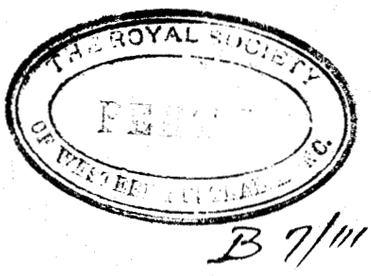
1940-41-42.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.



SIXTEENTH ANNUAL REPORT

OF THE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH,

FOR THE

YEAR ENDED 30TH JUNE, 1942.

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CONTENTS.

CONTENTS—*continued.*

COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

SIXTEENTH ANNUAL REPORT (FOR YEAR ENDED 30TH JUNE, 1942).

NOTE.—*A very considerable part of the Council's activities is now devoted to the solution of problems arising out of the war and to assistance and advice to various Government Departments and other institutions and organizations which are concerned with the war effort. This applies particularly to the Council's National Standards Laboratory, and the Divisions of Aeronautics, Forest Products, and Industrial Chemistry. The expenditure on this class of work forms a substantial part of the total expenditure of the Council, but as no specific information which might be of value to the enemy can be disclosed, reference to these activities is either confined to brief generalized statements or is omitted entirely.*

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* 1920-39, and include the initiation and carrying out of research in connexion with, or for the promotion of, primary and secondary industries; the training of research workers; the making of grants in aid of pure research; the testing and standardization of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardization; and the establishment of a bureau of information relating to scientific and technical matters.

2. THE WAR AND THE COUNCIL'S ACTIVITIES.

With the continuation and extension of the war and the rapid development of Australian production of munitions and associated secondary industries, the scientific resources of the Council have been called upon to an ever-increasing extent. Also in the sphere of primary production, the extension of the war, with the resultant cutting off or reduction of supplies from sources previously available has given rise to many new problems, with the result that the older established Divisions of the Council, which were developed to investigate problems of primary production, are now engaged on work of an essential and direct nature in regard to the war effort. Thus, investigations are being actively directed into such spheres as flax production, vegetable seed production, the latest possibilities of native and exotic Australian plants for rubber production, the planting and testing of rubber-producing plants from various parts of the world, the storage of foodstuffs and wool, and the development of special rations and high vitamin content extracts for the use of the various Services.

In general, all the work of the Council is now so definitely related to the war effort, that the greater number of the Divisions and Sections have been declared by the Department of War Organization of Industry as "protected establishments".

In common with other organizations, all the eligible staff that can be made available have enlisted in the fighting Services, while many officers of the Council with special knowledge have been seconded to the Ministry of Munitions or other war-time Departments. Staff shortages and the urgency of war-time projects have further curtailed the more fundamental investigations of the Council, and only those of long standing on which considerable time and money has been spent and which will be of direct assistance in the reconstruction period to come have been retained on a skeleton basis.

It is pleasing to report that during the year, the Division of Industrial Chemistry took possession of its new laboratories. This has assisted greatly in the proper planning and extension of the work on chemical industry, and rapid progress is now being made on many urgent problems, especially those requiring pilot plant investigation. The Council is particularly grateful to the University of Melbourne and to the Melbourne Technical College for making available laboratory accommodation and facilities, so that much of the Division's work could be initiated pending the completion of the Division's own laboratory.

3. FINANCE.

The total expenditure of the Council during the financial year 1941-42 was £427,519 of which £84,092 was contributed from sources other than the Commonwealth Treasury. The Council is particularly gratified with the way in which contributory bodies continue to support it and with the marked interest and donations for co-operative research received from certain sections of industry. Among the many contributions received, reference may be made to those of the Commonwealth Bank, the Australian Wool Board, the Australian Cattle Research Association, the George Aitken Pastoral Research Trust, the Dried Fruits Control Board, the New South Wales Water Conservation and Irrigation Commission, the Cement Manufacturers' Association, the timber industry, and the pulp and paper industry.

II. PLANT INVESTIGATIONS.

1. GENERAL.

Following the preparation of a report on the pastures of Queensland by Dr. J. G. Davies of the Division of Plant Industry, the University of Queensland made available a site for laboratories in and from which studies of pasture problems were to be undertaken. The exigencies of war have postponed the development of the work. At Lawes, the Government of Queensland, through the Department of Public Instruction, very generously made available a well-built and equipped commodious laboratory and glasshouse for the use of the Council, more especially for the plant

introduction and pasture plant breeding work which has been in progress there for some years. The laboratory was opened and its use made available to the Council officially by Hon. H. A. Bruce on the 7th December, 1941. At Dickson, A.C.T., land is steadily being prepared and laid out for use in experiments, but there is still a lack of certain accommodation.

A conference of State and Commonwealth officers on seed-testing problems was held in Melbourne in October, 1941. The Conference prepared and approved the main provisions of a Seeds Act which could be generally accepted by all States, and revised the schedules of weeds, purity standards and germination standards.

A conference representative of the Council, the Departments of Commerce and Supply and Development, the Army, the State Departments of Agriculture, and representatives of the seed trade, was held in Melbourne in January, 1942, to report on the problem of supplies of vegetable seeds following the submission of a survey report by an officer of the Division, Dr. J. R. A. McMillan. As a result, the formation of a Commonwealth Vegetable Seeds Committee, the function of which is to ensure the provision of adequate supplies of seed of essential vegetables during the war period and one year thereafter, was recommended.

Work is continuing in the field of vegetable fibres, and the Council is appreciative of the co-operation of the Botany Department of the University of Sydney in anatomical studies of fibre in flax. Studies are being made of the microbiology of dew-retting and of the actual process of retting in order to ascertain whether improvement is possible in practice. Considerable expansion has taken place in the programme on medicinal and drug plants in which the Council has the co-operation of the Pharmacy Department of the University of Sydney and the Physiology Department of the University of Melbourne. Increased attention is being given to those plants which may serve as a source of rubber.

2. Pasture Investigations.

(i) *Agrostology.*

(*a*) *Western Australia.*—The investigations in this State are designed to determine the best pasture species for the sheep country in the south-west Division (annual rainfall 15 to 25 inches), but some attention is also devoted to pasture development on the low fertility coastal sands with higher rainfall. The main work has been concerned with (1) pasture mixture trials throughout the south-west Division and the control of capeweed which has proved a serious obstacle to pasture establishment, (2) studies with perennial veldt grass, and (3) lupins.

(1) Pasture Mixture Trials.—These trials were commenced at seven centres in 1939 but an abnormally wet season that year, followed by the driest season on record in 1940, militated against successful establishment, so that when an average season was experienced in 1941, the experimental pastures were too weak to respond to the better conditions and the sown species were overwhelmed by annual weeds. In particular, the severe competition from capeweed was demonstrated in these trials, and it was evident that a means of control would have to be found before successful pasture establishment would be possible in districts where the capeweed infestation is heavy. So far, efforts to control this weed have been unsuccessful. The practice of clean fallowing during the summer preceding sowing has proved entirely ineffective. An autumn cultivation to kill the first crop of capeweed seedlings and a late sowing of the pasture has reduced the weed markedly, but such a practice is not favorable to successful pasture establishment. An experiment is planned in which an oat cover crop is used with a pasture mixture sown at different times, in order to set up vigorous competition with the capeweed for nitrogen.

(2) Perennial Veldt Grass.—This species is an accidental introduction from South Africa and has flourished on the poor coastal sands. Many strains exist, and work up to date has been concerned with the selection of desirable pasture types and a study of the problems connected with seed production and harvesting. Selected types of veldt grass outyielded *Phalaris tuberosa* on the coastal sands, and some of these types are now being tested under sward conditions.

(3) Blue Lupins.—The study of lupins was handicapped by a disease, a virus of the pea mosaic type, present among these plants in the experimental plots.

(*b*) *Queensland.*—In this State, the main studies are located at "Gilruth Plains" and have been concerned chiefly with the Mitchell grass association. Experiments at present in progress include (1) a grazing trial, (2) studies on the cutting of Mitchell grass for hay, (3) re-establishment of Mitchell grass on areas from which it has disappeared, (4) soil moisture studies, and (5) changes in the chemical composition of Mitchell grass throughout the year. This work was commenced in 1941 after excellent summer rains and with the Mitchell grass pasture in good condition. However, after the March rains in 1941 the following twelve months were without effective rain.

(1) Grazing Trial.—The objectives of this trial are to study the effect on the pasture and on the sheep of grazing Mitchell grass with sheep at different rates and frequencies. From a yield of approximately 17 cwt. dry material per acre at the initial sampling in February, 1941, the grazing residue has declined to less than half that amount in January, 1942. The decline has been greater with the heavier rates of stocking. There is evidence that the reduction in the grazing residue is primarily due to causes other than the grazing sheep—e.g., the losses through the breaking up of the dry feed are considerably greater than the quantities eaten by the sheep. A study of the chemical composition of the pasture has shown low values for nitrogen, calcium, and phosphorus in the Mitchell grasses and other grasses (mainly Flinders and button grasses) but the miscellaneous species (herbage) have been higher in these elements. Monthly records of the live weights of the sheep have shown a steady increase in weight of all groups to September, 1941, and since then a steady decrease, particularly at the heavier rate of stocking. The weights of wool produced at shearing were 10 lb. 1 oz., 9 lb. 15 oz., and 9 lb. from the groups grazing at 1 sheep to $7\frac{1}{2}$ acres, 1 sheep to 5 acres, and 1 sheep to $2\frac{1}{2}$ acres respectively.

(2) Studies on the Cutting of Mitchell Grass for Hay.—The object of this work is to study the effect of various cutting treatments on the yield and chemical composition of Mitchell grass hay and also on the persistence of the pasture. Pure stands of artificially established Mitchell grass have so far been established at only one centre, namely, Lawes.

(3) Re-establishment of Mitchell Grass.—Sowings made before and after the rains in the 1940-41 summer were unsuccessful. The experiment was repeated in 1941-42 but as the only rain of any consequence was received in May, 1942, it was too late to benefit the sowings.

(4) Soil Moisture Studies.—Monthly samples of soil to a depth of 4 feet have been taken since March, 1941. The chief results so far have shown—(*a*) that during a dry summer the surface soil may dry out to as low as 3 per cent. moisture, (*b*) the penetration of rainfall is relatively shallow, and (*c*) the moisture

content at the 3-ft. and 4-ft. levels does not change appreciably over twelve months even though the surface soil may dry out.

(5) Changes in Chemical Composition of Mitchell Grass.—Monthly samples of three species of Mitchell grass have been chemically analysed.

(*c*) *Australian Capital Territory.*—Pasture investigations centred at Canberra were commenced in 1939. After an excellent first year the seasons have been adverse. The spring rains failed in 1940 and 1941, and these two seasons and the early part of 1942 constitute the worst drought period recorded on the Southern Tablelands. Notwithstanding these conditions, at no time during the period has the experimental pasture carried less than two sheep per acre, and for the greater part it has carried three sheep per acre.

(1) Pasture Management Experiment.—This experiment is designed to test the effect of three methods of grazing a sown pasture, namely, (1) continuous grazing, (2) rotational grazing for one week in each month, (3) rotational grazing for one week in each two months. The pasture mixture, which was sown on fallow in March, 1939, consisted of *Phalaris tuberosa*, subterranean clover, lucerne, and cocksfoot. The yield of the pasture when first sampled in June, 1940, was 25 cwt. of oven-dry material per acre. Until December, 1940, there was no evidence to suggest that the treatments were affecting the yield. By April, 1941, however, the yield of the eight-weekly grazed pasture became distinctly greater than the continuous, and in July, 1941, the 4-weekly grazed plots gave a higher yield than the continuous grazing. By February, 1942, the yields had reached the low levels of 0.3, 0.8, and 2.1 cwt. per acre from the continuous, four-weekly, and eight-weekly grazing treatments respectively, owing to the adverse conditions. Until October, 1940, subterranean clover was the main contributor to the yield of the pasture, but the *Phalaris tuberosa* has contributed most since February, 1941. Lucerne yielded poorly at first but good summer rains early in 1941 resulted in that species making substantial growth, and during the subsequent spring and summer periods it became an important element in the pasture. This is particularly the case on the eight-weekly rotation, and it is clear that under continuous grazing in this experiment the lucerne failed. The cocksfoot also failed to establish, but this does not mean that cocksfoot may not be a valuable grass on the Southern Tablelands.

Weekly chemical analyses have shown little variation in the composition of the pasture at different periods of the year, owing to the drought conditions. There has been a high protein content even in the dried herbage, and this, together with a satisfactory lime level and low fibre content, has ensured an adequate nutritive level in the pasture. Liveweight records of the sheep, taken each week, have shown a steady increase in weight on all grazing treatments until October, 1941. From that date there has been a rapid loss of weight in all three groups, the loss being most severe in the sheep on continuously grazed plots. There has been little difference in weight of wool produced under each of the grazing treatments (average 12-13 lb.) but a higher percentage of fleeces from sheep on the rotationally grazed pasture was classed as spinners warp. All sheep have remained virtually free of internal parasites throughout the experimental period and no drenching has been done.

(2) Species and Strains Trials.—The two dry years of 1940 and 1941 have been a severe test of species and strains. *Phalaris tuberosa*, lucerne, and subterranean clover are the only species which yielded satisfactorily under the conditions. There is evidence that the Bacchus Marsh strain of subterranean clover may be superior to certified Mt. Barker under Southern Tableland conditions.

(3) Deficiency Disease of Legumes.—Both lucerne and subterranean clover have repeatedly shown disease symptoms and have frequently failed to make satisfactory growth even under good moisture conditions. The trouble is widespread on the Southern Tablelands and has become very apparent during the recent dry seasons. Field tests with various fertilizers and applications of minor elements have been negative, but dry conditions may have masked results. In a pot experiment with lucerne, an application of lime at the rate of 1 ton per acre has trebled the yield over the first six months. There was no further increase with an additional ton of lime, nor was there any response from applications of monocalcic phosphate at the rates of 2 and 5 cwt. per acre.

(*d*) *Griffith Research Station, N.S.W.—Experiments on Irrigated Pastures.*—The objective of these trials is to compare the efficiency of water usage by winter growing pastures (partially irrigated in autumn and spring) with summer growing pastures (fully irrigated). The two winter pastures under test are: (i) *Phalaris tuberosa* and subterranean clover, and (ii) Wimmera rye-grass and subterranean clover. The two summer pastures are lucerne alone and a mixture of perennial rye-grass, cocksfoot, and white clover.

With the winter pasture the results so far have shown that early autumn watering, commencing 1st March, followed by two later autumn waterings gave the best yield, particularly in the autumn and winter when the increase is most needed. Data are at present available for the lucerne only in the summer pasture series; they indicate that a medium application of $1\frac{1}{2}$ acre-inches per week is more economical than $\frac{3}{4}$ or $2\frac{1}{4}$ inches per week. No difference between the results of waterings at fortnightly and three-weekly intervals has been observed.

(ii) *Plant Introduction.*

(*a*) *General.*—During the year, 196 species, varieties, and strains of plants were introduced, making a total to date of 7,630, from 76 countries. Plant Introduction Inventory No. 7, comprising 639 new plants, was issued. Samples of seed of 276 plants were distributed to the several States, and 128 lots were sent abroad. The cultivation of guayule (Mexican rubber), introduced in 1931, is being accelerated.

(*b*) *Tests at Canberra, Australian Capital Territory.*—Further tests of ten promising white *wheats* gave yields per acre ranging from 24.8 to 19.6 bushels for Cambridge strains as compared with 19.2 and 18.5 bushels for Waratah and Ford, respectively. Of 11 varieties of *barley*, one equalled Trabut (Check) in yield with 35.5 bushels, while a second yielded one bushel less. Of 9 varieties of *oats*, four yielded 38.7 to 35.1 bushels as compared with Sunrise (34.3 bushels) and Mulga (29.5 bushels). The driest season in 50 years was not favorable to forage plants. Strains *of Agropyron cristatum, A. elongatum, Elymus junceus, Bromus inermis, Festuca Mairei, Phalaris stenoptera, Bromus porteri, Panicum bulbosum, Ehrharta calycina,* and *Oryzopsis miliacea* resisted drought the best and responded quickest to following rains. Cocksfoots, with the exception of dryland, winter-growing, North African strains, were killed out. Swards of nine years' duration consisting of *Dactylis glomerata* var. *hispanica, Trifolium tumens,* and *Medicago sativa* x *M. lupulina* are still intact. Of 14 varieties of lucerne, Hairy Peruvian, for the second year in succession, yielded best, followed by Argentine. The latter variety also gave the highest yield amid seventeen varieties in more recently seeded plots. Both are apparently of special value in dry seasons and areas,

One hundred and forty plots of promising introduced grasses have been established on the new farm at Dickson, Australian Capital Territory.

(*c*) *Tests at Lawes, Southern Queensland.*—Despite a very adverse season, new and promising introductions successfully established included strains of *Paspalum scrobiculatum, Digitaria smutsii* and other species of *Digitaria* from South Africa, and the legumes *Dolichos biflorus* and *Vigna unguiculata. Paspalum scrobiculatum* var. *commersonii, Urochloa pullulans, Panicum maximum* (strain), and *Phaseolus lathyroides* were the most outstanding plants selected for grazed sward investigation. Others chosen included *Paspalum larranagai, P. notatum, P. laeve, Urochloa mozambiquensis,* and *Dichanthium nodosum.* Legumes duly tried and selected as plants of potential value to Queensland agriculture were: *Phaseolus ricciardianus, Phaseolus acutifolius, Glycine javanica,* Iron Cowpea, *Crotalaria usaramoensis,* and *C. goreensis.* Various strains of Bilnon soybean, from South Rhodesia, appeared to offer the most promise.

Linseeds tested and pronounced "very good" were hybrids of Bison x Rio and Buda x Bison and the variety Bolley's Golden. Flaxes (Linum) so classified were Giza and the strain "B37-5310".

(*d*) *Tests at "Fitzroyvale", Central Queensland.*—In tests of new legumes, *Stylosanthes angustifolia* flowered and set seed earlier than *S. guianensis,* thus appearing to be more suitable than the latter for districts where frosts occur later than June. In grazing swards *S. guianensis* proved superior to all other legumes in productivity, palatability, and quantity consumed. The yield from *S. guianensis* and grass was superior to grass alone, and the yield of grass was invariably only slightly depressed by the legume. Superior mixtures were *S. guianensis* with each of the grasses *Brachiaria brizantha, Melinis minutiflora,* and Kenya No. 1 and Kafue strains of Rhodes grass. There were positive indications that the yield of natural pasture can be increased by inclusion of *S. guianensis* in the sward, that the legume component can be used for spring (dry period) grazing, and that the protein content of the pasture is increased by its incorporation. Tests revealed that the legume can best be established by broadcasting scarified and disinfected seed following burning off and surface cultivation and prior to summer rains. The legume *Cajanus indicus* (pigeon pea) is also under systematic investigation.

Grasses outstanding in total yield during three years included *Bothriochloa glabra, Brachiaria brizantha, Melinis minutiflora,* and the Kenya No. 1 and Kafue strains of *Chloris gayana.* The second was considered the most promising grass, while the third was the most palatable. Strains of *Panicum maximum* (Guinea grass) proved most adaptable for intercultivated row culture and for fodder and silage purposes. In comparison with natural spear grass pasture, *Brachiaria brizantha* produced during the same season, in six weeks less time, 50 per cent. more grass. *Melinis minutiflora* and strains of *Chloris gayana* were also markedly superior in yield to natural spear grass pastue. Jute (*Corchorus olitorius*) was found to grow well at "Fitzroyvale", 4 to 5 tons dry matter per acre being produced. Early December seeding was best.

(*e*) *Tests (dryland) at Griffith, N.S.W., Commonwealth Research Station.*—Some 56 grasses, 22 legumes, and 18 miscellaneous plants were seeded in triplicate rows in May, 1939. Despite three years of adverse climatic and seasonal conditions, the following species established well and persisted remarkably under non-irrigated conditions:—

Grasses (in order of persistence).—*Agropyron elongatum, Phalaris coerulescens, Phalaris stenoptera, Oryzopsis miliacea, Poa bulbosa, Ehrharta calycina, Brachypodium phoenicoides.*

Legumes.—Hairy Peruvian, Arizona Common, Chinese, Cape, Bolivian, and Hunter River lucernes, *Medicago falcata,* and *M. coerulea* were all highly persistent, also *Sutherlandia microphylla* from South Africa.

Miscellaneous Plants.—*Tripteris pachypteris* (shrub of the South African Karroo).

(iii) *Pasture Plant Breeding.*

(*a*) *At Canberra.*—Some promising *Trifolium subterraneum* (sub clover) selections combining early vigour, growth density, free seeding, and regeneration under adverse conditions, have been obtained from cross Tallarook-Wenigup. Several of these have been increased and are being tested under sward conditions at Canberra, Moss Vale, Orbost, and Tumbarumba. Further crosses to combine these desirable qualities were made between Tallarook, Bacchus Marsh, and Mulwala. From a large collection of Australian ecotypes of *Trifolium glomeratum* (cluster clover), some outstanding early and late strains were selected which are superior to commercial samples of this clover. These are being increased.

The most promising selections from a large collection of *Danthonia* ecotypes have been established in multiplication rows and swards at the Division's experiment station at Dickson. Hybridization between the best of these and *Danthonia californica* from California is to be attempted, with the object of producing a vigorous, hairless, seeded type with a relatively large and easily threshed out caryopsis suitable for the drier cereal belt.

The work on the three selected strains of *Dactylis glomerata* (cocksfoot) has been continued, and the seed of these is being increased. An extremely valuable collection of annual species of *Medicago* (Medics) has been obtained over the last few years. These have been studied agronomically and botanically and the most promising increased. Some of them should prove particularly useful in extensive areas of the wheat belt. A trial comprising 215 strains of lucerne, most of which were received from Lawes (Qld.), was commenced this year with the object of selecting strains suitable for the Australian Capital Territory and southern tablelands of New South Wales.

(*b*) *At Lawes (Queensland).*—The past two years have been characterized by a long dry period from early winter till mid-summer. Under such conditions it has been shown that lucerne sown thinly in a Rhodes grass sward provides a high protein pasturage, in satisfactory quantity, from early winter until summer rains fall. Yield trials, grazing trials, and time-of-cutting trials with lucerne strains have been continued. It has been found that numerous lucerne leaf diseases are of importance, especially under grazing conditions, and information has been obtained regarding the susceptibility of a large number of plants and strains. The discovery or production of a suitable legume for pastures in southern Queensland is a problem of great economic importance. In this connexion, observation trials have been conducted with 213 samples of native legumes collected in 1940-41. The long dry period experienced in 1941 enabled observations to be made on the survival, under drought conditions, of a large number of *Phalaris* progenies. Four distinct lines of Rhodes grass have been established, and are being multiplied and tested in several districts throughout Queensland.

(c) *At Moss Vale (N.S.W.).*—The higher rainfall pasture plant breeding programme was continued, but, as the drought persisted and intensified, further losses in experiments and material were sustained. In March the station was closed and the programme suspended for the duration of the war. Evidence has accumulated that the Welsh cocksfoots (S-26 and S-143) are both persistent and drought-resistant, and may under certain conditions prove superior to both the Victorian and Akaroa strains. There do not appear to be appreciable differences under sward conditions at Moss Vale between the Victorian and New Zealand Certified rye-grasses, but the new New Zealand "Pedigree" strain seems to be inferior in drought resistance. A rye-grass strain developed at the station from local material shows promise and is apparently more vigorous, particularly in the summer, than any commercial strain yet tested. Preliminary trials have indicated that some segregates from the Wenigup x Tallarook subterranean clover cross developed at Canberra may, under Moss Vale conditions, combine the late spring growth of Tallarook with the increased winter growth of Wenigup.

3. Weeds Investigation.

(i) *In Queensland.*—A rotation experiment on the control of nutgrass (*Cyperus rotundus*) has been continued during the past year. In this work, attempts to clear the land sufficiently by intensive cultivation and the use of competing plants to allow of several years' truck cropping are being studied.

Experiments on the control of galvanized burr (*Bassia birchii*) have been in progress for five years in the St. George district. The effects on a pasture heavily infested with burr, of light and heavy rates of stocking with sheep and the exclusion of stock altogether have been studied. Results to date have shown that under all grazing treatments applied, and including grazing at the rate of a sheep to two acres, the burr has been considerably reduced. However, there has also been a general reduction in burr infestation throughout the district and this has been attributed to atypical seasons during the past five years. Heavy late summer rains resulted in a dense growth of grass which competed strongly with the burr, and dry periods during winter and spring proved unfavorable to the development of the burr. The experiments with poison sprays have been inconclusive, for, with climatic conditions unsuitable for the growth of burr, it has been impossible to measure the regeneration of the burr after spraying.

(ii) *In Western Australia.—Berkhaya Thistle.*—In collaboration with the Department of Agriculture it has been shown that chlorate sprays can be successfully used to eradicate Berkhaya thistle. Repeated spraying is necessary to kill seedlings on the infested areas which are not extensive.

(iii) *In Victoria.—Hoary Cress.*—The effectiveness of poison sprays and soil sterilants in the control of hoary cress (*Lepidium draba*) has been investigated for three years at Murtoa and Werribee. The conclusion has been reached that the poison sprays used, which included chlorates and arsenicals, are both ineffective and uneconomic. A study of pasture species suitable for the Wimmera conditions was commenced in 1940 with the objective of developing pasture mixtures that would compete effectively with hoary cress and could be incorporated in a crop rotation. This work has been suspended for the duration of the war, but existing experiments are being retained for observation. *Phragmites.*—Growth of *Phragmites communis* in the main drainage canal of the Koo-weerup swamp was effectively killed during 1939-40 with weak concentrations of sodium chlorate (2½ and 5 per cent.), and regrowth in that growing season was negligible. In the subsequent growing season (1940-41) there was substantial regrowth estimated at 75 per cent. of unsprayed areas. This work has been discontinued for the duration of the war, but the evidence already available indicates that annual spraying of the *Phragmites* with 2½ per cent. solutions of sodium chlorate can be used to eradicate the weed from drainage channels and banks.

(iv) *In New South Wales.*—The investigations on the control of St. John's wort (*Hypericum perforatum*) in the Mannus Valley near Tumbarumba have been successfully concluded. The results and conclusions are to be published in the Council's Bulletin No. 151. Vigorous pastures of subterranean clover and *Phalaris tuberosa* will virtually eradicate the weed on agricultural land in southern New South Wales and north-eastern Victoria, the main centres of infection.

4. Wheat Investigations.

(i) *Take-all.*—(a) *In South Australia.*—An area of 20 acres, of which portions have been subjected to different cultural treatments since 1938, is being planted this year to wheat, in order to determine to what extent the treatments may have influenced the occurrence of and damage caused by take-all.

(b) *At Duntroon, A.C.T.*—The study of the effect of various agronomic practices on the incidence and control of take-all was continued. The treatments were designed to give information about the influence of rotational cropping, of a dry subsoil produced by cropping with lucerne for two years, the conservation of subsoil moisture by fallowing for one year, the reduction of the amount of *Ophiobolus graminis* in the soil by clean fallowing for two years, maintaining the fungus in the soil by growing susceptible hosts continuously, such as wheat and Wimmera rye. Much information was obtained on the positional relation of take-all patches to the occurrence of seedling blight and the effect of destruction of the roots of the organism on the collapse of the wheat plant at heading.

(c) *At Canberra, A.C.T.*—In the course of the above field studies, it appeared that typical take-all symptoms were associated with dry soil conditions following root destruction by *O. graminis*. Experiments were therefore started in the greenhouse to determine whether these factors were associated with the production of white heads. Although disease symptoms developed in all the inoculated ears and the yield was significantly less than in the controls, white heads were observed only in dry soil series. The experiments are being repeated. Using 5-gallon drums of soil, the previous years' experiments were repeated and extended in an experiment out of doors. Significant differences were obtained between crops grown in soil alone and in soil containing large amounts of added burnt lime. It is noteworthy that the differences were observed only when the amounts of added burnt lime were large; amounts proportional to those used commercially on soils poor in calcium were without effect. Plants grown in soil to which large or small amounts of ground limestone or of calcium sulphate were added were no better than the controls. Experiments now being made should help in evolving a satisfactory explanation of the extraordinary differences associated with the addition of large amounts of burnt lime only.

