny Smith apples; and this is being further investigated. A paper summarizing the results of experiments with Jonathan apples, period 1932–38, has been prepared for publication.

4. *Fruit Juice Investigations.*—(i) *Preparation and Preservation of Juices.*—Some preliminary work on the preparation and preservation of juices from Australian oranges and pineapples has been carried out. The processing method adopted was as follows :—The extracted juice was strained, de-aerated at high vacuum (about 29 inches of mercury), flash pasteurized at 190° to 203° F., and canned. It has not been possible, yet, to study in detail the effect of variations in processing treatment, and attention has been concentrated on the effect of maturity and variety.

(*a*) *Parramatta Oranges.*—In the United States of America, Valencia oranges are used almost exclusively for juice production, but it was thought that, in New South Wales, common oranges might prove suitable, since they are reputed to give a high yield of juice of excellent flavour. Plantings of common oranges in New South Wales have declined in recent years, because they contain an unduly high proportion of rag in the pulp, so that there is little demand for them in competition with better eating varieties. Common orange varieties (Joppa, Parramatta, Siletta) are still plentiful, however, so that conversion to juice, if practicable, would provide a valuable outlet for this fruit.

Thirteen batches of Parramatta orange juice were prepared, commencing during the first week in July and ending in October. The whole of the fruit was derived from one orchard. Early-picked Parramatta oranges yielded a juice that was somewhat unattractive in appearance, being of a pale straw colour, and the acidity was excessive (2 per cent. calculated as anhydrous citric acid). There was also a much greater tendency for bitterness and a "cooked" flavour to develop than in the juice from more mature fruit. It was found that rapid cooling of the juice after canning is necessary with all maturities in order to reduce the risk of producing a "cooked" flavour. For efficient sterilization of the can, hot filling at 158° to 167° F. is essential. Rapid cooling by immersion of the cans in cold water two minutes after sealing was satisfactory under the conditions of these experiments. An attempt to eliminate the harmful effects of excessive acidity by partial neutralization of the juice with sodium bicarbonate before processing was unsuccessful, as this practice imparted an unpleasant alkaline flavour to the juice.

In a test of methods of extraction carried out with early fruit, it was found that juice obtained by reaming extraction of halved unpeeled fruit was considerably more bitter than that obtained by pressure extraction of peeled whole fruit. Similar results have been reported by workers in other countries. As the maturity of the fruit advanced, both bitterness and cooked flavour diminished, while true orange flavour and aroma and general palatability increased. Juice from fruit picked during the last week in August was quite acceptable after six months' storage, while that processed early in November was in excellent condition when tested four months later.

The results of the initial season's work indicate that Parramatta oranges are suitable for the commercial production of orange juice. It would appear that the optimal picking date for the season is about mid-October, when the acidity is approximately 1.15 per cent. calculated as anhydrous citric acid, and that canning is possible from September to November, inclusive, provided that early and late maturity juices are blended to a suitable sugar-acid balance.

It is important to note that none of the samples possessed the natural properties of fresh orange juice in full measure, and that all were affected to some extent by storage. Juice of late maturity deteriorated more rapidly in store than that earlier processed, and it is suggested that storage could not safely be prolonged beyond six months by the preservation methods adopted.

(*b*) *Washington Navels.*—This variety is generally considered overseas to be unsuitable for juice production. A few batches of juice were prepared from this variety in mid-July when the fruit was full eating ripe. Both reaming and pressure extraction were tested, but in all samples there was a marked bitter flavour rendering the juices rather unpalatable. It has been suggested that excision of the navel before extraction may render this variety suitable for juice production; this possibility will be tested next season.

(*c*) *Valencia Oranges.*—Two batches of juice were prepared from this variety, one from relatively immature in October, and one from fully matured oranges at the end of January. Neither early nor late maturity juices attained the standard of that obtained from processed Parramatta juice. It is possible that the processing treatment was unsuitable in this case, and that detailed investigational work into maturity and time and temperature of pasteurization may effect improvement. The successful canning of Valencia juice is particularly desirable in view of the heavy annual losses from black spot (*Phoma Citricarpa*) in the Gosford and Hills Districts (New South Wales).

(*d*) *Pineapples.*—This investigation was carried out in co-operation with an industrial organization; it consisted in a comparison of the processing method used in this laboratory with accepted commercial practice. Juice was extracted by pressure from the peel, and also from the peeled fruit. Grated pulp was added to a number of cans in each series, so that finally four sets of samples were obtained, viz.: (i) peel juice, (ii) peel juice with grated pulp, (iii) juice from peeled fruit, (iv) juice from peeled fruit with grated pulp. The processing treatment was similar in all respects to that used for orange juice. Juice from comparable fruit was simultaneously prepared by the commercial method. Examination of all samples was made after two months' storage. Allowing for the fact that the pineapples were somewhat immature at the time of extraction, laboratory-processed juice had retained fresh flavour and aroma (almost unimpaired), whereas commercial juice possessed a distinct cooked flavour and had lost much of the characteristic aroma of fresh fruit. It is probable that the prolonged period of heating entailed in the batch pasteurization of the commercial juice was in a large measure responsible for the change. There is evidence, however, that many people may prefer the flavour of slightly " cooked " juice to that of fresh pineapple juice.

(ii) *Examination of Commercial Fruit Juices.*—During the year, a large number of juices from various sources were tested for appearance and palatability in order to gain some idea of the quality of products at present marketed in Australia and abroad. Orange, grapefruit, apple, prune, tomato, grape, cherry, pineapple, carrot, and sauerkraut juices were obtained and examined by a tasting panel constituted for that purpose. It would appear that attractive and palatable juices are already manufactured from tomatoes, pineapples, and oranges, while some at least of those from apple, cherry, grape, and grapefruit should be capable of improvement.

(iii) *Can Lacquer Investigation.*—The object of this work was to discover, if possible, corrosion resistant, non-tainting lacquers, suitable for internal application to tinplate containers. Lacquers manufactured in Australia in accordance with local and overseas formulae were supplied for investigation and were tested together with several lacquers of British origin. Initially, the cans were coated by pre-lacquering the tinplate in a commercial plant, and half were post-lacquered by spraying to cover damage to the film during tooling. Processed orange juice was filled into the containers which were held for varying periods in store before examination. Routine testing consisted in visual inspection of the film, tasting the juice for taint, and chemical determination of the tin content of the juice.

Two serious objections were noted in the first series of lacquered cans, viz.:—Abrasion of the film during manufacture, and failure to cover the corners effectively because of the buffering effect of the air in the can during spraying. With respect to the former it was noticed that lacquer from the second coat invariably penetrated fractures in the basic coat causing it to lift and thereby expose considerable areas of plate. This was particularly noticeable along the side seams where the primary coat had been scorched during soldering. In the matter of internal spraying, cushioning of air in the corners of the can was such that a continuous film could be

applied only by excessive spraying. Under these conditions, charring occurred during stoving, thus irretrievably damaging the protective coating. It was finally decided to spray-lacquer the body of the can and the two ends separately, the former being rotated on a turn-table to assist evenness of spread. Pre-lacquering was eliminated from consideration. Can bodies lacquered in this way exhibited no sign of corrosion by orange juice after six months' storage. The method of lacquering ends, however, has not yet proved satisfactory, and it is thought that these also will need to be rotated during spraying to ensure a perfect cover. Two new lacquers of Australian manufacture were shown to possess excellent corrosion-resistant properties without imparting taint to the juice. One British lacquer also gave promise, and with the two previously mentioned will constitute the basis for future work.

A striking observation made during the course of the experiments was the consistently harmful effect of tin on the palatability of fruit juices stored in unlacquered cans. The effect was first noted in canned pineapple juice, and subsequently detected in orange, grapefruit, prune, and sauerkraut juices. Apparently, this matter has been unnoticed overseas or considered unimportant, since lacquers are used commercially only with those juices which are known to be corrosive and apt to cause penetration. It might be suggested, nevertheless, that for most fruit juices the use of lacquered cans is essential to the preservation of the natural fresh flavour of the parent fruit. The tin content of a number of commercial fruit juices stored in unprotected cans is set out below. The flavour of each of these juices was seriously impaired by the presence of tin. In view of the limit of 280 parts per million of tin prescribed by the health authorities in Great Britain and Australia, the figures possess added significance. They are in contrast with tin contents of juices from lacquered cans which were usually found to be of the order of 30 to 40 parts per million,

Juice.	Origin.	Tin (parts per million).
Pineapple	Australia	113.4
Pineapple	Hawaii	276.7
Tomato	Australia	81.8
Tomato	United States of America ..	67.3
Grapefruit	United States of America ..	274.5
Prune	United States of America ..	251.2
Prune	United States of America ..	324.7
Apricade..	United States of America ..	101.2

5. *Preservation of Fish.*—(i) *Freezing and Cold Storage of Fish.*—A series of experiments designed to study the behaviour, during frozen storage, of the more common species of Australian sea fish has been commenced. For the first experiment, deep-sea flathead were used. The fish, caught by trawlers operating in the waters along the New South Wales coast, were iced within half an hour of capture, and held in the round state until required for freezing. They were then filleted, skinned, wrapped in waxed paper in blocks of 1-in. thickness, frozen, and packed in waxed cardboard cartons. The effects of the following variables are being studied: Period on ice prior to freezing, rate of freezing, temperature of storage, and period in the frozen state. At intervals composite samples were withdrawn from storage and examined chemically and physically. In addition, a selected panel of persons reported on the palatability of samples cooked by steaming.

The defects which became apparent in the stored fish were loss by " drip " on thawing, a relative " toughness " in the cooked flesh, and the development of unpleasant off-odours and taste. " Drip ", when measured by the loss of fluid by natural flow from frozen slices of regular dimensions, was influenced by the speed of freezing, being least when the period in the " critical zone of freezing ", 32° to 23° F., was less than 30 minutes, and greatest when this period was sixteen to eighteen hours. Periods in the " critical zone " outside this range have not been investigated. When " drip " was estimated by adding the loss due to natural flow and that due to the subsequent absorption of juice into filter paper, there was no significant difference between periods in the critical zone. More exact information will be available when the experiment has been repeated with fish caught at a different period of the year, and the results subjected to statistical analysis. There was no apparent increase in the percentage of " drip " from frozen fillets held up to seven months at either of the temperatures of storage, –12° and –20° C.

The " toughness " of the fish cooked by steaming was quite apparent to all members of the tasting panel who tasted samples subjected to storage in the frozen state for periods in excess of one month. The degree of toughness did not appear to be influenced by any of the factors included under the list of variables. Because of the method adopted, and the difficulty of

quantitative assessment, it has not been possible to determine whether there is a progressive increase in toughness of the fish stored for periods in excess of one month, but further experiments have been designed to test this more accurately. That some alteration has occurred in the muscle proteins has been indicated by some loss of their solubility in 1.0 M sodium chloride. After one month in frozen storage, it was estimated that approximately 25 per cent. to 30 per cent. of the original total salt-soluble proteins had been altered and rendered insoluble. Beyond one month there did not appear to be a progressive loss of salt-solubility at either temperature of storage, and the percentages insoluble in all samples after seven months did not, within the limits of experimental error, exceed those found at one month.

Off-odours and off-flavours became apparent to the majority of observers in the panel when the fish had been stored for approximately two months at −12° C., and four months at −20° C. Examinations indicated that the areas chiefly affected were in the lateral streaks immediately beneath the skin. Frequently, these were badly affected, while the deeper and whiter layers showed no detectable changes. Chemical examinations of the spoiled areas showed that there were no measurable amounts of amines but that the fats had developed marked rancidity as indicated by high peroxide and aldehyde contents. The fish used in this experiment had a body oil content of about 1.5 per cent., but this was found to exceed 3 per cent. in the dark subcutaneous streaks, and to be about 0.3 per cent. in the deeper white flesh.

(ii) *Chemical Methods for the Determination of the Extent of Bacterial Spoilage in Fish.*—Investigations have been carried out to test the methods adopted by workers in other parts of the world for the determination of the extent of bacterial spoilage in fish, and the possibility of their use for Australian species of fish. Briefly, the methods involve the estimation of trimethylamine developed in fish tissues as the result of bacterial breakdown of trimethylamine oxide. An account of this work will shortly be published.

(iii) *Smoking of Fish.*—Co-operative work has been commenced in conjunction with the Fisheries Section in order to determine the suitability of Australian species of fish for smoking. The work of the Section of Food Preservation has involved the determination of the most suitable types of instruments for measurement of temperature and relative humidity in the atmosphere of a simple type of smoke-house which has been erected.

6. *Egg Investigations.*—(i) *General.*—Investigations into various problems connected with the export and storage of eggs are in progress in each of the mainland States. These investigations are financed jointly by the Egg Producers' Council and the Council for Scientific and Industrial Research. Arrangements have been made for a programme of work extending over five years and the Section of Food Preservation and Transport has undertaken the responsibility of co-ordinating the experimental work in the various centres in addition to carrying out investigations itself. In each of the centres, the Egg Board and/or large exporters, the State Department of Agriculture, and the Department of Commerce are co-operating in the work.

(ii) *Fundamental Work.*—A large portion of the funds available has been devoted to detailed bacteriological studies at the Parafield Egg Laboratory of the South Australian Department of Agriculture under the direction of Professor A. E. Platt of the University of Adelaide, and at the central laboratory of the Section at Homebush. Bacteriological investigations are also being carried out by the Western Australian Department of Agriculture. The general objects of this work may be summarized as follows :—

(*a*) To identify the chief bacteria causing rotting.

(*b*) To elucidate the factors governing the resistance of eggs to invasion by bacteria present on the surface of the shell. Particular attention is being given to the effects of washing and of diet.

(*c*) To discover the chief sources of contamination with organisms likely to cause rotting and the mechanism of infection, paying particular attention to methods of cleaning.

In each of the States concerned a large number of rots and suspected rots obtained from other experiments have been examined, and cultures of the bacteria present have been prepared. These cultures are now being studied in detail. Preliminary work has been carried out to test various methods of reproducing rots in eggs using pure cultures of organisms isolated from rotten eggs.

(iii) *Experimental Shipments.*—Six experimental shipments were sent to London this season—two from each of the following States :—Queensland, South Australia, and Western Australia. For each experimental shipment this year it was possible to arrange for the storage and systematic examination of check lots of strictly comparable eggs retained in storage at the port of loading. These check lots were examined at the same time as the exported samples were

examined in England, and then subjected to a keeping test under conditions similar to those used in London. The results obtained in England and Australia were found to be in close agreement. A good deal of useful information on differences between farms was obtained from this work, and these differences will be followed up by work in Australia as opportunity offers. In most instances where full data are available the differences between farms have been consistent over several seasons, but there have been considerable variations in two or three cases. It is fairly evident that some of these changes were due to specific alterations in methods used on the farms. The close agreement between the results obtained in Australia and London indicates that the chief causes of spoilage must be sought in Australia.

(iv) *Cleaning Experiments.*—Experiments designed to test directly the effect on the keeping quality of cleaning eggs by various methods were carried out in Queensland, New South Wales, and Victoria. The results of the experiments and of similar experiments carried out in previous years indicate that, if the conditions are strictly controlled, eggs can be cleaned by a number of methods without causing any material increase in wastage when the eggs are stored for about ten weeks. Further experiments have been planned to attempt to define more exactly the conditions under which cleaning by various methods may be regarded as safe.

7. *Physics.*—(i) *General.*—The staff of the Physics sub-section are responsible for the maintenance of the equipment in the laboratory, the control of the cold rooms, and the design and construction of most of the apparatus which can be made in the laboratory. They also assist in the control of conditions and in physical measurements in connexion with the work of other sections of the laboratory, and carry out most of the statistical analyses of experimental results which are required.

(ii) *Cooling of a Wet Body.*—This work has been continued along the lines indicated in the last report, though graphical methods have been employed instead of arithmetic methods for the approximate integration of the equations in some cases. The work has not yet advanced far enough to draw any definite conclusions.

(iii) *Permeability to Water Vapour of Wrapping Materials.*—A standard method for measuring the permeability to water vapour of wrapping materials has been modified to give greater convenience without reducing the accuracy of the measurements, and a number of treated papers and other materials have been tested.

(iv) *Evaporation of Water from Oranges.*—The rate of evaporation from oranges under various conditions is of importance because of its bearing on desirable conditions for " sweating " the fruit before placing in cold storage, and also because loss of " condition " due to excessive water loss is often of considerable commercial importance. Measurements of the rate of evaporation at various relative humidities at 70° F. have been made with freshly picked Washington Navel and Valencia oranges in samples picked at intervals throughout the respective seasons. Surface waxing treatments are commonly used to delay " loss of condition " in oranges. Consequently, the effects on rate of evaporation of several different waxing treatments, and also of washing in a borax solution, have been studied in oranges stored at 40° F. and 70° F. It was found that treatment with borax led to a definite increase in the rate of loss of water, while some of the waxing treatments gave very marked decreases in the rate of evaporation. Further measurements will be made in order to obtain more exact data to check the consistency of the effects under different conditions.

(v) *Overseas Transport Investigations.*—A programme of experimental shipments of beef, eggs, and fruit, similar to those arranged in previous years, has been carried out in co-operation with the British Food Investigation Board. The liaison officer of the Section in London has also made a large number of examinations of samples from ordinary commercial shipments of various products, in order to obtain further data on matters which are being investigated by the Section. Towards the end of 1938 a further detailed survey of the physical conditions in refrigerated cargo spaces of a modern vessel stowed with chilled beef was carried out jointly by the Council and the British Food Investigation Board. In addition to the physical measurements, the loss of bloom and of weight were assessed and compared for comparable beef in each pair of cargo spaces being studied. Detailed analyses of the data obtained on this and previous occasions have served to define, but not solve, the problem of securing the rate of loss of weight desired to effect the minimum loss of " bloom ". They have indicated, too, that further progress in securing methods designed to give the optimum rate of loss of weight on shipboard is unlikely to be made until more detailed and precise knowledge is available concerning the physical conditions prevailing within the compact stacks of quarters stowed in the ships' cargo spaces, and plans are now being made to obtain these data. Owing to the considerable technical difficulties involved in securing the required measurements, the rate of progress must necessarily be slow.