As in previous years, crops on soil inoculated with *O. graminis* during the preceding year were significantly better than those in the uninoculated drums, the reversal of effect in the second year being apparently influenced by the different amounts of nutrients available to the plants. These results appear to lend support to the well-established practice of

avoiding growing wheat in the same field in successive years. The carbon and nitrogen requirements of *O. graminis* were determined. The fungus can utilize both inorganic and organic nitrogen even when carbon is supplied as relatively simple organic acids. Carbohydrates are the best source of carbon for synthesis, but the organic acids are as good as the carbohydrates as a source of carbon for respiration. The growth of the fungus on synthetic solutions containing optimal carbon and nitrogen was also studied.

5. Fruit Investigations.

(i) *Apples and Pears.*—(*a*) *In Tasmania.*—The new laboratory at Huonville has proved of great value in the conduct of the field experiment work and has resulted in a much closer contact and co-operation with the fruit-growing industry than was previously possible. Work on long-term problems has been reduced to a minimum consistent with the continuance of the experiments, while work on problems more closely associated with war-time economy has been considerably extended. An intensification of experimental work, in co-operation with the Division of Food Preservation on the surface coatings of apples in 1941 was followed in 1942 by full-scale commercial trials by machine and hand methods. Assistance has been given to commercial firms in the development of processes for manufacturing fruit products now unobtainable from overseas. These investigations carried out in co-operation with the Division of Food Preservation have resulted in the successful local production of pectin and pectin products, various fruit-juice concentrates, and crystallized fruits. The vitamin C content of local fruit samples has been determined, and methods of making fruit preparations rich in this vitamin have been investigated.

The 1940-41 growing season was cool and dry. Crops were generally light, but fruit size was reduced to some extent by the dry conditions. The incidence of tree-pit and watercore was not severe. The control of internal cork by soil dressings of ½ lb. of borax per tree has continued for the sixth year since the application was made. Injection and spraying experiments have failed to show that die-back or decline in apple trees, which has become increasingly prevalent on lighter soil types in Tasmania during recent years, is due to any particular mineral deficiency. The general conclusion has been reached that loss of soil by erosion, soil deterioration through excessive cultivation, ploughing too close to the trees, and unsatisfactory manurial programmes are contributing factors, the detrimental effects of which have been increased by the recent succession of dry seasons. Experiment plots of various leguminous cover crops have been established.

Work on general storage disorders was considerably curtailed. Only certain experiments relating to the effects of crop size, seasonal climate, storage temperature, delay in cool storage, and fruit maturity upon the incidence of storage disorders and the keeping qualities of the fruit were maintained on a small scale to preserve the continuity of these studies. In co-operation with the Tasmanian Department of Agriculture, the storage qualities of fruit from trees on different rootstocks and from trees subjected to different methods of pruning were studied. Of the rootstocks tested, fruit from Malling VII. again showed a lower susceptibility to pit and breakdown and that from Malling II. had high susceptibility, other stocks being intermediate. The fruit from heavily pruned trees was larger than that from lightly pruned trees and more susceptible to storage disorders.

Experiments on storage in artificial atmospheres were limited this year to a continuation of the investigation of the effects of seasonal climate on the incidence of disorders in gas storage. Surface coating experiments designed to determine the most useful and economical type of coating for increasing the life of Tasmanian varieties in cool and common storage were continued. Semi-commercial scale trials with the Sturmer variety were conducted to test the castor oil-shellac-alcohol bath, which appeared the most promising for Tasmanian varieties, against the various wax emulsion coatings developed by the Division of Food Preservation. Very little difference between the effectiveness of the two types of treatment was found; the solutions had, however, the practical advantage of durability and quick drying. Treatment retarded colour change and reduced shrivelling as well as the incidence of Jonathan spot. Storage pit and lenticel scald were also reduced or at least the appearance of these disorders was delayed. Treated fruit was superior in appearance and flavour to untreated, except in the case of light-crop fruit in which alcoholic flavours tended to develop. Granny Smith and Cleopatra proved unsatisfactory varieties under these treatments. In these varieties some of the fruits have an open passage between the core cavity and the calyx; these fruits ripen normally after treatment while in the other fruits the green colour is retained. The outturn is a sample of mixed colour. With some varieties, particularly Democrat and Crofton, treated fruit after common storage was equal to and often superior to untreated fruit held in cool store. Under no circumstances should over-mature fruit be treated. In the semi-commercial scale experiments with Sturmer, results were not as satisfactory as might have been expected, because the fruit used was generally from light crops. Susceptibility to brown heart and alcoholic flavours increased rapidly with the maturity of the fruit. This variety should not be treated after the first week in May.

In the 1942 season, the Apple and Pear Acquisition Committee, having been informed of the results of the above experiments, decided to make a full-scale commercial trial of the process. Provided the process could be applied on a commercial scale, mid-season varieties could be held without the necessity of using cool-storage space, and the quantity of varieties capable of long storage held for late markets and processing could be increased. An experimental waxing machine was installed at the Huonville laboratory and a hand-dipping plant at a commercial packing shed. Officers of the Council processed 10,000 cases by various methods in the former, and provided technical supervision for the latter where 50,000 cases of fruit were treated. Treated fruit placed on the market so far has been superior to untreated fruit.

(*b*) *At Stanthorpe.*—Growth measurements and records of fruit yield have been continued on the 6-acre rootstock trial plot planted in 1938. Next year it is hoped that sufficient information will have been obtained to publish a progress report on the effects of the various rootstocks used and the different manurial and pruning treatments applied.

Very satisfactory progress is being made by the nursery trial plots which were established to obtain an early and inexpensive estimate of the value of different types of apple rootstocks. The oldest of these plots consists of Jonathan budded to six different types of stock. These trees are now six years old. During the first five years, almost twice the amount of vegetative growth was made by trees on Merton Stock 793 as compared with trees on the commonly used Northern Spy. Trees made increasingly greater growth on the different stocks used in this trial in the following sequence:—Northern Spy, Stock D (local selection), Stock E (local selection), Merton No. 789, Malling XVI., and Merton No. 793. The amount of fruit borne in the sixth season was greatest in Merton 789,

followed by Merton 793, Northern Spy, Stock D, Stock E and Malling XVI. in sequence. The Merton stocks are immune to attack by woolly aphis, and the results of this preliminary trial give an indication of their possible value as stock types. The Merton stocks will be further tested in an orchard planting.

During the winter of 1941, rootstock material was collected with the assistance and co-operation of the Victorian Department of Agriculture from outstanding pear trees in the Goulburn Valley, Harcourt, and Bendigo districts. Over 60 of these selections are being grown at Stanthorpe, and trials are in progress to determine their response to various methods of vegetative propagation.

(ii) *Citrus.*—Investigations at the Griffith Research Station have been continued on rootstocks, shoot and root growth, and minor element deficiencies.

(*a*) *Rootstocks.*—Many factors undoubtedly contribute to the frequent unthriftiness and early decline of citrus groves in the Murrumbidgee irrigation area. The use of unsuitable stock types is probably one of these factors. Work in progress aims to find a series of rootstocks compatible with the main commercial varieties and suited to the various soil conditions that prevail in the Murrumbidgee and Lower Murray irrigation areas. Further collections of root cuttings from old trees of outstanding vigour and performance on the area have been made and are being propagated. Seedlings of nine different varieties of citrus used as rootstocks overseas have also been planted in nursery rows. Three of these, namely, Jamburi from India, Japanese Citron from Malay, and the Californian rough lemon, continue to make much more vigorous growth than most of the local types. In May, 1941, these plants were severely frosted, but recovered satisfactorily and were budded with Navel and Valencia during March, 1942. Seed of an additional five rough lemon, three Seville, and four sweet orange types has been selected from trees in Australia reputed to be good sources of rootstock material and planted for trial.

(*b*) *Growth Studies.*—The survey method of recording tree health has been continued in the experimental plots at the Research Station, on the March plots and project plots on grower farms. The health of the trees in the green manure experiment plots has continued to decline except where lucerne was the cover crop treatment. Trees receiving sulphate of ammonia also continue to decline less rapidly than trees receiving no applications of this fertilizer in the green manure field. On the field where only inorganic fertilizers have been used, the health of trees receiving ammonium sulphate is not better than trees receiving none. On the field the outstanding result is that phosphate applications have induced mottle leaf and accelerated tree decline. Improvements in tree health have been recorded on other plots following improvement of soil drainage and the use of zinc sprays on trees suffering from "mottle leaf".

A weekly record of root growth has been continued in the root observation trench. For the third successive season, no root growth was observed until late December. Growth continued from this time until the end of May. No root growth took place during spring. These observations were confirmed by the examination of samples collected by excavation at weekly intervals from healthy trees adjacent to the root trench. Soil moisture in the vicinity of the root trench was maintained at a higher level than during the previous season. During the heavy rains in May, a water-table appeared and rose to within 50 cm. of the surface.

The study of the horizontal and vertical distribution of citrus roots in different soil types was continued in conjunction with the Farm Project Scheme being carried out at the Griffith Research Station. It has been found that in moist soils the bulk of the feeding rootlets are concentrated in a zone 10–20 cm. below the soil surface; on very sandy soils these rootlets may be fairly evenly distributed from 10 cm. to 40 cm. On a sandy loam where a permanent stand of lucerne was established between trees the zone of feeding rootlets extended from 0 to 30 cm. The most healthy trees always seem to have the most evenly distributed and more deeply developed feeding root system.

(*c*) *Minor Element Deficiencies.*—Trials with zinc sprays were effective in reducing the amount of mottle leaf in affected trees at Red Cliffs and at the Griffith Research Station. The treatment did not, however, appreciably improve the general health of these trees. Spraying and dipping trials with eight minor elements used alone and in combination were carried out. Zinc and boron, when used in combination with zinc, resulted in improved leaf colour and size. In some cases a beneficial effect was also obtained by the use of iron salts.

6. Drug Plant Investigations.

The analyses and testing of material and research concerning methods of drug extraction are being carried out by the Department of Pharmacy, University of Sydney, and the Department of Physiology, University of Melbourne. The Departments of Agriculture in the various States and the Forestry Department of Queensland are co-operating in the conduct of field experiment plots of the different drug plants.

(i) *Hyoscine and Atropine.*—The satisfactory commercial extraction of hyoscine from the Native Corkwood tree (*Duboisia myoporoides*) growing in Queensland has been continued by local manufacturing companies. Further investigations have shown that the major alkaloid in this plant growing south of Gosford in New South Wales is hyoscyamine, from which atropine may be obtained. Atropine has not yet been satisfactorily manufactured on a commercial basis from this source; work at present in progress aims to evolve a suitable process for so doing in the near future. The assay of samples of dried leaf of *Duboisia leichhardtii* from Southern Queensland has revealed a total alkaloid content of 2.69 to 3.0 per cent.; the preponderating alkaloid has been hyoscyamine, but hyoscine has also been present. Seed of *Atropa belladonna* and *Hyoscyamus niger* has been distributed to intending growers together with advice and information on the handling of these plants.

(ii) *Digitalis.*—Supplies of *Digitalis purpurea* are now being locally produced. Leaf of *D. lanata* grown at Canberra and in Tasmania proved of satisfactory strength. Ample seed supplies of this species have been obtained and some has been distributed to intending growers.

(iii) *Opium Alkaloids.*—Plots of several acres of two varieties of opium poppy (*Papaver somniferum*) were grown last season in ten different localities. From these plots valuable information was obtained as regards the methods most suited to Australian conditions of cultivating and handling this crop. Adequate material for semi-commercial scale direct morphine extraction trials was obtained, and the results of the extraction trials were satisfactory. Ample seed supplies were harvested. This season a larger acreage has been sown under the direct supervision of the Council for the production of raw material for the manufacture of opium alkaloids. Smaller trial plots of other promising varieties of *P. somniferum* are also in progress.

(iv) *Ephedrine.*—A plot of *Ephedra gerardiana, E. intermedia,* and *E. nebrodensis* has been established at Canberra and smaller plots in several other districts. During the coming season, these plots are being increased to make a total planting of approximately 1½ acres. Material from the oldest plots will be sufficiently advanced to test for ephedrine content this year. It is also expected that seed will be harvested.

(v) *Ergot.*—Experiments carried out by the Victorian Department of Agriculture have shown that yields of 200 lb. of ergot per acre can be produced provided the rye is sown at the correct time (early) in suitable districts and the methods of ensuring a high ergot infection evolved during the present experimental work are followed. Entirely satisfactory methods of separating ergot from grain when the crop is harvested by mechanical means have not yet been devised. The use of hand-picking methods raises costs too high for profitable production unless the market value of ergot stands at a very favorable figure.

(vi) *Quinine, Strychnine, Emetine, and Strophanthin.*—Small plots of the tropical plants producing these drugs are being established in Queensland with the help of the Queensland Department of Agriculture and Stock and the Department of Forestry.

(vii) *Santonin and Filix-mas.*—The propagation of *Artemisia* (producing santonin) and *Dryopteris Filix-mas* has been continued. During the coming season, sufficient material of *Artemisia* will be available to plant about ¾ acre. Four dozen rootstocks of *Dryopteris* have been successfully raised.

(viii) *Other Drugs.*—Small lots of squill (*Urginea scilla*), buchu (*Barosma* spp.), colchicum (*Colchicum autumnale*), dill, aniseed, angelica, coriander, and grindelia have been grown for the production of propagating material. During the 1942-43 season additional types will be grown so far as it is possible to obtain seed for so doing.

(ix) *Native Plants as Sources of Medicinal Drugs.*—The search for sources of supply of medicinal drugs in indigenous plants has not yet been successful with respect to quinine, caffeine, and ephedrine. Investigations are proceeding. Seeds of *Strychnos lucida* have been found to contain a small percentage of strychnine, and promising results have been obtained in the search for a source of supply of natural cocaine. The bark of *Alstonia constricta* has been utilized as a substitute for imported gentian in the manufacture of certain pharmaceutical preparations.

(x) *Pyrethrum.*—A larger plot of *Pyrethrum* (*Chrysanthemum*) *cineraraefolium* was planted for the production of seed supplies. A small harvest of a few pound of seed was made during 1941-42, and this seed has been distributed to intending growers. During the 1942-43 season large supplies of seed will be available.

7. Tobacco Investigations.

(i) *General.*—During the year the physiological work at the Waite Institute was discontinued and one of the three remaining tobacco officers at Canberra was transferred to the Division of Food Preservation. The entomologist co-operating in the work on yellow dwarf completed his investigations for the time being. Special attention was given to grades and grade standards suitable for Australian-grown flue-cured leaf. Co-operative work with the States was maintained.

(ii) *Yellow Dwarf.*—A field test for the study of the reaction of various strains of the variety Hickory Pryor, and of thirteen other varieties, to the disease was conducted at Nathalia, Victoria. The varieties were also planted at Myrtleford (Victoria), and at Tamworth (New South Wales). The disease was not as serious as usual and the results of these tests were inconclusive. The study of the vector was continued at Canberra, the results being published in the May (1942) issue of the *Journal.* Other papers published in the *Journal* dealt with transmission by the jassid *Thamnotettix argentata* Evans (August 1941), and with the occurrence of the disease and the effect of agronomic practices (February, 1942). The study of the alternate host plants of the virus is being continued.

(iii) *Quality.*—Samples of the 1940-41 crop from all areas were tested for smoking quality and for other qualities of value when determining differences in type and grade. A system of grading based on leaf position on the stalk, leaf qualities, and colour was devised as an alternative to the present system which is based mainly on colour. All Australian-grown flue-cured tobacco was included in one or other of 72 grades, 36 of which included all damaged and/or injured leaf. Numerous samples obtained from various districts during the past ten years were used when establishing the grades which thus cover the product of different districts and seasons. Smoking tests conducted in co-operation with the States were continued on a reduced scale.

8. Vegetable Fibres.

(i) *Flax.*—(*a*) *Variety Trials*—The systematic testing of strains of flax introduced from other countries has been continued in the form of a variety trial. Eighteen varieties, principally strains from Ireland, Canada, and Holland, were grown in randomised blocks. In this trial as in the previous two years the varieties yielding the highest deseeded straw were Stormont Cirrus (Irish), Stormont Gossamer (Irish), Liral Monarch (Canadian), Stormont Cirrus (Canadian), Liral 2 (Canadian), and Stormont Gossamer (Canadian). The two strains of Stormont Gossamer had a fibre content exceeding 25 per cent., the two strains of Stormont Cirrus between 22 and 25 per cent., and Liral monarch and Liral 2 between 18 and 22 per cent. Seed of five of these strains was forwarded to the Flax Production Committee to be incorporated in a variety trial in a selected district in Victoria during the 1942-43 season.

(*b*) *Fertilizer Effects.*—A study of the effects of twelve fertilizer combinations was made on the variety Crown Norfolk. The fertilizers used were two levels of superphosphate and one each of potash and nitrogen. Nitrogen quite significantly decreased the straw weight (yield) and the phosphate tended to increase straw weight. Potash had no effect and there was no interaction. The nitrogen produced no significant effect on the seed yield, but the effects of both phosphate and potash were highly significant in increasing seed yield. No interactions between the fertilizers were apparent.

(*c*) *Rate of Sowing.*—In Australia the general practice is to sow a 70 lb. acre without regard to seasonal variations in the weight and germination of the seed. A comparison was made last year between six different rates of sowing. The variety Liral Crown was used and sowing rates from 20 to 120 lb. per acre. The crop yields increased steadily with increasing rates of sowing up to the 120 lb. acre, and the same effect was observed when deseeded straw and seed yields were considered separately. Increasing the seeding rate from 80 to 120 lb. acre resulted in a 25 per cent. increase in crop yield. Within the range of the rates of sowing employed there was no tillering compensation in the sparser sowings.

(*d*) *Morphological Studies at Sydney University.*—Stem samples from all experiment plots were forwarded to the Botany Department of the University of Sydney for morphological examination. The chief factors being studied are stem area, area of fibre, area of fibre

as a percentage of stem, mean size of individual fibres, and number of fibres per stem and degree of lignification. From results prepared by Dr. McLuckie it appears that phosphate increases the steam area, and fibre size, and the number of fibres per stem, and that potash has the reverse effect. It is hoped to publish the results in due course.

(*e*) *Microbiology of Flax Retting.*—A study has been commenced of the fungi which play a part in dew retting. The dominant fungi found in dew-retted flax retted both in the laboratory and the field are *Pullularia pullulans, Rhizopus nigricans, Cladosporium herbarum, Alternaria tenuis,* and *Cephalothecium roseum.* The relation of temperature and pH concentration to growth and flax-retting by pure cultures of these fungi is being studied.

(ii) *Jute.*—Strains of jute seed were obtained from India and Egypt and arrangements were made to have them grown at three different stations in Queensland. In eighteen months the seed of two strains has been increased from a few ounces to 46 lb., and arrangements are in hand to have some of this tested by the New South Wales Department of Agriculture.

(iii) *Urena lobata.*—Following a favorable report by a Sydney Firm of twine manufacturers on fibre obtained from *Urena lobata,* it was arranged with the Department of Agriculture and Stock, Brisbane, to have an acre of this plant sown as a crop. Unfortunately, the germination and ratooning of the crop was unsatisfactory and the crop was inferior to natural stands in the vicinity.

9. Potato Investigations.

(i) *Breeding.*—Breeding work has been commenced with potatoes to obtain virus-resistant strains. Crosses have been made between varieties possessing resistance to various viruses; seedlings have been raised and are being tested.

(ii) *Breaking Dormancy.*—The production of potatoes under certain conditions is often restricted because the "seed" is dormant. Various methods have been devised to break dormancy but they are of little practical value. A cheap commercial method has been discovered; it consists of using aqueous solutions of acetylene which should be of particular value under present conditions when "seed" is short and there is such an urgent demand for potatoes. It will also be extremely valuable in plant breeding work.

(iii) *Virus diseases.*—Formerly it was thought that virus X was carried in all plants and tubers of the standard Australian varieties, but a stock of up-to-date free from virus X has been isolated (1940-41 Report). Attempts to find tubers of other standard Australian varieties of potato free from all viruses including virus X have had some success. There is now a small stock of the Tasmanian Bismarck, part of which is being held by the Tasmanian Department of Agriculture, and this is being multiplied as rapidly as possible, as also are the virus-free up-to-dates (Factors) obtained the previous season.

A sudy of the effects of virus X on yield has been concluded. Even the mildest strains of virus X, which never produce symptoms on infected plants and have no apparent effect on their vigour, cause a 12 per cent. reduction in yield. Mixtures of strains of greater severity cause losses up to 45 per cent. These losses are caused in plants under conditions of heat, dryness, and high light intensity that prevent the development of any obvious symptoms. Under these conditions, the tops of the plants are not reduced in size by infection with the severer strain mixtures. Unlike other virus diseases of potatoes, there is practically no indication of infection with virus X that can be used consistently under Australian conditions as a basis for roguing these diseased plants in the field. Greenhouse or laboratory tests are thus the only means of establishing the health of virus-free stocks.

Spotted wilt has become of increasing importance in the potato crops in some regions, and the most urgent question for the control of this disease is whether the virus is transmitted through the tubers. In the greenhouse a number of tubers from diseased plants gave rise to diseased plants. Under field conditions only one tuber of the same lots of material produced a diseased plant. Sprouts from the majority of infected tubers failed to emerge. Under field conditions, emergence of plants from diseased seed tubers appears to be infrequent, but it might be frequent enough to provide sources of infection in crops where it occurred. Further work is contemplated to test this point.

10. Seed Experiments.

At Canberra experiments were conducted on the production of seeds of carrot, red beet, parsnip, and onion, the main trials being with fertilizer and spacing. The material for these investigations was obtained late in the season, and because of this and the lack of water in the spring, the best failed completely and the yields of the others were very low. In general, with regard to carrot, onion, and parsnip, no differences in fertilizer treatment were obtained although the dressings were very heavy.

Experiments are being conducted to investigate the possibilities of the use of vernalization, photoperiodic effect, and chemical treatment, in assisting seed production methods, in certain annual and biennial species of vegetables. Sprouted lettuce seeds were kept at 4°C. for periods of 28, 42, and 56 days, and subsequently grown in comparison with plants raised from untreated seed. Vernalized material produced seed stalks two to three weeks earlier than control material.

At the Council's Research Station at Griffith an experiment has been laid down to determine the possibility of producing commercially seed of perennial ryegrass, cocksfoot, red clover, and white clover. It has been widely held that commercial seed production of red clover is impossible in Australia owing to the absence of the bumble bee, but it was demonstrated that large seed yields could be obtained at Moss Vale, New South Wales.

11. Maize Diseases.

Under the cold, wet conditions prevailing during the 1941 sowing period at Orbost, Victoria, treatment of commercial maize seed with a fungicidal dust (Agrosan) gave a 38 per cent. increase in plant establishment, and an increase of about 20 per cent. in the yield of dusted as compared with undusted plots. Peas or vetches ploughed in as green manure about two months before sowing maize increased the yield of the resultant crop, but oats did not. The percentage of basally rotted stalks at harvest time was greater in maize following the leguminous green manure crops than in that following oats or without green manure, though the ears on these stalks were seldom reduced in size. There was no evidence that the percentage of rotted ears was decreased by green manuring. For the second time, attempts to grow green manure crops under standing maize by sowing the seed at tasselling time failed to produce satisfactory growth.

Several maize hybrids and top crosses from Lawes (Queensland) were tested at Orbost and Lindenow. Those that appeared capable of outyielding local varieties were later in ripening than is desirable for Victorian conditions. None of ten American inbreds grown at Canberra appeared more resistant to ear rot than Victorian open-pollinated varieties. A South

African hybrid which showed partial resistance to ear rot in 1940-41 was again compared with three Victorian varieties. It appeared less susceptible to ear rot than the Victorian varieties, but the difference was not great enough to make its growth a commercial proposition.

The percentage of barren stalks and those producing "nubbin" ears is an important factor in reducing the yield of commercial maize strains. This percentage was markedly increased in the first generation progeny of certain self-pollinated plants from an inferior strain of commercial maize, but was only slightly increased by selecting seed from nubbin ears produced on open-pollinated plants. A high percentage of "multiple nubbin" ears occurred in irrigated maize prevented from setting a normal amount of seed by withholding water at the time of pollination. These findings support the view previously expressed, that the percentage of barren plants in commercial crops of open-pollinated varieties is influenced much more by environment than by hereditary factors.

Experiments on the effect of shortage of soil moisture on maize at various stages of growth indicated that soil drought at, or after, tasselling reduced the severity of ear rot, but increased that of localized stalk rot. Natural senescence of the stalks was delayed by soil drought, at or after, tasselling, and the highest percentage of prematurely dead basally rotted stalks occurred in plants receiving ample moisture up to the early milk stage, but subjected to soil drought from then till maturity.

12. Other Investigations.

(i) *Diseases of Pine Trees.*—In field experiments on the effect of fertilizers on "needle fusion" and on rate of growth, *Pinus caribea* on infertile sandy soil in south-eastern New South Wales responded equally to broadcast applications of superphosphate or of ground rock phosphate. *P. taeda* responded equally well to superphosphate or to superphosphate plus borax, but there was no response to borax alone. *P. radiata* two or three years old responded markedly to superphosphate, but older trees were not affected. In general, the response to phosphatic fertilizers was not as pronounced as it is reported to be in Queensland plantations; this is possibly a result of the drought conditions which have prevailed in southern New South Wales since the treatments were applied.

(ii) *Disease of Grape Vines.*—A trouble termed "dying vines" in the Murray Valley has been under observation since 1938, when 65 healthy vines were inoculated with a fungus isolated from "dying vines". The symptoms did not appear in the inoculated vines, and it is thought probable that the trouble is of non-parasitic origin.

(iii) *Virus of Lupins in Western Australia.*—During the months of June-November, 1941, a virus disease of the Western Australian blue lupin (*Lupinus varians*) was investigated at the Institute of Agriculture, Crawley, Western Australia. The virus was proved to be that of common pea mosaic. The disease occurs throughout the lupin-growing areas wherever peas are grown in proximity to the lupins, but it appears to be of little economic significance. In the Perth district a common garden shrub, *Cassia corymbosa,* was shown to be a host of the virus enabling it to carry over the summer. To control the disease in the experimental lupin plots at Crawley it was recommended that nearby householders be induced to remove diseased Cassia shrubs and to grow only certain varieties of peas known to be immune to pea mosaic.

(iv) *An infusion beverage from cereals.*—An infusion cereal beverage was devised as a result of trials using various combinations of roasted cereals and cereal products with sugar-cane products. The best results were obtained by mixing six parts of specially roasted wheat with six parts of crystal malt and one part of cane or brown sugar. The mixture was then baked and ground ready for making hot infusions in similar manner to the infusions made from tea and coffee.

III.—ENTOMOLOGICAL INVESTIGATIONS.

1. General.

The process of transferring the activities of the staff of the Division of Economic Entomology to work of immediate importance under war conditions has been continued. Considerable progress has been made in the study of the conditions which lead to insect infestation of wheat, and in devising methods of dealing with these pests. A new problem studied during the past year is the infestation of stored raw wool by moths. Wool has never previously been stored in quantity for such long periods, and the possibility of serious insect infestation is quite definite. The primary object of the present work is to devise means of controlling insect pests of wool should they later become really serious. Numerous requests for assistance in dealing with insect pests have been received from the Army and Air Force. As a result rather extensive investigations concerning certain aspects of the control of mosquitoes, house-flies, blow-flies, and cockroaches have been undertaken, and results have been achieved which will materially help to maintain the health and comfort of our forces. Work is being continued on the problems of sheep blow-fly, cattle tick, plague locust, biological control of insect pests and of weeds, and insect carriers of virus diseases of plants, as all of these are of definite importance to the country's food supplies, and indirectly to the conservation of man-power. It has been necessary, however, to reduce work on such problems to those aspects which are likely to be of importance in the immediate future, in order to free investigators for work of more immediate importance to the war effort. For this reason, also, it has unfortunately been found necessary to terminate our investigations on the red-legged earth-mite problem for the time being.