X. FISHERIES INVESTIGATIONS.

1. *General.*—Occupation of the newly-erected biological laboratory in the Fisheries Reserve, Cronulla, took place during the last week of June, 1939. The building contains offices and a strong room, one bacteriological and one chemical laboratory (with common preparation room), five biological laboratories, a dark room, a balance room, a library, a stock room, and a draughting room. Several storage rooms and a workshop are also included in the new works. The pre-existing (hatchery) works have been re-conditioned and adapted. They include a centrifugal pump with pipe-line to a 25,000-gallon concrete sea-water reservoir, from which there is a gravity feed to the former hatchery buildings, which have been converted to contain two biological laboratories, a projector room, and a large main experimental aquarium. The latter is supplied with ordinary sea-water under pressure, and conditioned (heated or chilled) sea-water is also available for experimental work. Extra working space is also available in this room, which is fitted in addition with three thermostatically controlled refrigerating chambers (two maintained at zero and one at 30° F.), and a small canning plant. A small commercial-type smokehouse and a net-storage and fish-processing shed have been built on the foreshore, while a small jetty has been constructed from the end of which certain experimental work can be carried out. The large concrete tidal pond (100 feet x 42 feet) will be re-conditioned during the coming year. For esturial surveys, a 16-ft. 3½ h.p. skiff has been constructed, and, for field work, a 2-ton Bedford mobile unit has been acquired and fitted with the necessary apparatus.

The research vessel M.V. *Warreen*, which was placed in commission in May, 1938, has successfully carried out its first full year of deep-sea investigation, covering approximately 30,000 miles. It has been decided to confine the initial operations at sea to the south-eastern area, and the area covered (many portions of it repeatedly) has extended from the tropic of Capricorn to the eastern limit of the Great Australian Bight, with frequent visits to Tasmanian waters. The principal objective has been to keep in touch with the distribution and movements of the chief pelagic fishes. Much increased evidence of the tuna group of fishes has been obtained and it now seems virtually certain that the numbers and distribution of this group are such that a commercial fishery can be envisaged—particularly in eastern Tasmanian waters. It is proving more difficult to determine the possibilities of developing a pilchard fishery, since the pilchard, although so frequently detected at depth, appears to frequent surface waters only in the three or four colder months of the year. Furthermore, the average size attained by the pilchards captured to date has been a low one. Investigations on Australian salmon, mullet, barracouta, bait fishes (such as sprats, anchovies, &c.), and on oysters have been initiated during the year, as has also an intensive study of the basic physical and biological factors at work in the whole of the area covered.

Additions to the staff during the year consisted of a biologist, a hydrologist, and a graduate technical assistant. Certain necessary information and material were obtained from the southern portion of Western Australia through the part-time employment of a field assistant as collector and observer.

2. *Aerial Reconnaissance.*—Two further series of flights were carried out during the year. As on previous occasions, a *Seagull* amphibian machine, kindly made available along with its crew by the Royal Australian Air Force, was employed, one of the Council's officers acting as observer and photographer. A brief summary of these operations since their inception may now be given, since this type of reconnaissance has definitely passed beyond the experimental stage and has been established as a regular instrument to be used as required in the investigation of the distribution of pelagic fishes.

Spring Series.—Flights were carried out in the south-eastern area between 21st October and 1st December in 1936; and between 15th November and 6th December in 1938. In both years pelagic fish were observed chiefly off the southern portion of the coast of New South Wales—typically in the vicinity of Montague Island. Salmon were especially conspicuous in 1936, whereas in 1938 they were not so prominent (although found to be massed in a more southerly position—east of Lakes Entrance on the Victorian coast, and also in the Flinders Island area). In 1938, tuna were observed in very great abundance—over 100 individual shoals being seen (and parts clearly photographed) in the region east of Montague Island.

Summer Series.—Flights were carried out between 25th February and 28th March, 1937; and between 2nd February and 28th March, 1939. The whole south-eastern area of the continent was again covered, and, in addition, the 1938 flights were extended to the northern portion of New South Wales coast and the 1939 flights to the head of the Great Australian Bight. It is noteworthy that in both years the location of the chief pelagic fish shoals showed a shift, from the spring location, southwards to the eastern Bass Strait and Tasmanian regions. There salmon were seen to be plentiful, whereas they had been scarce further north. (Shoals of this fish were however seen in the waters of South Australia and at the head of, and in the eastern portion of,

the Great Australian Bight). Tuna were observed in vast shoals in both years east of the Furneaux group of islands (Bass Strait) and off the eastern Tasmanian coast. Off the New South Wales coast only one small shoal was observed in 1937, and none in 1939. The extended flight of 1939 revealed considerable quantities of tuna in South Australian waters, particularly near reefs (near Kangaroo Island and in the southern part of Spencer Gulf; and in the Great Australian Bight at various points to Port Eyre, the westerly limit of the flights). The South Australian tuna appeared to be exclusively bluefin, often of a larger size than has been seen or captured in the south-eastern region.

Winter Series.—In 1937 (from 7th July to 8th August) a series of flights was carried out in the south-eastern region and off the Queensland coast, with Cairns as the northerly limit. No large scale shoals were seen in the latter region, which included portions of the Barrier Reef, but weather conditions were adverse. A few shoals of salmon were observed near Flinders Island (Bass Strait), and large shoals of this species occurred off the southern coast of New South Wales. A large belt (probably of anchovies) was seen off the south Victorian coast, and off the northern coast of New South Wales large shoals of pilchards were seen in the vicinity of Port Stephens and between Coff's Harbour and Cakora Point. One of these shoals extended in practically a straight line formation for 2 miles. This occurrence at the surface (pilchards normally remain below the surface in daytime) is noteworthy. On the 31st August, 1937, a single flight over Port Phillip Bay was undertaken to confirm local reports of a large occurrence of pelagic fish (anchovies).

Other observations of interest were made during these various flights, e.g., of krill (*Nyctiphanes australis*), a common food of tuna; of sea birds, whose presence often indicates that of pelagic fish feeding on a common prey such as krill; and of large fish or mammals such as sharks, porpoises, or whales.

A notable occurrence during 1938–39 was the co-operative work carried out, mostly by wireless communication, between the aeroplane and the research vessel *Warreen*. The latter was frequently directed to areas of fish occurrences. and in all cases confirmed the observations made from the air. In one instance the vessel found shoals which had not been observed from the air; probably the fish were swimming below the surface. It should be noted that on none of the many occasions on which the flights have extended many miles beyond the edge of the continental shelf have shoals of pelagic fish been observed. Birds have also been scarce. The occurrence of tuna close in to the coast is seemingly a point favorable to their economic commercial exploitation. Particularly does this refer to the discovery, for the first time, of large shoals in Tasmanian waters.

It was found possible to drop drift bottles (for current determination) from a height of about 100 feet without fracture. This procedure may prove of use where areas unfrequented by shipping are traversed.

3. *Tuna Investigations.*—The research programme on tuna consists of (*a*) exploration of local waters to determine the seasonal occurrences of economically important species, an attempt being made at a quantitative assessment by the routine use of a standard catching gear on the *Warreen*; (*b*) biological enquiries carried on simultaneously, including the exact identity of the various species, the size and age composition of the shoals and their movements during the year, biometrical studies to determine local differentiation within a species, feeding habits and the consequent correlation with the presence of other organisms, and the efficacy of aerial spotting of tuna shoals.

Data from Western Australia, obtained by a temporary field investigator, proved particularly valuable in the interpretation of south-east Australian records. It was unfortunate that the summer of 1938–39 revealed a temporary comparative dearth of bluefin tuna as compared with the previous year's experiences, but available records indicate that this appears to be a non-periodic fluctuation, probably due to some adverse factor in the environment, as bluefin were abundant at the commencement and in the latter part of the season. Moreover, whilst these tuna were scarce for a time off south-east Australia, they were quite abundant at the same time in South Australian waters. During the year, two commercial undertakings for the canning of tuna began operations, one at Hobart (Tasmania) and the other at Port Lincoln (South Australia), and efforts have been made to establish relations both with the canners themselves and the responsible authorities in the States concerned, in an endeavour to obtain as complete statistical data in connexion with the fishery as possible. An investigator in modern fisheries investigations, who has not access to accurate statistics of the commercial catch, lacks one of the most potent tools at his disposal. The data required are something more than the gross catch and should include particulars of the fishing effort (man-power and gear) employed in making it, and furthermore, should include adequate sampling, for size composition, of the catch at the various canneries themselves. In the case of the tuna, the Section has, given the necessary co-operation, the advantage of obtaining this information right from the inception of the fishery.

4. *Mullet.*—Biological investigations of this group of fish commenced in January, 1939. Large numbers of mullet have already been examined (35 lots of samples in the fishmarkets and thirteen lots in the field). Sizes, weights, degree of development of reproductive organs, age and growth rate classifications, and racial composition of stocks have been studied. The study of migrations by tagging has been commenced. Spawning habits are also being investigated. The area dealt with extends from Bateman's Bay (New South Wales) to Mary River (Queensland). Material for study has also been secured from Western Australia. The chief species dealt with has been *Mugil cephalus* (?)—the common bull-head, sea and river mullet of the east coast. Incidental work has also been done on *Mugil argenteus* (fantail mullet) and *Myxus elongatus* (Tallegalane mullet).

5. *Oysters.*—Work has been commenced on a programme which covers fundamental studies of the biology of the oyster, and practical studies in cultivation and the control of its diseases. This programme involves the co-operative activity of biologist, biochemist, bacteriologist, hydrographer, and physiologist. It includes regular sampling and comprehensive analysis of oysters from representative situations to show general conditions and rate of growth, spatting, &c., also the survey of oyster habitats, experimental aquarium work, establishment of an experimental farm and of spatting experiments, and the investigation of the winter mortality. The taking of samples has already commenced, and the handling procedure is practically decided. A survey has been made of oyster habitats and distribution in the course of work at Lake Illawarra, Moonee Moonee Creek (Hawkesbury River), and Port Stephens, and during general visits to the south and north coasts of New South Wales and to Queensland. Arrangements are on foot for the establishment of an experimental farm and also for setting up plots for the study of the winter mortality.

6. *Clupeoid Fishes* (*Pilchards, Anchovies, Sprats, &c.*).—The principal lines of investigation followed in respect of these fishes are those relating to distribution and size. Studies on age, maturity and race-differentiation are also proceeding.

(i) *Pilchard* (*Sardinops neopilchardus*).—No definite occurrences of adult pilchards were noticed during the first five cruises of MV. *Warreen* ; the sixth cruise, however, added considerably to the knowledge of the distribution of this fish, as pilchards were found to be very numerous and widespread in South Australian waters (along the Coorong, around Kangaroo Island, and in Spencer and St. Vincent's Gulfs) in February and March, 1939. Here they were observed to constitute the principal food of the bluefin tuna, from the stomachs of which the Section's specimens were all obtained. However, although on many occasions the fish were observed shoaling at the surface, attempts to capture them in the lampara net proved unsuccessful. In New South Wales waters, pilchards were first noted in February, 1939, in the catch of a commercial trawler off Jervis Bay, but they did not become conspicuous until April and May, when they were found from Brush Island to Coff's Harbour. In the latter month, MV. *Warreen* sailed almost continuously through pilchard shoals from Port Stephens to Newcastle, and obtained a sample catch. There were no definite records of pilchards from Tasmanian or Victorian waters throughout the year, although they had been numerous in Port Phillip Bay in the spring and summer of 1937–38.

A generally confirmatory but rather more complete record of the distribution was provided by the examination of the plankton-net catches made by MV. *Warreen* for pilchard eggs and larvae. The results of the second cruise, made in September, 1938, from Sydney to the Capricorn Islands and back, while showing no definite traces of adult fish at the surface, revealed, by the presence of eggs and larvae, that they had been spawning very recently practically along the entire coastline from Port Hacking to Harvey Bay (Queensland), up to at least 20 miles offshore and to depths of at least 60 fathoms. With the exception of the Port Hacking region, where eggs and larvae were found in November and December, 1938, and January, 1939, no such well-marked occurrence was noticed again on the New South Wales coast until April and May, 1939, when they were found fairly constantly between Montague Island and Crowdy Head. Doubtless it will be found that the spawning season will continue this year until September, concurrently with a concentration of adult fish. The presence of spawn in other months, together with the occasional out-of-season records of adult fish that have been noted by various workers on the subject, suggests that pilchards are possibly present in the area all the year round, the winter occurrences representing a migration upwards to the surface waters. In South Australia, concurrently with the surface concentrations of fish previously mentioned in February and March, eggs and larvae were also found.

The total length of the pilchards measured, independent of locality, ranges from about $2\frac{1}{2}$ to 8 inches. The range for the only catch for which a thoroughly representative sample was obtained, that from Port Stephens in May, 1939, was from $4\frac{1}{2}$ to 8 inches, the average size being in the vicinity of $5\frac{1}{2}$. Pilchards have been recorded for Australian waters as attaining a length of 9 to 10 inches, and even up to 11, but until fish of this size can be constantly located there seems

little likelihood of utilizing these fish for oil extraction, as the analysis already performed for pilchards ranging in size from 6½ to 7 inches (*Coun. Sci. Ind. Res.* (*Aust.*) *Pamph.* 85, p. 23) reveals an oil content of only 1.2 per cent. of the whole weight. On the other hand, this low oil content renders the fish eminently suitable for the manufacture of fish meal. They also have possibilities for canning and smoking.

(ii) *Anchovy* (*Engraulis australis*).—Although shoals have occasionally been noticed, the presence of these fish has generally been indicated by their occurrence in the stomachs of tuna, salmon, and barracouta. They appear to have no well-marked seasonal distribution, having been noted from the south-eastern waters of Australia at all times of the year. The specimens so far examined range in total length from 1½ to 4½ inches. The larvae have been recognized and will be described subsequently ; their distribution in the plankton-net catches of MV. *Warreen* suggests that there is no seasonally restricted spawning season in south-eastern Australia.

(iii) *Other Species.*—Considerable attention has been paid to two other species, in particular, the blue sprat (*Stolephorus robustus*) and the sandy sprat (*Hyperlophus vittatus*). These are small species, not exceeding 5 inches in total length, but they, like the anchovy, may yet prove to be useful as live bait for a tuna fishery. They appear to be more typically estuarine than either the pilchard or anchovy, and there is some evidence, at least for the blue sprat, to suggest that the populations of different regions are fairly distinct from one another, and that therefore there is little or no migration or intermingling of populations. If this proves to be the case, these fish can be expected to remain in, or close to, their own estuaries or harbours all the year round, and, as they are fairly easily caught in fine-mesh beach seine nets, an initial source at least of live bait can be assured. Both species spawn during the summer, and apparently tend to form dense shoals in the spawning period : this was the case, for example, in Port Hacking in November, 1938.

Two other species, the herring (*Harengula castelnaui*) and the maray (*Etrumeus jacksoniensis*), were noticed in the region of Sydney in April and May, 1939. Specimens of the latter had a range of from 5 to 8½ inches in total length, the largest exceeding in size the largest observed pilchards.

7. *Bacteriological Investigations.*—(i) *Determination of Sources and Degrees of Fish Spoilage.*—This research has been continued, and a report has been prepared discussing the hygienic aspects of the fishing industry in New South Wales, Queensland, South Australia and Victoria. Bacterial counts were made of fish on landing at the wharf, at the fishmarket, and as sold to the consumer, and the general high range of these counts suggests that improved methods might well be introduced in certain respects. Increased use of disinfective measures are recommended, as are the provision of improved facilities on fishing boats, transports, and in markets and shops. The fluctuation of the catch, inseparable from a purely inshore fishery, makes transport something of a problem, as it is impossible to provide special insulated vans or motor trucks and to run them profitably except in rare cases. The fact that fish is a perishable commodity which requires rapid and efficient transport and careful handling comparable with that of milk is apparently not fully recognized. The use of special fish boxes is urged. These should be sufficiently shallow so that the weight of the upper layers will not bruise the lower.

(ii) *Qualitative Investigations.*—The number of cultures studied in this section of the research is nearing 1,000, and the results, though not complete, are of considerable interest. Bacteria have been isolated from fish slime, gills, and intestinal contents (both of estuarine and demersal fish), air at various fishing ports and in Melbourne city and fishmarket, tap-water used in ice making and for washing fish, sea-water, also from surfaces with which fish come in contact—on boxes, boats, and market benches. The types of organisms have been compared with those occurring in fish muscle in the case of recently caught fish, fish at the market, and retail fish. It has not been the purpose of this work to go into great taxonomic detail but to obtain an indication of the probable sources of various genera of bacteria. One question to be answered is—do different genera in fish muscle indicate the source of the contamination, or have we also to consider a stage-by-stage decomposition in which the genera play successive parts ?

(iii) *Oyster Condition.*—Assays of the bacterial content of oysters from various sources have been carried out. In general, a very high degree of purity has been disclosed. In isolated instances where improvement seemed called for, recommendations as to how this could be secured have proved beneficial.

(iv) *Fish Smoking.*—A small kiln of the usual commercial type has been constructed and some preliminary experiments have been made to determine the relative importance of humidity and temperature factors and in order to obtain data as to the requirements in constructing an experimental kiln. Preliminary tests have been made on mullet, the various tuna species, salmon, sprats, " gummy " shark, and garfish. Not all of these fish are suitable for smoking, but it would appear that there is considerable scope in Australia for an increase in the use of smoked fish. For example, the mullet produces a first-grade product, equivalent in quality to the imported kipper.

Bacteriological tests are being made of the keeping qualities of smoked fish under different conditions.

8. *Hydrological Investigations.*—These investigations were initiated during the year under review and were naturally of a more or less exploratory character. Studies were made of the continental shelf water off the east Australian coast. This is strongly influenced by the east Australian or Notonectian current, which strikes the coast south of the Barrier Reef and moves southward with its inner margin at about the 100 fathom depth contour line. Off Cape Howe it is diverted to the east by the wedge of water which seems to originate in Bass Strait and does not seem to have affinities with the east-flowing current through Bass Strait from the region of the Australian Bight. This latter current seems to flow through Bass Strait and enter largely into the composition of the east Tasmanian coastal waters. The sub-tropical convergence appears to occur some 15 to 20 miles south of Hobart, although occasionally water of sub-antarctic origin was found to penetrate into Storm Bay and even to the north of Cape Pillar. The richness of the food resources at this convergence makes the mapping of its seasonal variation in position of importance to the Tasmanian fisheries.

On data so far obtained, the Notonectian current seems to be of tropical rather than sub-tropical origin. It is extremely deficient in phosphate, in certain cases down even to 200 fathoms depth. Nitrate is generally present in quantities which approach a sub-tropical value, but its efficacy as a nutrient salt is greatly diminished by the paucity of phosphates. Salinity, temperature, and oxygen data indicate a combination of tropical and sub-tropical components. At somewhat above the 200 fathom level there has been detected a persistent wedge of water of salinity about 35 parts per mille which hinders vertical circulation and thus prevents the augmentation of the phosphates and nitrates in the surface layers by upwelling from deeper layers. It is of considerable importance to determine the seasonal and other variations in the degree in which this relatively infertile Notonectian current influences the composition of the coastal waters, since these variations will deeply affect the movements of the pelagic fishes.

A noteworthy finding was that of very high salinities (up to 38.1 parts per mille) in Spencer and St. Vincent's Gulfs, South Australia.

XI. STANDARDS, TESTING, AND RESEARCH FOR SECONDARY INDUSTRIES.

1. *General.*—In the previous report, reference was made to the Government's approval of the recommendations made by the Secondary Industries Testing and Research Committee concerning the extension of the Council's activities in the field of secondary industries and, in particular, to the proposed establishment of an Australian National Standards Laboratory, an Aeronautical and Engine Testing Research Laboratory, a research service to carry out chemical and physical investigations of value to the secondary industries, and an information service. It was also reported that, to give effect to this decision, an amount of £250,000 had been appropriated under the *Science and Industry Research Appropriation Act* 1938, mainly for the purpose of financing the capital expenditure involved.

Further steps in the organization of this work have now been taken and are outlined in the paragraphs that follow.

2. *National Standards Laboratory.*—The University of Sydney has greatly assisted the establishment of this Laboratory by providing a suitable site, 250 feet by 230 feet, within its grounds. Plans for the Laboratory have been prepared in consultation with the authorities of the National Physical Laboratory of Great Britain, who have been most helpful in this and other ways. A contract for the excavations and foundations is to be let early in August, and tenders for the erection of the main building will be invited at an early date. The cost of erection and equipment will be of the order of £100,000.

The work of the Laboratory will be organized in three sections, viz., Metrology, Electro-technology, and Physics. The Metrology Section will be the custodian of the national standard units of mass and length and, in addition, will maintain the more direct derivatives such as those of volume, density and pressure. It will play a vital part in the all-important standardization of high precision gauges on which modern mass production and interchangeability of parts depend. The Electro-technology Section will be responsible for the derived electrical standards of capacity, inductance, &c. The Physics Section will have charge of the Australian legal electrical standards—the ampere, the volt, and the ohm—and will deal with standards of heat, light, and sound, and with other matters having a physical bearing and not dealt with by the other two sections.

Officers to take charge of these three sections have now been appointed and been sent to the National Physical Laboratory, England, where, amongst other things, they will be responsible for the purchase and calibration of the necessary apparatus for the Australian Laboratory. Three

travelling studentships have also been created, one for each section, and appointments to them have been made. The three appointees will spend a period of up to two years abroad obtaining special experience in standards work.

The establishment of the Laboratory is but a part, although a particularly vital one, in the general movement for the dissemination of uniform accurate measurement throughout Australian industry. It will not ordinarily be the function of the National Laboratory to carry out the routine work of calibrating instruments actually used in industrial works. It will be concerned primarily with the high precision sub-standards with which working standards will be checked in other testing stations established in intimate collaboration with it by local authorities in the several States. In this way close co-ordination will be effected.

In its organization of the National Standards Laboratory the Council has received much assistance from an Advisory Standards Committee established last year. The personnel of this Committee is given in the Appendix.

3. *Aeronautical Research Laboratory.*—Considerable progress has been made with the establishment of the research laboratory for aeronautical and engine investigations. Mr. L. P. Coombes arrived in Australia at the end of January, 1939, to take charge of the work. After a preliminary survey, he set out detailed proposals for organization under four sections:—Aerodynamics, structures and materials, engines and fuels, and instruments and electrical equipment. Officers to take charge of three of these sections have been selected, and one has commenced duty. Each of these officers has had experience in the particular branch of work he is to undertake, and, while two are Australian graduates, all have had some part of their training abroad. No appointment has yet been made in the instrument and electrical section, but a young physics graduate of the University of Sydney has been sent abroad in order to gain experience in this class of work; he is also a qualified pilot.

Based on sketch plans prepared by the staff of the Laboratory, the Department of the Interior has completed the working drawings for the buildings to be erected on the site at Fisherman's Bend mentioned in the previous report. Incidentally, the area available has been increased by the lease of an adjoining block of 4 acres, making the total now 14 acres. The whole of it, however, will not necessarily be used for aeronautical work. A contract has been let for the levelling, grading, and fencing of the site, for the roads, and for two buildings—one an administrative building to include staff offices and the physics and fuel laboratories, and the other a workshop building of seven bays for the machine and woodworking shops, mechanical test laboratory, and stores. The greater part of the equipment of these buildings has been ordered.

Two other projected buildings, namely, the engine test house and the wind tunnel, remain to be finalized. Plans are being prepared and will be completed in the near future. The wind tunnel is a large and expensive piece of equipment of a very specialized nature, and it is being designed by the staff of the Laboratory. It is advantageous to make and test a small-scale model of this kind of equipment, and the University of Melbourne has kindly consented to construct such a model. In the meanwhile, tenders have been invited for the construction of the necessary 500 horse-power motor, fan, and control gear. The main portion of the tunnel, which is to be 105 feet long and 44 feet wide, with a working section 7 feet high and 9 feet wide, will be made of welded steel. This material was chosen in place of wood, as the maintenance of air tight joints has proved a problem with wooden tunnels in other countries.

The second recommendation of Mr. H. E. Wimperis, that a University Department of Aeronautics be established, has been carried into effect at the University of Sydney, and Mr. A. V. Stephens, of Cambridge University, has been appointed to the newly created Chair. As he will not arrive in Australia until October, the Council has afforded practical help to the University by making available, for two weeks, the services of Mr. Coombes, who delivered a series of ten lectures to the first students of the aeronautical course.

4. *Other Research.*—The Executive Committee has given much consideration to the development of research into problems affecting secondary industries. It is impressed by the importance of a thorough study on what may be termed the raw material side of secondary industry, using the term "raw material" in a wide sense, that is, as indicating the present starting materials of industrial processes in Australian factories. In this connexion a considerable amount of information has been collected, and in this initial work the Council is collaborating with certain committees which have been established by the new Commonwealth Department of Supply and Development.

Facilities for investigations into physical problems will be available in the building which is being erected for the National Standards Laboratory, and it is satisfactory to know that the officers of that Laboratory will have an opportunity of carrying out research work and that their activities will not be limited to the maintenance of the national reference standards and the

routine calibration of sub-standards. It is hoped that the Council will soon be able to provide for the erection of a chemical laboratory for secondary industrial research, and it has been suggested that an appropriate site for such a laboratory would be adjacent to the Aeronautical Research Laboratory at Fisherman's Bend, Melbourne. To some extent, laboratories at existing institutions may be used, particularly in cases where there is provision of special facilities not ordinarily available in a chemical laboratory. Thus, for example, steps have already been taken for the initiation of investigations into foundry sands in the new Metallurgical Laboratories of the Melbourne Technical College.

5. *Information Section.*—In the previous report mention was made of the organization of an Information Section located at the Council's Head Office. The Section was organized along the lines suggested by the Secretary of the Council (Mr. G. Lightfoot) subsequent to a visit he made to Europe and America in the latter part of the year 1937.

The need for such a section is due to the fact that technical literature has become so voluminous and its rate of increase during the last decade so rapid, that its efficient use has become a definite problem. In Australia, far distant from more highly industrialized centres, it can easily happen that much time and money may be spent on scientific research work aimed at obtaining information already existing elsewhere. Large chemical and engineering enterprises in Europe and America have recognized this need, and thus many private information services are now in existence in those countries. In a country such as Australia, where large-scale secondary industries are not numerous, there is a call at the present time for an information service of a somewhat different type, viz., one which will cover secondary industries as a whole in a fairly general way and without an elaborate staff.

The functions of the Section were given in full in the last report. In short, they are 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 Council's 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.

The staff of the Section consists of five 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.

One important activity of the Section is the provision of cheap photographic copies of scientific articles. Such work is of particular value 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. A small commencement has also been made in organizing a translator's panel, whereby industrialists may be put into touch with translators capable of handling articles in foreign languages in which they may be specially interested. A feature of scientific literature to-day is the diversity of language in which important information may be found.

During the year, a large number of inquiries for information on a variety of subjects was dealt with. The following is a selection from subjects not directly under investigation by the Council:—

(i) *Primary Industries.*—The growth of plants without soil, dehydration of vegetables, pyrethrum, mutton bird oil, chicle gum, sericulture, esparto grass, lumbang oil, Angora rabbits, sparrow control, candlenuts, soya beans, tomato ripening, and wattle growing.

(ii) *Manufactures.*—Carbon brushes, disposal of dairy factory effluents, wool fat utilization, maize products, papain, industrial uses for wheat, caustic soda, nicotine sulphate, power alcohol from wheat and straw, buttons, pectin, invisible glass, printing inks, caramel, invert sugar, eucalyptus oils, apple vinegar, clay products, tiles, galvanizing wire, producer gas-driven vehicles, waterproofing containers, mineral oil, cathode sputtering, casein, plastics, anodizing, sodium silicate, calcium lead alloys, jelly crystals, celluloid, water softening, terne plate, alloy steels, beryllium copper alloys, colloidal sulphur, light magnesium carbonate, Pederson aluminium process, and saponin.

(iii) *Industrial Minerals.*—Asbestos, mica, mercury ores, magnesite, bentonite, rutile, and vermiculite.

(iv) *Miscellaneous.*—The efflorescence and shrinkage of concrete, utilization of ashes from power stations, pozzolanic cement, salt sprout in leather, power alcohol blends, celluloid covers, bottle washing, lightning protection, cockroaches, cellophane wrappings, reduction of factory noises, television transmission, research in Australia, research in other countries, coloured bitumen.

XII. OTHER INVESTIGATIONS.

1. *Commonwealth Prickly Pear Board.*—In the previous report, attention was drawn to the very marked increase in prickly pear growth and the rather light population of *Cactoblastis* in many districts of Western Queensland between Dalby and Charleville and for 100 miles north and south of the main western railway. During the past twelve months, *Cactoblastis* has increased very definitely and is now in good numbers. Some destruction has already occurred, and greater collapse of re-growth and seedling plants should take place in the next few months. However, owing to a very favorable season, considerable young pear growth has again developed. In Central Queensland, *Cactoblastis* continues to exert control over the scattered re-growth and seedling plants.

Abnormally high temperatures were experienced in south-western Queensland and throughout New South Wales in December, 1938, to January, 1939; the heat waves were more severe than for many years. *Cactoblastis* increased very well in the spring generation, as a result of favorable winter conditions, but the extreme heat prevented a further increase from the summer generation. Thus, little alteration has occurred to the rather extensive areas of persistent re-growth in the St. George-Thallon sector and adjacent Mungindi-Collarenebri district of New South Wales, although the population of *Cactoblastis* is greater than it was twelve months ago. The insect has continued to destroy the areas of seedling plants on improved pastures in the Goondiwindi district. It has caused destruction in some similar areas in the vicinity of the Mungle Scrub, where, however, various patches of seedling pear still flourish.

Further progress has been made in the resistant pear country of the Warialda-Bingara-Inverell section, but there is a good deal of re-growth in places. In the Pilliga-Baradine district, there is little change in the amount of seedling pear and re-growth. The pear infestation in the Hunter Valley has been further gradually reduced during the year; certain areas of resistant pear on elevated country still show little sign of destruction.

Regarding the lesser pest pears, breeding and distribution of the beetle, *Lagochirus funestus*, has been continued among the Central Queensland tree-pears, *Opuntia tomentosa* and *O. streptacantha;* established liberations show a partial to good recovery from last season's setback. Further excellent destruction has been wrought by the Argentine cochineal, *Dactylopius confusus*, among the rather extensive areas of tiger-pear, *O. aurantiaca*, in the Roma-Surat, Thallon-St. George, and Warwick districts, Queensland, and good progress has been made in several smaller areas in New South Wales.

In collaboration with the Council's weed investigations, large shipments of the Noogoora burr seed-fly, *Euaresta aequalis*, have been received from North America, and 32,500 flies have been released. Larvae of the second Australian generation have been found in one area indicating that the insect is now established in the field.

Overseas investigations have been concerned mainly with the biological control of *Xanthium*. In North America, the knowledge of the insect enemies of these plants has been considerably widened, and large numbers of *Euaresta* have been forwarded to Australia; some attention has been given to the insects attacking *Lantana*, *Salvia*, *Argemone*, and *Bassia*. In India, an officer has made a general survey of the *Xanthium* situation, and has gathered considerable information regarding the insect enemies of that weed.

2. *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 the Universities of Melbourne and of Sydney.

The Sydney observations on the ionosphere have been continued; with improvements in apparatus and technique more detailed information is being obtained. The connexion between conditions in the F_2 region of ionosphere and the meteorological conditions at the ground has been definitely established; the results of this work have been set out in a paper that will be published at an early date. The discovery of this association has aroused considerable interest, and it was recently discussed at a joint meeting of the Chemical Society, the Physical Society, and the Royal Meteorological Society in London; a review of this discussion appears in *Nature* for 24th June, 1939. The "pulse-phase" equipment for recording very small changes in atmospheric heights has passed its preliminary tests very satisfactorily and is now being prepared for regular observations. The Sydney work of the Board is being greatly assisted by the co-operation of several allied investigators working in the University, the Sydney Technical College, and the Solar Observatory, Mount Stromlo, on such problems as the ionization of the regions below the ionosphere proper, the possible effects of radio waves on the ionosphere, the formation of aurora, potentials necessary to produce a visible glow in gases, and absorption of solar radiation by the gases of the atmosphere. Finally, arrangements have been made for the interchange of ionospheric data with the Radio Research Boards in Great Britain and New Zealand and with the Carnegie Institution of Washington. This interchange should prove most valuable in the Australian investigations.

In Melbourne, the investigations on the reflection of atmospherics at the ionosphere were continued and a large proportion of oscillograms of atmospheric wave form were found to show the presence of reflected waves. The complete results of the investigations have been written up and sent to the Royal Society of London for publication. The suggestion made in the last report that the height of the reflecting layer and the distance of the source mainly determine the character of an oscillogram, has been confirmed by Professor B. F. J. Schonland and his co-workers in South Africa (*vide Nature* 143 : 893, 1939). Another development has been the commencement by a University Research Scholar on a programme of work of interest to the Board and dealing with the refractive index of gases for wavelengths in the region of about 2 to 5 metres. During the year, the cathode ray direction finder was completely overhauled, and the minimum wavelength to which it can be tuned reduced to 850 metres. Work at the Melbourne end will be greatly facilitated in the future by reason of the increased laboratory space which has been provided for it subsequent to recent additions the University authorities have made to the Natural Philosophy School buildings.

3. *Mineragraphic Investigations.*—During the past year, 24 investigations have been carried out into the mineral associations of the valuable minerals in ores, mill products, and rocks, submitted by mining companies and institutions. In many of these, the gold is present in particles of microscopic size, and special methods of preparation for microscopical examination in reflected light are employed to render possible direct observations of the way in which the gold occurs. Such observations are of considerable value to those engaged in developing the best methods of treatment or of investigating losses in milling.

Seven of these investigations have determined the mineral association of ores which have been subjected to the ore-dressing tests discussed in the section (4) that follows. A petrological examination of drill cores and altered lavas at Wiluna for the Aerial, Geophysical, and Geological Survey of Northern Australia also proved that lavas, which are most susceptible to electro-magnetic methods of geophysical prospecting, are characterized by numerous microlites and crystals of magnetite.