2. Insect Pests of Stored Wheat.

(i) *Investigations in Western Australia.*—An officer of the Division spent several months in Western Australia studying the local conditions of wheat handling and storage in relation to the development of insect infestation. His most important finding was that the infestations in the big depot-bulkheads became, and remained, localized in the surface layers of the grain. Deep infestations, such as those developing on the floors, seem to die out after a time, presumably because of the high temperatures built up in the grain mass. Detailed observations were made on the heating of the wheat in storage structures; and the conclusion was reached that the temperatures attained would prevent insect infestations penetrating downward into the wheat for more than 3 or 4 feet. The wheat was found to heat less rapidly at Bunbury than at Fremantle and Geraldton; and evidence was obtained that wheat trucked into the southern depots during the winter might take a long time before it started heating to a noticeable extent. The most important insect pest in the early stages of storage was found to be *Calandra oryzae,* which is able to multiply rapidly owing to the moisture content build-up in the surface layers. Later, as wheat temperatures increase, *Rhizopertha dominica* becomes the dominant species. Effective control of the surface infestations in the depot-bulkheads seems likely to depend on the development of a practicable method of removing the affected, or susceptible, surface layers, which is essentially an engineering problem.

(ii) *The Heating of Wheat.*—As the temperatures attained in bulk wheat are of great importance in determining the nature and extent of the insect infestation that is liable to develop, a study of the respiration of wheat and the associated temperature changes has been undertaken in co-operation with the Department of Botany, University of Sydney. The experiments to date have yielded somewhat inconclusive results; but calculations have indicated that even the low respiration rate that could be demonstrated in wheat with a moisture content comparable with that normally held in bulk storage in Australia would result in a substantial temperature build-up over a period of months in large masses of grain, because of its low thermal conductivity. Some indication has been obtained of a difference in behaviour of samples from the 1940 and 1941 harvests.

A further study of the temperature changes resulting from the "turning" of bulk wheat in a concrete silo has been carried out, this time under winter conditions. In contrast with the results obtained in a previous experiment, carried out in summer, a substantial degree of true cooling (as measured by the decrease in mean grain temperature) was recorded. These two experiments indicate that turning bulk wheat to reduce its temperature will only be effective when there is a considerable difference between the atmospheric and grain temperatures.

(iii) *Biology of Wheat-infesting Insects.*—Attention has been concentrated chiefly on determining the upper temperature limits for the breeding of *Rhizopertha dominica*, as this is a point of considerable practical importance in connexion with stored wheat. The experiments, using wheat conditioned to different moisture contents, are not complete; but the results so far obtained indicate that breeding in grain of less than 10 per cent. moisture is unlikely to take place at temperatures of over 100° F.

The movement of *Calandra* and *Rhizopertha* in temperature and humidity gradients has been studied. It was found that both insects tended to move from drier into moister grain, at any rate within the range of the moisture contents employed (i.e. 7 to 15 per cent.). The preferred temperature of *Calandra oryzae* has not been accurately determined, but is below 77°F. (25°C.). The behaviour of *Rhizopertha* is complicated by sex and age differences. The preferred temperature of adults over one week old lies betwen 82.5° and 95°F. (28°-34°C.). In order to determine whether any degree of practical control of an infestation by *Rhizopertha* could be obtained by periodic "screening", cultures of this insect in grain maintained at just below 80°F. and just above 90°F. were subjected to sieving at varying intervals to remove the adults. It was found that at the lower temperature, sieving at fortnightly intervals kept the insects under reasonable control; but at the higher temperature even weekly sieving failed to prevent rapid population increase, indicating that screening by itself was unlikely to be very effective in practice.

(iv) *Stack-Site Sterilization.*—As it was found that the efficacy of mineral oil emulsions, used as contact insecticides, depended on the nature of the surface on which they were applied, a new and more thorough and adaptable method of testing materials was developed. (Previously the toxicity of emulsions under consideration for shed and stack-site sterilization was assessed by a simple dip technique.) It was found that no mineral oil emulsion gave a satisfactory kill on an absorbent surface, such as sand; though certain coarse, unstable emulsions were very effective if used on a surface that could be flooded easily. A proprietary mineral oil emulsion containing an added toxicant, was found to be satisfactory, and has been recommended for general use. It not only gives a high kill in dip tests, but is effective when sprayed on to an absorbent surface at a reasonable concentration and dosage. Creosote emulsions have also been studied. They possess a slow-killing action, due apparently to a "fumigation effect", which tends to counterbalance their rather poor "immediate contact toxicity". So far attempts to increase the "quick kill" of creosote emulsions have failed; but it is felt that this is not a grave disadvantage when, in practice, a whole shed floor or stack-site would be soaked, giving the weevils infesting it very little chance of escaping the effects of the treatment.

Experiments to determine the relative efficacy of various mineral and tar oils used in their normal form (i.e. unemulsified) have been carried out. The materials found most effective were distillate diesel fuel oil, spraying creosote, and middle oil. The toxicity of the diesel oil was greatly augmented by the addition of 2 per cent. of dinitro-o-cyclohexylphenol. Practical trials are required, and are being arranged, to determine the relative cost and ease of application of the proprietary emulsion mentioned above, creosote emulsion, and fuel and tar oils applied "straight".

(v) *Treatment with "Inert" Mineral Dusts.*—The trials mentioned in the previous report, carried out at Toowoomba, Queensland, and near Sydney, have borne out the results of laboratory tests. A very real degree of protection from attacks by the two species of *Calandra* was given by magnesite, even at a concentration of 4 oz. per bushel, over a period of twelve months. (The treated bags in Queensland were invaded by *Rhizopertha*, against which the dusts did not show up so well.) Dolomite gave good protection in the Queensland trial, but not so good in New South Wales. A trial has also been set up in Western Australia, in which the surface of bulk wheat has been treated. The dust used—a diatomaceous earth—was raked into the top 6 inches of the grain. The results have not yet been checked, but it has been observed that large numbers of weevils have worked their way to the surface and died.

(vi) *Fumigation.*—A careful study has been carried out of the penetration through wheat and the kill obtained with carbon bisulphide, and with the recently developed fumigant methylallyl chloride. An exposure period of 72 hours was selected so that the results obtained would be applicable to a special fumigation plant which had been planned for operation in Western Australia. Varying dosages and temperatures were employed, and both *Calandra* spp. and *Rhizopertha* were used in the experiments. Methylallyl chloride was found to be approximately three times as toxic to these insects as carbon bisulphide, and to have comparable penetration at one-third the dosage. The experiments indicated that a dose of 15 lb. per 1,000 cubic feet of carbon bisulphide, or 4.5 lb. of methylallyl chloride, when applied at intervals of 5 feet through the depth of wheat, should give a satisfactory kill in 72 hours in wheat with a temperature of 80° F. or over.

3. Insect Pests of Stored Wool.

(i) *General.*—War conditions have produced problems of the bulk storage of raw wool which are analagous to those of the bulk storage of wheat. Enormous quantities of wool are being stored for periods very much longer than was normal in peace-time, and it is anticipated that the inferior types will remain in store for the duration of the war and perhaps longer. Under these conditions it is not surprising that damage from insect pests of wool has been reported from the wool stores in both Sydney and Brisbane. Although the damage is not serious at the present time, there

is a real threat that it may become so, and the Council was accordingly asked to undertake investigations into large scale methods of control. Two officers of the Division have been transferred to this work, which is being assisted by a grant from the Central Wool Committee. The investigations are being conducted in Brisbane and Canberra, but a preliminary examination of the situation in Sydney has also been made.

The only species involved at present are the two cosmopolitan clothes-moths, *Tineola biselliella* and *Tinea pellionella*. These two species are present in greater or smaller numbers in almost all the wool stores in Brisbane, and in a number of those in Sydney. The larvae attack the baled wool, particularly at points where the pack has been damaged, and, in addition to consuming a certain amount of wool, spoil its appearance by the accumulation of frass, silken tunnels, and cocoons, in the surface layers. There are stacks in Brisbane in which this damage is extensive in all the bales; fortunately only the outer 2 inches have so far been attacked. From the very widespread character of the infestation, it appears probable that a high proportion of bales entering the stores already contained a nucleus of larvae from which in time the present infestation was built up; the source of the original mild infestation has not been determined. As it would be most difficult to prevent such an infestation altogether, attention has been concentrated rather on devising methods for dealing with the present infestation in the stores, and for rendering incoming bales unfavorable media for the further multiplication of any moths they may contain. These two aims would not necessarily be achieved by one and the same process, although obviously a treatment which did confer protection as well as killing the larvae present at the time would be specially suitable.

(ii) *Tests of Possible Control Methods.*—In view of the high cost of dismantling stacks for individual treatment of the bales, and the difficulty of obtaining labour for this purpose, it was decided to consider at first only such methods of control as would have a reasonable chance of success when applied to the stacks as they stand. Three general methods suggest themselves, namely, heat sterilization, treatment with a "solid fumigant" such as naphthalene or paradichlorbenzene, and treatment with a "liquid fumigant", preferably persistent and with contact insecticidal properties. A preliminary examination of the possibilities of these three methods has been made in Brisbane.

In connexion with heat sterilization, engineering advice was obtained to the effect that it would be impossible, at reasonable cost, to secure heat penetration through a stack sufficient to kill all stages of the insect and not damage the wool and further work on this method of control has therefore been abandoned. Of the solid fumigants, naphthalene was regarded as the most promising, both from considerations of cost, and of the fact that it evaporates relatively slowly. Attempts were made to distribute a crude "whizzed" naphthalene in the spaces between the bales of a stack by shovelling from above, and also by the use of a "Messenger" dusting machine from the sides. The shovelling produced numerous small heaps of naphthalene on all irregular projections within the stack, such as corners of bales, lines of contact between bales, and scantling boards, and these heaps were little reduced in size or number after a period of three months. Both the shovelling, and, more particularly, the blower, also produced a fine coating of crystals on all faces of the bales, but these evaporated relatively quickly. Samples of surface wool were taken from the bales three months after the treatment, and are now being tested for toxicity against moth larvae confined on them.

The most hopeful method at present appears to be spraying the stacks with a slow liquid fumigant. Certain materials such as creosote which would probably be very effective from the insecticidal point of view, have to be discarded because they stain the wool. A wide range of possible alternatives is being tested on the small scale; from these it is hoped to select a few for further testing against infested stacks. A proprietary spray has been tested against individual bales by the Queensland State Wool Committee, and has given a very satisfactory kill. It also appears to have conferred protection on a treated bale for a period of about five months, but further tests on this point are being made.

(iii) *Studies of the Moths.*—Observations on the habits of the two species of moth have been made in the Brisbane stores, and a trapping technique has been developed for following fluctuations in their numbers. It has been found that the female moths very rarely fly. They lay their eggs on wool protruding through bursts or wool-hook holes, and are probably also able to penetrate the pack with the ovipositor and lay on the wool beneath. The larva of the *Tineola* ultimately tunnels perpendicularly into the wool mass to a depth of ½ inch; that of *Tinea* is not normally found under the pack, being confined to the loose wool of "bursts". Pupation of *Tineola* may take place underneath the pack, or the larva may bore through the pack and pupate on its surface. Where the pack is separated from the wool surface by folds consequent on the "dumping" process, adult moths may emerge frm the pupa underneath the pack, and are probably then capable of mating and laying their eggs without leaving the bale.

Flight in both species is largely confined to a period from half an hour to two and a half hours after sunset. At this time large numbers of males may be caught on tanglefoot traps. The number caught is closely related to the temperature prevailing during the flight period, i.e., from about 6 to 8 p.m., but is also influenced by other unknown factors. It is hoped that further work may enable allowance to be made for variations in such factors, so that the number of moths caught on traps can be used as a measure of the effect of alternative stack treatments in reducing the moth population of a stack.

Experiments will shortly be started to determine the optimal conditions of temperature and humidity for multiplication of both species. Studies have been made of the microclimate of the Brisbane wool stores, and the results have been compared with conclusions already published as to the conditions favorable to clothes moths. It appears that the wool stores are highly favorable to multiplication of these insects. On the other hand, stores in inland localities would certainly be much less favorable, and, if suitably constructed with this end in view, could probably be made quite unsuitable for the breeding of moths.

4. Insect Control of Noxious Weeds.

As mentioned in the previous report, all overseas investigations of possible insect enemies of noxious weeds have been terminated. Work during the past twelve months has therefore been concerned with those insects which have already been introduced.

(i) *St. John's Wort (Hypericum perforatum).*—Entomological work on the control of this weed has been confined to the distribution of the leaf-eating beetle, *Chrysolina hyperici,* to new St. John's wort areas, particularly in New Suth Wales and to examinations of other areas where the insect has been liberated during the past two or three years. Surveys during the past twelve months showed that the area occupied by *Chrysolina* in the vicinity of Bright had increased considerably due to the natural spread of the

insect, and that colonies established at Myrtleford, Harrietville, and Tawonga were all showing satisfactory signs of progress. Perhaps the most outstanding progress has been observed in the Dargo district, where approximately 20,000 adults of *C. hyperici* were liberated in three localities during 1940. The insects were found to be established in all three localities, and in one the numbers had increased in such a satisfactory way that host plants at the point of liberation were already showing signs of considerable attack and defoliation. A further 50,000 adults of *Chrysolina* were liberated at three new points in the same district. If the present rate of progress is maintained, there is reason to believe that supplies of *C. hyperici* will be available within the next two or three years for distribution elsewhere from certain of the Dargo establishment sites. Distribution of *C. hyperici in* St. John's wort areas in New South Wales was continued during the year. In August, 1941, examinations were made of *Hypericum*-infested areas in the vicinity of Orange, Sodwalls, and at Nulla Mountain, near Rylstone. This work was carried out in co-operation with officers of the State Department of Agriculture concerned with weeds control. Early in December approximately 40,000 adults of *C. hyperici* were liberated in the localities mentioned. At two of four localities near Tumbarumba, in which *C. hyperici* had been liberated earlier, the insects showed signs of establishing themselves. In the Mudgee district the beetles were found to have survived and completed a generation under field conditions in one of two localities in which they had been liberated in the previous year.

At Baker's Gully, Bright, where liberations of the root-boring beetle, *Agrilus hyperici,* had been made during the previous two years, only odd individuals of *Agrilus* were recovered, these being from *Hypericum* roots taken from the experimental area where paired adults had been isolated on sleeved plants during 1940. No recoveries of *Agrilus* were made from any of the liberation sites in the Mudgee district, New South Wales. A further examinations of the various sites is to be made in the near future. No further liberations of *Chrysolina gemellata* have been made, but efforts are being made to increase the numbers in the insectaries, in order that a trial liberation may be made in the Mudgee district, possibly during the coming spring.

(ii) *Lantana (Lantana camara).*—The general position concerning *Teleonemia scrupulosa* is much the same as that reported last year. Small colonies of the bugs have been maintained in the insectaries at Canberra, but no further distribution from this source has been made. Although the position in Northern Queensland appears to be very satisfactory and to be improving as time goes on, there is as yet no sign that liberations in South Queensland and Northern New South Wales can result in the establishment of the insect in numbers sufficient to exercise any control over the weed.

5. Sheep Blowfly.

Progress has been made during the year in the deevlopment of a satisfactory and inexpensive dressing, in the study of repellents, and in an investigation of the population density and breeding habits of *Lucilia cuprina.*

(i) *Dressings.*—The boric acid—tar oil—bentonite dressing, "B.T.B.15" (described in last year's report), is now marketed by a number of firms at a price substantially below that of most commercial dressings. it has been used extensively in the field with excellent results. Owing to war-time needs, the tar oil fraction originally recommended is not now available. A mixture of equal parts of kerosene and certain creosotes or middle oils was found to be a highly satisfactory substitute. However, the contact toxicity of this dressing, and of several other otherwise satisfactory dressings, is not high. Investigations at present in progress show that with further modification a stable and rapidly penetrating dressing can be produced which has excellent contact toxicity. Samples of unprocessed Australian bentonites were not as satisfactory in the B.T.B. dressings as the processed American bentonites.

(ii) *Repellents.*—The work on repellents has been continued, using the sheep method described in previous reports. The repellency of 10 per cent. Ceylon citronella in paraffin was confirmed, while Java citronella was ineffective at this concentration. To obtain information on the active principle or principles in Ceylon oil, four fractions were tested. Three had no effect, but the fourth, consisting largely of geraniol and citronella in the proportions 7:3, was as effective as the whole oil. This repellent fraction forms about one-third of the whole citronella oil, but surprisingly is no more repellent than citronella itself. Thus it seems probable that the other fractions, ineffective by themselves, enhance the repellency of the repellent fraction.

Seven out of a further seventeen substances exerted some repellent effect: of these Huon pine oil (95 per cent. methyl eugenol) and Zieria oil were most effective. Pure oleic acid, which was found to be effective against the English sheep blow-fly, *Lucilia sericata,* proved to be repellent, while commercial oleic acid was not. Five eucalyptus oils have been tested. Three exerted no repellent effect and two proved attractive under the conditions of test. Ten per cent. camphor oil and Tagetes oil from both Australian and South African sources were not repellent.

(iii) *Carrion Studies.*—Further detailed informamation has been obtained on the relative importance of live sheep and carrion as breeding grounds for *L. cuprina.* Only seven out of a total of 25 sheep carcasses exposed at regular intervals to blowfly attack produced *L. cuprina,* these seven carcasses producing an average of 46 *L. cuprina* per carcass.

In a further series of ten carcasses, the effect of predators and parasites was virtually eliminated (this gives the maximum number of *L. cuprina* which can breed in a carcass under field conditions). Nine carcasses produced *L. cuprina,* giving an all-over average of 335 *L. cuprina* per carcass. Many thousands of other flies were produced in both series of exposures, the species composition varying with the season. A small strike can produce 400 or more *L. cuprina* and a large one 4,000. Thus a carcass in the Canberra district is never likely to produce more *cuprina* than a single small strike, and there are many more strikes than carcasses in any normal season. It appears then that the *cuprina* population in Canberra is largely dependent upon the living sheep as a breeding ground. Trapping in relatively sheep-free areas on the coast adjacent to Canberra indicates that the population of *L. cuprina* is probably one-fifteenth to one-twentieth as great as would be expected if sheep were present.

(iv) *Population Density of L. cuprina.*—The density of the natural population of adult *L. cuprina* was estimated in an area of 50 square miles on four occasions during the 1941-42 blowfly season. The area chosen was typical of the open grazing country in the Canberra district. On each occasion a known number of *L. cuprina* were stained by spraying with alcoholic solutions of dyes and liberated at the centre of a 4-mile circle containing 102 equally spaced Western Australian blowfly traps. From the ratio of stained to unstained flies recovered in the traps during the period that most of the stained flies remained within the circle, it was possible to calculate the natural population density. Densities ranging from 0.4 to 2.5 adult *L. cuprina* per acre were found at different times of

the year. Significant differences were established between populations of different areas within the 4-mile circle. The distribution of marked flies from the centre to the periphery of the circle was found to agree fairly closely with the theoretical distribution calculated on the assumption that the flies spread by random movements in all directions from the point of liberation. In each experiment the first flies reached the perimeter of the 4-mile circle in the first day, and on some days the distance flown by some flies was probably considerably more than 4 miles. With freshly baited traps spaced at ¾-mile intervals (each trap serving about 300 acres), between 1 and 4 per cent. of the *L. cuprina* population was trapped per day. In other words, with present traps, the possibility of effectively reducing the population of *L. cuprina,* except with an extremely high concentration of traps, appears to be remote.

6. Medical Entomology.

(i) *Fly and Mosquito Sprays.*—To enable the efficiency of fly sprays and mosquito sprays to be determined, a biological test against living insects is necessary. A standard Peet-Grady chamber was constructed for this purpose and has been used in testing sprays for army use. Various species of mosquitoes have been found to be far more susceptible to pyrethrum sprays than the standard test insect which is the house-fly, *Musca domestica.* The results of the tests have been used as a basis for army fly spray and mosquito spray specifications. Some progress has been made in the development of pyrethrum sprays in which water is the diluent instead of kerosene. A satisfactory spray of this kind could be transported in a concentrated form so overcoming the difficulty of transporting large amounts of dilute fly spray to inaccessible places.

(ii) *Contact Insecticide for Maggots.*—Following a request from the Army authorities for a spray for use against maggots of the house-fly and blow-flies, ten oils, undiluted and emulsified in water, and five arsenical solutions were tested. Several coal tar fractions proved effective, and of these, middle oil (boiling point range 200–260° C.), which was at the same time cheap and highly efficient, was best suited to the purpose for which the spray was required. It is very satisfactory that a by-product of one of our own industries has proved so effective against maggots which are notoriously difficult to kill.

(iii) *Mosquitoes.*—Experiments are in progress designed to obtain information on the cold tolerance of *Aedes aegypti,* the dengue fever mosquito. Cold tolerance data are necessary to define the southern limits of winter survival of this important disease carrier, and this information would be necessary in the launching of a control campaign. Co-operation is proceeding with the Army entomologists on the development of effective methods of applying Paris green for the control of Anopheline mosquitoes which transmit malaria. Oils for use on the surface of mosquito infested water are also included in the scope of these investigations.

(iv) *Fleas.*—Flea control measures were investigated as part of a policy of testing the usefulness of measures recommended at present for the control of insect pests affecting troops under war-time conditions. The cat flea, *Ctenocephalis felis,* was used. Powdered naphthalene or pyrethrum, sprinkled at the rate of 1 oz. per 5 square yards, killed larvae and adults, and fly spray was also found to be effective against adult fleas.

7. Cattle Tick.

Work on the biology of the non-parasitic stages of the cattle tick, *Boophilus australis,* and on the effect of arsenical dipping fluids on the tick, have been continued. In addition, some preliminary observations have been made on the parasitic stages. The effect of temperature and humidity on the duration of the non-parasitic stages, and on the mortality in each stage, has been studied for a wide range of both factors. Thus, for example, the lowest temperature at which hatching of the eggs will take place has been found to be 16.5° C., although some development occurs below this. According to the conditions of temperature and humidity prevailing, the non-parasitic period of the life-cycle may last anything from 18 to 359 days. Under natural conditions on a beast, the parasitic period was found to be divided among the three parasitic stages as follows:—Larva, 5–10 days; nymph, 7–11 days; adult 6–14 days. The whole life-cycle may therefore require anything from 36 to 394 days.

Good evidence has been produced that certain ticks have a high degree of resistance to arsenical dips, in the sense that they will survive treatments that have hitherto been considered to give a complete kill; moreover, this resistance does not depend entirely upon the ticks being in the moult when the dip is applied. Further attention is therefore being given to the extent to which arsenic penetrates the tick's integument in the "resistant" and "non-resistant" ticks, and to the selection of the most suitable substance for use as a wetting adjuvant in the dip. Promising results have been obtained in tests made with dips containing sulphuric acid as well as sodium arsenite. It was found that 0.4 per cent. H_2SO_4 did not harm the beast under the conditions of the test.

8. Sheep Louse.

Preliminary investigations of the sheep louse (*Bovicola ovis*) have been conducted at the School of Veterinary Science, Brisbane, in association with the work on the cattle tick. The insect has been successfully reared in the laboratory (i.e. off the sheep). It appears to subsist for the most part on the waxy material adhering to the wool fibres. At 38° C., which was found to be a favorable temperature for rearing, the life-cycle was completed in 40–55 days. Three developmental instars were recorded.

9. Australian Plague Locust (*Chortoicetes terminifera*).

(i) *General.*—Several aspects of the locust problem which have been studied during the past few years were dropped during 1941-42 in favour of new projects of a more immediately practical nature. Study of the data furnished by the New South Wales and Queensland Locust Information Services has been deferred, and the issuing of monthly forecasts of locust development has been discontinued. On the other hand, tests have been started of methods for changing the vegetation and soil characteristics of the outbreak centres in such a way that they will cease to function as foci of swarm production. A start has also been made in investigating the possibility of using poison bait as a means of preventing multiplication in the outbreak centres to the point where swarm-formation occurs.

(ii) *The Locust Position during* 1941-42—At the end of the 1940-41 season the fear was expressed that the adult locusts then present in certain outbreak areas would be capable of giving rise to incipient swarms in the following spring. This actually happened on a small scale in the eastern part of the Warren-Dandaloo outbreak area and the western part of the Warrumbungles outbreak area, but the spring proved so dry that a further development of the swarming cycle was arrested. With the exception of a few in the western Coonabarabran Pastoral Protection district, New South Wales was again free from swarms.

(iii) *Laboratory Work.*—Experiments on the effect of various constant temperatures and relative humidities on the rate of development, fecundity, and

mortality of *Chortoicetes* were continued during the early part of the year. Newly hatched hoppers maintained at 60° F. failed to moult into the second instar, although they were observed to take a small amount of food; all died within six weeks. At 70° F. development was very slow, but a small proportion of hoppers succeeded in reaching the adult stage; they did not live long thereafter, and did not reproduce. In some cases the nymphal period at this temperature lasted for almost six months. These results should be considered in relation to those reported last year for higher temperatures.

(iv) *Survey Work in the Warren-Dandaloo Outbreak Area.*—Surveys have been made of the distribution of the more important soil types and vegetation associations along two diagonal transects of this outbreak area, with special reference to the relation of soil and vegetation to minor variations in relief, which are very important in this level country. Profiles have been studied at sites typical of eight of the main soil types, and periodical appraisals of the vegetation of these sites will be made. This work forms part of a study of the distribution of the outbreak centres in relation to soil and vegetation.

(v) *The Outbreak-Centre Environment.*—The observations of 1940-41 on the associated population, vegetation, and weather changes on observation zones on Bundemar Station, Trangie, were continued during the first half of 1941-42. These observation zones include several outbreak centres. The vegetation data obtained have been expressed in the form of three vegetation "factors", namely, the percentage of bare ground, the weight of green plant material, and a compound height factor representing the "shelter" status of vegetation. The relationship between the level of these factors and the tendency for the locust population to increase or decrease has been analysed statistically. The results point to the existence of an optimal combination which is most frequently realized in one or other part of an outbreak centre, and which is now being investigated further. Owing to the possibility of migration taking place into, or out of, an observation zone, according to its favourability in relation to the surrounding country, it has been necessary to extend the scope of the original observations to include estimates of the population in surrounding areas within migration range of each observation zone.

Climatic observations made concurrently with the population and vegetation estimations are in general agreement with the conclusions detailed in previous reports, and recently published as *Bulletin* 146. Observations on the water and air content of various soil types occurring in the observation zones suggest that only very extreme values of these factors, maintained for relatively long periods, completely prevent the hatching of eggs.

(vi) *Methods of Control in the Outbreak Centres.*—Work such as that which has been described in the previous section, has suggested ways in which the vegetational characteristics of an outbreak centre might be modified so that it would no longer be able to function as a nucleus of swarm-formation. Two types of modification appear practicable, and these are now being tested for their effectiveness. The first involves the ploughing of oviposition sites and the revegetating of their bare areas, thereby removing the two essential features of an oviposition site, which are a compact soil and bare ground. The second involves the planting of a barrier of suitable shade trees between the oviposition sites and the concentration zones; this should prevent locusts from moving freely between the one habitat and the other according to their stage of development. These are long-term experiments from which results cannot be expected for several years. If successful, they will provide a means for rendering outbreak centres unfavourable for swarm-production, and thus a means for preventing outbreaks. The treatments are of such a nature that they will improve grazing land by reducing erosion and the proportion of bare ground, and by providing belts of shade for stock.

Another method for preventing swarm-formation in the outbreak centres is being tested; it consists in baiting the non-swarming population with the standard bran bait used in campaigns against swarms, with a view to preventing an increase in population to the point where there is a risk of swarms being formed. Various dosages of bait have been tested against various population densities. A kill of at least 30–40 per cent. has been obtained, but there are indications that this is a considerable under-estimate. Methods are being investigated for prolonging the period of attractiveness of poison baits by the addition of a deliquescent constituent. Success in this direction will be particularly important in the control of non-swarming populations, since in this case there is no risk of the insects suddenly leaving the area altogether, while on the other hand their scattered distribution renders it desirable that as much time as possible should be available for them to find and consume the bait.

10. Red-legged Earth Mite (*Halotydeus destructor*).

(i) *Effect of Earth Mite on Pastures.*—The experiment started in 1939 at Katanning, Western Australia, to measure the effect of earth mite attack on the yield of subterranean clover (*Trifolium subterraneum*) and associated pasture plants was continued. After three years of mite attack, reduction of subterranean clover yields were obtained varying from about a half to two-thirds, according as the mite population was the natural one or an artificial one deliberately maintained at a high level. Apart from showing these direct effects of the mite on subterranean clover, an important feature of the season's results was the demonstration that the small direct effects of mite attack on other plant species in the pasture were greatly over-shadowed by the secondary effects of their association with subterranean clover. At the establishment of the plots, Wimmera rye-grass was sown at an even rate throughout, whereas on some of the treatments no subterranean clover was sown. At the end of the third season the rye-grass yield from plots where no subterranean clover had been sown was very light and not significantly affected by mite attack. On the plots where subterranean clover had been sown the Wimmera rye-grass yield was in direct proportion to the subterranean clover yield, and where this had been reduced by the mite the growth of the rye-grass was correspondingly reduced, presumably because of a dependence of the grass on the increase in soil fertility brought about by the subterranean clover.