The Haultain superpanner, in conjunction with the infrasizer in the Melbourne Ore-dressing Laboratory, has greatly facilitated a number of investigations on the occurrence of gold in mill products and tailings. Rosebery tailings, carrying 1 dwt. a ton, were found to contain particles of free gold, particles of gold embedded in arsenopyrite and attached to pyrite and gangue. Granular and slime flotation tailings from Mount Morgan, containing 1 dwt. of gold and 0.2 per cent. copper, were examined for both their gold and copper content, and the way in which both these metals occurred was determined despite their low percentage. An experimental flotation concentrate from the Emperor Gold Mining Company, consisting essentially of pyrite with smaller amounts of arsenopyrite and marcasite, was found to contain particles of free gold and the tellurides—sylvanite, hessite, and native tellurium. Some of these valuable particles consisted of intimate intergrowths of free gold and tellurides. The corresponding flotation tailings also contained free particles of gold and rare inclusions of sylvanite in pyrite. The nature of the copper minerals and their relative proportions to each other were determined in flotation tailings from Mount Lyell containing 0.19 per cent. copper. Chalcopyrite, bornite, chalcocite, covellite, and native copper are all present in these tailings, but approximately 80 per cent. of the copper-bearing particles are composite grains containing chalcopyrite with pyrite, hematite, or gangue. The mineral composition and the proportion of free and composite particles were determined in a comprehensive series of sized and assayed mill products from the Zinc Corporation mine. The results were expressed quantitatively to show the variations in mineral trends in each sizing of each mill product. Definite information was thus provided relative to the amount of galena and zinc blende as free or combined grains, to the association and distribution of the silver minerals, and to the distribution of the copper and iron minerals. During the course of this examination, a particle of gold was observed in the lead concentrates, embedded in tetrahedrite in a grain composed largely of chalcopyrite. This observation suggested that tetrahedrite was the host of the small quantities of gold that occur in the lead concentrates, amounting to about 5,000 oz. annually at the Port Pirie smelters. A search for gold was then extended to a rare specimen of tetrahedrite from the Zinc Corporation mine, in which more than a score of minute particles of gold were observed for the first time in a specimen from the Broken Hill lode.

Variations in the composition of zinc blende naturally affect the values of zinc concentrates independently of ore-dressing. In order to determine whether any such variation could be detected in the Zinc Corporation mine at Broken Hill, seven specimens of massive zinc blende from different horizons in the mine were examined microscopically. In each case the massive zinc blende was found to be associated with variable quantities of chalcopyrite and pyrrhotite, sometimes with a little galena or cubanite and rarely with niccolite, a nickel arsenide which had not been previously observed in the Broken Hill lode. Two specimens with least

contamination were chemically analysed, and it was found that while the iron content was approximately the same, manganese varied from nil to 2 per cent. with a corresponding variation in the percentage of zinc.

A study of the occurrence of cobalt and nickel in the Broken Hill lode has been carried out. The parent mineral, which contains both metals in small amount, is lollingite, an iron arsenide. Lollingite preceded the formation of the sulphides, and is converted into arsenopyrite with the incoming of the sulphides. With the complete replacement of lollingite by arsenopyrite, the cobalt and nickel should be discharged. They may remain in combination in the rare sulphide, arsenical willyamite, but in the Zinc Corporation mine it appears that they are separated at least in part, and the nickel re-appears in niccolite, and the cobalt is retained in arsenopyrite. The source of the commercial cobalt at Risdon is partly due to lollingite, but mostly to cobalt-bearing arsenopyrite, both of which are present in small amounts in the zinc concentrates.

A microscopical examination of the Mount Lyell copper ores has also been completed. Pyrite is the dominant sulphide, and the major copper mineral is chalcopyrite. Bornite is subordinate, and other copper minerals, present only in small amounts, are enargite, tennantite, tetrahedrite, cubanite, chalcocite, covellite, and native copper. Traces of nickel and cobalt occur as pentlandite and linnaeite respectively.

All 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 its Geology School.

4. *Ore-dressing Investigations.*—These co-operative investigations are being 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.

The demand for investigations into the treatment of ores and metallurgical products has shown no sign of decreasing during the past year, and the comments received from those for whom work has been done indicate that the service thus offered to mining companies and owners of treatment plants has been of great benefit in establishing suitable practice in new plants and in removing difficulties met with in the operation of existing plants.

In Kalgoorlie, some 35 reports discussing work done on different gold ores were issued. High grade gold—copper tailings from Ravensthorpe, which had lain untouched for years, are now being profitably treated on lines laid down in a report from the laboratory. A scheme of treatment has also been worked out in the laboratory for the profitable extraction of gold from an alluvial pug at Norseman which has previously defied attempts to exploit it. In addition the practicability of the use of a mixture of colloidal and crystalline lead sulphide has been demonstrated in the flotation of soft low grade oxidized gold ores.

New equipment added during the year consists of an Ingersoll rand compressor, Haultain superpanner, Denver conditioner and agitator, and Fagergren flotation cell (new type), while a Haultain infrasizer is also being procured.

In Adelaide, the operations of the Bonython Laboratory are regarded by the Department of Mines as being of the utmost service to the State in the development of its mineral resources of all kinds. Gold continues to be the most important metal, but as the facilities for testing become better known, an increasing demand is arising for investigations on non-metallic minerals in many of which South Australia is well supplied, e.g., barytes, sand for glass-making, and clays.

In Melbourne, there has been, during the year, a steady demand for gold-ore investigations from all four eastern States; there has also been a consistent demand for base metal and other work for which the laboratory is well equipped. The amount and complexity of the work carried out is increasing, and both fundamental and practical problems require investigation. The amount of routine work done during the period has prevented the thorough investigation of many points deserving of further attention.

A fairly thorough investigation of the effect of graphitic shear material on the cyanidation of ore from Cowra Creek was made. It was finally concluded that the gold lost from this source would be negligible. A study of the sizes of gold particles recovered provided interesting information on the efficiency of modern jigs. An investigation of the nature and location of residual gold in a gold-antimony ore showed the relative amounts held in the stibnite and quartz and the amounts not available owing to the reducing conditions developed during cyanidation. An extended programme of tests on a sulphidic cassiterite ore provided comparative information on gravity and flotation processes as applied to this class of ore. This year, further information was obtained about the refractory auriferous sulphide ores of north eastern Victoria. Further unfinished work on the flotation of scheelite from King Island shows that the treatment is quite unsuccessful when carried out in the saline mine water. In the previous work, using fresh water, excellent results were obtained.

5. *Standards Association of Australia.**—The Association has had a record year of progress and achievement; the number of new and revised standards published exceeds that of any previous year, and includes some which represent the culmination of several years of intensive effort. New committees have been appointed and others which had been temporarily in abeyance have been re-constituted as new work has been allocated to them.

For the electrical industry the list of standards has been added to, principally by the issue of approval and test specifications for electrical apparatus. A tentative issue has been made of an X-ray code on which a committee of experts has been engaged for some years.

Highway engineering has been given three important standards, including a glossary and two specifications for bitumen and road machinery parts, respectively. Revised standards for springs and steel castings for locomotives represent railway engineering activities. For the paint trade there are eleven new pigment specifications, and the timber industry has been provided with 32 new and three revised grading-rule standards. Hospital equipment, to the extent of eleven items, has been standardized, and there are sundry specifications in the mechanical and metallurgical groups. The total number of Australian standards now exceeds 400.

A notable feature of the year's record was the visit of the Deputy-Director of the British Standards Institution, Mr. Percy Good. This was arranged primarily for the purpose of discussing with the Standards Association of Australia plans for joint effort by the standardizing bodies of the Empire to secure authority for the use and control of standard marks to indicate conformity to national standard specifications. Mr. Good's tour strengthened the friendly co-operation between the British Standards Institution and Associations in this and the other Dominions.

The financial position of the Association has been somewhat improved during the year, but any gain has been more than absorbed by the expenditure upon increased activities. Accordingly revenue limitations continue to retard the rate of the Association's development.

6. *Biometrics Section.*—The services of the Biometrics Section are being increasingly sought in all aspects of the experimental work of the Council, and it has been found necessary to extend the statistical staff in order to meet the growing demand. Accordingly, an appointment to a studentship in statistics has been made, and the appointee is at present training in London under Professor R. A. Fisher; arrangements have also been made for the appointment of a new assistant for statistics work in the immediate future.

During the past year, a statistical study was made of field counts of yellow dwarf diseased tobacco plants grown under a wide range of conditions. Experiments were planned and analysed for determining the effect of bunt and flag smut inoculations on the growth of wheat plants. Statistical analyses were made on the results of comparison of the growth of foot-rot organisms in varying environments, of the factors affecting the yield of potatoes in sequences of years, and of the effect of different methods of handling oranges. Complex field experiments have been designed for comparing a large number of strains for wheat crosses, for testing different cultural methods on irrigated soils, for studying the behaviour of the subterranean clover mite under varying conditions, and for examining linen fibre produced under different environmental conditions.

In connexion with weeds investigations, significance tests have been made on the results of foliage spray experiments carried out along the water channels, and data on the contact angles and penetrabilities of different sprays have been examined; also, experiments to test the toxicities of different sprays and times of application have been analysed. A statistical survey has been made of the distribution of *Bassia Birchii* in an experimental area in Queensland. The results of this will be used as a basis for future counts in connexion with control experiments. Counts of wool fibres from areas of given size and positions were examined statistically, with a view to finding the optimum size and number of samples to be taken in future experimental work with fleeces. The toxicities of certain sprays to larvae were examined by means of the probit method.

A variety of problems in connexion with Forest Products investigations have received statistical attention, including a study of the pentosans in wood, a regression equation being found relating the weight of furfural to the weight of furfraylidene malonylthiourea. A booklet was prepared on elementary statistics for timber research workers.

XIII. FINANCIAL MATTERS, STAFF, AND PUBLICATIONS.

1. *Finance.*—The statement of expenditure from 1st July, 1938, to 30th June, 1939, is as follows:—

	£	£	£
1. Salaries and contingencies	..	..	20,907†
2. Remuneration of Chairman and Members of Council ..	..	..	2,433‡

* 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.

† 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—	£	£	£
(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) ..	5,904		
Less contribution from the Australian Pastoral Research Trust ..	50		
		5,854	
(*b*) Mastitis (Victoria)	5,312		
Less contribution from Australian Cattle Research Association and part Berwick Farm Revenue ..	4,523		
		789	
(*c*) Rabbit myxomatosis (at Animal Health Laboratory, Parkville, Victoria, and Wardang Island, South Australia) ..	..	507	
(*d*) Tick and tick fevers, pleuro-pneumonia, &c., (at Animal Health Laboratory, Parkville, Victoria, and Field Stations at Tooradin, Victoria, and Helenslee, Queensland) ..	6,949		
Less contributions from Queensland Government, part proceeds from sale of vaccine, and C.P.P. Revenue Fund	2,937		
		4,012	
(*e*) Haematuria (Victoria and South Australia)..	..	288	
(*f*) Toxaemic jaundice (at State Research Farm, Werribee, Victoria)	76		
Less contributions from Toxaemic Jaundice Revenue Fund.. ..	25		
		51	
(*g*) Parasitology (at McMaster Laboratory, University of Sydney)..	9,861		
Less contributions from Australian Pastoral Research Trust, University of Sydney, Australian Wool Board, and Parasitology Revenue Account	1,947		
		7,914	
(*h*) Bacteriology (at McMaster Laboratory, University of Sydney)..	2,467		
Less contributions from University of Sydney and Australian Pastoral Research Trust..	475		
		1,992	
(*i*) Biochemical problems (at McMaster Laboratory, University of Sydney)	1,052		
Less contributions from Australian Wool Board..	36		
		1,016	
(*j*) Parasitology and genetics (at F. D. McMaster Field Station, St. Mary's, New South Wales)	4,541		
Less contributions from Australian Wool Board, University of Sydney, and Infertility Revenue Fund ..	782		
		3,759	
(*k*) External parasites (at McMaster Laboratory, University of Sydney)..	368		
Less contributions from Australian Wool Board..	345		
		23	

3. Investigations—*continued.*	£	£	£
(i) Animal Problems—*continued.*			
(*l*) Wool research (at McMaster Laboratory, University of Sydney)	..	392	
(*m*) Pregnancy toxaemia in ewes (at McMaster Laboratory, University of Sydney)	..	317	
(*n*) National Field Station "Gilruth Plains", Cunnamulla, Queensland	13,194		
Less contributions by Australian Wool Board, Commonwealth Bank, Australian Pastoral Research Trust, and Station Revenue Account	13,194		
	..	..	
(*o*) Entero-toxaemia (braxy-like disease), Moora (Gingin) disease, ataxia in lambs, &c. (Western Australia)	..	360	
(*p*) Biochemical and Agrostological Studies (at Animal Nutrition Laboratory, Adelaide)	10,402		
Less contributions from Australian Pastoral Research Trust and Nutrition Revenue Account	538		
		9,864	
(*q*) Feeding Experiments (at Waite Agricultural Research Institute, Glen Osmond, South Australia)	1,201		
Less contributions from Australian Pastoral Research Trust	100		
		1,101	
(*r*) Field Experiments on Mineral Supplements (at Field Stations Wambanumba, New South Wales; Penola, South Australia; and Robe, South Australia)	1,215		
Less contributions from Australian Pastoral Research Trust	300		
		915	
(*s*) Drought feeding (at Animal Nutrition Laboratory, Adelaide)	1,263		
Less contributions from Australian Wool Board	1,263		
	..	..	
(*t*) Wool Biology (at Animal Nutrition Laboratory, Adelaide)	515		
Less contributions from Australian Wool Board	515		
(*u*) Nutrition and Wool Production (at Animal Nutrition Laboratory, Adelaide)	161		
Less contributions from Australian Wool Board	161		
		..	
(*v*) Suspense account	..	88	
(*w*) Central Office	..	4,266	
		43,508	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)	..	7,000	
			36,508
(ii) Plant Problems—Division of Plant Industry—			
(*a*) Central Laboratory—			
Annual	6,020		
Capital	677		
		6,697	

3. Investigations—*continued.*	£	£	£
(ii) Plant Problems—Division of Plant Industry—*continued.*			
(*b*) Experimental plots		549	
(*c*) Plant pathology		2,798	
(*d*) Plant genetics		5,265	
(*e*) Herbarium		257	
(*f*) Weeds investigations		2,484	
(*g*) Fibre investigations		27	
(*h*) Experimental Farm, Duntroon		1,160	
(*i*) Potato virus studies		705	
(*j*) Plant introduction		2,997	
(*k*) Apple rootstocks, Stanthorpe, Queensland		685	
(*l*) Agrostology	1,635		
Less contributions from Australian Wool Board	775		
		860	
(*m*) Fruit problems	2,534		
Less contributions from Victorian Central Citrus Association ..	100		
		2,434	
(*n*) Tobacco investigations	5,106		
Less contributions from Tobacco Trust Fund	5,106		
		..	
(*o*) Cumbungi weed pest, Murrumbidgee Irrigation Area, New South Wales	475		
Less contributions from New South Wales Water Conservation and Irrigation Commission, and Victorian State Rivers and Water Supply Commission	475		
		..	
			26,918
(iii) Entomological Problems—Division of Economic Entomology—			
(*a*) Central Laboratory—			
Annual	5,073		
Capital	365		
		5,438	
(*b*) Agricultural entomology and museum ..	..	1,974	
(*c*) Agricultural entomology (orchard and fruit pests)	..	104	
(*d*) Agricultural entomology (grasshopper investigations)	..	978	
(*e*) Agricultural entomology (red-legged earth mite)	..	550	
(*f*) Forest entomology	..	2,663	
(*g*) Noxious weeds	..	3,988	
(*h*) Veterinary entomology	4,555		
Less contributions from Australian Pastoral Research Trust, Australian Wool Board, and Economic Entomology Revenue Account ..	218		
		4,337	
(*i*) Oriental peach moth	924		
Less contributions from Department of Agriculture, Victoria	924		
		..	
(*j*) Constant temperature chambers	143		
Less contributions from Sir MacPherson Robertson	143		
		..	

3. Investigations—*continued.*	£	£	£
(iii) Entomological Problems—Division of Economic Entomology—*continued.*			
(*k*) Cotton investigations	455		
Less contributions from Ministry of Agriculture, Egypt	455		
		..	
			20,032
(iv) Horticultural Problems of the Irrigation Settlements—			
Citricultural—			
(*a*) Research Station, Griffith—			
Salaries and incidentals	6,079		
Capital	2,183		
	8,262		
Less funds provided from Station Revenue	1,948		
	6,314		
Less contributions by New South Wales Water Conservation and Irrigation Commission ..	1,500		
		4,814	
Viticultural—			
(*b*) Research Station, Merbein—			
Salaries and incidentals	6,270		
Capital	634		
	6,904		
Less funds provided from Station Revenue	556		
	6,348		
Less contributions by Dried Fruits Control Board and Nyah-Woorinen Dried Fruits Enquiry Committee	1,857		
		4,491	
(*c*) Ripening, processing, &c., of vine fruits Mildura District	855		
Less contributions by Irymple Packing Pty. Ltd., Mildura Co-op. Fruit Co., Red Cliffs Co-op. Fruit Co. Ltd., Aurora Packing Pty. Ltd., Swallow and Ariell Ltd., and Aden Packing Co.	850		
		5	
			9,310
(v) Soil Problems—			
(*a*) Investigations at Waite Agricultural Research Institute, Glen Osmond, South Australia—			
Annual	9,564		
Capital	1,889		
		11,453	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)		2,500	
			8,953

3. Investigations—*continued.*	£	£	£
(vi) Food Preservation and Transport—			
(*a*) Central Laboratory, Homebush, New South Wales—			
Annual	2,868		
Capital	1,930		
		4,798	
(*b*) Meat investigations, Homebush, New South Wales	986		
Less contributions by Australian Meat Board and Metropolitan Meat Industry Commissioner, New South Wales	856		
		130	
(*c*) Fish investigations, Homebush, New South Wales		2,028	
(*d*) Non-tropical fruits, Homebush, New South Wales		1,998	
Less contributions from New South Wales Department of Agriculture ..	393		
		1,605	
(*e*) Physics and Transport, Homebush, New South Wales		1,275	
(*f*) Citrus Preservation		1,670	
(*g*) Meat investigations, Brisbane Abattoir ..	1,089		
Less contributions by Queensland Meat Industry Board	950		
		139	
(*h*) Egg Investigations	897		
Less contributions from Egg Producers' Council	449		
		448	
(*i*) Non-tropical fruits, Melbourne		727	
(*j*) Fruit juice investigations, Homebush, New South Wales		368	
(*k*) Adviser on Food Preservation		149	
		13,337	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)		2,000	
			11,337
(vii) Prickly Pear—			
(*a*) Grant for investigations	2,750		
Less contributions from Commonwealth Bank (Rural Credits Development Fund)	2,750		
		..	
(viii) Forest Products—			
(*a*) Central Laboratory—			
Annual	9,722		
Capital	930		
		10,652	
(*b*) Seasoning		1,729	
(*c*) Preservation		1,679	
(*d*) Chemistry	2,667		
Less contributions from Australian Paper Manufacturers Limited, Associated Pulp and Paper Mills Ltd., and Australian Newsprint Mills Pty. Ltd.	1,500		
		1,167	

3. Investigations—*continued.*	£	£	£
(viii) Forest Products—*continued.*			
(*e*) Wood structure	2,489		
Less contributions from Bureau of Forestry, Canberra, and Queensland, New South Wales, Victorian and Western Australian Forests Services	156		
		2,333	
(*f*) Mechanics		2,232	
(*g*) Utilization		1,799	
(*h*) Physics		1,077	
(*i*) Fibres		888	
(*j*) Statistics and computing		241	
(*k*) Veneer and Gluing		725	
		24,522	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)..		1,500	
			23,022
(ix) Mining and Metallurgy—			
(*a*) Mineragraphic investigations		793	
Less contribution by Australian Institute of Mining and Metallurgy		368	
			425
(x) Radio Research—			
(*a*) Melbourne and Sydney Universities ..	5,813		
Less contributions by Postmaster-General's Department	4,360		
		1,453	
(*b*) Advisers on radio research		97	
			1,550
(xi) Information Service including Library		..	3,648
(xii) Gold Mining—			
(*a*) Mineragraphic investigations, Melbourne University		734	
(*b*) Ore-dressing, Melbourne University		1,502	
(*c*) Ore-dressing, South Australian School of Mines ..		1,089	
(*d*) Ore-dressing, Kalgoorlie School of Mines		1,010	
(*e*) Advisory Committee		249	
			4,584
(xiii) Fisheries Investigations—			
(*a*) Administrative—			
Annual	4,315		
Capital	1,456		
		5,771	
(*b*) Marine biology		1,339	
(*c*) Marine bacteriology		731	
(*d*) Chemistry (including Fish and by-product analyses)		173	
(*e*) Investigations at sea		6,603	
(*f*) Aerial observations		908	
			15,525
(xiv) Apple and Pear Investigations—			
(*a*) Grants to States		9,553	
(*b*) Thrips		118	
(*c*) Codling Moth		470	
(*d*) Experimental consignments of pears		93	
(*e*) Experimental consignments of apples		31	
(*f*) Shipboard survey of brown-heart problem		106	
(*g*) Storage investigations on apples and pears		72	
		10,443	
Less contributions from Department of Commerce		10,443	
			..

3. Investigations—*continued.*	£	£	£
(xv) Aeronautical Research Laboratory			3,769
(xvi) National Standards Laboratory			2,524
(xvii) Secondary Industry Research			713
(xviii) Training of Students—Secondary Industry Research			473
(xix) Miscellaneous—			
(*a*) Dairy research		752	
(*b*) Architectural section		579	
(*c*) Tomato wilt		185	
(*d*) Mineral deficiency in pastures		938	
(*e*) Statistical section		1,002	
(*f*) Evaporation from dams	100		
Less contribution from Australian Wool Board	100		
		..	
(*g*) Co-operative Primary Industry Research in Western Australia		959	
(*h*) Secretarial, Waite Institute		282	
(*i*) Various		2,149	
			6,846
Total of Item 3—Investigations			176,137

2. *Contributions.*—The following statement shows the receipts and disbursements during the year 1938–39 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled " The Specific Purposes Trust Account " :—

	Receipts 1938-39 and balances brought forward from 1937–38.	Expenditure 1938–39.
	£	£
Commonwealth Bank (Animal Health and Nutrition, Horticultural, Food Preservation and Transport, Prickly Pear, and Forest Products Investigations)	17,500	17,500
Commonwealth Bank (Bee Investigations)	92	..
Postmaster-General's Department (Radio Research)	4,580	*4,446
Australian 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)	311	237
Victorian State Rivers and Water Supply Commission (Cumbungi Investigations)	336	237
Queensland Government (Animal Health Investigations—Cattle Research)	1,000	1,000
Australian Wool Board (Animal Health and Nutrition Investigations—Sheep Research)	14,994	14,073
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	368	368
Dried Fruits Control Board (Dried Fruits Investigations)	1,777	1,777
Nyah-Woorinen Dried Fruits Enquiry Committee (Dried Fruits Investigations)	80	80
Australian Dairy Council (Wood Taint in Butter Investigations)	20	..
Queensland Meat Industry Board (Food Preservation Investigation)	950	950
Sir MacPherson Robertson (Entomological Investigations)	173	143
Carried forward	45,681	44,311

* Includes £86 on account 1937–38 expenditure.

	Receipts 1938-39 and balances brought forward from 1937-38.	Expenditure 1938-39.
	£	£
Brought forward	45,681	44,311
Ministry of Agriculture, Egypt—Cotton Investigations (Entomological Investigations)	479 ..	455
University of Sydney (Animal Health and Nutrition Investigations)	780 ..	780
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Nutrition Investigations) ..	59 ..	25
Revenue Fund—Contagious Pleuro-pneumonia Investigations (Animal Health and Nutrition Investigations	440 ..	413
Revenue Fund—Oonoonba Research Station—Sale of Vaccine (Animal Health and Nutrition Investigations)	2,378 ..	1,522
Revenue Fund—Parkville Laboratory (Animal Health and Nutrition Investigations)	39 ..	..
Revenue Fund—Berwick Farm (Mastitis Investigations)	1,973 ..	1,973
Revenue Fund—National Field Station "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations)	2,931 ..	1,655
Revenue Fund—Bacteriological Investigations (Animal Health and Nutrition Investigations)	7 ..	..
Revenue Fund—Parasitological Investigations (Animal Health and Nutrition Investigations)	147 ..	100
Revenue Fund—F. D. McMaster Field Station (Animal Health and Nutrition Investigations)	649 ..	300
Revenue Fund—Nutrition Laboratory (Animal Health and Nutrition Investigations)	325 ..	38
Revenue Fund—Plant Industry Investigations ..	16 ..	..
Revenue Fund—Entomological Investigations ..	222 ..	100
Revenue Fund—Griffith Research Station (Citricultural Investigations)	7,073 ..	1,948
Revenue Fund—Merbein Research Station (Viticultural Investigations)	3,054 ..	556
Revenue Fund—Citrus Preservation Investigations ..	130 ..	..
Revenue Fund—Section of Food Preservation and Transport	5 ..	..
Revenue Fund—Ore-dressing Investigations	325 ..	..
Tobacco Trust Fund—Prime Minister's Department (Tobacco Investigations)	10,930 ..	5,106
New South Wales Department of Agriculture (Food Investigations)	393 ..	393
Australian Meat Board (Meat Investigations)	452 ..	428
Metropolitan Meat Industry Commissioner of New South Wales (Food Investigations)	625 ..	*601
Department of Commerce (Apple and Pear Investigations)	10,811 ..	10,443
Mildura Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	143 ..	†143
Irymple Packing Company (Dried Vine Fruits Investigations, Merbein)	143 ..	143
Red Cliffs Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	143 ..	143
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	143 ..	143
Swallow & Ariell Limited (Dried Vine Fruits Investigations, Merbein)	143 ..	143
Carried forward	90,639	71,862

* Includes £173 on account 1937–38 expenditure. † Includes £7 on account 1937–38 expenditure.

	Receipts 1938-39 and balances brought forward from 1937-38.	Expenditure 1938-39.
	£	£
Brought forward	90,639	71,862
Aden Packing Company (Dried Vine Fruits Investigations, Merbein)	143	143
Australian Dairy Cattle Research Association (Mastitis Investigations)	2,550	2,550
Department of Agriculture, Victoria (Oriental Peach Moth Investigations)	924	924
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	..
Bureau of Forestry, Canberra, and Forest Services of Queensland, Victoria, New South Wales, and Western Australia—Wood Structure (Forest Products Investigations)	157	157
South Australian Railways (Treatment of Railway Sleepers)	17	..
Sundry Contributors (Forest Products Investigations)	793	..
Western Australian Sawmillers' Association (Division of Forest Products—Design Data Text-book) ..	50	..
Sydney and Suburban Timber Merchants' Association (Division of Forest Products—Design Data Text-book)	50	..
Tasmanian Timber Organization Pty. Ltd. (Division of Forest Products—Design Data Text-book) ..	50	..
Institution of Engineers, Australia (Division of Forest Products—Design Data Text-book)	50	..
Plywood and Veneer Board (Queensland) (Division of Forest Products—Design Data Text-book) ..	50	..
Queensland Timber Export Association (Division of Forest Products—Design Data Text-book) ..	25	..
Brisbane Timber Merchants' Association (Division of Forest Products—Design Data Text-book) ..	25	..
Queensland Timber Stabilization Board (Division of Forest Products—Design Data Text-book) ..	25	..
Hardy's Pty. Ltd. (Division of Forest Products—Veneer and Gluing Work)	30	..
Queensland Timber Export Association (Division of Forest Products—Veneer and Gluing Work) ..	50	..
Plywood and Veneer Board, Queensland (Division of Forest Products—Veneer and Gluing Work) ..	250	..
Ricketts & Thorp Ltd. (Division of Forest Products—Veneer and Gluing Work)	20	..
G. L. Briggs & Son (Division of Forest Products—Veneer and Gluing Work)	5	..
Veneer & Plywood Pty. Ltd. (Division of Forest Products—Veneer and Gluing Work)	10	..
Plywood Manufacturing Co. Pty. Ltd. (Division of Forest Products—Veneer and Gluing Work) ..	11	..
Beale & Co. Ltd. (Division of Forest Products—Veneer and Gluing Work)	5	..
Brisbane Timber Merchants' Association (Division of Forest Products—Veneer and Gluing Work) ..	25	..
Carried forward	98,704	77,136

	Receipts 1938-39 and balances brought forward from 1937-38.		Expenditure 1938-39.
	£		£
Brought forward	98,704		77,136
Victorian Central Citrus Association (Citrus Problems)..	100	..	100
Egg Producers' Council (Egg Investigations) ..	600	..	449
Egg Producers' Council (Watery Whites in Eggs) ..	2	..	..
Revenue Fund—Mining and Metallurgy	3	..	..
Sundry Contributors (Council for Scientific and Industrial Research Publications)	6	..	..
	99,415	..	77,685

3. *Staff.*—The following is a list of the staff of the Council as at the 30th June, 1939. 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., A.A.C.I.
Assistant Secretary (Finance and Supplies)—H. P. Breen, A.I.C.A.

Information Section—
E. J. Drake.
F. G. Nicholls, M.Sc.
G. H. Payne, B.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.

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.
C. Munro.
J. Farey.
F. J. Whitty.
R. Bennett.
J. Bourne.
J. Smithwick.

Orders and Transport—
J. M. Derum.
L. Graham.

Staff—
R. D. Elder.

Records—
P. Domec-Carre.
P. Knuckey.
R. McVilly.
F. Butler.
B. Gooley.
B. Gaynor.
M. Combe.

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.
Local Secretary, Canberra—R. F. Williams.
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., A.A.C.I., 314 Albert-street, East Melbourne.

Queensland—
Miss H. F. Todd, Commonwealth Offices, Anzac-square, Brisbane.

South Australia—
J. Ward Walters, Animal Nutrition Laboratory, University of Adelaide.

Western Australia—
L. W. Phillips, M.Sc., M.Ed., A.A.C.I., Technical College, St. George's-terrace, Perth.

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

3. Australia House, London.

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

4. Division of Plant Industry.

At Canberra—

Administration—
Chief—B. T. Dickson, B.A., Ph. D.
Librarian (part-time)—Miss 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, B.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—Miss A. T. Melvaine, B.Sc.

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. M. Moore, 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.
Assistant Research Officer (quality)—K. E. Murray, 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—

Assistant in plant physiology (part-time)—Miss R. Watson, B.Sc.
Assistant in plant physiology (part-time)—Miss J. Brooke, B.Sc.

At Moss Vale, New South Wales—

Assistant Research Officer (genetics)—K. L. Hills, B.Agr.Sc. (on study leave).

At Griffith, New South Wales—

Assistant Research Officer (weeds investigations)—R. W. Prunster, B.Sc.Agr.
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)—R. Roe, B.Sc.Agr.

At Stanthorpe, Queensland—

Assistant Research Officer (horticultural investigations)—L. A. Thomas, M.Sc.

At Fitzroyvale, Central Queensland—

Assistant Research Officer (plant introduction)—J. F. Miles, B.Sc.Agr.

At University of Tasmania, Hobart—

Assistant Research Officer (fruit investigations)—D. Martin, B.Sc.

At University of Western Australia, Perth—

Research Officer (agrostology)—A. B. Cashmore, M.Sc.

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.
Assistant Research Officer (blowfly investigations)—Mrs. M. J. Mackerras, M.Sc., M.B.
Assistant Research Officer (blowfly investigations)—D. F. Waterhouse, M.Sc.
Assistant Research Officer (biochemist)—F. G. Lennox, M.Sc., A.I.C.
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.
Assistant Research Officer (termite investigations)—M. F. Day, B.Sc. (on leave abroad).
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—

Senior Research Officer—A. L. Tonnoir.
Assistant Research Officer—T. G. Campbell.
Assistant Research Officer (grasshopper investigations)—K. H. L. Key, M.Sc., Ph.D., D.I.C.
Technical Officer—D. A. C. Cameron, B.Sc.Agr.

At Mooroopna (Victoria)—

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

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

Weeds Investigations—
At Canberra—
Principal Research Officer—G. A. Currie, B.Agr.Sc., D.Sc.
Assistant Research Officer—R. V. Fyfe, B.Sc.Agr.

At Farnham Royal, England—
Research Officer—S. Garthside, B.Sc.Agr., M.S.

At Le Lavandou, France—
Assistant Research Officer—F. Wilson.

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

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.
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 S. E. R. Clark, B.Agr.Sc.
Technical Officer—Miss M. J. Monsbourgh, B.Sc.
Technical Officer—E. Wold.
Librarian—Miss S. Church, M.Sc.
Biological Assistant—Miss J. Maclean, 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.
Research Officer (parasitology)—G. Kauzal, D.V.Sc.
Research Officer (bacteriology, foot-rot)—W. I. B. Beveridge, B.V.Sc. (on leave abroad).
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.
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.
Assistant Technician—H. Munz.

At Animal Nutrition Laboratory, Adelaide—
Chief Nutrition Officer and Officer-in-charge—H. R. Marston.
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., A.I.C., A.A.C.I.
Assistant Research Officer (biochemistry)—S. T. Evans, B.Sc.
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.

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.
Records Officer—S. J. Cossar.

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.A.C.I.
Assistant Research Officer (soil chemistry)—A. Walkley, B.Sc., B.A., 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.
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.
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.
Assistant Research Officer—R. R. Pennefather, B.Agr.Sc.
Orchard Superintendent—B. H. Martin, H.D.A.
Accountant—D. Chalmers (part-time).
Clerical Assistant—Miss A. Gralton.

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.
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.

Flax Fibre Investigations—

Officer-in-charge—A. M. Munro, M.A.
Assistant Research Officer—Miss J. F. Couchman, B.Sc.

Seasoning Section—

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

Preservation Section—

Officer-in-charge—J. E. Cummins, B.Sc., M.S., A.A.C.I.
Assistant Research Officer—H. B. Wilson, B.Sc., A.A.C.I. (on leave abroad).
Assistant Research Officer—N. Tamblyn, M.Sc.

Wood Structure Section—

Officer-in-charge—H. E. Dadswell, M.Sc., A.A.C.I.
Assistant Research Officer—H. D. Ingle, B.For.Sc.
Assistant Research Officer—Miss A. M. Eckersley, M.Sc.
Assistant Research Officer—Miss J. Ellis, B.Sc.
Technical Assistant—Miss J. Galbraith.
Technical Officer—E. S. Smith.
Technical Officer—Miss A. M. Lightfoot.

Timber Mechanics Section—

Officer-in-charge—I. Langlands, B.E.E.
Assistant Research Officer—R. S. T. Kingston, B.Sc., B.E.
Technical Officer—B. Whitington, B.Sc.
Technical Officer—A. L. Gunn.

Timber Physics Section—

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

Timber Utilization Section—

Officer-in-charge—R. F. Turnbull, B.E.
Assistant Research Officer—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.
Technical Officer—R. Deeble.

Maintenance Section—

Technical Officer—S. G. McNeil.