Hop clover (*Trifolium procumbens*), and important volunteer plant on the plots, showed pronounced negative correlation with the subterranean clover. Direct effect of the mite on hop clover in the absence of subterranean clover was small. On plots where freedom from mites permitted good growth of subterranean clover, hop clover was greatly reduced, but where mite attack depressed the subterranean clover there was a corresponding increase in the growth of hop clover. Doubtless this effect was due to weakness of the hop clover in competition with subterranean clover and Wimmera rye-grass.

The results quoted give some indication of the complexity of the effects produced by the mite on the experimental subterranean clover pasture. To the important direct loss of subterranean clover foliage, burrs,

and seeds, was added a secondary loss of grass and other less important plants, the growth of which is favoured by the improvement in soil fertility brought about by the subterranean clover. Quantitatively this loss was partly, though by no means wholly, counterbalanced by an increase in the volunteer legume hop clover. Although the results obtained permit the formulation of some idea of the economic importance of the mite, there is a need for further work taking into consideration the effect of introducing controlled grazing into the experiment.

(ii) *Tests of Insecticides.*—Testing of dusts, sprays, and poisons to control the mite in closely mown pastures was continued. Dust from Western Australian-grown tobacco leaf mixed with slake lime produced kills varying in different experiments from poor to fairly good. Owing to its low nicotine content, the dust made from this leaf is unsuitable as an insecticide without the incorporation of other active constituents. The outstanding results earlier reported for a dinitro-o-cyclohexylphenol dust were not confirmed, possibly owing to different seasonal conditions. The most satisfactory dusts tested were proprietary nicotine and nicotine-creosote mixtures. Under the conditions of the experiments the most promising sprays tested were lauryl thiocyanate and a white oil nicotine sulphate emulsion.

As in the previous year the most satisfactory method of applying insecticides proved to be the distribution of chaff moistened with a sweetened poison solution which is readily sucked up by the mites. Sodium arsenate was more effective in these baits than sodium arsenite, sodium fluoride, sodium fluosilicate, and tartar emetic. Cane sugar was found to be the most suitable sweetening agent, and oaten or wheaten chaff was found to be better as a carrier than sawdust.

An experiment to determine the most suitable time of application of insecticides to pastures showed that only treatment very early in the season was effective in protecting the pasture. Heaviest yields of foliage and seed of subterranean clover were obtained on plots kept free of mites for the entire year. Next in the yield figures were the plots treated in May, the first month after the appearance of the mites, whilst plots treated in each succeeding month were consistently low in yield, showing that the critical attack occurred at the beginning of the season. An interesting point emerging from this experiment was that the subterranean clover was able to compete quite strongly with the capeweed (*Cryptostemma calendulaceum*) in the absence of the mite, but, whereas under mite attack the capeweed was not measurably affected, the clover was greatly reduced. Had this not been a carefully controlled experiment it is practically certain that the tendency would have been to place undue emphasis on competition with the capeweed as a reason for the disappearance of the subterranean clover.

11. Oriental Peach Moth (*Cydia molesta*).

In the Goulburn Valley, infestation of the mid-season peaches was negligible and very light in the late Pullars Cling (5 per cent.). In December, 1941, a survey was made by an officer of the Victorian Department of Agriculture to determine whether the parasite *Macrocentrus ancylivorus* had become established and whether it was spreading naturally in the peach-growing district. No further parasites were introduced from the United States of America, as it was considered that the number already introduced and liberated was more than ample to ensure their establishment if conditions in this country were favourable. As in the previous season, the results of the survey are most disappointing for no evidence of the presence of parasites was obtained, and unless small numbers are breeding in some orchards apart from those points where colonies have been released and collections made, it must be concluded that the parasite has failed to establish itself.

12. Biological Control of Insect Pests.

(i) *Cabbage Butterfly* (*Pieris rapae*).—In the previous report mention was made of the introduction into Victoria of the cabbage butterfly and its subsequent spread throughout south-eastern Australia. In the past twelve months the area of infestation has undoubtedly extended, but the exact limits of the area are not known with any great degree of accuracy, since no opportunities have presented themselves for making any detailed surveys.

Two parasites have recently been introduced by the Division from overseas. These are Braconid wasps, *Apanteles rubecula* and *A. glomeratus*. Studies on the life histories and habits of *A. rubecula*, which was introduced from England, have shown that, under certain conditions, up to 39 per cent. parasitism may occur as a result of the activity of this species. Normally, only one parasite develops in each host. From a small consignment sent from England towards the latter end of last year, enough parasites were obtained to breed an Australian generation. More than 100 cocoons of this species which are in diapause are on hand, and from these it is hoped to continue breeding work in the spring.

The second parasite to be introduced, *Apanteles glomeratus*, was forwarded from the Dominion Parasite Laboratory, at Belleville, Canada. This species which is a multiple parasite, has already been introduced into New Zealand, where its establishment has resulted in some additional measure of control over *Pieris*. From the introduced material an Australian generation has been bred, and a small surplus of 100 parasites has already been liberated in the city area of Canberra.

(ii) *Underground Grass Grub* (*Oncopera spp.*).—Two further trial consignments of *Alomya debellator* were introduced during the year, one of which proved to be the most promising consignment of this parasite yet to be received. It was the first occasion on which any of the parasites reached their destination alive.

(iii) *Green Vegetable Bug* (*Nezara viridula*).—One small trial consignment of the Tachinid parasite, *Trichopoda pennipes*, introduced for use against the Green Vegetable Bug, *Nezara viridula*, was received from the Dominion Parasite Laboratory, Belleville, Canada. The material was shipped as all adult hosts carrying eggs of *Trichopoda*. All host material was dead on arrival, and there was no indication that any development of the parasite had taken place.

13. Insect Vectors of Plant Virus Diseases.

(i) *Tobacco Yellow Dwarf.*—A study of the life-history, habits, distribution, and host preferences of a brown jassid, *Thamnotettix argentata* Evans, a known vector of tobacco yellow dwarf, has been completed and was published in the Council's *Journal* (Vol. 15 pp. 175-184, 1942).

(ii) *Potato Virus Diseases.*—In 1941 a detailed survey was begun on the abundance of the green peach aphis, *Myzus persicae* Sulz., and the potato aphis, *Macrosiphum gei* Koch, which are responsible for the transmission of leaf-roll and mosaic viruses of potato. The survey was made at Black Mountain and Dickson, Australian Capital Territory, and in Tasmania, where officers of the Tasmanian Department of Agriculture surveyed the aphis population at Penguin, Yolla, Tewkesbury, and Hobart, and forwarded the records to Canberra.

In Canberra the green peach aphis hatched from eggs on peach trees in early spring and produced winged individuals which invaded the experimental plots about the end of October. Wingless individuals continued to breed on the potatoes, and the population built up to a peak late in November, decreased, and disappeared for two months in January and February when hot, dry climate conditions prevailed. Later, an autumn generation appeared on potatoes, and in April produced winged individuals which migrate back to the peach. Here overwintering eggs were laid later.

Throughout the winter the potato aphis bred on a number of hosts, chief of which was sow-thistle, *Sonchus oleraceus*. Like the peach aphis, it produced winged individuals which invaded the plots about the same time in the spring, rose to a peak of population early in November, and then disappeared from potatoes for the rest of the season. It continued to breed slowly on other hosts during summer and then increased to a high peak of population on these in the late autumn. In Tasmania very few aphids were present on potatoes in the northern districts, whereas at Hobart the population was much greater and rose to a very high peak in January. About this time large numbers of a predaceous lady-bird, *Coccinella, transversalis* Fabr., reduced the population to a very low level. The time of invasion of potato fields by aphis and the date on which the population attains its spring peak are both important, as the time and rate of infection by virus diseases is affected by these two factors. A thorough knowledge of these may enable planting dates for the production of virus-free seed to be selected so that the potatoes will miss the peak of aphis population and avoid serious infection from outside sources.

14. Potato Moth (*Phthorimaea operculella*).

The potato moth, which is an important pest of potato crops in all potato-growing districts on the mainland, was particularly serious in Canberra during 1941-42. Late in the season it greatly interfered with the aphis survey by its almost complete destruction of leaves and stems of plants in the experimental plots. Mother tubers of virus-free stock, which were being multiplied for seed, were seriously infected in the field, and were threatened with further attack in storage. The latter would have been particularly serious, in view of the probability that fumigation would interfere with the later, dormancy-breaking treatment of the stock.

The New South Wales Department of Agriculture had shown that dusting stored tubers with derris would control the pest, but, when supplies of this insecticide became unprocurable, it was necessary to look for a suitable, cheap, and readily available substitute. Certain "inert" mineral dusts were accordingly tested, and of these finely ground magnesite gave the most promising results in small scale laboratory trials. With a view to checking the results under conditions of higher humidity than obtains at Canberra, a trial of selected dusts, using full-sized (3-bushel) bags has been set up in Sydney with the co-operation of the New South Wales Department of Agriculture. The acetylene treatment for breaking dormancy in tubers has been found to have no ovicidal action, but is fatal to most of the larvæ. Re-infection readily takes place.

15. Systematic and General Entomology.

(i) *Insect Identification.*—Throughout the year numbers of insects have been identified for individual workers and institutions both in Australia and overseas. Information and assistance with taxonomic problems has been supplied in response to numerous requests.

(ii) *Additions to Collection.*—The Divisional Collection has been increased during the past twelve months by the addition of about 200 specimens. Many of these were insects of economic importance and were obtained from the Queensland Department of Agriculture and the Waite Institute, Adelaide. Others were donated by Mr. G. F. Hill and other members of the staff.

IV. ANIMAL HEALTH AND NUTRITION INVESTIGATIONS.

1. General.

Progress has been maintained in most branches of the work of the Division of Animal Health and Nutrition. The general programme of the work has been modified to meet war-time needs, and some attention has been given to the early application of knowledge gained. Shortage of man-power in the animal industry has called for the application of special methods in the control of animal diseases and in animal management. Attention has been given to these requirements.

The work has been carried out, as in the past, at the three main centres in Sydney, Melbourne, and Adelaide, as well as at field stations at Cunnamulla (Q.), Badgery's Creek (N.S.W.), and at Werribee (V.) Co-operative work with the State Departments of Agriculture has continued. Co-operation with the Division of Economic Entomology and with the Division of Plant Industry has been maintained as heretofore through the Veterinary Entomological Committee and the Inter-divisional Committee for Agrostology, respectively. The secretarial work for the Committee on Animal Production was carried out as previously. At the Laboratory at Parkville, some officers of the Division of Industrial Chemistry and of the Division of Food Preservation have been housed and given facilities.

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

2. Animal Health Research Laboratory, Melbourne.

(i) *Pleuro-pneumonia of Cattle.*—The experiment referred to in the last report has shown that immunity against experimental pulmonary infection persists for at least three years. A new series of experiments was commenced and is designed to determine (*a*) if satisfactory immunity will persist when vaccinated animals are maintained on a low plane of nutrition, and (*b*) if under these conditions repeated yearly vaccination is advantageous. Work has continued on the preparation and standardization of a prophylactic vaccine. During the year 391,000 doses of vaccine were issued for use in the cattle country.

(ii) *Entero-toxaemia of Sheep.*—Considerable progress on the mode of toxin production of the causal organism in cultures has been made. Further work has justified the hopes expressed in the last report, and a considerable improvement in the antigenic value of vaccines for preventing the disease may now be expected.

(iii) *Caseous Lymphadenitis of Sheep.*—Work was continued on the evolution of a prophylactic vaccine. Physically disrupted bacilli were found to stimulate immune body production in experimental animals. A field trial of a vaccine prepared in this way was started. Several field trials run concurrently are desirable, but under war-time conditions the shortage of man-power has prevented extension of the work.

(iv) *Bovine Haematuria.*—Evidence continues to accumulate that top-dressing of pastures with gypsum delays the onset of haematuria appreciably, although complete control has not been obtained. Previous

observations had suggested the possibility of molybdenum playing a causal role in the production of the disease. Daily administration of small amounts of a salt of molybdenum during 2½ years has not produced signs of the disease in experimental cattle.

(v) *Myxomatosis.*—Studies on the virus were continued and a plan for a field trial was developed. This plan is based on the fact that in some areas the density of the rabbit population is reduced to vanishing point from time to time by drought. If, as the population density builds up subsequently, it could be reduced to vanishing point again by the spread of the virus disease, the density could be kept below the point at which damage to vegetation occurs. A suitable area for a field trial was chosen, but seasonal conditions remained unfavourable to the rabbits. The trial will be started when suitable conditions occur.

(vi) *Mastitis in Dairy Cattle.*—Systematic studies have been continued on the experimental herd and on one commercial herd. Laboratory studies were continued on several bacteriostatic substances which were thought to have possible value in the prophylaxis of mastitis, and a start was made on their use under field conditions.

(vii) *Toxaemic Jaundice of Sheep.*—The co-operative investigation of the disease was continued. Observations on the experimental flock at Barooga were continued, but an outbreak of the disease did not occur. Field observations were restricted, as natural outbreaks of the disease were very limited. Laboratory studies on copper metabolism were continued and progress was made.

(viii) *Peg-leg of Cattle.*—The new experiment mentioned in the last report was started. In this, the influence of trace elements (copper, zinc, nickel, cobalt, and manganese) added to the phosphatic salt lick is being investigated. The experiment is designed to last for three years.

3. The McMaster Animal Health Laboratory.

(i) *Parasitological Investigations.*—(*a*) *Studies on the Administration of Phenothiazine.*—Phenothiazine powders now on the market mixed in the proportion of 1 lb. of powder to 16 fluid ounces of water make a thick suspension which can be administered with a drenching syringe provided the piston is washed periodically and oiled frequently. Suspensions in a light mineral oil can be administered from automatic drenching guns provided care is taken, but clogging and sticking of valves lead to many breakdowns.

(*b*) *Dose Rate of Phenothiazine.*—Experiments showed that the previously recommended dose rate of 25 grammes for adult sheep could be reduced to 20 grammes in treatment against the nodule worm, but the original dose rate is required in treatment against the black scour worm.

(*c*) *Efficiency of and Economy in the Use of Anthelmintics.*—During the year much attention was given to the study of the efficiency of several anthelmintics which could be used to replace those in short supply, and also to the most economical use of these anthelmintics in short supply but which are essential for specific purposes. Carbon tetrachloride has been used widely as a general anthelmintic, but at present the small supply available must be reserved for the treatment against liver fluke. Mixtures of copper sulphate and sodium arsenite or arsenic pentoxide have been found to be efficient against the large stomach worm, and they can save the use of nicotine sulphate or carbon tetrachloride. Tetrachlorethylene, given after a preliminary dose of copper sulphate solution, has been found to be most efficient against the black scour worm.

(*d*) *Parasitological Studies at Armidale.*—Epidemiological studies have been continued on haemonchosis, trichostrongylosis, and oesophagostomiasis. Studies on the seasonal fluctuations in the number of larvae of the large lungworm (*Dictyocaulus filaria*) showed that infestations were acquired from the late autumn through the winter into early spring. Later in the spring with improvement in the pasture most of the sheep threw off their infestations completely. Another trial of the effect of rotational grazing in the control of bowel parasites was started. A trial to determine the value of supplementary feeding and drenching at selected intervals in the control of diseases due to worm parasites was concluded. It was demonstrated that drenching at "epidemiological" intervals was as effective as regular monthly treatments, and that the supplementary ration fed to the sheep was uneconomical and had no measurable influence on the control of worm infestation. Further studies on the value of phenothiazine in the control of nodule worm infestations were conducted.

(ii) *External Parasites of Sheep.*—(*a*) *Psorergates ovis.*—Studies were continued on the infestation of the skin of sheep by *Psorergates ovis.* The parasite has been found to occur occasionally and mainly in the cooler areas of southern Australia. Under experimental conditions it was found that transmission of the parasite from sheep to sheep is fairly rapid when infested and clean sheep are kept in close contact after shearing. The parasiticidal value of several common dipping agents was tested. Of these, calcium polysulphide in a concentration as low as 0.4 per cent. polysulphide killed all the mites. A field trial was carried out with the use of a dip containing about 1 per cent. of sulphide sulphur. The results obtained were good, but in three heavily infested sheep the wetting about the back of the head was poor and live mites were recovered from this area.

(*b*) *Chorioptic Mange in Sheep.*—Cases of foot mange were seen during the year. Lesions were found on the feet and on the scrotum of rams at the Laboratory. Previous record of this parasite in Australia does not appear to have been made.

(iii) *The Blow-fly Problem.*—Assistance was given in the campaign for the application of strike control methods in New South Wales.

(iv) *Infectious Diseases of Sheep.*—(*a*) *Contagious Ophthalmia or "Pink Eye".*—Experiments showed that the disease can be transmitted to healthy sheep by the transfer of tears from an infected eye. In infected eyes a small micro-organism, *Rickettsia conjunctivae,* is always to be found. An attack of the disease confers resistance which lasts for a period of about 100 days. Infection is probably transmitted by flies under natural conditions. All treatments tried were found to be ineffective.

(*b*) *Pizzle Rot.*—Field and laboratory investigations were carried out on this disease during the year. The incidence of the disease varies greatly from district to district but is found to be highest where the content of the pastures in clovers and similar legumes is high. The disease does not appear to be contagious. Some promise of control was obtained by placing sheep on a restricted diet for a few weeks.

(v) *Biochemistry.*—(*a*) *Studies on the Mineral Metabolism of Sheep.*—Studies on calcium metabolism in sheep being fed on a diet rich in cereal grains and their by-products were continued. A preliminary report was published. An experiment was started on the effect of relative calcium deficiencies on fertility of ewes.

(*b*) *Studies on Hypocalcaemia and Pregnancy Toxaemia in Ewes.*—Experiments showed that complete starvation for a few days reduces the level of

serum calcium in both pregnant and non-pregnant ewes. With an extension of the fasting period the serum calcium returns to prestarvation levels or higher. Some ewes did, but the majority did not, show symptoms of hypocalcaemia. Starvation also resulted in the production of fatty livers and in increases in blood ketone bodies and a fall in blood sugar.

(*c*) *Urinary Calculi in Sheep.*—Analyses were made of calculi collected from rams. In all the specimens the main constituent was found to be calcium carbonate.

(vi) *Chemical and Physical Studies on Wool.*—Systematic chemical analyses were made on the fleeces of grazing sheep. Physical and chemical studies were made in the investigation of handle, felting and pliability of wool.

(vii) *Wool Biology.*—(*a*) *General Histology of the Follicle Group in the Merino.*—Advance was made towards the completion of the studies on foetal and adult skin.

(*b*) *Studies on "Density".*—The results of the work seem to indicate that group size rather than the number of groups per unit area is the dominant factor governing the population density of follicles in the skin.

(*c*) *The Effects on Wool Production of Parasitism.*—Preliminary studies showed a steady decline in wool production in animals with trichostrongylosis, the decline continuing even after the parasites had been expelled.

(*d*) *Influence of the Plane of Nutrition on the Structure of the Merino Skin and Fleece.*—The study was continued in association with the Animal Nutrition Laboratory.

(viii) *Statistical Work.*—Officers of the Biometrical Section permanently attached to the Division were stationed, as in the past, in the McMaster Laboratory. Assistance was given in the planning of experiments and in the analysis of results obtained in many investigations, including (*a*) parasitology, epidemiological, and field trials, (*b*) wool biology, (*c*) mastitis, (*d*) progeny testing, and (*e*) peg-leg of cattle.

4. The F. D. McMaster Field Station.

(i) *General.*—(*a*) *Seasonal and Pastoral Conditions.*—During the year, 1,750 points of rain fell. The average annual rainfall is approximately 27 inches. The average for the last three years is 16.7. There was no beneficial fall during the year until February and by the end of March 1,084 of the total 1,750 points had fallen. The dams were filled and water storage has remained satisfactory. Urgent farming operations were carried out at opportune times. About 160 acres were placed under crop. In the pastures, Rhodes grass is the only introduced grass that has withstood the arid conditions prevailing.

(*b*) *Livestock.*—Stocking was reduced by disposing of 226 sheep and at the end of the year the total sheep on the Station was 824. In addition there was one Zebu heifer and seven draught horses.

(*c*) *Afforestation and Improvements.*—Tree planting was carried out according to plan, but only a small proportion of the young trees withstood the dry season. No permanent improvements were effected during the year.

(ii) *Zebu Hybridization.*—The experimental herds in Queensland were visited during August, 1941. The numbers in these herds had increased to 7,794 head, of which 6,306 were quarter-breds. Evidence has accumulated to show that cross-bred cattle reach chilling weights approximately one year earlier than British-bred cattle. Two hundred and thirty-five cross-bred bullocks were killed during the year and 88 per cent. were graded first quality.

(iii) *Fertility of Sheep.*—Investigations were continued into the effect of the absence or aberrant occurrence of heat. They have shown that at the particular centres of observation Merino ewes, Border Leicester, Dorset, and first-cross Merino x Border Leicester ewes have a fundamental reproductive rhythm. Broadly, the mating season is in the autumn and winter months, and the non-breeding season is in the late spring and early summer. The influence of green feed on the periodicity and incidence of oestrus is being studied at the Werribee Field Station and other aspects are being studied at the National Field Station, Cunnamulla.

(iv) *Inheritance of Skin Wrinkles in Sheep.*—These studies were continued. The observations are incomplete, but, broadly, the absence of skin folds has been dominant, although the dominance has not been complete.

(v) *Inheritance of Black Wool in Sheep.*—This investigation was discontinued and the results obtained were published.

(vi) *Polledness in Sheep.*—These observations were continued.

(vii) *Inbred Sheep.*—Shortened lower jaw was found to be a recessive condition. By the same technique it is planned to classify similar faults and to determine the nature of their inheritance and the method of their control. The inbred flock is also being used to provide material suitable for investigations on wool characters.

5. The Animal Nutrition Laboratory, Adelaide.

(i) *Energy Metabolism.*—During the year intensive study was made of the efficiency with which the sheep is able to utilize the available energy in its fodder when fed at different levels. The efficiency of two groups of mature ewes was estimated by the energy and nitrogen balance technique when fed at a series of levels ranging from half maintenance to double maintenance, one group being taken in steps of increasing and another being taken in decreasing levels of food intake.

(ii) *Drought Feeding.*—(*a*) The amount of available and useful energy provided by a range of fodders that might find application in drought feeding in Australia has been established. The results which are directly applicable in station practice have been published. These allow the cost of maintaining sheep at any desired body weight to be calculated precisely and simply, and render possible the selection of the most economic fodder to employ for this purpose. Some further work was done on the evaluation of the available and useful energy content of various grass hays, and of Stylosanthes hay which was found to be very little better than average wheaten straw.

(*b*) *Vitamin A in Drought Feeding.*—Preliminary experiments were started to estimate the vitamin A requirement and to establish means for rapidly assessing the vitamin A status of sheep, as a deficiency of this accessory food factory is likely to become an important consideration in dry grazing, and especially in drought feeding.

(*c*) *Inorganic Nitrogen in Drought Feeding.*—Experiments to determine the possible usefulness of inorganic nitrogenous materials such as urea for providing part of the nitrogen in drought-feeding rations were started.

(iii) *Influence of the State of Nutrition on Wool Production.*—The experimental observations of the groups of sheep referred to in previous reports were continued. Both the strong-wool and the fine-wool groups have completed two years of growth. The

influence of the plane of nutrition on the conformation, wool production, &c., is now even more apparent than before. The following figures obtained during the second year of growth indicate the order of the influence that nutrition has on wool production:—

Type.	High plane of nutrition.		Low plane of nutrition.	
	Weight of fleece.	Mean diameter of fibres.	Weight of fleece.	Mean diameter of fibres.
	lb.	microns.	lb.	microns.
Fine-woolled ..	13.3	20	7.3	17.9
Strong-woolled ..	18.4	28	8.0	21.5

The staple length and other characteristics of the fleece are similarly dependent not only on the genotype, but, to a large degree, on the quality and quantity of the fodder consumed. The object is, when growth has finished, to measure the efficiency as a wool producer of each type as a product of the nutritional environment during the growing period. This will be estimated over a range of different levels of food intake.

(iv) *Plant Proteins.*—The work on cryptogram tissue proteins was completed during the year, and so it is possible to amplify the conclusions mentioned in previous reports. The close similarity of the tissue proteins of the families Bryophytes, Pteridyphytes, and Spermatophytes, which are in increasing order of evolutionary development, provides powerful support for the hypothesis that the leaf proteins of the flowering plants are of similar composition. One Thallophyte was studied. The composition of its tissue protein departed considerably from the composition of other plants. In addition to the large-scale preparation of protein from lucerne leaves, mentioned in the last report, large-scale preparations from Phalaris and burr medic were made, and detailed analytical work on these was started. During the course of an investigation of the changes in the proteins during germination of the seeds of blue lupin (*Lupinus angustifolius*), it was observed that the seed protein itself had a low methionine and a fairly low tryptophan content. In view of these findings, and in view of the importance attached to seeds of another species of *Lupinus* and to legume seeds generally as a source of protein for human and stock nutrition, plans were developed to conduct analytical work on legume seeds.

(v) *Physiological Studies.*—(*a*) *The Process of Deglutition in Sheep.*—The accumulated data of the studies of deglutition were prepared for publication. Functional activity of the oesophageal groove mechanism appears to form a constituent feature of the pattern of behaviour which surrounds the act of sucking the ewe, and is not part of the pattern which is associated with the act of consuming liquid in order to quench thirst. The changes in the liquid intake as the animal grows older are accompanied by changes in the relative proportions of it which pass to the forestomachs and to the abomasum. Observation of the influence of copper sulphate solution on the course taken by liquids has been repeated with animals which had been maintained on a low nutritional level for some months. The results show clearly that the influence of copper sulphate is as great, if not greater, under such circumstances and indicate that the functional activity of the oesophageal mechanism is not altered in sheep which have been weakened by poor nutrition.

(*b*) *Absorption of Copper in the Intestinal Tract.*—Observations on the absorption of copper in the alimentary canal were continued. Study of the influence that hydrogen ion concentration in the abomasum exerts on absorption of copper ions necessitated a study of the normal range of pH of this viscus. This was found to vary between pH 7.5 and pH 2.0.

(vi) *Minor Element Deficiencies.*—(*a*) *Experiments at Robe, South-East of South Australia.*—The trial to determine the ability of copper-dressed improved pasture to supply the copper requirements of the sheep proceeded. Ewes with depleted reserves of copper, and which previously had dropped ataxic lambs, recovered and produced normal lambs when transferred to these copper-dressed pastures. Results of experimental trials on "coasty" country have shown that, even when adequate copper is supplied regularly, cobalt must be supplied frequently to ensure optimal health. The efficacy of the treatment declines steadily as the interval between successive doses of cobalt is increased. However, the least frequent dosing in a series, once in five weeks, does exert a considerable effect. Experiments were started to investigate the frequency with which copper needs to be supplied in order to overcome completely the deficiency of this element. No marked differences have been detected between the behaviour of Merino and of Border-Leicester sheep towards levels of copper administered in doses ranging from 0–100 mg./day.

(*b*) *Copper Deficiency in Southern Australia.*—In order to investigate further the origin of "straight steely wool" mentioned in the last report, observations were initiated on experimental flocks at six field stations situated at sites representing the range in copper deficiency of affected areas. The results of the observations during the first nine months have shown that straight steely fleece definitely correlates with a marked degree of copper deficiency.

(*c*) *Cobalt Deficiency.*—In collaboration with the Institute of Medical and Veterinary Science, observations of experimental flocks situated at Glenroy in south-eastern South Australia were initiated on country where the well-being of young sheep is suspected to be adversely influenced by uncomplicated cobalt deficiency.