11. Food Preservation Investigations.

At State Abattoir, Sydney—

Officer-in-charge—J. R. Vickery, M.Sc., Ph.D.
Research Officer (physicist)—E. W. Hicks, B.A., B.Sc.
Research Officer (biochemist)—S. A. Trout, M.Sc., Ph.D.
Research Officer (biochemist)—W. A. Empey, B.V.Sc.
Research Officer (citrus fruit)—L. J. Lynch, B.Sc.Agr.
Assistant Research Officer (biochemist)—C. C. Kuchel, B.Sc.
Assistant Research Officer (organic chemist)—J. F. Kefford, M.Sc.
Assistant Research Officer (physicist)—M. C. Taylor, M.Sc.
Assistant Research Officer (bacteriologist)—Miss L. R. Alford, B.Sc.
Technical Officer (plant pathology)—P. R. Maguire.

At Government Cool Stores, Melbourne—
Assistant Research Officer (biochemist)—F. E. Huelin, B.Sc., Ph.D., A.A.C.I.
At Brisbane Abattoir—
Assistant Research Officer (biophysicist)—A. R. Riddle, M.A., M.Sc.
At Australia House, London—
Assistant Research Officer—N. E. Holmes, B.E.E.

12. Fisheries Investigations.

At Port Hacking, Sydney—
Officer-in-charge—H. Thompson, M.A., D.Sc.
Fisheries Officer—S. Fowler.
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 (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.

13. Radio Research.

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

14. Ore-Dressing Investigations.

At University of Melbourne—
Investigator—J. G. Hart.
At School of Mines, Adelaide, South Australia—
Investigator—R. J. Caney.
At School of Mines, Kalgoorlie, Western Australia—
Investigator—

15. National Standards Laboratory.

Electrotechnology 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.

16. Aeronautical Research Laboratory.

Officer-in-charge—L. P. Coombes, B.Sc.
Aerodynamics Section—
G. N. Patterson, B.Sc., M.A., Ph.D.
Structures and Materials Section—
H. A. Wills, M.E.
Draughtsman—D. W. Eaton.

17. 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)—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.

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

(i) *Bulletins.*

No. 120.—Some Effects of Green Manuring on Citrus Trees and on the Soil, by E. S. West, B.Sc., M.S., and A. Howard, M.Sc.

No. 121.—Observations on the Toxicity of Fluorine for Sheep, by A. W. Peirce, M.Sc.

No. 122.—The Establishment of Pastures on Deep Sands in the Upper South-East of South Australia.

(1) The Origin and Scope of the Investigations, by H. C. Trumble, D.Sc., M.Agr.Sc.

(2) The Influence of Cover Crops and Fertilizer Treatment on the Establishment of Selected Herbage Species, by C. M. Donald, B.Sc.Agr., and C. A. Neal Smith, B.Agr.Sc. With an Appendix on the Role of Seed Inoculation, by T. H. Strong, M.Sc.Agr.

No. 123.—A Soil Survey of the Merbein Irrigation District, Victoria, by F. Penman, M.Sc., J. K. Taylor, B.A., M.Sc., P. D. Hooper, and T. J. Marshall, M.Agr.Sc.

No. 124.—The Wood Anatomy of Some Australian Meliaceae with Methods for their Identification (Division of Forest Products—Technical Paper No. 31), by H. E. Dadswell, M.Sc., and Dorothie J. Ellis, B.Sc.

No. 125.—A Soil Survey of Part of the Kerang Irrigation District, Victoria, by J. G. Baldwin, B.Agr.Sc., G. H. Burvill, B.Sc.(Agric.), and J. R. Freedman, B.Agr.Sc.

No. 126.—Investigations on Chilled Beef. Part I.—Microbial Contamination Acquired in the Meatworks, by W. A. Empey, B.V.Sc., and W. J. Scott, B.Agr.Sc.

No. 127.—Radio Research Board : Report No. 14—

(1) Further Studies of Directions of Atmospherics at Toowoomba and Canberra, by H. C. Webster, Ph.D., F.Inst.P., G. H. Munro, M.Sc., A.M.I.E.E., and A. J. Higgs, B.Sc.

(2) An Aperiodic Amplifier for Investigating the Wave-form of Atmospherics, by H. C. Webster, Ph.D., F.Inst.P.

(3) Applications of the Modulating Electrode of Television Cathode-Ray Tubes in Investigations of the Wave-form of Atmospherics, by H. C. Webster, Ph.D., F.Inst.P.

No. 128.—An Investigation of the Problems of Salt Accumulation on a Mallee Soil in the Murray Valley Irrigation Area, by J. E. Thomas, B.Sc., B.Agr.Sc., B.V.Sc.

(ii) *Pamphlets.*

No. 81.—The Properties of Australian Timbers. Part 3—*Pinus radiata* D. Don (*Pinus insignis* Doug.). Insignis, Monterey, or Remarkable Pine (Division of Forest Products—Technical Paper No. 28). A Report Prepared by the Division of Forest Products.

No. 82.—The Humidity of the Atmosphere and the Moisture Conditions Within Mounds of *Eutermes exitiosus* Hill, by R. V. Fyfe, B.Sc.Agr., and F. J. Gay, B.Sc.

No. 83.—Fleece Investigations, by F. G. Lennox, M.Sc., A.I.C.

No. 84.—A Population Study of the Red-legged Earth Mite (*Halotydeus destructor*) in Western Australia, with Notes on Associated Mites and Collembola, by K. R. Norris, M.Sc.

No. 85.—A Chemical Study of Some Australian Fish, by W. G. Jowett, M.Sc., and W. Davies, D.Sc., D.Ph.

No. 86.—A Study of the Pulping Properties of Three Trees of *E. sieberiana*, using the Sulphate Process (Division of Forest Products—Technical Paper No. 29), by J. C. Cavanagh, B.Sc., H. E. Dadswell, M.Sc., A. W. Mackney, M.Sc., and T. M. Reynolds, M.Sc., D.Phil.

No. 87.—The Mechanical Properties of South Australian Plantation-Grown *Pinus radiata* D. Don (Division of Forest Products—Technical Paper No. 30), by Ian Langlands, B.E.E.

No. 88.—The Oriental Peach Moth (*Cydia molesta* Busck.). Investigations in the Goulburn Valley, Victoria, Progress Report for the Seasons 1935–38, by G. A. H. Helson, M.Sc.

No. 89.—Needle Fusion of *Pinus* in Southern New South Wales, Second Progress Report (1937–38), by W. V. Ludbrook, B.Agr.Sc., Ph.D.

No. 90.—Studies of the Physiology and Toxicology of Blowflies.

(1) The Development of a Synthetic Medium for Aseptic Cultivation of Larvae of *Lucilia cuprina*, by F. G. Lennox, M.Sc.

(iii) *Trade Circulars.*

No. 41.—The Selection of Timber. Part 2: Structural Timber.

No. 42.—The Selection of Timber. Part 3: Plywood—Its Use and Grading.

No. 43.—Figure in Timber.

No. 44.—Termite (White Ant) Proof Construction for Brick Buildings in Adelaide, South Australia.

(iv) *Quarterly Journal.*

Vol. 11, No. 3, August, 1938.
Vol. 11, No. 4, November, 1938.
Vol. 12, No. 1, February, 1939.
Vol. 12, No. 2, May, 1939.

(v) *Annual Report for the Year ending 30th June*, 1938.

XIV. 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 reference to the help given by the various State Departments, especially those of Agriculture, and by the Universities, and to the contributions either in money or in kind provided by the Commonwealth Bank Board, Australian Wool Board, Australian Cattle Research Association, Australian Pastoral Research Trust, Postmaster-General's Department, New South Wales Water Conservation and Irrigation Commission, Australian Dried Fruits Control Board, Queensland State Government, Queensland Meat Industry Board, Mr. Russell Grimwade, and by other bodies, companies, and individuals. The Council also wishes to acknowledge the assistance it has received from its State 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.
20th September, 1939.

APPENDIX.

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

COUNCIL (AS AT 30TH JUNE, 1939).

EXECUTIVE.

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

CHAIRMEN OF STATE COMMITTEES.

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

CO-OPTED MEMBERS.

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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, 1939).

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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.
Professor J. C. Earl, D.Sc., Ph.D., F.I.C.
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.
G. D. Ross.
F. J. Walker.
Lieut.-Col. H. F. White, C.M.G., D.S.O.

VICTORIA.

Russell Grimwade, C.B.E., B.Sc. (*Chairman*).
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W. Baragwanath.
N. K. S. Brodribb, O.B.E., F.I.C.
G. S. Colman, C.B.E.
Sir Herbert W. Gepp, Kt., M.Aust.I.M.M., M.Am.I.M.M.
H. Herman, D.Sc., M.M.E., B.C.E.
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.
F. J. Rae, B.A., B.Sc., B.Agr.Sc.
W. E. Wainwright, A.S.A.S.M., M.Aust.I.M.M., M.Am.I.M.M.
L. J. Weatherly, M.A.
Professor H. A. Woodruff, B.Sc., M.R.C.V.S., M.R.C.S., L.R.C.P.
Professor W. J. Young, D.Sc.

SOUTH AUSTRALIA.

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A. J. Allen, A.A.C.I
E. H. Bakewell.
J. H. Gosse.
Professor Kerr Grant, M.Sc., F.Inst.P.
W. A. Hargreaves, M.A., B.C.E., D.Sc., F.I.C.
Professor T. H. Johnston, M.A., D.Sc.
F. T. Perry.
Professor J. A. Prescott, D.Sc.
W. J. Spafford, R.D.A.
L. K. Ward, B.A., B.E., D.Sc.

QUEENSLAND.

Professor H. C. Richards, D.Sc. (*Chairman*).
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F. H. Foster, M.H.A., B.M.E., A.M.I.E.Aust.
F. W. Hicks.
Professor A. L. McAulay, M.A., B.Sc., Ph.D., F.Inst.P.
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The Hon. R. O. Shoobridge, M.L.C.
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Professor J. A. Prescott, D.Sc., Waite Agricultural Research Institute, University of Adelaide.
F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, New South Wales.
P. Malloch, Commonwealth Dried Fruits Control Board.
E. J. Casey, Commonwealth Dried Fruits Control Board.

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A. Lever, Mildura Shire Council.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein
F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, New South Wales.
J. A. Lockhead, Mildura Shire Council.
A. E. Cameron, Red Cliffs Settlement.
J. Gordon, Citrus Growers' Association, Merbein.
W. Heaysman, Cardross Horticultural Society.
L. W. Andrew, Waikerie, South Australia.
O. Weste, Renmark, South Australia.
S. Heaysman, Coomealla, New South Wales.
S. P. Taylor, Curlwaa, New South Wales.
P. T. Byrnes, Woorinen, Victoria.
W. Grundy, Nyah, Victoria.
A. Rawlings, Merbein Growers' Union.

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T. T. Morley, Griffith Producers' Co-operative Co. Ltd.
L. J. Rydon, Yenda Producers' Co-operative Society Ltd.
E. S. West, B.Sc., M.S., Commonwealth Research Station, Griffith.
V. C. Williams, Murrumbidgee Irrigation Areas Research Bureau, Griffith.
A. G. Enticknap, Leeton Fruit-growers' Co-operative Society Ltd.
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E. S. West, B.Sc., M.S., Commonwealth Research Station, Griffith, New South Wales.
C. G. Savage, Director of Fruit Culture, Department of Agriculture, New South Wales.
R. J. Benton, Fruit Instructor, Department of Agriculture, New South Wales.
F. M. Read, M.Agr.Sc., Chief Inspector of Horticulture, Department of Agriculture, Victoria.
J. Hepburn, Manager, Government Cool Stores, Melbourne.
A. G. Strickland, M.Agr.Sc., Chief Horticultural Officer, Department of Agriculture, South Australia.
Miss E. Archer, M.Sc. (*Secretary*).

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A. G. Strickland, M.Agr.Sc., Chief Horticultural Officer, Department of Agriculture, South Australia.
C. G. Savage, Director of Fruit Culture, Department of Agriculture, New South Wales.
E. S. West, B.Sc., M.S., Commonwealth Research Station, Griffith, New South Wales.
D. Quinn, Department of Agriculture, Victoria (*Secretary*).

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A. J. Nicholson, D.Sc., Chief, Division of Economic Entomology, C.S.I.R.
G. A. Currie, B.Agr.Sc., D.Sc., Officer-in-Charge, Weeds Section, C.S.I.R.

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A. M. Stewart, B.Sc.(Agr.) (Acting), University Institute of Agriculture.
I. Thomas, Department of Agriculture, Western Australia.
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A. J. Nicholson, D.Sc., Chief, Division of Economic Entomology, C.S.I.R.
I. M. Mackerras, B.Sc., M.B., Ch.M., Division of Economic Entomology, C.S.I.R.

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W. Kent, Jonbaryan, Darling Downs, Queensland.
R. H. Nantes, Queensland United Graziers' Association.

NEW SOUTH WALES MEAT RESEARCH ADVISORY COMMITTEE.

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E. J. Bowater, Messrs. Angliss & Co. Pty. Ltd., Sydney.
J. M. Davidson, Commonwealth Veterinary Officer, Sydney (Representing the Department of Commerce).
J. Merrett, Metropolitan Meat Industry Commissioner, Sydney.
F. J. Walker, Sydney.
J. R. Vickery, M.Sc., Ph.D., Section of Food Preservation and Transport, C.S.I.R.

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F. Ayre
D. H. Ferguson } Representing Victorian Chamber of Manufactures.
P. L. Martyn.
F. Moss, F.A.C.I., Melbourne Technical College.
A. A. Robertson, B.Sc., Melbourne Technical College.
G. A. Cook, M.Sc., B.M.E., A.A.C.I., Council for Scientific and Industrial Research.
F. G. Nicholls, M.Sc., Council for Scientific and Industrial Research (*Secretary*).

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Sir Harry Brown, C.M.G., M.B.E., M.I.E.E., Postmaster-General's Department, Melbourne.
Professor T. H. Laby, M.A., Sc.D., F.R.S., F.Inst.P., Department of Natural Philosophy, University of Melbourne.
Commander H. M. L. Waller, R.A.N., Department of Defence, Melbourne.

NATIONAL STANDARDS LABORATORY COMMITTEE.

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Professor O. U. Vonwiller, B.Sc., Department of Physics, University of Sydney.
N. K. S. Brodribb, O.B.E., F.I.C., Controller-General of Munitions and Supply, Department of Supply and Development, Melbourne.
F. J. Shea, Department of Supply and Development, Melbourne.
G. Lightfoot, M.A., Council for Scientific and Industrial Research.
F. G. Nicholls, M.Sc., Council for Scientific and Industrial Research (*Secretary*).

B.—COMMITTEES CONCERNING WORK IN WHICH THE COUNCIL IS CO-OPERATING.

SCIENTIFIC PUBLICATIONS COMMITTEE.

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Sir David Rivett, K.C.M.G., M.A., D.Sc., Council for Scientific and Industrial Research.
W. G. Woolnough, D.Sc., Geological Adviser to the Commonwealth.

STANDING COMMITTEE ON AGRICULTURE.

(*Of Australian Council of Agriculture.*)

G. D. Ross, Under-Secretary, Department of Agriculture, New South Wales (*Chairman*).
H. A. Mullett, B.Agr.Sc., Director, Department of Agriculture, Victoria.
————, Department of Agriculture and Stock, Queensland.
W. J. Spafford, Director, Department of Agriculture, South Australia.
L. 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. (*Deputy Chairman*)
Professor A. E. V. Richardson, C.M.G., M.A., D.Sc.
} Members of Executive Committee of C.S.I.R.

TECHNICAL COMMITTEE—PASTURE PLANT IMPROVEMENT INVESTIGATION.

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.
Professor E. J. Goddard, B.A., D.Sc., University of Queensland, and
B. T. Dickson, B.A., Ph.D., C.S.I.R., *ex officio* members.
R. Veitch, B.Sc.Agr., B.Sc.For., F.R.E.S., Department of Agriculture and Stock, Brisbane.

WEEDS INVESTIGATIONS—NEW SOUTH WALES COMMITTEE.

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E. Griffiths, B.Sc., Department of Agriculture, New South Wales.
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G. A. Currie, B.Agr.Sc., D.Sc., Weeds Section, C.S.I.R.

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A. V. Lyon, M.Agr.Sc., Officer-in-Charge, Commonwealth Research Station, Merbein, Victoria.

CURLWAA AND COOMEALLA HORTICULTURAL ADVISORY COMMITTEE, NEW SOUTH WALES.

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Chairman*).
W. H. Middleton, Water Conservation and Irrigation Commission, New South Wales.
F. Mathews, 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*).

COMMITTEE ON KERANG-COHUNA IRRIGATION INVESTIGATIONS.

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Chairman*).
W. R. Scriven, Kerang Seepage Investigation Committee.
L. C. Bartels, B.Agr.Sc., Senior Agrostologist, Department of Agriculture, Victoria.
F. Penman, M.Sc., Assistant Agricultural Research Chemist, Department of Agriculture, Victoria.
F. Rogerson (with H. B. Lincoln as deputy), Victorian State Rivers and Water Supply Commission.

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.
T. P. Taylor, Department of Agriculture, New South Wales.
F. Mathews, Rural Bank, New South Wales.
E. E. Ellis
E. J. Grant
H. J. Jackson
R. Martin
R. Redfearn
} Representing Landholders (Wakool Irrigation Area).

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.)

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C. G. Savage, Department of Agriculture, New South Wales.
G. Enticknap, Yenda Producers' Co-operative Society Ltd.
R. R. Pennefather, B.Agr.Sc., Irrigation Research Station, Griffith.

MURRUMBIDGEE IRRIGATION AREA CO-ORDINATING COMMITTEE.

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C. J. Horth, Department of Agriculture, New South Wales.
F. K. Watson, M.A., B.Sc.(Agr.), B.Sc., A.M.I.C.E., Water Conservation and Irrigation Commission, New South Wales.
J. G. Youll, Water Conservation and Irrigation Commission, Leeton.
H. N. England, B.Sc., Water Conservation and Irrigation Commission, Leeton (deputy to either Mr. Watson or Mr. Youll).
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith.
R. R. Pennefather, B.Agr.Sc., Irrigation Research Station, Griffith.

VITICULTURAL COMMITTEE FOR NON-IRRIGATED AREAS.

Chas. Russell, Dried Fruits Board for South Australia (*Chairman*).
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.
W. N. Twiss, Dried Fruits Board, South Australia (*Secretary*).

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C. Haselgrove, representing the Federal Viticultural Council.
Professor A. E. Platt, M.D., D.T.M., D.T.H., representing the University of Adelaide.
L. N. Salter, representing the Australian Wine Board.

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E. C. Orton, B.Sc., A.A.C.I.
} Representing C.S.I.R.
A. R. Hampton, Mildura Packers' Association.
W. Heaysman, Merbein Advisory Committee.
W. R. Jewell. M.Sc., B.Met., Victorian Department of Agriculture.

Growers' Representatives.

S. R. Mansell, Mildura.
A. R. McDougall, Merbein.
A. P. Lochhead, Irymple.
J. Moore, Red Cliffs.
D. Taylor, Dareton, New South Wales.
F. A. Meischell, Dareton, New South Wales.
G. S. Potts, Mildura.
K. H. C. McCallum, Red Cliffs.

JOINT FRUIT STORAGE INVESTIGATION COMMITTEE, NEW SOUTH WALES.

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H. Broadfoot, Department of Agriculture, New South Wales.
Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne.
J. R. Vickery, M.Sc., Ph.D., Section of Food Preservation and Transport, C.S.I.R.
S. A. Trout, M.Sc., Ph.D., Section of Food Preservation and Transport, C.S.I.R.

ADVISORY COMMITTEE ON FRUIT COOL STORAGE INVESTIGATIONS.

Professor W. J. Young, D.Sc., Biochemistry School, University of Melbourne (*Chairman*).
S. Fish, M.Agr.Sc., Department of Agriculture, Victoria.
F. M. Read, M.Agr.Sc., Chief Inspector of Horticulture, Department of Agriculture, Victoria.
J. R. Vickery, M.Sc., Ph.D., Section of Food Preservation and Transport, C.S.I.R.

ADVISORY COMMITTEE ON ORIENTAL PEACH MOTH INVESTIGATIONS.

A. J. Nicholson, D.Sc., Chief, Division of Economic Entomology, C.S.I.R. (*Chairman*).
F. M. Read, M.Agr.Sc., Chief Inspector of Horticulture, Department of Agriculture, Victoria.
H. J. Williams, General Manager, Ardmona Fruit Products Ltd.
G. A. H. Helson, M.Sc., Division of Economic Entomology, C.S.I.R.
S. Fish, M.Agr.Sc., Biologist, Department of Agriculture (Victoria), (*Secretary*).

JOINT BLOWFLY CONTROL COMMITTEE.

(*As a means of co-ordination of activities of New South Wales Department of Agriculture and of C.S.I.R.*)

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A. J. Nicholson, D.Sc., Chief, Division of Economic Entomology, C.S.I.R.
W. L. Hindmarsh, M.R.C.V.S., B.V.Sc., D.V.H., Director, Glenfield Veterinary Research Station, New South Wales.
W. B. Gurney, B.Sc., F.E.S., Entomologist, New South Wales Department of Agriculture.
H. G. Belschner, D.V.Sc., Department of Agriculture, New South Wales.
I. M. Mackerras, B.Sc., M.B., Ch.M., Division of Economic Entomology, C.S.I.R. (*Secretary*).

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R. C. Philp, Queensland United Graziers' Association.
N. Bourke, Queensland United Graziers' Association.
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P. A. Brown, Queensland United Graziers' Association.
G. A. Fairbairn, Queensland United Graziers' Association.
Professor H. C. Richards, D.Sc., University of Queensland.
A. H. Cory, M.R.C.V.S., Department of Agriculture and Stock, Queensland.
Professor H. R. Seddon, D.V.Sc., University of Queensland.
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Professor H. R. Seddon, D.V.Sc., Department of Agriculture and Stock, Queensland.
W. J. Spafford, R.D.A., Department of Agriculture, South Australia.
G. K. Baron-Hay, Department of Agriculture, Western Australia.
F. W. Hicks, Department of Agriculture, Tasmania.
Ross Grant, Department of Commerce, Melbourne.
J. Proud, representing Australian Dairy Produce Board.
A. E. V. Richardson, C.M.G., M.A., D.Sc., Deputy Chief Executive Officer, C.S.I.R.
L. B. Bull, D.V.Sc., Division of Animal Health and Nutrition, C.S.I.R.
A. J. Vasey, B.Agr.Sc., Division of Animal Health and Nutrition, C.S.I.R. (*Secretary*).

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H. St. J. Somerset, Electrolytic Zinc Co. of Australasia Ltd., Melbourne.
W. E. Wainwright, A.S.A.S.M., M.Aust.I.M.M., M.Am.I.M.M., Broken Hill South Ltd., Melbourne.

Melbourne Sub-Committee.

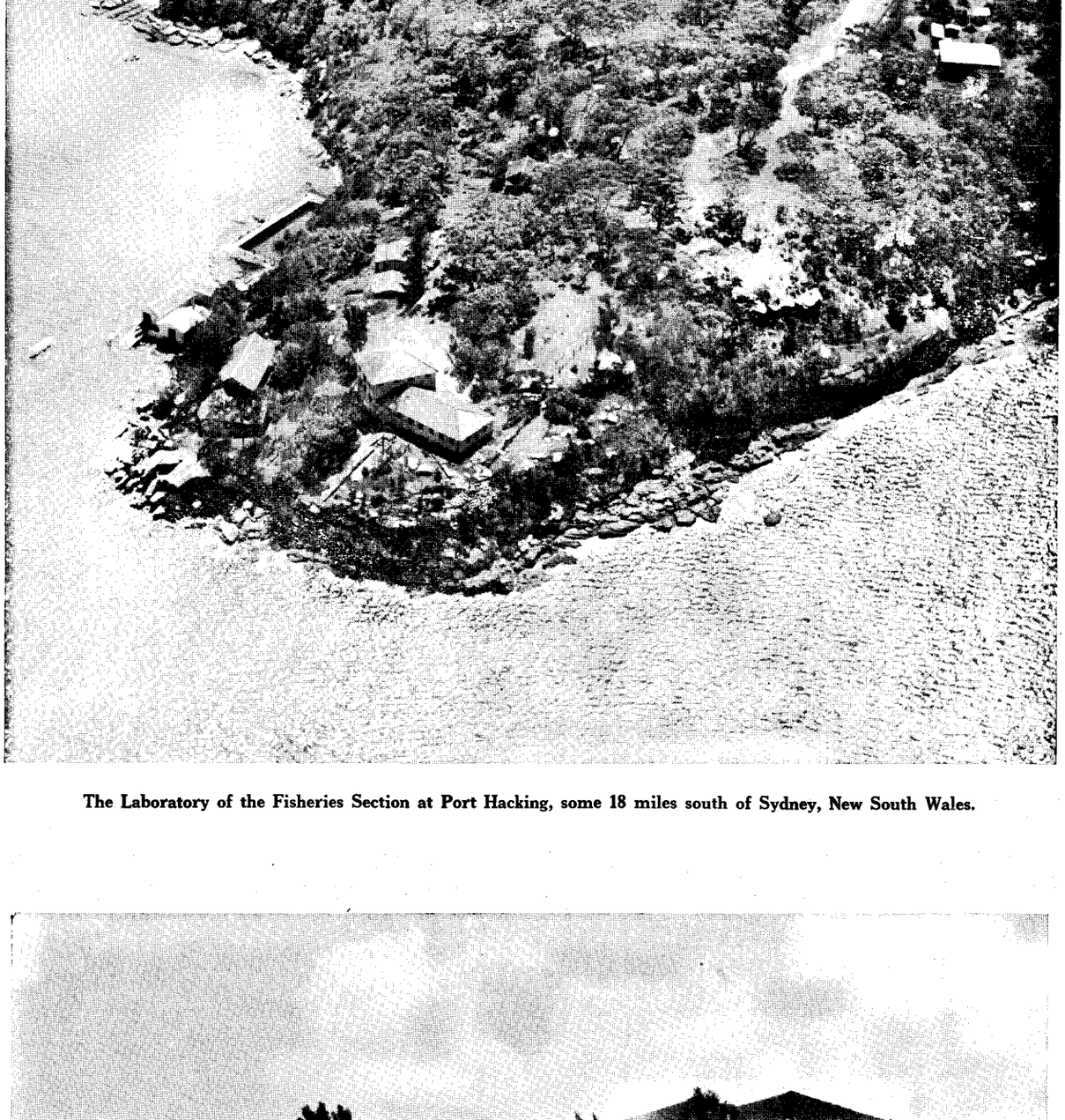
Professor J. N. Greenwood, D.Sc., School of Metallurgy, University of Melbourne (*Chairman*).
W. Baragwanath, Director, Geological Survey, Victorian Department of Mines.
H. Hey, Electrolytic Zinc Co. Ltd., Melbourne.
W. J. Rose, B.M.E. (Melb.), Commonwealth Tariff Board.
G. B. O'Malley, B.Met.E.

Adelaide Sub-Committee.

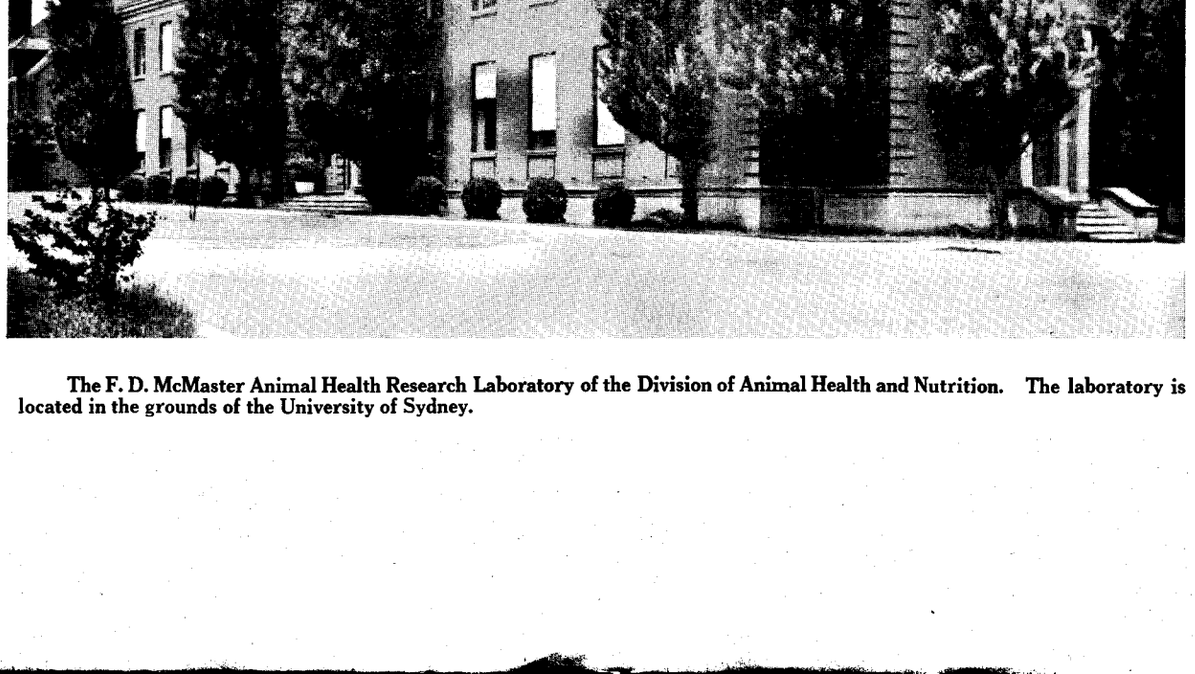
L. Keith Ward, D.Sc., Director, South Australian Department of Mines (*Chairman*).
Professor H. W. Gartrell, M.A., B.Sc., Bonython Laboratory, South Australian School of Mines and Industries.
Professor Kerr Grant, M.Sc., F.Inst.P., Department of Physics, University of Adelaide, South Australia.
F. W. Reid, Principal, South Australian School of Mines and Industries.

Kalgoorlie Sub-Committee.

R. C. Wilson, B.Sc., B.E., M.Inst.M.M., State Mining Engineer, Western Australian Department of Mines (*Chairman*).
B. H. Moore, D.Sc., Principal, School of Mines, Kalgoorlie, Western Australia.
F. G. Brinsden, Australasian Institute of Mining and Metallurgy, Western Australia.
J. R. Hylton, Great Boulder Pty. Gold Mines Ltd., Fimiston, Western Australia.

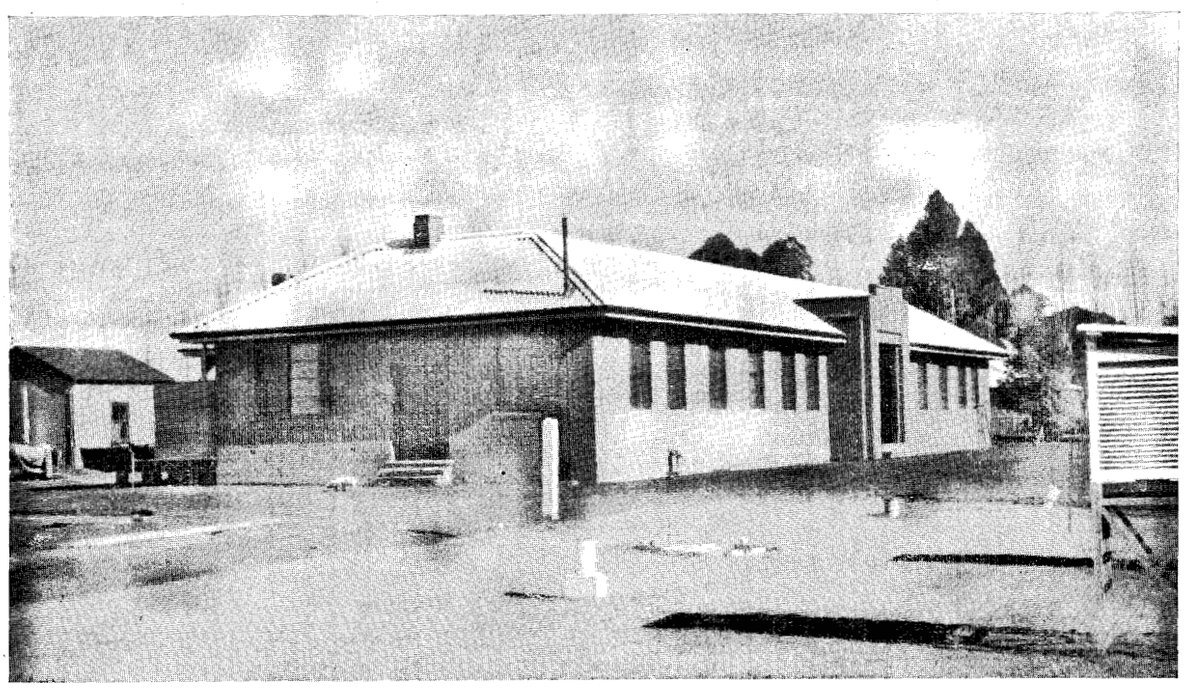


The Laboratory of the Fisheries Section at Port Hacking, some 18 miles south of Sydney, New South Wales.

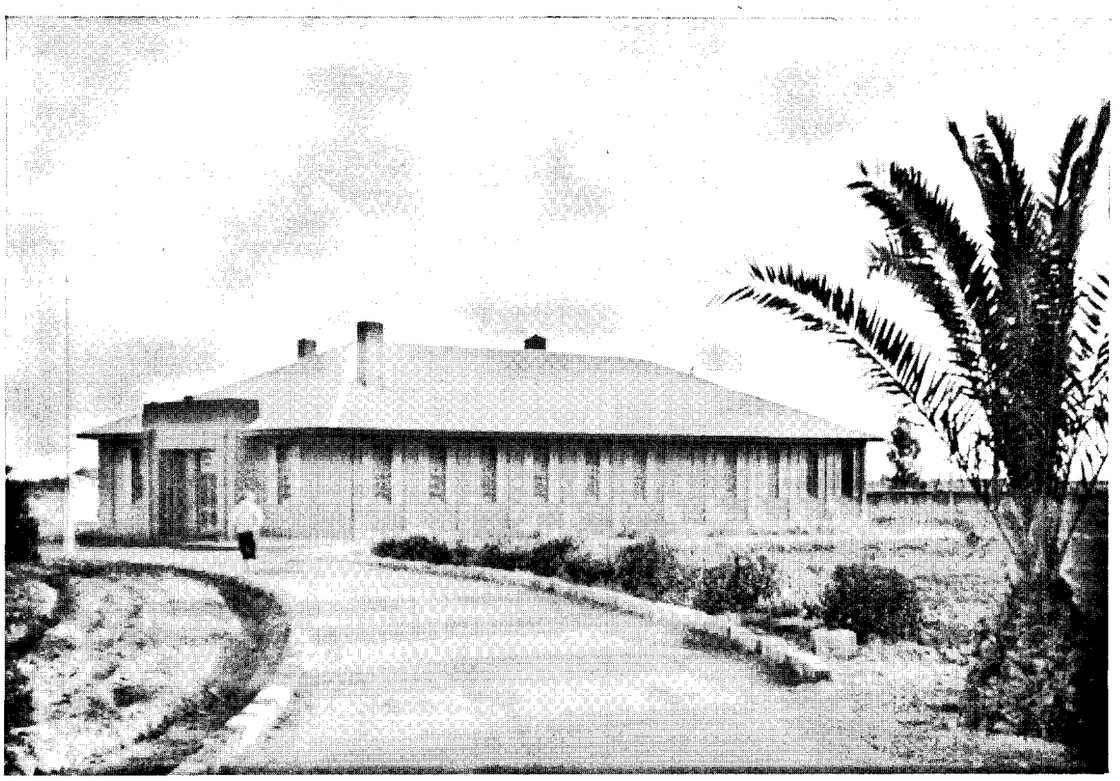


The F. D. McMaster Animal Health Research Laboratory of the Division of Animal Health and Nutrition. The laboratory is located in the grounds of the University of Sydney.