(vii) *Agrostological Investigations.*—During 1941, it was observed at Robe that the growth of oats on land treated with 14 lb. copper sulphate per acre in 1940 was very much superior to that of oats on adjacent areas which were sown in 1941 and treated with 14 lb. of copper sulphate per acre, and was in no way inferior to that of an adjacent crop treated with copper both in 1940 and 1941. The capacity of the Rotenburger Black oat to grow in copper-deficient country was again confirmed, and seed was made available to the Department of Genetics of the Waite Institute for crossing with other varieties. The favorable response of certain species to zinc sulphate was confirmed, and it is now amply proven that the calcareous sands are deficient in the minor elements cobalt, copper, and zinc. Evidence that cobalt is essential for the growth of plants has not been obtained. In order to select species most desirable for the development of these deficient tracts a wide variety of herbage plants has been tested. An excellent crop of Hubam clover (*Melilotus alba annua*), estimated to yield 3 tons per acre, was obtained from seed secured from America. "Pilot trials" of a standard pattern, including combinations of different fertilizer, four rates of superphosphate, and a wide range of species were commenced in the following centres, representative of many soil types, but all on terrain suspected to be copper-deficient:—Naracoorte, Kybybolite, Wattle Range, Rendelsham, Mount Benson, Tailem Bend, Houghton, Mount Compass, Wailpinga, Kangaroo Island, and the West Coast area. Investigations in co-operation with the Waite Institute were undertaken at Wood's Well, which is typical of the Coorong country. Slight but significant responses with

manurial dressings of zinc sulphate and an apparent response with copper sulphate in these areas have been observed.

6. National Field Station, "Gilruth Plains", Queensland.

Seasonal conditions continued to be unfavorable to production and some of the experimental work suffered. However, taking a long view, data collected under unfavorable seasonal conditions are just as important as those collected under more favorable conditions. Good rains fell in January and March, 1941, but thereafter conditions were dry until May, 1942. The total rainfall for 1941 was 18.83 inches, of which 14.25 inches fell in the first three months. In 1942, only 3.28 inches had fallen up to the end of April. During May, however, 276 points fell, but the rain was too late to do the maximum good, although the general position was improved. In spite of the dry conditions, the stock maintained their condition well. Lambing in September-October was fair, with an all-over average of 76 per cent. Quarters for the bachelor members of the staff were erected during the year.

(i) *Fly-strike Observations.*—(*a*) *The Effects of the Length of Tail and the Mules Operation.*—Following the good rains in January and March, there was sufficient fly-strike during the autumn to give significant results in the experimental groups. There were three main groups of sheep; one started in 1938 to measure the effect of tail length only, one in 1939, and another in 1940 to measure the combined effect of the Mules operation and tail length. The incidence of strike in the several groups may be summarized as follows:—

Percentage Incidence of Strike.

Groups of Ewes.	Length of Tail.			
	Long (4 inches).	Medium.	Short.	Undocked.
1938	13.7	33.3	50.7	..
1939 M. ..	1.9	3.6	19.6	7.5
1939 C. ..	21.1	59.4	89.6	36.8
1940 M. ..	0.9	..	9.2	..
1940 C. ..	19.2	..	56.2	..

M = Mules Operation. C = Untreated Control.

These results show the great value of the Mules operation combined with a 4-in. tail in the prevention of crutch strike. In the 1939 and the 1940 groups it is seen that there was from 47 to 62 times more strike in the short-tailed control groups than in the long-tailed groups which had been operated upon. Neither the longer tail nor the Mules operation by themselves give such striking results.

(*b*) *Study of Jetting.*—The fly wave did not maintain its severity for a sufficient length of time to enable significant results to be obtained.

(*c*) *Dressings and Carrion Ecology.*—Study of fly dressings was continued and satisfactory results were obtained with B.T.B. 15, which appears to be the most useful and satisfactory dressing available. Further observations on sheep carcasses showed that, under the climatic conditions at the Station, sheep carrion is relatively unimportant as a breeding ground of *L. cuprina.*

(ii) *Periodicity of Oestrus.*—Observations were commenced to determine the influence of the continued presence of the vasectomized ram on the occurrence of oestrus each month in groups of ewes.

(iii) *Lamb-marking Methods.*—Results of experiments showed that healing is more rapid in younger lambs and more rapid when the tail is cut longer. Infection is far more frequent when the tails are cut short. There is little difference in healing rate whether the tail is cut through a joint or through the bone. The usual method of doubling the tail back over the knife gave more rapid healing than the method of making the cut with the tail extended.

(iv) *Breeding Observations.*—A series of observations linking with others being made within the Division was started, but results cannot be reported at this stage.

V. SOILS INVESTIGATIONS.

1. General.

During the past year, the Division of Soils has passed through a period of change produced partly through diminishing staff absorbed in other services and partly by a swing to work in soil mechanics and soil stabilization in association with the defence services. Owing to the pressure of other work and inability to secure aerial photographic surveys, two large surveys were suspended until more favorable times, and only limited field work has been in operation since December, 1941. Research work has tended to be subordinated to immediate requirements, and the lack of research chemists and physicists has been felt.

The work of the field staff has continued on much the same lines as indicated in last year's report, if on smaller scale. It is highly desirable that the study of soils should go hand in hand with that of land use, agricultural and irrigation experiment, and with investigations of rural economics. More and more it is hoped that the field surveyors will be able to co-operate with and co-ordinate the work of skilled investigators in these lines so that the maximum benefit may arise from the surveys at the earliest date. The cessation of large surveys has imposed an unfortunate restriction on the continuance of pedological studies in the field. The scope of research work in the laboratory has contracted through the secondment of two chemists to other Divisions of the Council in the early part of 1942 and by the necessity for dealing with a considerable volume of routine analytical work associated with the soil surveys.

The Division of Soils has its head-quarters at the Waite Research Institute, Adelaide, and has enjoyed a happy association with the University staff of the Institute engaged on allied agricultural research. There has been ready co-operation of the Departments of Lands, Agriculture, and Irrigation in the various States with the Division in the work undertaken.

2. Soil Surveys.

The Field surveys carried on during 1941-42 were as follows:—

New South Wales.—Wakool Irrigation District—250 square miles—total completed 840 square miles. Deniboota District—475 square miles.

Victoria.—County Moira—25 square miles—total completed 355 square miles.

South Australia.—County Victoria—475 square miles—total completed 625 square miles. Eight Mile Creek Swamp—4,000 acres. Area adjoining Renmark settlement—2,000 acres. General reconnaissance of lands within and adjacent to Murray Valley.

(i) *Wakool Irrigation District.*—The field survey, including soil napping, study of land use, and some economic inquiries, was completed in November, 1941. The area, which is gazetted as an irrigation district with limited water right sufficient for the irrigation of about 10 per cent. of each holding, presents considerable difficulties in general development. No satisfactory methods of improvements are yet available for

certain extensive areas of intractable soil types. It is essential that either the allotment of water be varied to suit soil quality or that investigation of the means of improving these poor soils economically to make them suitable for pasture establishment be undertaken. The survey has provided a sound basis for necessary experiment in the future both along irrigation and agronomic lines.

The use of the soils on economic grounds as well as on the basis of purely agricultural suitability has been examined in a preliminary manner by collection of data on costs and production rates of properties on different classes of country. As the Wakool Irrigation District is representative of considerable areas in south western New South Wales for which irrigation water may become available in the future, the survey gives a lead to study of stability of this territory under more intensive development.

The laboratory work on collected soil samples is complete and the material collected in MS. form for publication.

(ii) *Deniboota Area.*—Adjoining the Wakool Irrigation District on the south-eastern flank is the Deniboota area, proposed for channel reticulation as an irrigation area similar to Wakool on the basis of a 10 per cent. water right. Extensive and expensive construction is involved in bringing the water to the area, and lengthy channel lines have been designed and partly constructed. At the invitation of the New South Wales Water Conservation and Irrigation Commission, a reconnaissance survey was made to determine the general suitability of the area for irrigation. The field work is now complete and the data being assembled for report to the Commission.

(iii) *County Moira.*—This survey in a new irrigation district in north-central Victoria was continued to cover the Parish of Baulkamaugh. No further work is contemplated on the project, which is now a little over half completed, owing to shortage of field staff. The portion surveyed has been dealt with in a bulletin now in the press.

(iv) *County Victoria, South Australia.*—The soil, erosion, and land use survey of County Victoria was continued in 1941 until the area covered by aerial photographs was completed. It is impossible to make accurate erosion studies of large areas without photographs. As these cannot be procured under the present conditions, it was decided to halt the survey and assemble the data on the area. The soil maps, erosion maps, and analytical work on collected samples are now complete. It is interesting to note that, arising out of the survey, certain economic studies are about to be undertaken by the Economics Faculty of the University of Adelaide on portion of the area.

(v) *Eight Mile Creek Swamp.*—The South Eastern Drainage Board and the Land Board of South Australia have undertaken the reclamation of a peat swamp near Port McDonnell in South Australia. At their request a survey was made of the swamp before clearing had proceeded so that the ecology could be studied. The plant collection and identification was done by the University of Adelaide in the latter stages of the soil survey. Through the courtesy of the Air Board and Air Force personnel, aerial photographs were obtained of the swamp, materially assisting in the accuracy of mapping. The swamp gives every promise of being a highly productive area for intensive settlement.

(vi) *Renmark.*—At the request of the Department of Lands, South Australia, a rapid survey was made of 2,000 acres adjoining the old settlement at Renmark which had been suggested as suitable for an extension of the irrigated area. A report was presented showing the position to be somewhat less promising than the sponsors believed, both as to soil type and salinity. The matter of development turns on the usefulness of a maximum of 800 acres, the remainder being of poor or mixed soil types not recommended for development.

(vii) *General Reconnaissance of Murray Valley.*—In 1941 the South Australian Government requested an examination of irrigation potentialities on low pumping lift in the Murray Valley in South Australia. A general survey has been made of the whole valley in this State. The principal conclusions are (*a*) there is no large area suitable for irrigation development intensively or extensively by Government enterprise either to horticultural or grazing uses; (*b*) investigation is required of the possibility of developing at low cost the large expanses of low-level flats of heavy soils subject to periodic inundation by the river; (*c*) possibilities appear to exist for individual land holders to make better use of river frontages, but experiment is necessary before clear advice can be given.

Considerable data have been accumulated on the field character of the soils in the Valley, and a wide range of samples is being examined in the laboratory. It is perhaps noteworthy that there are no significant areas of soils of similar character to those on the established settlements of Renmark, Berri, Lyrup, and Cobdogla; any development therefore must be on problem lands of inferior value and difficult to manage effectively.

The high lift land fringing the Murray Valley was also inspected on both sides of the river for 230 miles from the State border to Blanchetown. The examination was not complete but was made selectively in association with an officer of the Department of Lands and after collecting information on likely areas. Much of the land in this region is unsuitable, as it is in parts stony and shallow and in others on very high lift or not accessible conveniently to the river, where the valley may be six miles wide. From the restricted choice three selections were made for future survey—one above Renmark of 10,000 acres, one near Loxton 5,000 acres, and one near Lake Bonney of 3,000 acres. The Lands Department has carried out preliminary surveys on the areas sufficient for a soil investigation to be made, but it has not yet been practicable to do this.

3. Laboratory Investigations—Chemical and Physical.

Spectrochemical work on soils has been concerned with three main projects. A complete survey of the metallic composition of the surface soil at the Waite Institute was made with an examination of the hydrochloric acid extract of the soil and of the residue left after extraction. This work was an attempt to discover the maximum amount of useful information which may be revealed by spectrochemical methods. A lot of eighteen samples of ironstone gravels was studied qualitatively, and later fourteen quantitatively, both on hydrochloric acid extracts and remaining residues. Arising out of these analyses the scope of the work was widened to include additional ironstone gravels and the soils associated with them. The profile of the Waite Institute soil has been studied for the distribution of all detectable metallic elements present in low concentrations including the analysis of the parent rock. It is proposed to extend this project to include profiles of typical soils of major soil types of south eastern Australia.

Spectrographic analyses were made for various bodies including the University of Adelaide, the Council's Division of Animal Health and Nutrition, Commonwealth Research Station, Griffith, New South Wales, the National Standards Laboratory, and the Department of the Interior. The materials concerned were samples of grass, chemical, glass, pigment, sewage sludge, farmyard manure, wood ashes. In connexion

with the last-named the analyses were directed to tracking down a possible deficiency of molybdenum in a South Australian soil.

The problem of anion exchange with particular reference to the fixation of phosphoric acid by certain soils has been the subject of investigation for two years. Interest in this problem has arisen out of the investigation of certain Tasmanian soils. Recent investigations in California have suggested that soils containing clay minerals which are dominantly kaolinitic have the greatest fixing power for anions, and evidence is being sought in Australian soils for confirmation or otherwise of this suggestion. Studies are being undertaken in the hope of developing laboratory methods of detecting and assessing the fixing power of such soils for anions parallel to those which have been used for assessing cation exchange capacity.

Parallel to this laboratory work, pot experiments with subterranean clover on the Cressy shaly clay loam, which has a high capacity to fix phosphate, were again conducted. As well as the alkaline earths which had been used in previous years, silicates were also included in the trial. In addition an experiment with white clover on basaltic soil from the north-west coast of Tasmania was conducted. Although this soil responds better to superphosphate than the Cressy soil, it also exhibited the phenomenon of increased response between pH 6 and 7.5 and of depression due to the creation of a too alkaline environment above pH 8. Both experiments have a very practical bearing on the use of phosphates and various alkaline materials in the field in the above districts in Tasmania. In addition they provide a body of data to be correlated with the work on anion exchange capacities now being undertaken in the Division.

The determination of small amounts of copper in soil and its availability to plants has been investigated in previous years in this laboratory. The availability has presented a problem only solved by the use of indicator plants. Mulder's biological method using the spore colour of the fungus *Aspergillus niger* as indicative of the sufficiency or lack of available copper in a nutrient medium has been shown to be effective when soils are used as the source of copper in the medium. Apparently, the copper requirements of the fungus parallel those of higher plants, and the method finally adopted permits the division of soils into deficient and "sound" types for crop growth.

An examination for zinc content of oat plants grown on a wide range of soils in South Australia was carried out by the polarographic method as part of a joint study with the Waite Research Institute of the distribution of minor elements. A number of analyses was made of crop plants and weeds growing on soils of known character to serve as a standard for evaluation of the results from all parts of the State. Zinc with copper and manganese is known to be deficient in certain parts, and the investigation was designed to indicate possible areas likely to be affected.

Soil physics has been increasing in importance as a branch of the Division's work and has received a strong impetus in the recent interest in engineering properties of soils. A considerable amount of testing of soils both for their properties as subgrades for constructional purposes and their suitability for making soil-cement as a paving material has been done. The latter is a result of an undertaking to investigate the suitability of Australian soils for soil-cement purposes and to interpret their character according to United States standards.

A project to study the erodibility of several soil types in the area covered by the soil survey of County Victoria (South Australia) was begun during the year but has been temporarily set aside. It was desired to establish the efficiency or otherwise of soil treatments under rotations of varying length and type in stabilizing the soil. The current practice of wheat-fallow has proved extremely destructive and an amended rotation is essential.

4. Soil Microbiology.

Symbiotic nitrogen fixation has remained the main subject for investigation. In the first part of the year interest was maintained directly in the establishment of leguminous crops on the poor soils of Kangaroo Island. Attempts were made also to perfect the practice of preserving bacterial cultures *in vacuo* in viable state as a possible means of distribution, instead of in the usual wet or agar culture.

Temperature requirements of strains of *Rhizobium* isolated and maintained in the laboratory have been studied with particular interest in relation to tropical legumes. An improved technique for more successful growth of tropical legumes under southern glasshouse conditions has been devised. Cultures have been prepared for the inoculation of lupins, soya beans, and lespedeza to be grown in trial areas, particularly where clover crops are not successfully grown. There has been a record demand by farmers for cultures for inoculation of field legumes before planting, chiefly subterranean clover, lucerne, and field peas. During the 1941 season a total of 1,350 cultures of high symbiotic effectivity were sent out to 170 individual farmers in South Australia providing for the sowing of 14,000 acres.

VI. IRRIGATION SETTLEMENT INVESTIGATIONS.

A.—COMMONWEALTH RESEARCH STATION (MURRAY IRRIGATION AREAS), MERBEIN, VICTORIA.

1. General.

The work of the Station has been subject to very material changes arising from the war, and staff reduction, owing to military duties and special war work, has been extensive. The Station has been established for over twenty years, and considerable progress has been made in the major problems of the dried fruits industry. These include the method of irrigation, frequency of distribution, soil preservation, reactions of the vine to pruning, and the processing and preservation of dried fruit. At the outbreak of war, it was considered that few of these projects could be viewed as urgent, as the major investigations had advanced to the stage where improved practices based on the investigations were incorporated in the routine work of the industry; further investigations were viewed as refinements rather than as necessities. We have previously reported an average increase in yield of approximately 40 per cent. over twelve years, and naturally the rate of increase is now decreasing. Long-dated investigations dealing with the reclamation of the heavier soil types, and the cumulative effect of fertilizers and of pruning on the bearing of the vine, are being continued. Initial investigations dealing with trace elements as affecting yield, and the usage of irrigation water by plants in relation to application by irrigation, had been commenced; but as these investigations were only in the initial stages, they have been postponed. Viticultural investigations and agricultural drainage had reached the stage where publication of the results was advisable, and two bulletins and one pamphlet have been published. Investigations on these projects have been discontinued for the present.

The curtailment of the normal programme has permitted attention to urgent problems associated with the war. These include assistance in aerodrome construction; production of special crops including drug plants and vegetables; the dehydration and processing of additional fruits and vegetables; and in particular the

utilization in the dried fruits industry of substitute requisites rendered necessary by cessation and reduction of normal imports.

2. Drainage Investigations.

The inquiry into methods of agricultural drainage covered the depth and spacing of agricultural drains for reclamation and preservation of fertility of the major light-textured soil types. The results of these investigations have been prepared for publication, and further investigations are limited to the reclamation of heavier soil types. The limitation of reclamation and drainage studies during the war is justified by the almost complete cessation of large drainage works undertaken by the States in the irrigation areas; and by the fact that the investigations have advanced to the stage where the results can be incorporated in large scale drainage plans.

3. Irrigation Investigations.

Irrigation investigations are now practically discontinued, and the work of the Station is directed to assistance in planning and establishing new areas irrigated for war needs; these include areas for vegetables, drug plants, and pastures. Assistance has also been given to the Air Board in planning and establishing pasture covers on aerodromes.

The shortage of fuel has necessitated a curtailment of irrigation supplies to the horticultural settlements, and the Station has assisted in arranging a reduced frequency based on the minimum requirement with the elimination of cover crops as green manure. Considerable economies in fuel consumption have been effected.

4. Viticulture.

An important feature of the past season's work has been the utilization of seasonal maturation studies to meet the changed conditions arising from labour shortage, reduction of fuel supplies, and excessively hot weather in mid-summer. Adjustments were brought about, in co-operation with the dried fruits industry and the State officers concerned, which resulted in earlier harvesting of certain varieties, and extension of the harvest period to permit fuller utilization of available labour. Seasonal conditions included an early and definite break in the weather which ended the drying season abruptly, and measures to commence harvesting earlier proved particularly effective in securing the maximum dried fruit crop under the prevailing conditions.

Long-dated viticultural studies which are being continued include fertilizer trials at three sites, viz., Woorinen, Red Cliffs and the Research Station. In work where the cumulative effects of several years' operations can be measured, such as pruning, cincturing, trellising, topping, disbudding, application of minor elements, and oil-emulsion sprays for delay of sprouting, the treatments are being continued and the yield measurements abandoned.

5. Fruit Processing.

The cessation of imports of certain essential commodities required in the industry has necessitated the incorporation of substitute requisites. Potassium carbonate is essential for the cold dip used in processing sultanas. No other chemical equally suitable for this purpose has been found, but it has been shown that suitably prepared extracts of vine ash, in which potash is the main constituent, give satisfactory results. The ash obtained by burning packing waste, consisting mainly of stems and immature fruit, yields about 35 per cent. of potash and is now the main source of supply. Additional savings of potash have also been secured by the greater use of wetting agents, which permit a reduction of about 40 per cent. in the concentration of potash without adversely affecting the efficiency of the dip.

As a result of work carried out on oil emulsions for use in dipping it has been found possible to substitute Australian produced cotton seed oil for imported olive oil, with equally satisfactory results. This is fortunate in view of the fact that olive oil is unobtainable. A delay in harvest prolonged the drying season, and unfavorable weather in May resulted in damage to the fruit by rain and subsequent mould growth. The loss in fruit and extent of damage was considerably decreased by enclosing the racks for sulphuring and also by spraying with a 1 per cent. solution of sodium salicylanilide in water.

The method of marketing dried apricots and peaches has been altered to conform with the requirements of the Department of Supply and Development. The products are now packed in sealed tin containers, which necessitated readjustment of the moisture and sulphur dioxide content. The Station undertook storage trials to determine the requirements for keeping qualities, and also prepared tables for use with an electric moisture meter for measuring the moisture content of the dried packs. With a shortage of tinplate, and a preference for dried peaches instead of the canned product, trials in drying cling-stone peaches were carried out. These varieties were formerly almost exclusively canned, and as they ripen late in the year, drying is necessarily carried out in dehydrators. Trial lots of two varieties (Pullar's Cling and Golden Queen) were railed from Shepparton to Mildura, to study the sulphuring and drying methods for these varieties, and also to examine the possibility of utilizing Mildura dehydrators for drying Shepparton peaches. The trials showed that both these varieties could be dried in Mildura district, though an increase in wastage and increased cost would result.

6. Additional District Activities.

The problem of the food supply of Australia as influenced by the war is naturally bringing diversity of products to the irrigation areas. There has been a marked increase in the production of vegetable and vegetable seeds. The Station has co-operated with the Department of Supply and Development and with the State Department of Agriculture in this work, and has assisted in the selection, planning, and development of new areas. Small investigational plots, dealing with the establishment and seasonal development of vegetables and vegetable seed, have also been commenced.

The dehydration of vegetables for use for the fighting services is very desirable, and a commencement was made by drying potatoes commercially in the Mildura district. Technical assistance was given continuously by the Station in this project, mainly in the direction of preventing discoloration during the trimming, blanching, and cooling processes, by eliminating metallic contamination, by controlling the pH of the water, and by the addition of 0.05-0.1 per cent. sodium (or potassium) metabisulphite, to the water used in the trimming vats.

The possibility of making cream of tartar and alcohol from fruit waste has also been investigated. These waste fruits usually contain 5 to 8 per cent. of cream of tartar, and from 50 to 70 per cent. sugar. Service trials showed that it is possible to recover 4 to 5 per cent. cream of tartar and 40 to 50 gallons of rectified spirit from one ton of waste fruit. The extraction of spirit from the waste is carried out commercially.

The Station is associated with the Division of Plant Industry in investigating the suitability of the district for drug plants. The stage has been reached where seed for sowing and material for commercial extraction are produced in the district.

7. Financial Assistance.

Financial assistance for the work of the Station has been well maintained. Contributing bodies include the Australian Dried Fruits Control Board, Mildura Packers Association, Nyah Woorinen Research Committee, Red Cliffs, Curlwaa, and Coomealla Branches of the Australian Dried Fruits Association, Rural Bank of New South Wales, State Rivers and Water Supply Commission of Victoria, and the Water Conservation and Irrigation Commission of New South Wales. Contributions for the year totalled approximately £2,500, of which the major portion is used for investigations of general interest to the dried fruit districts, with minor investigations of special interest to the contributing districts.

B.—IRRIGATION RESEARCH STATION (MURRUMBIDGEE IRRIGATION AREAS), GRIFFITH, NEW SOUTH WALES.

1. General.

The Irrigation Research Station at Griffith was established in 1924. It has 90 acres of irrigable land, 30 acres of which are planted up, and it is provided with good laboratory facilities.

The New South Wales Water Conservation and Irrigation Commission provided the land and co-operated in the establishment of the Station. During the year its annual contribution of £1,500 was increased by £500 to initiate tile drainage experiments. Officers of the Commission have given excellent assistance with the Station's work on tile drainage and on research project farms. The Murrumbidgee Irrigation Areas Joint Executive Committee, representing settlers' co-operative organizations on the Areas, contributed £100 for the appointment of a junior assistant for research project farm work.

Much of the recent work of the Station has been concerned with the serious problem of the deterioration of the soil structure after several years of cultivation. This greatly reduces the fertility of the soil, often to such an extent that the land is of very little economic value. The problem is being tackled from several angles.

As far as possible the Station is concentrating on problems of immediate importance in the war economy. War conditions have caused a big expansion of the vegetable industry on the Murrumbidgee Irrigation Areas, and there is thus a good opportunity to solve the many problems that inevitably arise in a rapidly expanding primary industry on a new area, thus materially increasing production.

2. Orchard Survey.

Statistics compiled from the information obtained in this survey have now been published and comprise 136 pages relating to the fruit trees and vines of the Murrumbidgee Irrigation Areas. The classifications include: crops, varieties, districts, ages of trees, soil type, aspect, health of trees and trees flooded in the wet 1939 winter. A statistical analysis indicating the effect of soils, aspect, various cultural factors such as fertilizers, tillage methods, and irrigation methods on the size and health of trees, has been completed and is being prepared for publication. Popular views on the suitability of soil types for particular crops are often the result of imagination coloured by the prevailing fashion, and a careful statistical study seems to be the only way of obtaining satisfactory evidence on what is admittedly an important question. Amongst other things the statistical analysis has shown that most crops grown produce equally well on most soil types used on the Murrumbidgee Irrigation Areas provided the correct method of management for the soil type in question is used.

3. Soil Deterioration.

After some years of tillage the structure of the soil is adversely affected by the puddling effect of tillage implements and traffic on the soil. The process is rather rapid in irrigated orchards and vegetable plots that are intensively farmed. The result is that the yielding capacity of the soil is greatly reduced, and in the case of orchards the health of the trees decline. Some trees, particularly citrus trees, are so badly affected that they cease to be profitable. This soil deterioration is one of the main problems of the irrigationist. The earlier planted Experimental Orchard Plots which are now seventeen years old give important clues as to causes, effects, and possible remedies. For example, where the soil is untilled as in plots that have had continuous cover crops of lucerne, the trees are still quite healthy. In other plots the degree of unhealthiness seems roughly proportional to the amount of tillage that has been given.

Besides field and laboratory examinations of the soil, using appropriate technique, the problem is being studied by:—

(*a*) Experimental plots on settlers' groves ("Project Farms") where straightforward experiments are carried out on a wide range of soils, crops, and managements.

(*b*) A field experiment on mature trees that should yield fairly quick results.

(*c*) A comprehensive field experiment on an orchard specially planted for the purpose.

These three investigations are described below. In each case other factors are also being investigated:—

(*a*) *Research Project Farms.*—With the ready co-operation of settlers, nine farms have now been selected for conducting a series of co-ordinated experiments. They represent a good cross-section of the Areas' varying conditions, and enable the Station's effectiveness to be multiplied. The first farm projects, started in autumn 1941, have already demonstrated the value of this work, and during the year additional projects were begun at Merungle Hill and Yanco, in the Leeton district, and at Lakeview, in the Griffith district. Many experiments on these farms replicate, in simpler form, experiments carried out on Research Station plots. The chief aim of all these experiments is to find the most suitable legume cover crop and attendant management methods for maintaining healthy, productive trees. The Station's long-term green manure plots have shown that cultivation must be reduced and good soil structure maintained. Accordingly, the following treatments have been laid down on all project farms:—

(i) Present Standard Treatment.—A winter legume followed by summer clean cultivation. This treatment has given best growth and yields, but has not prevented tree decline after about sixteen years. It forms a standard for comparision with other treatments.

(ii) Lucerne as a cover crop, grazed off with sheep, but with no tillage.

(iii) Intermediate Treatment.— Subterranean clover. A winter reseeding leguminous cover crop. Summer herbage growth prevented by grazing with sheep, and again an entire absence of tillage.

Irrigation experiments and differential nitrogen treatments are also carried out on these plots and other portions of project farms.