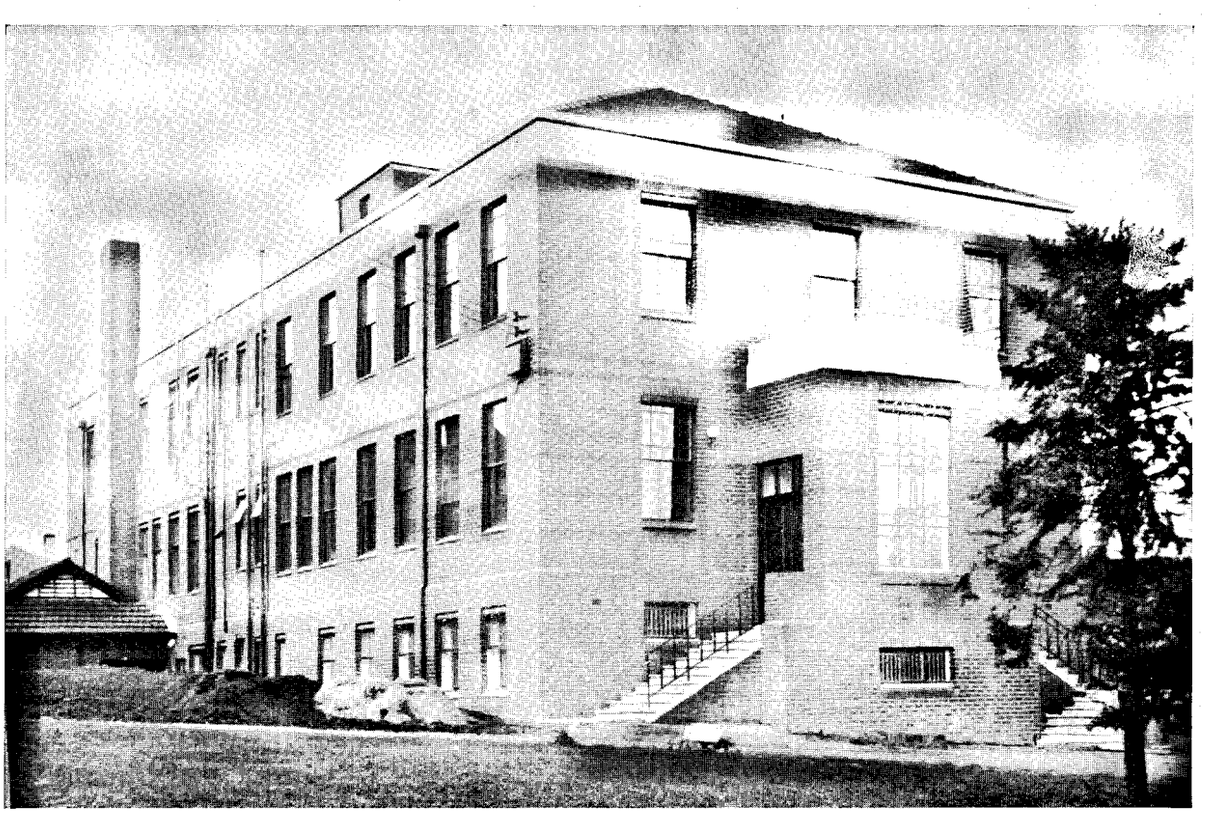
The Laboratories of the Division of Economic Entomology (on the left) and of the Division of Plant Industry (on the right) at Canberra, Australian Capital Territory.



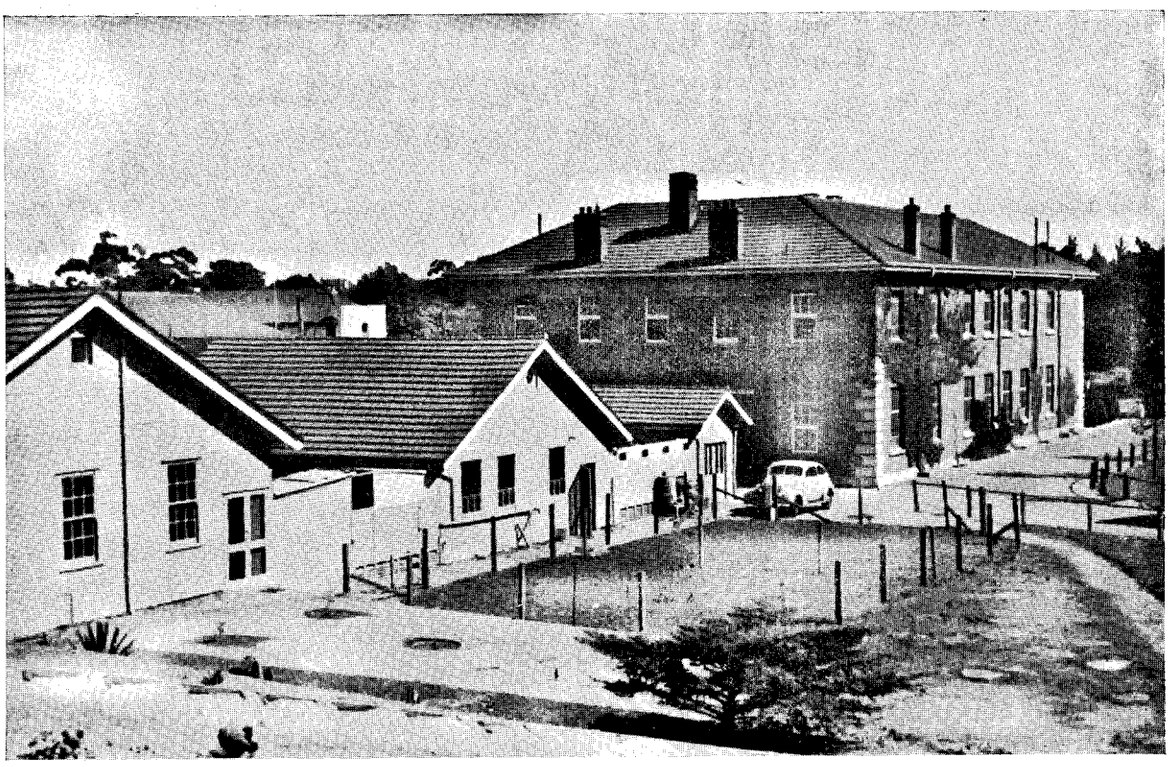
The Council for Scientific and Industrial Research Irrigation Research Laboratory at Griffith, New South Wales.



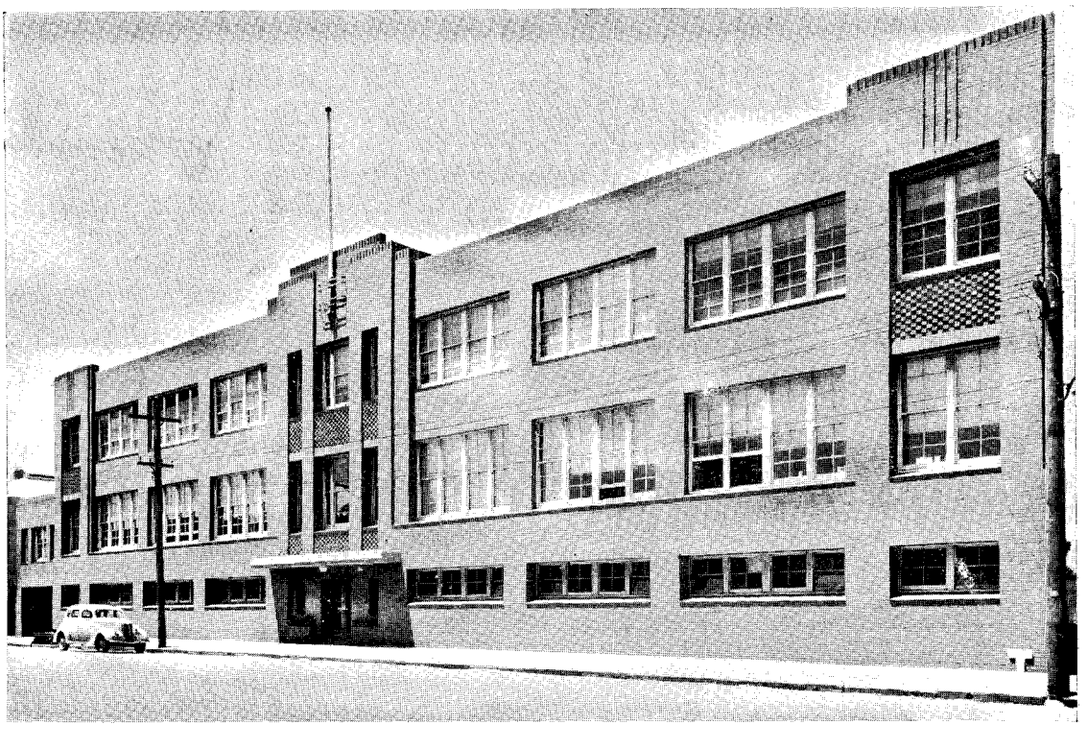
The Council for Scientific and Industrial Research Viticultural Research Laboratory at Merbein, Victoria.



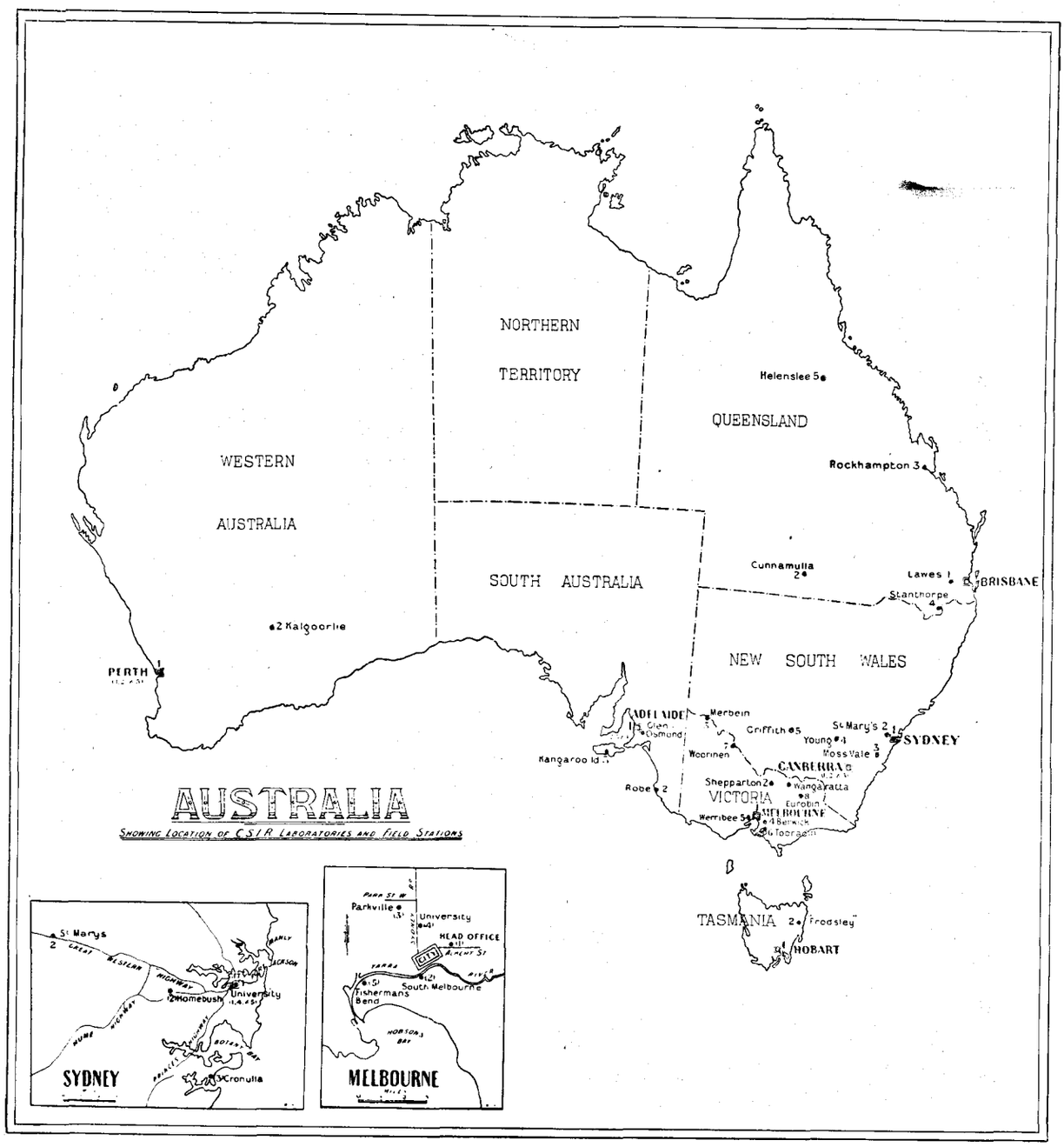
The Animal Health Research Laboratory of the Division of Animal Health and Nutrition. It is located in the grounds of the Veterinary Research Institute of the University of Melbourne.



Animal Nutrition Laboratory of the Division of Animal Health and Nutrition. The Laboratory is located in the grounds of the University of Adelaide. The photograph shows some of the annexes for metabolism and other work on experimental animals.



The Laboratory of the Division of Forest Products, Yarra Bank-road, South Melbourne.



Map showing Locations of C.S.I.R. Laboratories and Field Stations (see Key below).

KEY TO MAP SHOWING LOCATIONS OF COUNCIL FOR SCIENTIFIC AND INDUSTRIAL LABORATORIES AND FIELD STATIONS.

New South Wales.—1. *Sydney* (*see* inset).—(1) F. D. McMaster Animal Health Laboratory, University ; (2) Laboratories for Food Preservation and Transport, Homebush ; (3) Laboratory for Fisheries Section, Cronulla ; (4) National Standards Laboratory, University ; (5) Radio Research, University. 2. *St. Mary's.*—F. D. McMaster Field Station (Animal Health). 3. *Moss Vale.*—Pasture Improvement Field Station. 4. *Young.*—Field Station (Animal Health and Pasture Improvement). 5. *Griffith.*—Irrigation Research Station (Citrus).

Victoria.—1. *Melbourne* (*see* inset).—(1) Head Office, East Melbourne (Administration) ; (2) Forest Products Laboratory, South Melbourne ; (3) Animal Health Laboratory, Parkville ; (4) Radio Research, Mineragraphy, and Ore Dressing, University ; (5) Aeronautical Research Laboratory, Fisherman's Bend. 2. *Shepparton.*—Entomological Laboratory (Oriental Peach Moth). 3. *Merbein.*—Irrigation Research Station (Viticulture and Dried Fruits). 4. *Berwick.*—Field Station (Mastitis in Dairy Cows). 5. *Werribee.*—Field Station (Animal Health) and Dairy Research. 6. *Tooradin.*—Field Station (Cattle). 7. *Woorinen.*—Viticultural Field Station. 8. *Eurobin.*—Tobacco Field Station.

Queensland.—1. *Lawes.*—Field Station for Plant Introduction, Plant Genetics and Noxious Weeds Investigations. 2. *Cunnamulla.*—" Gilruth Plains " Sheep Station (Animal Health). 3. *Rockhampton.*—Field Station for Plant Introduction. 4. *Stanthorpe.*—Field Station (Apple Stocks and Scions). 5. *Helenslee.*—Field Station for Animal Health (Cattle Problems).

South Australia.—1. *Adelaide.*—(1) Animal Nutrition Laboratory, University ; (2) Soils Division Laboratory, Waite Institute, Glen Osmond ; (3) Mineral Deficiencies of Pastures, Waite Institute, Glen Osmond ; (4) Ore Dressing Investigations, University. 2. *Robe.*—Field Station (Animal Nutrition). 3. *Kangaroo Island.*—Field Station (Animal Nutrition).

Western Australia.—1. *Perth.*—(1) Agrostological Investigations ; (2) Animal Health Investigations ; (3) Entomological Investigations. 2. *Kalgoorlie.*—Ore Dressing Investigations.

Tasmania.—1. *Hobart.*—Laboratory and Field Station (Storage Disorders of Apples). 2. " *Frodsley* ".—Field Station (Animal Health and Pasture Improvement).

Australian Capital Territory, Canberra.—(1) Laboratory and Field Station of Division of Plant Industry ; (2) Laboratory and Insectaries of Division of Economic Entomology ; (3) Experimental Farm, Duntroon, for Plant Introduction, Plant Genetics and Pasture Improvement Investigations.

NOTE.—Many other investigations are being conducted in co-operation with Universities, Commonwealth and State Departments at various places in Australia.

By Authority: L. F. JOHNSTON, Commonwealth Government Printer, Canberra.