The range of soil and slope conditions on project farms has greatly facilitated the study of irrigation lay-out and management. More exact specifications have been obtained for using border, furrow and contour check methods under the stringent irrigation

requirements of many Murrumbidgee Irrigation Areas soils. A new method of land preparation has been developed for border irrigation under steep side-slope conditions. In these experiments, soil, irrigation and plant aspects cannot be considered as isolated problems, but must be studied with all their interactions under field conditions. Research at the Station and on project farms is co-ordinated for this purpose, and a very complete record is being kept of all important changes occurring to the soil and tree. These include water consumption, watertable, soil structure, salt content, and soakage rate. The response is measured by trunk growth, spread of foliage, health rating, root distribution and yield, including size of fruit. It is hoped to evolve a satisfactory system of fruit culture that does not involve the deterioration of the soil structure.

(*b*) *Field Experiment on Cultural Methods.*—The field trials on the project farms cover a wide range of conditions, but it is also desirable to study the question of the effect of different methods of management of orchard soils in greater detail than it is practicable to do on commercial orchards. For this reason a more complex field experiment has been established on a grove of mature orange trees at the Research Station. Plots receive different soil management treatments which embrace different tillage methods, entire absence of tillage both combined with grazing by sheep and leaving the herbage growth ungrazed, and using different types of leguminous cover crops or sods. For example, a possible solution to the problem of soil deterioration is the entire absence of tillage together with the growth of a reseeding winter leguminous crop, such as subterranean clover or burr medic, which can be left as a protective covering to the soil during the summer, and the use of sheep in the summer to entirely suppress all summergrowing herbage. This experiment on mature trees is designed to give results as quickly as possible.

(*c*) *Complex Factorial Field Experiment.*—As all the multitudinous factors controllable or uncontrollable by the farmer are inter-related in their effect on the plant, it is necessary to test out as many as possible of the important controllable factors together. For example, if it is found necessary to entirely eliminate tillage, it is conceivable and in fact probable that prevailing methods of irrigation, use of fertilizers, etc., that have been evolved under intensive tillage methods will have to be drastically modified. Such a complex experiment has to be carefully designed and necessitates the planting of an orchard specially for the purpose. The trees for such an experiment were planted in the spring of 1941. Factors include soil management methods (described above), irrigation treatments, fertilizers, stock, and variety. The experiment is so designed to permit the possibility of including two more factors at some future date.

4. Vegetable Investigations.

The vegetable industry on the Murrumbidgee Irrigation Areas is a new development and many problems require investigation.

(*a*) *Irrigation Methods.*—Particular attention is being given to applying irrigation research results to the many soil, slope, and other conditions of the Murrumbidgee Irrigation Areas. The orchard aspects of this work are described in the section on research project farms. Irrigation research data are now being applied to vegetable growing, which is rapidly becoming an important industry.

The hurried establishment of the vegetable industry raises a new set of irrigation problems. Production in the first year of the Supply Department's scheme will be decreased by irrigation lay-out and management difficulties, and the Research Station is co-operating with growers and departmental organizations to overcome these as rapidly as possible. The Station's work on furrow irrigation is proving particularly important in this. It has established working standards for grading, slope, length of run, and watering flows, and farms are being designed to comply with these. The watering slope used, for example, has often been too great, resulting in erosion and slow or inadequate moistening of the root zone. For germinating root crops it is particularly important that the lay-out and land preparation allows fairly rapid moistening of the raised beds by lateral soakage, without actual surface contact with the irrigating stream. The Station's experiments show that slopes of 1½ to 3 inches per chain will permit this, provided the land has been carefully smoothed. To obtain these grade conditions the furrows can often be curved to suit the topography. The Station has constructed smoothing implements and simple levelling devices for use by farmers.

Experiments, which can later be used as demonstrations, have been begun to study further the best irrigation methods for vegetable growing. These include the use of raised vegetable beds in contour checks, which may greatly simplify irrigation lay-out and management. It is important to consider not only the yield per acre, but the man-power per ton required by the method of irrigation used.

(*b*) *Fertilizer.*—More accurate information of the fertilizer requirements of the variety of vegetables produced on the Murrumbidgee Irrigation Areas is required. This is being studied together with other cultural factors such as spacing on many field trials.

(*c*) *Time of Seeding.*—The time of seeding of different varieties for the district is very important. Often the best seeding time is quite sharply delimited. Even the delay of a week will make a big difference in the yield per acre or man-power cost per ton. Field trials have been established to supply this important information.

5. Drainage Investigations.

On many parts of the Murrumbidgee Irrigation Areas, over years of irrigation, high-perched watertables have been built up on impervious layers 10 to 20 feet from the surface. During wet periods, especially in winter, these conditions are aggravated and the level of the watertable may rise to the surface. Because of the reduced influence of the natural factors causing recession of the watertable, its level falls but slowly, and damage to trees results. Surface and underground drainage are being investigated to overcome and remedy those conditions.

Experimental tile drains are being laid down on Farm 713 to determine the efficiency of tile drains in preventing the salting of the land. The soil is a Yenda Sandy Loam which is a difficult soil type to irrigate without incurring salt accumulation. Tile drainage is being compared with lucerne as a reclamation agent. Besides this experiment, investigations into the efficiency and behaviour of other tile drains already installed in the district, are being carried out.

6. Pasture Investigations.

These include field trials to determine the most economic irrigation programmes for both winter and summer pastures and to determine the relative merits of winter and summer pastures. In the case of summer pastures the effect of rates and frequency of irrigation is being investigated, and in the case of winter pastures comparisons of different times of the first (germination) irrigation are being studied. This work is being carried out co-operatively with the Agrostology Section of the Division of Plant Industry. This section is

also co-operating in the study of no-tillage systems of orchard husbandry which involve the control of weeds by grazing. Most agrostological investigations aim at obtaining the greatest herbage growth economically possible, but in this study the reverse effect is being investigated, i.e., the reduction of herbage growth to a minimum by means of grazing management.

7. Botanical Studies.

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

VII. FOREST PRODUCTS INVESTIGATIONS.

1. General.

The work of the Division during the year 1941-42 has continued on the lines set out in last year's report, covering as far as possible the utilization of timber in every branch of the war effort where this material plays a part. No new major lines of investigation have been begun, but those in hand have been intensified and directed wherever possible to the most immediate solution of the numerous problems that arise.

A departure from the ordinary functions of the Division was the production for the Army of 500 wooden felloes for Army wagons using a laminated construction. This involved considerable experimentation to establish a satisfactory technique in bending and gluing to meet the rigid requirements of the specification. As there was no existing commercial plant suitable for the method evolved, and the need was urgent, the Division undertook the manufacture of the first 500. These have mostly been delivered, and the percentage of rejections by Army inspection officers was extremely low.

Use has been made of the Division's equipment and the experience of its officers to tackle the solution of some problems associated with materials other than timber, e.g., a solution was found of a difficulty which had arisen in connexion with the use of a specific type of synthetic resin in aircraft construction. Other investigations of this type covered the working out of a quick and economical method of preventing the drip of condensed moisture in Army huts, and certain problems in camouflage.

The publication of the second edition of the *Handbook of Structural Timber Design* was rendered necessary because of the rapid absorption of the first edition of 6,000 copies. Advantage was taken of the opportunity to increase the scope of the handbook. The new issue is in great demand and has proved of value to American engineering officers, who have had no experience with our local timbers and consequently needed information about them in a readily accessible form. There has also been a considerable demand for the pamphlet *Building Frames—Timbers and Sizes,* covering both permanent and temporary structures.

There has been an extension of the use of the Division's process for prevention of powder post beetle attack on veneers. Eleven commercial plants are now operating this process. Manufacturers write to say that they are using it on more and more timbers, thus bringing into use many species previously of no value. They state that no complaints have ever been received of any attack on treated veneers.

The extensive programme of construction of Army buildings, large stores, and hangars has led to a greatly increased use of timber connectors and properly designed wooden structures. In this, the Division's officers have co-operated by advising in problems of design, and by inspecting building during erection. It is correct to state that without the Division's work on connectors and the issue of its handbook, this type of structure, which leads to big saving in timber, could not have been undertaken and the erection of the buildings would have not only been more costly but greatly delayed. An Emergency War Specification covering the use of timbers in such buildings was issued by the Standards Association of Australia as No. (E.) 0.54.

Further Aircraft Standards were prepared in the Division and issued by the Standards Association of Australia. The principal timbers likely to be used for aircraft are now covered by Emergency Standards.

All branches of the Army, Navy and Air Force, the Ministry of Munitions and the Department of Supply and Development regularly seek the advice of the Division on problems connected with the use of timber, and a great deal of the time has been spent in this work. The majority of the queries can be answered as the result of the data accumulated over the past years, but new problems continually arise which call for fresh investigation.

Officers of the Division have continued to carry their work from the laboratory to the factory, and it is in this direction that a great strain is placed on the Division because of the impossibility of finding staff with the necessary knowledge and experience. In every case where a new method of manufacture is worked out or suggested by the Division, its officers supervise the initiation of the factory operations and train the factory staff, and frequently design the layout of the necessary plant. Such work has been done, for example, in connexion with manufacture of rifle furniture, battery separators, new designs for boxes, waterproof plywood for pontoons and folding boats. An officer is occupied full time in supervising the production of the wooden furniture for rifles. Others have supervised the selection, seasoning, and testing of all timber purchased for aircraft construction. The volume of work in connexion with aircraft timbers can be gauged from the fact that over 250,000 mechanical tests have been carried out and many thousands of microscopic sections of timber cut and examined.

To enable the work on flax and paper to be more satisfactorily handled, it has been found necessary to add an extension to the building. This is now well on the way to completion and will result in a great saving of time, as present operations are very widely scattered.

It has always been recognized that the one weak feature in the site of the laboratory was its limited area, but the advantages of its central position have more than compensated for this. With an increase of staff and the associated increase in volume and variety of the work done, limitations of space have naturally made themselves felt. Yet with some difficulty and much contriving the position has been met. Many factories have made their facilities available for the Division's use and have been generous in giving time and material, thus greatly assisting in overcoming the foregoing difficulty.

It has been found advantageous to break down the more or less defined boundaries between sections of the Division to meet the requirements of special problems that constantly arise. Consequently, work reported below under a section heading may be the result of the efforts of the staff in several sections. It is convenient, however, to continue to report work under section headings.

2. Wood Chemistry.

During the year the study of fundamental problems on behalf of the Australian Pulp and Paper Industry has been continued. However, on account of depleted staff and of the demands of investigations and tests related to the war effort, the research programme has not been advanced as far as could be expected in normal times.

The chemistry of eucalypt lignin has received a considerable amount of attention. Various known methods for isolating lignin from wood were explored in relation to their application to eucalypt woods, and modifications of these were developed. In addition to the extraction of "native lignin" by means of ethanol, the use of higher alcohols was considered. Likewise the use of methanol at elevated temperatures (under pressure) was studied in detail, and lignins have been prepared using dry and wet methanol (under pressure) and methanol containing hydrochloric acid (methanolysis). Lignins which have been isolated by these different methods have been found to have characteristic colours. Some have definite melting points while others show melting ranges. Both melting points and molecular weights, the latter having been determined by depression of the melting points of selected solvents, have been used in an effort to characterize the lignins.

An attempt has been made to isolate and characterize the colouring principle in eucalypt hardwoods. Dioxan was found to be a selective solvent for the colouring principle in *E. regnans,* and it has been established that the material is aldehydic in nature.

The study of the variables in connexion with the operation of the Lampen mill has been continued, attention having now been given to the beating of coniferous pulps. The limits for pulp charge, total charge stock concentration, and temperature have been established as the result of this work. Preliminary tests concerning the correlation of the Lampen mill with the Clark Kollergang have been undertaken and the technique to be followed in making this comparison has accordingly been developed. With regard to paper testing, a considerable amount of time has been devoted to the correlation of tear-testing instruments of British, American, and Australian manufacture. This study has included instruments owned by the three co-operating companies, and it is satisfactory to know that each company, as well as this Division, possesses an Australian-made tear-testing instrument which gives comparable results. In view of the difficulty in securing from overseas supplies of rubber diaphragms for Mullen Bursting Strength testers, arrangements were made to have an order filled by a local manufacturer of rubber goods. A comparison between the imported and local diaphragms using an assortment of paper has shown that, providing care is taken in fitting the diaphragms to the tester, the local article may be substituted for the imported one without loss of precision.

The Section has undertaken various minor investigations on behalf of other institutions and for other sections within the Division. These have included the analysis of woods used for battery separators, analysis and testing of papered wood cellulose used in the manufacture of nitrocellulose, paper tests in connexion with the laying down of an Australian Specification for A.R.P. blackout paper, determination of carbon dioxide admitted to certain enclosed spaces as an explosion retardant, preparation of wood extracts for trial as substitute insecticides, and the extraction of linseed oil from flax seed.

3. Wood Structure.

(i) *The Investigation of Wood Structure in Relation to Properties.*—This important phase of the Section's activities has been given priority during the year under review. Systematic examinations have been, and are being, carried out on all those species considered worthy of test as possible aircraft timbers. The results of these examinations have in all cases been correlated with the properties of the timber. Records have been thus obtained on the extent and influence of such features as brittle heart, reaction wood, rate of growth, and percentage latewood on the properties of mountain ash, alpine ash, King William pine, blackwood, silver quandong, Queensland maple, and silver ash. The tremendous amount of routine work entailed in these examinations can be gauged from the fact that every specimen of the above species tested in the Section of Timber Mechanics has been examined macroscopically and microscopically. That this routine is of considerable value has been demonstrated in a number of instances. For example, the amount of tension wood and associated brittle heart found in blackwood was such that it was considered that the selection of aircraft quality material from this species would be extremely difficult. On the other hand, preliminary examination of silver quandong for extent of brittle heart and amount of sapwood susceptible to attack by Lyctus suggested that this species was well worth further trial. Similar results were obtained in the preliminary examinations of silver ash. In the case of Queensland maple, the examination of Izod test specimens taken from material being subjected to aircraft specification tests showed that brittle heart was common in all material with Izod values less than 6 ft. lb., but that in material with Izod values greater than 7 ft. lb. brittle heart was rare. These results indicated the minimum acceptable Izod value if brittle heart is to be eliminated.

(ii) *Reaction Wood.*—The investigation of the occurrence of both compression wood and tension wood in Australian timbers and the study of the reactions and properties of such reaction wood has been continued. Material collected from young bent trees of various Victorian eucalypts was found to contain definite bands of tension wood. This tension wood was particularly distinct in some specimens of *E. regnans.* Several important results were obtained in the examination of the properties of the material containing these tension wood bands. Firstly, the relation between distribution of tension wood and distribution of brittle heart was again demonstrated. Previously, in the examination of blackwood specimens, it had been recorded that there was an association between the two, but in the investigations referred to, it was most apparent that the brittle heart zone was situated inside the tension wood bands, whereas the wood from the opposite side of the log was free from brittle heart. The second most interesting fact was the abnormal collapse of tension wood in these eucalypts during air-drying. This collapse, which was most extensive, did not respond to the normal reconditioning processes. Thirdly, the tension wood zones were much higher in basic density than normal wood from the same tree. Fourthly, the comparative analyses of tension wood and normal wood by the Section of Wood Chemistry showed the higher cellulose content and lower lignin content of the tension wood.

Tension wood was also recorded in certain specimens of silver ash (*Flindersia pubescens*), in bollywood (*Litsea reticulata*), and to a smaller degree in silver quandong. Of particular interest were specimens of Tasmanian myrtle beech (*Nothofagus cunninghamii*) submitted by the Munitions Supply Laboratories, which were of very poor bending quality and had a low impact strength. These specimens were practically 100 per cent. tension wood, and microscopic examination revealed the presence of the associated brittle heart (demonstrated by broken fibre test).

The extent of compression wood in King William pine and celery top pine has also been investigated. Whereas, in the former species, this abnormal wood was not of common occurrence and therefore not a problem, in the latter species it was extremely common, and so extensive that celery top pine can be disregarded as a possible aircraft timber. In both cases, the influence of the compression wood on the longitudinal shrinkage was most marked, and some influence on both radial and tangential shrinkages was noted.

Numerous specimens of aircraft quality hoop pine have been examined for compression wood, and it has always been found that microscopic methods are the most definite in detecting the presence of this defect. The method developed by the United States Products Laboratory, in which thin cross sections are viewed against a strong source of light, has been tried, but with not very marked success, with the various Australian timbers containing compression wood.

(iii) *Identification Work.*—The card-sorting method of identification has been applied to the timbers of the genus *Eucalyptus*. A series of 76 notched cards representing 83 different timbers has been prepared and successfully utilised. Copies of these cards have been forwarded to the Commonwealth Forestry Bureau and the State Forest Services of New South Wales, Victoria, Queensland, and Western Australia. A paper discussing the application of this type of key to, and the results obtained with, the various members of one genus was published in the Council's *Journal* (Vol. 14, No. 4).

The Section has been called upon during the year to carry out numerous identifications for the Defence forces. The total of 384 identifications completed does not include several particular jobs where, for example, several thousand super feet of timber were sorted and classified into species.

(iv) *Improved Wood Examinations.* — Numerous microscopic slides have been prepared from various test boards of improved wood made under varying conditions of pressure and treatment. All these have been examined microscopically and a record made of the amount and distribution of resin observed, the degree of compression of the individual veneers, and the general appearance of the sections. Preliminary experimental work has been carried out to obtain some information as to the actual position of the resin in the wood and to determine its presence or absence in the cell walls. This work will be correlated with the various improved wood investigations.

(v) *Miscellaneous.* — Other investigations have covered a variety of subjects, the more important being in connexion with the identification and examination of fibres for the Ministry of Munitions and others. The photographic work has again increased two-fold. Since the beginning of 1942, by the courtesy of Professor Turner of the Botany Department, University of Melbourne, Dr. Isobel Cookson of that Department has given valuable assistance to the work of the Section in a voluntary capacity.

4. Timber Seasoning.

(i) *Laboratory Investigations.*—The planned programme of work on the development of kiln-drying schedules for Australian aircraft timbers was continued throughout the year and constituted the greater part of the laboratory work of the Section. Although preliminary air-drying of such timbers and their purchase in 1-inch thicknesses wherever practicable have been advocated from the outset, schedules for drying green stock in various thicknesses are being developed. The essential difference between these schedules and those for ordinary stock of the same species is the limitation of temperatures to those found to have no effect on the ultimate strength of the timber. The information in this regard is obtained by the Timber Physics Section. Species have been dealt with in order of importance as indicated by the progress results of investigations in the Timber Mechanics Section. Schedules for several species have been completed, incorporated in Aircraft Timber Specifications, and applied in the commercial drying of timber for aircraft construction.

Investigations of a wide variety have been carried out at the request of various branches of the Army and Air Force or of associated departments. In many instances, these investigations have borne no relation to timber seasoning but have been undertaken because the equipment of the Section and the experience of its officers were of value in tackling the problems in hand. As examples of these might be cited: (*a*) the determination of the degree of permanent set caused in certain methyl methacrylate resins with temperature and relative humidity change; (*b*) investigation of an economical and simple means of preventing condensation on the under side of corrugated iron army huts.

(ii) *Direct Assistance in War-time Production.*—One officer of the Section spent the whole year in an advisory and supervisor capacity in connexion with the construction of kilns and the drying and testing of timber for rifle furniture, and it is doubtful if this production, which has developed remarkably, could have been carried on at all satisfactorily without the constant benefit of his experience. The percentage rejections have been reduced to one-tenth of the previous number.

Another officer of the Section spent the bulk of his time throughout the year in the inspection of green and partly dried stock for aircraft timber orders, being authorized to accept such stock on behalf of the Department of Aircraft Production. He also assisted this Department in the initial organization of a receiving store and resawing set-up for dried timber. This officer and one other were responsible for the supervision of all kiln-drying done in Victoria for the above Department and for the carrying out of moisture content tests on every board dried and certification of all stock as complying with moisture content specification.

Plans of kilns and drying rooms were supplied to many plants engaged on defence contracts, and advice was given during the erection and initial running of such installations. In addition, advice on the modification or improvement of existing installations was given in a number of cases, and two surveys were made in connexion with special aspects of kiln-drying activities in the Melbourne Metropolitan area. Throughout the year the correspondence course for the kiln operators was continued.

5. Timber Physics.

An essential adjunct to the work of the Seasoning Section in determining kiln drying schedules for aircraft timbers is a knowledge of the effect of the temperatures used on the mechanical and physical properties of the timbers after drying. Obviously, temperatures must be limited to those found to have no detrimental effect. Investigations to obtain this information have been completed on a total of thirteen timbers; results have been analysed, reports prepared, and a number of standard specifications for aircraft timbers have already been issued giving permissible kiln drying schedules.

An investigation of the strength of timber at low temperatures such as might be encountered at high altitudes has been concluded for twelve different timbers. In practically all strength properties there is an increase in value as the temperature is reduced and in some instances this was found to be very appreciable. The results of these tests created so much interest in the question of temperature coefficients when evaluating strength properties of timber that the work is now being extended to include high as well as low temperatures.

Further investigations have been concluded on the damping capacity or internal friction of untreated and resin impregnated or "improved" wood. High damping capacity is very desirable in materials used for aeroplane parts, for example, where vibration is likely to be serious. Results show that timber is much more highly damped than any of the metals commonly used.

The work of determining suitable Australian timbers as substitutes for Port Orford cedar for battery separator manufacture has been continued with considerable success. In particular, hoop pine and Queensland kauri are recommended for general purposes and King William pine for certain special uses such as radio batteries where vibration is not severe. Much of this work has been carried out in co-operation with the Air Force, which has assisted by supplying test batteries. Measurements of density and shrinkage have been continued, especially for those timbers suggested for use in aircraft construction. For these, a thorough survey has been made of the above physical properties. Similar measurements have also been made for a considerable number of plywoods for which it is desired to have information regarding "working" with moisture content change.

There has been little new development as far as electrical moisture meters are concerned. A preliminary investigation was made of methods suggested for controlling the moisture content of paper as it leaves the drying rollers of a paper machine, but no commercial tests have yet been made.

6. Timber Mechanics.

During the year approximately 68,000 tests have been carried out, 36,000 of which were specification tests. These exclude moisture determinations of which about 46,000 were made.

(i) *Tests on Timber for use in Spars, Ribs, Longerons, &c.*—During the year, strength tests on alpine and mountain ash were completed and tests carried out on additional air-dried and reconditioned material. The testing of blackwood and King William pine was completed, and examination of silver quandong, celery top pine, and northern silver ash has been commenced.

(ii) *Tests on Aircraft Plywood.*—During the year routine tests have been carried out on leatherwood for plywood and, in addition, a series of tests was designed to show the effect of pin-knots and other small knots. These characteristic knots were found to affect the pliability appreciably. Service tests have been carried out on this species. Routine examinations of other species included hoop pine have been continued and an investigation into the shear strength of plywood using a series of double and single shear specimens of various proportions was commenced.

(iii) *Specification Testing.*—The section carries out specification testing of aircraft timber for the Department of Aircraft Production. Species so far tested include maple, hoop pine, and mountain ash. To cope with this work, three shifts per day are being worked with the help of additional staff.

(iv) *Bending Reconnaissance of Australian Timbers.*—During the year, a number of heavy eucalypts were tested in an attempt to find suitable timbers for laminated felloe construction. Two of the timbers tested bent really well, namely, brown stringy bark and manna gum. Other species tested included red gum, myrtle beech, yellow stringy bark, blackwood, mountain ash, and blue gum; all proved satisfactory except yellow stringy bark, the gluing of which was unsatisfactory. From a production point of view, mountain ash seems to be the best proposition and field trials have been arranged. Various glues have also been tested for felloes and suitable types have been found to meet the requirements. A hot process was first developed but there were longitudinal shear failures presumably owing to the high end pressure used in the simultaneous gluing and bending. This was overcome by bending without end pressure, and by using many thin laminations. For production, prebending was finally adopted, with cold gluing, and has proved satisfactory and more convenient.

At present a small experimental production schedule is being carried out using blackwood with two laminations. Army ordnance and army inspection are arranging to observe the behaviour of wheels made of these felloes.

(v) *Testing and Design of Boxes.*—During the year factories making munition and other boxes have been visited and various problems discussed, faults corrected, and steps taken to prevent their recurrence. Work has also been done on expensive transit boxes and redesign carried through to save timber and cost. Ammunition boxes were redesigned, and tests were carried out on plywood cases for foodstuffs and condensed milk cases with 3/16 inch and ¼ inch plywood tops and bottoms. A further series of tests was arranged on a patented box with plywood sides, tops, and bottoms in one piece and solid ends with rounded corners. This box appears to have good possibilities, and stands a considerable amount of rough handling. It is considerably superior to the conventional type of box, and is now in commercial production.

(vi) *Timber Buildings.*—Observations have been made during the year on timber buildings, including hangars and workshops. The behaviour of roofs using timber connectors has been observed, deflection measurements being made in some cases. These will be followed up periodically for some years. The number of inquiries regarding timber structures has greatly increased and some structures have actually been designed in connexion with these problems. A timber factory building was also designed for the Victorian Forests Commission.

7. Wood Preservation.

Experimental work was reduced to a minimum during the year. Inspections of test plots in Victoria were made as usual, but were abandoned in other States. The creosote investigations were discontinued early in the year and the staff transferred to more important work.

The following is a brief summary of the work which has been carried out:—The installation of two test lengths of sleepers of less durable eucalypts has been completed at Heathcote Junction and Glenrowan (Victoria). Inspections were carried out of the messmate stringybark pole test plots at Belgrave and Benalla (Victoria). At Belgrave, the damage to creosote impregnated poles by decay is practically negligible. All the poles surface-treated over truewood are in reasonably good condition, but those treated over sapwood are breaking down badly. Out of twenty untreated controls nine have been condemned after ten years' service.

Efforts were made to find a suitable method of construction of a vat for the treatment of solid timber with boric acid. Wooden vats proved to be most satisfactory and a number of semi-commercial treatments were carried out in a vat of this type. Specifications were prepared for the treatment to prevent borer attack of bollywood (*Litsea reticulata*) for use in aircraft construction.

Changes which take place in Australian vertical retort creosotes when in use as wood preservatives were kept under observation, and the examination of the oils extracted from boards after six and twelve months' exposure to air and water has been completed. Tests of sludge formation in mixtures of creosotes of different boiling ranges with various petroleum oils have been carried out. They indicate that low boiling creosotes give less sludge than high boiling creosotes; oxidation of the creosote increases sludge formation; in an unoxidised creosote the sludge is derived from the tar acids; and in an oxidized creosote it is derived partly from the tar acids and partly from the neutral oil.

Miscellaneous investigations involved the testing of one proprietary brand of fire-retardant paint, recommendations for the termite-proofing of certain Defence structures, some experimental work on the fire-proofing of bark for the Victorian State Camouflage Committee, and tests on the mould-proofing of nitrocellulose storage bags.

8. Veneering and Gluing.

(i) *Veneering of Australian Timbers.*—The peeling of Australian timbers in an endeavour to find a substitute for birch (*Betula*) plywood for the stressed and lightly stressed parts of aircraft has continued throughout the year. Altogether a total of 350 billets of fifteen species has been peeled in this investigation. As reported previously, Tasmanian leatherwood (*Eucryphia lucida*) proved to be the most promising substitute and a field test of this species is under way at present time.

Thirty logs of hoop pine (*Araucaria cunninghamii*), i.e., 60 lathe lengths obtained from Queensland, have been peeled into veneer of a range of thicknesses. The veneer is being used for various test purposes.

Twenty-three billets of five different species were peeled in the investigation on match splint veneer. Mountain ash (*E. regnans*) and silver wattle (*Acacia dealbata*) proved to be most satisfactory from the peeling point of view. From considerations of supply, however, the mountain ash would be the most suitable. Trials indicated that a satisfactory match could be made from this species. It is more difficult to peel than the species normally used and the percentage of waste would be greater. With the correct technique, however, the peeling is relatively simple, and proper selection of the logs would keep waste down to a minimum. Manufacturers are now definitely interested in using this species for match splints.

(ii)) *Testing and Examnation of Adhesives.*—Three different type of urea resin glues have been studied in considerable detail and a fairly complete knowledge obtained of their use characteristics. These adhesives are likely to be of importance in the aircraft industry. for laminating wagon felloes, and for the laminating of plywood for Army huts. The information obtained has been particularly valuable in enabling an adequate reply to be given to queries from the many furniture factories and wood-working establishments who are now turning over to war work and who, previously, have never used adhesives of this type.

Close contact has been maintained with the Australian firm which is about to produce film glue. The preliminary batches of film were not up to the standard required, but as a result of assistance from the Division, a product which appears to be equal in all respects to the imported article has been produced. Australia should be able, in the future, to produce its full requirements of this essential material. Experiments carried out with a phenolic resin prepared by the Division of Industrial Chemistry have shown that it produces a suitable adhesive when impregnated into paper.

Assistance has been given in the development of a method to make rennet casein suitable for use as a plywood adhesive. It is understood that a fairly large amount of rennet casein (not needed by the plastics industry) is available and this material can be used to augment supplies of lactic casein for glue-making purposes. A large number of tests have been carried out on proprietary brands of casein adhesives, mainly aircraft cements.

(iii) *Utilization and Testing of Plywood.*—Regular tests have been carried out to determine the quality of the material being produced for use in folding boats, pontoons, &c., and also to determine the suitability of new species. As a result of this work, hoop pine, sassafras, brush mahogany, and a number of other species have been accepted for certain purposes, thus easing the drain on maple and scented satinwood which are urgently required for more important defence uses.

(iv) *Improved Wood.*—The improved wood investigations were made a joint project between the Veneer and Gluing and Timber Mechanics Sections. The staff engaged on this work has been considerably augmented by the transference of officers from within the Division and in one case by the transfer of a technical assistant from another division.

One or two developments of value to the Services have taken place and the bulk of the equipment at one producing plant was designed by officers of the Division, and its initial operation was under the supervision of the officer in charge of improved wood investigations. Apart from this class of work, attention is being given to the evaluations of resins manufactured by the Division of Industrial Chemistry as to their suitability for the manufacture of improved wood. Efforts are also being made to find a resin or resins which will give improved wood with superior mechanical and physical properties. Inquiries of late have indicated that an improved wood with electrical properties similar or better than bakelite would find extensive use. Other lines of work include the evaluation of additional species of timber for the manufacture of improved wood, its gluing and the examination of coatings.

(v) *Miscellaneous.*—Many short investigations have been undertaken to find solutions to urgent problems. These include the causes of the buckling of plywood between the ribs and stringers in aircraft and between the rails and stiles of hollow core flush doors, the laminating of thin stock to replace solid timber which cannot be obtained in a seasoned condition—shoe lasts and rollers for agricultural machinery are examples where successful results have been obtained—and the gluing of canvas bakelite sheet to wood.

9. Timber Utilization.

The work of the Utilization Section was devoted largely to technical and supply matters connected with the use of timber for Navy, Army and Air Force equipment, for munitions, and for other essential construction and requirements until August, 1941, when the Timber Control Office was set up under the Ministry of Munitions to deal with matters relating to supply. This section was consequently relieved of those problems and its attention again devoted purely to advisory and technical work. As the number of requests for assistance was large and extended into many fields, no particular programme of research was possible. Information collected during the pre-war period, and experience gained in the early period of the war, again constituted a valuable aid in the solution of many problems. Visits to Queensland, New South Wales, and South Australia were made in connexion with various investigations. The main activities during the year have been set out below:—

(i) *Advisory Work.*—Liaison with the Departments of the Navy, Army, Air, Supply and Development, Munitions, and others was maintained, and contact with the United States Forces in Australia has been established. Information has been supplied to the Aircraft Advisory Committee, Army Design Directorate, Army Inspection, Department of the Interior, Ordnance Production Directorate, Contract Board, Foodstuffs Committee, Timber Control, Department of Trade and Customs, and many others.

The section has been represented at conferences on Army bridging equipment, motor boat construction, timber economy, wagon wheel felloes, producer gas, emergency timber standards, and aircraft timbers. Advice has been given to inquirers seeking information on timbers for and the manufacture of munitions and service equipment covering approximately 50 types

ot manufacture, among which were:—Acid vats, aircraft timbers; balls for black powder grinding mill; battery separators; boat construction; cases for food, clothing, machinery, &c.; charcoal for gas respirators and explosives; cordite trucks; wireless masts; dockyard gates; machine gun slide rules; oars; pontoons; prefabricated huts; propellers; ship's fittings, decking, masts, &c.; shuttles; woodmeal for explosives; wagon poles, spokes, and felloes.

Inquiries concerning the use and manufacture of timber for essential and other civil needs covered also about 50 materials, including: Activated charcoal; agricultural machinery; air raid shelters—indoor and trench; ambulance stretchers; butter boxes; coffin manufacture; decking—bridge and wharf; fencing; fire doors; flax-spinning bobbins; handles—axe, hammer, and pick; laminated wooden constructions; matches; picking sticks; pike poles; printers' blocks; railway carriages; scaffold planks; sluice gate runners; woodwool; wooden stoppers as cork substitutes.

Information was also given on a wide variety of queries such as: substitutes for cork for insulation purposes; the nailing of Australian hardwoods; the briquetting of woodwaste and charcoal; the use of sawdust for drying and polishing metal parts; calorific value of wood; the disposal of shavings, sawdust, &c.; the marking of green timber; huon pine oil; eucalyptus oil; use of lawyer cane in lieu of imported canes; sawmill layout and speeds of circular saws; staining of timbers.

(ii) *Grading of Australian Timbers and Preparation of Standards.*—The secretarial work of the Timber Sectional Committee of the Standards Association of Australia was continued and one meeting of the Timber Sectional Committee held in Sydney was attended.

The issuing of A.S. No. (E) 0.54—*Sawn and Hewn Structural Timbers* as an Australian emergency standard, constituted the most important progress achieved during the year. This has provided a valuable basis on which large timber structures for defence and other essential purposes have been designed, and it has been extensively used by Australian Government Departments, the Allied Works Council, and the United States Army engineers. Other drafts and standards prepared and/or revised during the year included those for milled lining and weatherboards, unseasoned dressing quality sawn timber and doors.

Assistance has been given in the preparation of specifications for veneer and saw logs, aircraft timbers, veneers and plywood, and timbers for various purposes. Inspections were made of parcels of flooring and building timber, and advice was tendered to inspectors, clerks of works, and others on the major points to observe in inspecting timbers for various purposes.

(iii) *Substitution of Australian for Imported Timbers.*—Further reductions in imports caused by Customs regulations and shortage of shipping space, increased demands overseas, and war conditions in the Far East and Pacific zones caused even greater dependence on Australian timbers instead of imported timbers. During the year recommendations were made for the use of Australian timbers instead of ash, aspen, balsa, Baltic timbers, beech, birch, box, dogwood, Douglas fir, elm, greenheart, hemlock, hickory, lauan, mahogany, maple, oak, persimmon, Port Orford cedar, redwood, southern cypress, southern yellow pine, sugar pine, teak, walnut, western yellow pine, western red cedar.

(iv) *Rewriting of Specifications.*—Specifications for many wooden articles or components of articles have been rewritten to meet Australian conditions. In some instances this was relatively a simple matter, as the suggestion that one or more Australian timbers would be suitable if properly seasoned and selected to suit the particular purpose was all that was necessary. In others, the position was more complicated, and modifications of size and construction were necessary for economy reasons or to enable the use of Australian trade sizes and existing plant. The use of laminated, instead of solid, members was suggested and adopted in some instances.

(v) *Ship and Boatbuilding.*—Shipbuilding yards were visited, and numerous contacts were made with the Ship Constructors Branch, Department of the Navy, and the Directorate of Technical Services, Department of Air, in connexion with ship and boatbuilding programmes.

10. Flax Processing.

That phase of flax processing to which most attention has been directed is retting. In water retting, small-scale studies have been made of various types of ret, including the so-called "channel" or continuous retting, and of various factors which influence retting, such as temperature, temperature change, amount of dilution, and the ratio of straw to water. Operations at two new commercial water retteries, constructed by the Flax Production Committee, were commenced during the year. For the first few weeks both of these were controlled by officers of the Division of Forest Products, and during this time, technical officers of the Committee were trained to take charge.

Further work has been carried out on the method of determining the rate at which water retting is proceeding by measuring changes in the buffer capacity of the liquor. The value of such tests in indicating the progress of a ret has been demonstrated for both commercial and experimental tanks. A number of samples of water from various sources have been examined to determine their suitability for water retting. Tests have been made to determine the biological oxygen demand of the effluent from water retteries and the likely effect on the aquatic life of any stream into which it may be discharged.

Considerable advances have been made with chemical retting, and spinning tests on fibre produced by several of the processes under consideration have given very satisfactory results. A design has been prepared for a pilot plant which it is hoped to have installed at one of the flax mills during the next few months. Dew retting has received some attention, particularly the possibility of dew retting in racks to conserve the area normally required for spreading and to place the process under some degree of control, but these tests were not successful. Dew retting tests at three mills were carried out to compare summer with autumn retting.

Co-operation has been extended to the Victorian, South Australian, Tasmanian, Western Australian, and New South Wales State Departments of Agriculture and the Waite Institute, Adelaide, by retting the straw and evaluating the fibre from their flax field trials. These trials include rate of seeding, time of sowing, time of harvesting, and fertilizers as well as variety trials. In a recent investigation of the maturity at time of harvesting, an analysis was also made of the yield and quality of the oil in the seed.

The artificial drying of water-retted straw is being investigated at the two flax mills now equipped with full-size dryers. Preliminary tests of the effect of drying with and without preliminary rolling have failed to show any appreciable effect on the yield or spinning quality of the fibre, but further work on this subject has been planned. A model scutching machine has been made and used to study the action of the blades in cleaning the straw. A stroboscope has been used in making these tests, and from the results certain suggestions have been put forward which it is confidently expected will result in an

appreciable increase in line fibre yield. Tow cleaning experiments have been made to determine the value of various methods suggested from time to time. Physical and chemical tests for fibre evaluation have been developed and some of these are now extensively used. In certain cases, actual spinning tests are made to confirm laboratory fibre tests.

The shortage of fibres in general to-day has resulted in many substitutes being suggested. Samples of different plants which are thought to have possible fibre value frequently arrive at the laboratory for evaluation. In each case, a careful study is made of the fibre, of methods of extracting it, of any possible uses, and of the quantity of raw material available. One plant being examined at present, namely, *Urena lobata*, may have considerable value as a jute substitute.

VIII. FOOD PRESERVATION INVESTIGATIONS.

1. General.

The re-organization of the work of the Division of Food Preservation and Transport has been completed, and all its officers are now engaged on problems of direct importance in the war effort. Most of the investigators are engaged on problems relating either to the canning or drying of foodstuffs, and many investigations on cold storage have been temporarily abandoned.

Close liaison with food supply officers of the fighting forces and of the Department of Supply and Development has been maintained, particularly through the Scientific Advisory Committee (Foodstuffs) of the Australian Food Council. The Substitute Containers Committee of the Tinplate Board, to which this Division sends a representative, has referred a number of problems to the Division for investigation. By such co-operation, a close study can be made of the changing needs of the fighting forces and the necessary experimental investigations can be commenced with the minimum delay. The Division has co-operated with the Department of Supply and Development in drawing up, or revising, many specifications for processed foodstuffs. Several surveys of food processing plants have also been carried out on behalf of this Department.

As there are no courses of instruction available on the canning and drying of vegetables, lack of technical knowledge on the part of departmental inspectors examining these foodstuffs has been a serious handicap. Consequently, at the request of the Scientific Advisory Committee (Foodstuffs), a short, intensive course on the fundamental and practical aspects of the canning and drying of vegetables was given by the Division's officers to selected inspectors of the Department of Commerce at the Homebush laboratory. This venture proved very successful, and further instructional courses are likely to be held.

An additional laboratory has been built at Homebush, and it is being shared by the canning and fruit processing staffs. Extensive mechanical equipment for the coating of fruit has been installed in this laboratory, and it will now be possible to carry out commercial scale tests on this new method of preservation.

Owing to the need for concentrating solely on problems of importance in the war effort, the fruit storage investigations at the Government Cool Stores, Melbourne, have been temporarily abandoned, and the investigator has been transferred to more urgent work on the drying of vegetables. It is hoped that these fruit storage experiments, carried out in co-operation with the Victorian Department of Agriculture, will be resumed later.

2. Meat Investigations (Brisbane).

(i) *General.*—With the continuation of the war, this laboratory has given increased technical assistance to many branches of the food industry, involving advice, and often some investigation on problems of refrigeration, packaging, and transport. Close liaison has been established with the Deputy Controller of Foodstuffs of the Department of Supply and Development.

(ii) *Buildings and Equipment.*—To meet the need for increased laboratory space, and to provide a more adequate supply of electricity, the Queensland Meat Industry Board carried out and met the cost of the necessary alterations and additions. A pilot plant, of special design, for studies on the dehydration of foodstuffs has been installed. Initially, it is being used for investigations on the drying of beef.

(iii) *Frozen Packaged Boneless Beef.*—Reports on the first experimental shipment to Great Britain have been received, and they indicate that the beef arrived in excellent condition, while the "drip" was not excessive despite the numerous cut surfaces and relatively slow freezing. The out-turn of the second shipment late in 1941 was also very satisfactory. For both shipments, the only adverse criticism concerned what was regarded as the excessive weight of the containers. The over-all stowage density on shipboard was approximately that of boneless beef in bags, and the saving in space as against quarter beef was about 30 to 40 per cent. Further precise experimental data are required, particularly on the rate of temperature reduction of the packaged beef during freezing. This information is needed as a guide to the best methods of stacking, to ensure optimum conditions of initial temperature reduction immediately after packing.

(iv) *Interstate Chilled Beef Consignments.*—Action has been taken by the railway authorities to give effect to the Division's recommendations concerning the desirable procedures for the reduction in deterioration of chilled beef sent by rail from Queensland to the southern States.

(v) *The Ripening of Beef.*—Investigations on the ripening of beef at elevated temperatures were carried out early in the period under review. Three series of experiments were carried out. Left hindquarters were stored for two to four days at 60° F. and 87 per cent. relative humidity, with a small constant air flow, while the control quarters (rights) were stored at 32° F. and 95 per cent. relative humidity. Determinations were made of weight losses, surface moisture content, microbial proliferation, and "bloom" as a function of the physical conditions of storage. The results obtained were such as to encourage further work when more urgent "war-time" problems no longer occupy the whole attention of the laboratory.

(vi) *Packaging of Ox Kidneys and Ox Livers.*—At the request of the Queensland Meat Industry Board, extensive investigations have been carried out with the object of effecting improvements in the packaging of these edible offals for prolonged storage in the frozen condition. The experiments have not been completed, but the results so far obtained indicate that one method evolved in the course of the experiments is very satisfactory and cheaper than existing methods. No "freezer burn" occurs up to eight months' storage, and after fourteen months only very small, isolated spots.

(vii) *Moisture Content of Meat Extracts.*—An accurate method for determining moisture content within a few minutes has been evolved; it is based on the relationship between the moisture content and the specific gravity of the diluted extract. This method is proving of considerable value to meat-canning establishments, because it enables the operator to decide

rapidly the exact time when a batch should be finished off, and it eliminates any need for re-treating finished extracts to adjust the moisture content.

3. Preservation of Fish.

(i) *Freezing and Cold Storage of Fish.*—A large-scale experiment with sea mullet in which the body oil content was less than 2 per cent. indicated that the storage life in the frozen state was considerably longer than that of similar fish in which the oil content exceeded 5 per cent. Mullet showed less tendency than deep-sea flathead to the development of "dryness" and toughness in texture during frozen storage under similar conditions.

(ii) *Spoilage of Shark Flesh.*—In conjunction with the Division of Fisheries, some preliminary work has been done on the spoilage of edible shark flesh which is marketed as white fish in Victoria. Shark flesh was found to become inedible owing to the development of ammonia before there was any measurable production of trimethylamine, the bacterial end-product which is mainly responsible for the "fishy" off-flavours in most species of sea fish stored in the unfrozen state.

(iii) *Smoke Curing of Fish.*—Fairly definite indications of the upper limits of temperature and humidity for the successful curing of sea mullet and Australian salmon have been obtained. These limits for Australian salmon are not very different from those reported for British and Canadian fish, but with sea mullet it appears that considerably higher temperatures may safely be used.

(iv) *Refrigeration in the Fishing Industry.*—A circular (No. 4-P) entitled "Notes on the Application of Refrigeration to the Australian Fishing Industry" has been published and circulated amongst people engaged in the catching, processing, and distribution of fish.

4. Canning Investigations.

(i) *General.*—During the year the Division's canning investigations have been co-ordinated and greatly expanded. The officers of the Canning Section have been called upon to assist the Controller, Defence Foodstuffs, in bringing about increased production of canned foodstuffs, particularly vegetables, in Australia.

The defence authorities and individual canners have submitted to the laboratory for examination and report a large number of cases of spoilage in commercial canned foods, including potatoes, cabbage, beetroot, bacon rashers, sausages, corned beef, meat and vegetable ration, pineapple, and jams. In all these the cause of spoilage was found and positive steps were taken to assist the manufacturers to avoid further outbreaks. It was frequently found that the spoilage was caused by leaky cans, and the laboratory has devoted considerable attention to the mechanical examination of can seams and to the correct adjustment of can-sealing machines.

As a result of negotiations following the Lease-Lend agreements, the Division has established a liaison with the National Canners' Association of America for the exchange of information on all aspects of canning. Already a considerable amount of technical assistance has been given by the research staff of the American body.

On the experimental side, canning investigations have been facilitated by the installation of a high-pressure retort, equipped with an automatic temperature controller and also provided with means for rotating the cans during the sterilization process.

(ii) *Vegetable Canning.*—Vegetable canning was the least-developed branch of the Australian canning industry prior to the war. The great expansion in vegetable canning has raised a large number of problems in general canning technology which this Division has been called upon to solve. Many requests have been received for complete instructions in the canning of certain vegetables, and a comprehensive series of recommended procedures has been drawn up for distribution.

In addition to general problems, a special problem early arose in that it became apparent that most Australian canned vegetables showed very poor retention of the natural nutrients of the fresh vegetables, particularly vitamin C. This Division undertook a broad investigation into the effect of each step in the canning process on the loss of vitamin C from canned vegetables. The green leafy vegetables cabbage and silver beet, being rich in vitamin C, were specially studied. The process of blanching was found to cause the greatest losses of vitamin C, and variations in this process were investigated in the laboratory and in commercial canneries. At present a blanching treatment consisting of three minutes in steam is recommended as causing minimal losses while ensuring a canned product of satisfactory quality. This project of bringing about general improvement in the nutritive value of canned foods is being actively continued.

The threatened shortage of tinplate prompted a move to increase the weights of vegetables filled into cans. This necessitated a large number of studies on heat penetration into vegetable packs. As a result of these studies it has been possible to indicate safe processes for different filled weights of canned vegetables and to set maximum filled weights for certain products, having regard to the keeping quality, appearance, and flavour of the final product. Lye peeling of carrots and potatoes was investigated and satisfactory procedures determined.

(iii) *Meat Canning.*—The canning of bacon rashers has been a major investigation. The type of spoilage occurring in this product is described in this report under "canning bacteriology". The problem has been to give canned bacon a heat treatment adequate to prevent spoilage and yet not as severe as to destroy the quality of the pack, particularly in relation to the texture and form of the rashers. Heat penetration tests and quality studies have been made on a large number of experimental packs without reaching a completely satisfactory solution to this problem. The work is being continued.

An occurrence of black staining in canned corned beef and mutton was studied and means for its prevention by a reduced heat treatment were discovered. The Division has tested approximately 45 commercial can lacquers from the point of view of their suitability as internal linings for sausage cans. A small number of the lacquers gave satisfactory performances in sausage cans and they have been recommended to the trade.

An assignment to increase the vitamin C content of Meat and Vegetable Ration was successfully undertaken. An appetizing ration was prepared having approximately three times the vitamin C content of the standard ration.

(iv) *Container Investigations.*—The shortage of tinplate has prompted intensive investigations into substitute materials for the manufacture of foodstuff containers. A small-scale test on the use of lacquered bonderized black-plate containers for processed foods indicated that such containers will probably be suitable for some meat products and the less acid vegetables, but not suitable for more acid foodstuffs. The Section co-operated in tests of mild steel drums coated internally with beeswax as containers for honey. Over a short storage period the containers gave an entirely satisfactory performance. The tinplate industry in the United States of America has commenced the manufacture of electrolytic tinplate having a much lighter coating of tin than hot-dipped tinplate. In co-operation

with local canners, the Division is conducting tests of the serviceability of electrolytic tinplate-containers for a complete range of canned foods.

(v) *Miscellaneous.*—At the request of the Department of the Army, the production of a compressed cake of dried fruits and nuts was investigated. A formula was devised for the production of a suitable cake of low water content, and commercial products based on this formula are now incorporated in the emergency rations of the Australian armed forces. The production of a substitute for coffee was undertaken, following many requests, and a simple process has been evolved, based on the roasting of whole wheat and glucose syrup. A method of utilizing surplus wheat to produce a vitamin B1 rich wheat honey has been worked out.

5. Dried Foodstuffs.

(i) *General.*—Investigations undertaken during the year have been concerned with dried meat, eggs, and vegetables. During the first six months of the year the greater part of the time of the small staff available was devoted to work on dried meat and eggs. The staff has been increased during the past six months, making it possible to investigate some of the problems arising in the dehydration of vegetables. The co-operation of some members of the staff of the University of Sydney has been of great assistance in certain phases of the work.

(ii) *Dried Eggs.*—The two main lines of work in this field have been the development of methods for the evaluation of initial quality and the study of the storage life of a number of samples. Controlled tasting tests have been used as the basis for the evaluation of the quality of both fresh and stored samples and it has been found that the solubility of the protein is closely related to the flavour score. During the first few months of commercial production of dried egg, a large number of samples collected by officers of the Department of Commerce were tested. More recently the production of dried egg in a milk-drying plant has been followed.

Storage experiments have been carried out on eight samples of dried egg prepared in four plants and with rather different characteristics and history. Storage temperatures used ranged from 50° to 98° F., with control samples at 10° F. Samples were packed in both air and nitrogen. These experiments have shown that, in the case of a good sample held at 68° F., the changes taking place in six months are so small as to be of no practical importance and the product is still edible after ten months. However, samples of only slightly inferior initial quality may deteriorate appreciably in four months at 68° F., depending on the conditions of preparation and the quality of the pulp used. All samples deteriorated rapidly at temperatures above 85° F., although here again the change was more rapid in the case of the poorer samples. Even a very good sample was inedible after two months at 85° F. Throughout this work no appreciable difference could be detected between samples stored in air or nitrogen.

(iii) *Dried Meat.*—Samples from various sources have been examined and a system of tasting scores worked out. In the case of the dried meat it has been found necessary to rely almost entirely on tasting tests for the evaluation of quality. An extensive storage experiment investigating the effects of fat content, temperature, gas-packing, and blocking over a period of ten months is almost complete. It has been found that the products changed very little when stored in air for six months at 68° F. and were still quite palatable after eight months. There was less deterioration in the samples packed in nitrogen or compressed into blocks, but it is not possible to predict the increase in storage life with any exactness. One unexpected result has been the marked deterioration in the flavour of samples stored in air at 50° F. Samples stored at 98° F. developed a slightly burnt flavour but remained palatable for four to six months. A smaller experiment in which oat flour was incorporated in the mince before drying has not yielded any definite results.

(iv) *Dried Vegetables.*—In this field more work has been done on the preliminary processing and drying of the vegetables than on the storage of the dried vegetables. Vegetables studied have been potato, carrot, parsnip, cabbage, and onion, and in less detail silver beet, beetroot, swede turnips, and sweet peppers. Losses in the ascorbic acid and carotene content of vegetables during blanching by different processes and during the subsequent drying have been studied to determine the best methods for commercial practice. Work has also been done on processing in commercial plants. The dried products have been studied with respect to moisture content, vitamin content, power of reconstitution, and palatability. Experiments are in progress to determine changes occurring during storage.

6. Microbiological Investigations.

(i) *General.*—Some alteration and expansion of the activities of this Section has occurred during the year. In the early part, egg investigations were resumed at Melbourne, and both there and at Sydney these required the major part of the investigators' time. Subsequently, problems in the bacteriology of canning formed an increasing portion of the work in hand at the Sydney laboratory. Much of the work on canned foods is of an urgent nature, and extra staff has been engaged to cope more effectively with the increased volume of work. Studies on mould wastage in apples have been continued, but are now being reduced in favour of more urgent work.

(ii) *Egg Investigations.*—(*a*) *Cleaning and Storage Experiments at Sydney and Melbourne.*—In co-operation with the Egg Producers' Council, investigations on the storage of eggs were continued in five States. This Division planned the experiments, which involved a heavy programme of bacteriological work. It was reported last year that the micro-flora of egg shells showed considerable changes in its constituent type after passage of the eggs over certain cleaning machines. The technique for these determinations was improved by mechanical aids in washing the bacteria from the egg and by the addition to agar of small quantities of Crystal violet which enabled an approximate determination of Gram-negative bacteria to be obtained by the plate-count method. Determinations on the shells of several hundred eggs were carried out and the results examined in relation to the wastage observed after storage of the various treatment lots.

The main conclusion was that the wastage induced by cleaning on certain machines was due primarily to the rot-producing bacteria which the machines transferred to eggs passed over them. Similar cleaning machines which, due to their new condition or effective cleaning and disinfection, carried only low numbers of bacteria did not enhance wastage in eggs passed over them. The interchange of eggs and cleaning machines on different farms has shown that the method of cleaning, rather than the origin of the eggs, is the important factor which controls both wastage in the stored eggs and the bacterial population of the shells of the cleaned eggs. The importance of other factors contributing to bacterial spoilage has again been found to confirm previous experience.

(*b*) *At Sydney.*—Experiments on the actual mechanism of infection were continued and considerable progress has been made. It is hoped that these studies will enable safer methods of cleaning to be devised. Detailed measurements on some physical factors in egg

shell quality were made on eggs from the storage experiments. No significant relation between these measurements and the development of rotting could be demonstrated.

(*c*) *Egg Pulp Bacteriology* (*at Melbourne*).—The dried whole egg now being produced in Australia is prepared from eggs which usually have been cleaned and often stored for some time. Rots are often numerous in such eggs and are rejected when the eggs are cracked. The bacterial content of commercial pulp produced from such eggs has often been high. When pulp is produced under carefully controlled conditions, to exclude eggs of doubtful quality, the bacterial content of the pulp rises sharply with the number of eggs rejected. There is, therefore, a need for the bacteriological grading of pulp which has been prepared from stored eggs containing some rots. Experiments are now in progress in which it is hoped to develop a simple rapid method for the evaluation of the bacteriological quality of egg pulp under industrial conditions. Promising results have already been obtained with dye-reduction methods, and the methylene-blue method used for milk grading would be suitable for detecting inferior grades of pulp. The use of resazurin promises to be more rapid and somewhat better adapted for use with pulp of better quality. These investigations are proceeding, and it is hoped that an outline of suitable standard procedures for the industrial application of these tests will shortly be available.

(iii) *Canning Bacteriology.*—Work in this field is expanding rapidly, and already detailed bacteriological examination of some 130 cans representing twelve products has been completed. Much of this work has been with spoiled commercial packs, and information has been forwarded to other government departments or to the processors enabling the faults to be rectified. Other examinations have been of experimental packs processed in the canning laboratory. All work is carried out in close co-operation with the Canning and Physics Section of the Division.

The calculation of adequate thermal processes for canned foods is carried out jointly with the Physics Section; this Section undertaking the necessary determinations of thermal death times of bacterial spores. The Department of Bacteriology, University of Sydney, is rendering valuable assistance by carrying out some of these determinations.

Detailed work on the spoilage of canned bacon rashers has been in hand for some time. Spoilage in the products from several canneries has been found to be caused by many different strains of *Bacillus.* They all reduce nitrate, are well adapted to grow in the high salt content of the bacon, and produce carbon dioxide from suitable sources such as the sugar used in curing. Owing to the variability in curing practice, bacons have been found to vary widely in respect of the concentration of several of the curing ingredients. Some of these variations have a profound influence on the ability of the *Bacillus* strains to grow in the can, and certain underprocessed material may remain commercially sterile or spoil only very slowly. Canning trials with bacon produced in experimental cures have helped to elucidate many of the factors involved and it is expected that useful information shortly will be available for those engaged in canning this product.

The question of botulism in relation to canned foods is under consideration, and a bacteriologist from the veterinary staff of the New South Wales Department of Agriculture is being seconded for work on this problem. The importance of this health hazard cannot easily be overestimated, particularly as it is desirable to maintain processes at the minimum safe level in certain packs for defence requirements.

(iv) *Mould Wastage in Apples.*—Surveys of the extent of mould wastage and the pathogens involved were continued with the 1941 crop. The principal pathogens continue to be species of *Gloeosporium* and *Penicillium.* It is not proposed to continue these detailed surveys for the present. Of the control measures tested last year the only successful one was the use of Bordeaux spray (3:3:80) about ten days prior to picking. This gave a useful and significant control of *Gloeosporium* wastage in Jonathan apples from Batlow. An indication of control in Delicious apples from the same district was not significant. Inoculation by spraying two maturities of Delicious apples from Batlow with conidia of *Gloeosporium* had no effect on wastage by this fungus, irrespective of whether the fruit had or had not previously been partially disinfected by immersion in hypochlorite solutions. In another experiment with Granny Smith apples the use of hypochlorite dips failed to confirm overseas reports that this treatment would control wastage by *Penicillium expansum.*

In conjunction with experiments on skin coatings for apples, nine different fungicides are being tested for their possible use as control agents. Each fungicide was used as a dip, prior to the application of the emulsion, and also by direct incorporation in the emulsion. It is hoped that some treatments may prove effective in overcoming the increased mould attack which sometimes follows the use of these emulsions.

In co-operation with the Department of Botany, University of Sydney, studies of the rate of growth of fungi inoculated into apples were carried out. One strain of *Gloeosporium* sp. and one of *Penicillium* sp. were used, each in Delicious and Granny Smith apples from Batlow and Orange and stored both at 32° F. and 40° F. Measurements of the rate of radial advance of the fungi revealed considerable differences due to maturity, district, and variety. More mature fruit was generally more susceptible to invasion. Granny Smith fruit from both districts did not differ in susceptibility, although Delicious fruit from Batlow allowed a greater rate of fungal advance. Differences due to variety, although often considerable, were not consistent for the two districts. This work is being continued this year and the experimental procedure modified to determine whether the resistance of the tissue to invasion is due primarily to physical or chemical factors.

7. Fruit Storage Investigations.

(i) *At Sydney* (*in co-operation with New South Wales Department of Agriculture*) (*a*) *Apples.*—Long term investigations on the various factors associated with the keeping quality of apples have been discontinued, and attention has been concentrated on the use of skin coatings for prolonging the storage life of fruit under the unrefrigerated storage conditions of the packing shed. A thin protective film of oil or wax is placed on the skin of fruit by immersing it in a solution of castor oil and dewaxed shellac in alcohol (a method suggested by Tomkins of the Low Temperature Research Station, Cambridge), or in a water base emulsion of oil or wax. The alcoholic solution dries rapidly and can be used for hand dipping fruit in the packing shed. Emulsions are more difficult to prepare as they have to be finely dispersed to give a bright and clear film on the fruit. They are slow drying and can only be used satisfactorily in packing sheds equipped with a dipping tank and hot air tunnel for drying the fruit. Skin coatings may induce alcoholic flavours and internal breakdown in very immature fruit, large fruit, or in fruit from trees bearing light crops, especially if atmospheric temperatures are high when the fruit is being treated. However, under conditions prevailing in the apple-growing districts of New South Wales and Tasmania, the later maturing varieties have given very

satisfactory results. Experiments during the two previous seasons have demonstrated the value of skin coatings for prolonging the storage life of apples in cool storage and under shed storage conditions. Fruit treated with skin coatings retains its fresh condition, flavour, and colour longer, is less wilted than untreated fruit, and can be stored at temperatures above the range at which low temperature disorders develop without reducing its available cool storage life. Thus, the incidence of bitter pit and the skin blemishes of Jonathan spot, lenticel, and late scald, which invariably result from storage at higher temperatures, is markedly reduced by skin coatings. The ripening of fruit after removal from cool store to warmer atmospheric conditions is also delayed by treatment. The extension of storage life of many of the chief varieties grown in New South Wales and Tasmania has been of the same order as that obtained by the less practicable method of gas storage.

Commercial trials are being conducted in the various apple-growing districts of New South Wales, and quantities of Jonathan, Delicious, Granny Smith, Rome Beauty, and Democrat apples have been hand dipped in an alcoholic solution of castor oil and dewaxed shellac and stored in the packing shed. Smaller lots of Granny Smith apples have been treated with an emulsion of oil and wax with the object of using this coating to replace the imported oiled wrapping paper for controlling superficial scald. The results already obtained by treating Delicious apples with skin coatings have been very satisfactory. Considerable quantities of various varieties of apples are also being treated in Tasmania under the direction of officers from the Division of Plant Industry. Experiments with skin coatings on Jonathan apples grown in Victoria are being carried out in this laboratory and semi-commercial trials are being conducted by the State Departments of Agriculture in Western and South Australia.

Considerable attention has been given to the preparation of emulsions of wax, oil, and mixtures of wax and oil, and in determining their effect on water loss from fruit and on the resistance of the fruit to the diffusion of oxygen and carbon dioxide. Oil emulsions restrict the diffusion of oxygen more effectively and spread more readily on the waxy surface of an apple than wax emulsions, but they give the fruit an unattractive and oily appearance. The incorporation of wax and shellac into an oil emulsion results in a bright and attractive film, and the spreading power of a wax emulsion is considerably increased by using a mixture of three parts of wax and one part of mineral oil. The preparation of these mixtures is dependent on the hydrogen ion concentration of the emulsifying agent, and finely dispersed emulsions can be obtained with sodium carbonate and oleic acid. Emulsions containing paraffin wax can only be prepared in a finely dispersed state when waxes such as carnauba, lac, or beeswax containing hydrophilic groups in the molecule are incorporated. There is a very limited supply of these waxes in Australia, and the possibility of using wax extracted from sugar cane residues is being investigated. Emulsions of paraffin wax and sugar cane wax have now been prepared.

Experiments with emulsions have been carried out on a laboratory scale by dipping small quantities of fruit and drying it on trays. There are, however, certain technical problems associated with waxing fruit commercially, and to aid in their solution a commercing plant with dipping tanks and an air drying tunnel has now been installed in this laboratory.

Certain fundamental work is being conducted on the effect of the thickness of various skin coatings in relation to the size, maturity, and the variety of fruit and the temperature of storage. Samples of fruit are being examined for wastage after definite intervals. The effect on the metabolism of Granny Smith and Delicious apples is being investigated in conjunction with officers of the Botany Department of the University of Sydney by studying the changes in external respiration and in the composition of oxygen and carbon dioxide in the intercellular spaces of the apple.

There is a very marked temporary increase in the internal carbon dioxide concentration of fruit treated with alcoholic solutions, but this does not occur when emulsions are used. This probably indicates that carbon dioxide diffuses through the continuous soap phase in which the wax of oil particles are dispersed. All coatings increase the resistance of the fruit to the diffusion of oxygen and the respiration rate is related to the internal oxygen concentration. Although the greatest reduction in internal oxygen concentration is obtained at the highest temperature, the relation between temperature, internal oxygen concentration, and external respiration rate appears to be very complex.

The rate of colouring in both untreated and treated fruits is related to the internal oxygen concentration in the tissues and is markedly retarded by most skin coatings.

(*b*) *Pears.*—During the 1941 season, Packham, Bosc, and Winter Cole pears were stored at 30° and 32° F. in air and at 32° F. in an atmosphere containing 5 per cent. of carbon dioxide and 16 per cent. of oxygen. These varieties were also treated with an emulsion containing 5 per cent. wax. The storage life of the Packham variety was 4½ months at 32° F., 5½ months at 30° F., and 6½ months in gas storage. The Winter Cole variety kept 4½ months at 30° and 32° F. and 7 months in gas storage. The Bosc variety which has given very unsatisfactory results during the previous seasons only ripened normally when kept in gas storage and when treated with the wax emulsion. The storage life of the Bosc pear in both treatments was 4½ to 5 months.

(*c*) *Chemical Investigations.*—During 1941, an investigation was carried out on the natural waxy coating of the Granny Smith apple, in order to determine its influence on gaseous exchange and on the response of the fruit to artificial waxing. With this object a large sample of dried peelings was extracted with petroleum ether. The crude extract was separated by means of acetone into fractions: (*a*) a hard wax, melting at 62°–69° C., which appears to be similar to that isolated by other investigators and composed mainly of unsaponifiable material (hydrocarbons and higher alcohols), and (*b*) a saponifiable oil, which solidifies at about 50° C., and exhibits quite a considerable degree of unsaturation (iodine value 66). During storage the amount of petroleum ether extract tended to increase, more particularly at higher temperatures. There is evidence that the greatest increase is in the oily fraction, as the saponification value of the petroleum ether extract tends to increase during storage. These changes can be correlated approximately with changes in the resistance of the cuticle to gaseous exchange (calculated from measurements of respiration and internal atmosphere).

After removal of the petroleum ether soluble material, the peelings were subsequently extracted with sulphuric ether. The amount of the second extract showed little change during storage, and, in ripe apples, appeared to be mainly ursolic acid. Probably other substances are present at picking as indicated by changes in the saponification value during storage. Most of the work was done with extracts of dried peelings, in which the lipoid substances of the cuticle were contaminated with pigments and other substances derived from the cells immediately beneath the cuticle.

It was found that the cuticular lipoids could be extracted fairly completely with little contamination by (*a*) extraction of whole intact apples with boiling petroleum ether, or (*b*) extraction of fresh undried peelings with petroleum ether, or (*c*) separation and subsequent extraction of the cuticle after soaking the peeling in dilute ammonium oxalate solution for several days. The first method is by far the most convenient and rapid.

Extractions were also carried out on artificially waxed apples, but the whole of the added wax was never recovered. A considerable amount of time was also devoted to routine chemical analyses of stored fruit; and to determination of alcohol and acetaldehyde in apples, in order to correlate with data obtained in the studies on internal atmospheres. A preliminary investigation was carried out on the factors responsible for development of bitterness in orange juice after extraction. Evidence of reduction of bitterness was obtained by reducing the acidity (above pH 4).

(ii) *At Melbourne (in conjunction with the Victorian Department of Agriculture).*—(*a*) *Apples (Air Storage).*—Jonathans were stored with eight temperature treatments, three sizes, three maturities, and three examinations being used. Scald was severe only in the second pick, where fruit stored initially at 32° F. or 36° F. was severely affected, but that stored initially at 40° F. was free from this disorder. Breakdown was found in all picks and was least severe in the fruit stored initially at 40° F. Jonathan spot was severe in fruit stored continuously at 36° F. or higher, but was largely controlled if the temperature was reduced to 32° F. at the end of April or May. The effect of increased storage temperature is thus to increase Jonathan spot and decrease breakdown and scald. The most satisfactory temperature treatment was 40° F. to the end of March, 36° F. during April and 32° F. thereafter. Breakdown was most severe in the larger fruit and spot in the smaller. Bitter pit in the Granny Smith variety was increased by delay in storage and decreased by later picking. The incidence of pit also increased with rising storage temperatures.

(*b*) *Apples (Gas Storage).*—Jonathan, Delicious, King Cole, Rome Beauty, Democrat, Stewart, and Granny Smith varieties were stored with five carbon dioxide treatments, the temperature being 36° F. until the end of April, 34° during May, and 32° F. thereafter. One examination was made in late November. In susceptible varieties (Jonathan, Delicious, Stewart) there was a very high incidence of breakdown, especially at 10 per cent. CO_2. In other seasons Stewart had given good results in gas storage. The breakdown this season was worst in the second pick. It is perhaps relevant that the fruit was very large (average 3 in.). Jonathan spot was, as in previous work, controlled by the gas treatments. It is possible that, as in the air storage experiments, a higher storage temperature in the initial stages might control breakdown, in which case gas storage for the Jonathan varieties would offer definite advantages. King Cole kept excellently both in air and gas. This very attractive red dessert variety is a much better storage apple than the Jonathan but is not as yet widely grown. Delicious kept badly both in air and gas, wastage from breakdown and mould being high. Rome Beauty showed little waste in any treatment but the condition of the gas-stored fruit was superior. Democrat gave excellent results in all gas treatments. Gas-stored Granny Smith fruits were in markedly better condition than the air-stored controls, and bitter pit was much reduced. Superficial scald was severe in the first pick gas-stored fruit, even with oil wraps, although these controlled it in air.

(*c*) *Waxing Experiments.*—Waxing with a castor oil—shellac mixture eliminated Jonathan spot but increased mould in this variety and also in Rome Beauty, Democrat, and Delicious. No difference from the controls was found with Stewart or King Cole. Pit was much reduced in Granny Smith. Waxing inhibited colour changes in Granny Smith even after prolonged storage at 60° F.

(*d*) *Pears.*—Gas-stored pears gave much increased life in the early varieties, Williams, Bosc, Packham, but little in the late varieties Winter Nelis and Winter Cole.

(*e*) *Peaches.*—Spectacular increases in storage life were obtained by holding the fruit for three days at 60° F. before transfer to 32° F., the results being consistent for all varieties tested (Zerbe, Smith, Millicent, Catherine Anne, Late Crawford). These results have been confirmed in the 1942 season. A storage life of 7–10 weeks is now possible with these varieties.

(*f*) *Plums.*—Fruit was picked rather immature and delayed storage experiments on the same lines as for the peaches carried out. Greengage ripened successfully in all treatments, Cole's Golden Gage did best with immediate storage, and President, Grand Duke, Satsuma, and Jefferson failed to ripen in any of the treatments, though they could be held in good cooking condition for several weeks. In 1942 the plums were given longer delays before cool storing, and six days' delay at 60° F. gave considerably increased storage life with King Billy, Satsuma, and Grand Duke, but reduced the storage life of President and Cole's Golden Gage. These two varieties are juicier than the others, though still firm, at the picking maturity and it seems that delayed storage only allows them to become overripe.

(*g*) *Oranges.*—Washington Navels were treated with a number of waxes but none was found to give any advantage over the controls.

(*h*) *Lemons.*—Five case units were sweated at 70°F. for one and two weeks and subsequently stored at 40°, 45°, and 50° F., together with controls stored immediately at each of these temperatures. Both sweating treatments gave similar results, being much better than the controls. At 40° F. the control fruit showed 40 per cent. mould after three months and 94 per cent. after four months' storage, the corresponding figures for the sweated fruit being 6 per cent. and 18 per cent. Similar results were obtained at the other two temperatures, but the amount of mould in the controls was somewhat less, although still much higher than in the sweated fruit, except at the four month examination of the fruit at 50° F. where mould was high in all treatments.

(*i*) *Grapes.*—The main experiment was a continuation of earlier work on the control of mould in storage by various chemical treatments of the packing materials, using the varieties Gordo, Purple Cornichon, Waltham Cross, Ohanez, and Black Malage. A small experiment indicated that rice hulls, an Australian product available in large quantities at low cost, provide a satisfactory substitute for the cork previously used in the packing of export grapes. The only treatments giving satisfactory and consistent control of mould attack were those using cork which had been sprayed with iodine. This treatment has given very satisfactory results over a number of seasons, but its practical application seems unlikely owing to the high cost and the difficulties of applying the treatment in the packing shed.

8. Fruit Products Investigations.

(i) *Fruit Juices.*—Considerable activity in the production of fruit juice concentrates has occurred during the year. This work was made possible by the installation of an improved type of vacuum concentrator designed on the heat-pump principle and by the acquisition on loan of a small steam-jacketed vacuum pan.

The demand by the defence services for citrus juices for anti-scorbutic purposes has caused a sudden expansion in the production of pure citrus juices. The Division has given direct assistance to the industry in achieving a greatly increased output of good quality, deaerated, and pasteurized citrus juices retaining a high content of vitamin C. Attempts to prepare Washington Navel juice free from bitterness have not been entirely successful, but the difficulty has been avoided by producing a palatable beverage from blended Washington Navel and grapefruit juices. The possibilities of using citrus juice concentrates as rich sources of vitamin C were investigated. Orange juice concentrates of satisfactory quality and retaining 80-90 per cent. of the original vitamin C were prepared in both the concentrator and the vacuum pan. Open pan concentration yielded a concentrate less satisfactory in palatability and vitamin C content.

Investigations on the processing of apple juices were continued with the varieties Jonathan, Granny Smith, Delicious, Scarlet, Rome Beauty, and Alfriston. Particular attention was given to the problems of apple juice clarification, concentration, mould control, and Bochi tank storage. Freshly pressed juices of several varieties were successfully stored by the latter method, i.e., in stainless steel tanks at a temperature of 40° F. and under a high pressure of carbon dioxide.

Owing to the difficulty in obtaining commercial preparations of pectolysing enzymes, the gelatin-tannin method of juice clarification was thoroughly investigated. This method was satisfactorily applied to juices from several varieties. The clarified juices gave satisfactory concentrates, free from gel formation, when evaporated in the vacuum concentrator. By adding back the condensed ester to the cold concentrate a product of improved apple flavour and aroma was obtained.

The regular testing of apple juices and ciders under the Australian Apple and Pear Board Certification Scheme has continued throughout the year. There are now 18 apple beverages, from five States, which bear the seal of approval. The standard of quality of many of these products has been raised by direct technical assistance given to the manufacturers. Investigations on other fruit juices, including prune juice, pineapple juice, and tomato juice have been on a reduced scale owing to the pressure of war-time problems.

(ii) *Products Rich in Vitamin C.*—The importance of developing adequate sources of supply of vitamin C led to the investigation of certain fruit products known to be rich sources of vitamin C. Of special interest in this connexion were extracts prepared from rose hips. Rose hips collected from a number of areas in the eastern States had vitamin C contents ranging from 300 to 800 mg. per 100 g., the higher values being associated with hips from Southern Tasmania. Extracts and concentrates, containing up to 1200 mg. per 100 g. vitamin C, were prepared from the hips and were successfully incorporated in such products as jam, tomato soup, tomato sauce, and baked beans in tomato sauce. Commercial canned blackcurrants and blackcurrant juices had vitamin C contents of the order of 150 mg. per 100 g. It was also found possible to prepare a concentrated aqueous extract of passion-fruit skins which at present are not utilized in any way. The extract contained 100–150 mg. per 100 g. vitamin C, and attempts are being made to incorporate it successfully in certain food products.

9. Physical Investigations.

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

(ii) *Wrapping and Packaging Materials.*—Many additional wrapping materials and packages have been tested for permeability to water vapour. With a number of containers the relative importance of various likely paths for water vapour transfer have been investigated. A direct test of the suitability of a number of containers, of materials other than tinplate, for the storage of various dried foodstuffs under tropical conditions has been carried out, and a summary of the results has been submitted to the Substitute Containers Committee of the Tinplate Board. Tests for the tainting of various dried foodstuffs by packaging materials themselves, or by the penetration of taint producing substances through the packaging materials, have also been carried out.

(iii) *Wilting of Fruits.*—A few further tests with oranges have shown that the differences in the direct effect on rates of water loss of different processing machines is very large, varying in fact from an effect of little practical importance to one that is so large that the effects of detergents are almost completely masked. In co-operation with the Griffith Irrigation Research Station, measurements were made of the weight losses in apricots between the time of picking and loading on the train and during the rail journey to Sydney. Some measurements of the rate of evaporation under constant conditions were also made in the laboratory.

(iv) *Cooling of Wet Body.*—Some further measurements and calculations have been made but more urgent jobs have delayed work on this project.

(v) *Canning Problems.*—In order to estimate adequate heat processes for a number of vegetable and meat packs which have recently been introduced in Australia, rates of heat penetration have been measured using a thermo-couple system. With many of the vegetables the effect of put-in weight has been in the main subject for investigation. Most of the measurements have been carried out in a small retort in the laboratory, but measurements have also been made on a number of packs in commercial canneries.

(vi) *Dehydration of Foodstuffs.*—A laboratory size drier using recirculated hot air has been constructed and used for obtaining data on the drying of vegetables and also meat. The data obtained have been used in designing dehydrators for commercial operation. Some tests on the drying of vegetables have been carried out on commercial and semi-commercial drying tunnels of the counterflow type. A small roto-louvre drier has been constructed in the laboratory and found useful for drying some products, particularly apple rings.

IX. FISHERIES INVESTIGATIONS.

1. General.

During the past year the preliminary examination of most of the south-east Australian area, with reference to possible development of pelagic fisheries, was concluded, although final tests in tuna-seining by skilled personnel are desirable when this is possible. Arrangements for such tests were nullified by war developments. Pole-fishing for striped tuna will likely give rise to a considerable industry if a regular supply of live bait can be guaranteed. Experiments were begun to determine whether this is possible. There also appear to be good possibilities of establishing small or moderate local pelagic fisheries, based on small boats operating small modified purse-seines in bays or semi-sheltered waters—e.g. in south-eastern Tasmania for sprats, mackerel, and salmon, in the bays of the east coast for pilchards chiefly, in Port Philip for

anchovies and occasional pilchards, and in South Australia for pilchards, anchovies, and sprats. Increased attention has recently been given to improvement of methods of mass-catching of inshore fish such as salmon for cannery purposes, this work being particularly apposite during the present crisis when increased output per man-power unit is important. A survey of the distribution and biological characteristics of edible and other sharks has been inaugurated with the object of stabilising or, if possible, increasing the supply of vitamin-rich oils for the recently established and successful fish oil industry. Tagging of sharks is being included in this work in order to further knowledge on migrations and seasonal distribution. The past year saw the beginning of commercial agar production, and progress has been made in the study of red seaweed distribution and of chemical and physical problems encountered in the manufacturing process. General biological and oceanographic studies were conducted on a reduced scale during the year, but continuity was maintained where necessary for the supply of basic information on the fluctuating course of the major fisheries or on possible new fisheries. To facilitate contact and co-operation with fishery administration officials and with the industry generally, the publication of a periodical newsletter was commenced. In this production, the progress of the work of the Division is summarised in popular form, and occasional articles of general interest are included.

2. Technological Investigations.

(i) *Agar Research.*—Agar research has been intensified this year so that not only the medical requirements of Australia could be met at an early date, but also the rest of the Australian demand. The studies have been carried far beyond the preliminary stages required to establish the fact that industrial manufacture is possible, and a great deal of detailed information has been obtained.

The seaweed used in *Gracilaria confervoides* which occurs in a number of inlets on the New South Wales coast. The weed is harvested, either on the beach or from the sandy beds on which it grows, and is dried and bleached on the shore. It is then baled and sent to the manufacturer. In the factory, it is again washed and is minced and digested at 95° C. with live steam at pH 5.0. When digestion has proceeded for enough, the solid matter is allowed to subside and the liquor is run off and filtered with activated carbon and filter aid. The sludge is centrifuged or filtered hot through bags and the solid material boiled again and filtered. The resulting liquor is used in the digestion of fresh weed. The filtered liquor is allowed to set, and is frozen on ice cans. It is later crushed in an ice crusher, thawed, and washed in water; the water is removed by a hydro-extractor. The agar is finally dried by any convenient means. Agar manufacture has now begun in Sydney, and two firms are in production of small quantities. There seem to be possibilities of producing agar at a price which will allow of export even in peace-time and at pre-war prices owing to the comparative ease of harvesting the raw material.

Studies have begun on the preparation of carrageen (Irish moss). This is also prepared from red seawoods, but has rather different properties from agar. Besides its use in medicinal preparations, it has general uses as a stabilizer for emulsions. The preparation of alginates from the kelp or brown seawoods is also under consideration. These, too, are used as stabilizers, and their manufacture may prove highly important. The question of stabilizers is of great importance. Those normally used include gum tragacanth, gum acacia, and karaya gum, which are now in short supply. The most likely substitutes are agar and agaroids such as carrageen, and the alginates, which have varying properties, but are related to the plant gums and pectins.

(ii) *Salt Fish.*—In view of the world shortage of tinplate, studies have been made on the salting of some of our common fish such as mullet and salmon. As there is likely to be only a very limited amount of refrigeration available for fish, it is thought that it may be desirable to use salt fish and marinated fish for storage as emergency food supplies or as rations for the Army. In this way, fish not usually marketed could be preserved and used. Many of the varieties concerned do not keep well under ordinary conditions, but could be pickled in brine on board and kept in perfect condition. In this way the inshore fisheries might supplement more adequately the offshore trawler fishery which has been reduced by the war.

(iii) *Shark Preservation.*—Studies begun in conjunction with the Division of Food Preservation have been continued. It has been shown that bacteria produce ammonia from shark flesh and that they do so almost solely when in contact with air, i.e., in the surface layers. This means that the skin should be cut as little as possible and that ammonia production is heaviest at the cut surfaces of the nape, the belly flap, and the vent. Removing these cut surfaces gets rid of the ammonia, provided that it has not penetrated too deeply into the flesh. The reason for the intensive research in the shark is that from it Australia is already producing her own supplies of medicinal vitamin oils, and even using some of these oils to vitaminize margarine.

(iv) *Fish Oils.*—Studies on fish oils are continuing, and the most noteworthy experiment has been the treatment of 3¼ tons of offal from the Sydney fish market. This showed that about 50,000 gallons of oil suitable for poultry and stock food is being wasted each year by the failure of the fish markets of the eastern States to treat their offal. The test showed, too, that this offal could be treated and show a profit, provided the right plant were installed and the capital cost was not too great. The California Press was the type used, and a similar screw press is recommended. Such plant could be erected for a relatively low cost and would be most efficient in operation. Other work on vitamin oils is proceeding, and some useful information has been gained on the oils of other fish, including the black-fin shark and the northern blue-fin tuna. Consideration is being given to the standardization of methods for determination of vitamin potencies in Australian fish oils.

3. Tuna Investigations.

The principal activity during the year has been the continuation of practical fishing experiments with the various types of gear used overseas. Previously, the live-bait method of fishing had been tested, and the evidence pointed to its being successful with the striped tuna shoals in north-eastern Tasmania if the bait problem could be solved (*see* section 4 below for experiments in this field). During the year under review, the Division's investigation vessel, m.v. *Warreen*, was chiefly employed in intensive testing of the purse-seine gear, both on the southern blue-fin and the striped tuna—the two most abundant species of commercial importance. In both cases the results were disappointing and give little encouragement that this type of gear will be capable of any extensive commercial use for tuna production in south-eastern Australia. The comparatively small number of calm days and the erratic changeability of the weather, for which the coast is noted, are a serious obstacle. In addition, the shoals of striped tuna proved too "wild" to be caught even when the weather was favorable.

With regard to troll fishing, a test by commercial vessels was subsidized both in the Tasmanian area and in New South Wales. Both resulted in failure, and the New South Wales experiment, from which more success was hoped, suffered from a poor tuna season. The available data suggest, nevertheless, that trolling in New South Wales for southern blue-fin (the main species caught by this method) can only be regarded as a borderline fishery, suited to the operations of small boats with low operating costs. The matter is entirely one of economics, however, and were the Californian scale of prices ruling, a rather brighter conclusion might be drawn.

Possibilities of a beach-net or trap fishery for a third species of tuna, the northern tuna (*Kishinoella tonggol*) have been investigated and a short report has been published in the Council's *Journal*. This method has the advantage of a very small overhead cost compared with the standard methods of tuna fishing as usual in California, but the question remains whether the species is abundant enough to make it a reasonably profitable fishery. Additional data are being sought on this subject.

Biological work on the tuna species continues on the lines laid down in former years. The survey of South Australian waters was continued with the co-operation of Mr. K. Sheard, of the South Australian Museum, and again the commercial canneries in New South Wales and Tasmania lent every facility for the collection of biological data.

4. Clupeoid Fish Investigations.

Clupeoid Fishes (Pilchards, Sprats, Anchovies, &c.).—Investigations have proceeded on lines indicated in earlier reports, relating principally to the pilchard, sprat and anchovy.

(i) *Pilchard (Sardinops neopilchardus).*—Shoals of medium-sized spawning pilchards were abundant as usual off the New South Wales coast in the autumn and winter of 1941, and were also present at the same seasons in 1942. The spring shoals of small pilchards were also present in 1941, but not as abundantly as in the previous year. Apparently these spring pilchards, like the anchovies of these waters at the same season (*vide infra*), vary considerably in abundance from year to year.

Studies on age and rate of growth of New South Wales pilchards have reached an advanced stage. The results indicate that the fish attains an age of one, two, three and four years at mean lengths of about 4, 6, 7, and 8 inches respectively, and that probably few fish survive to any greater age. These conclusions, together with those derived from other lines of investigation, have given a fairly clear outline of the somewhat involved life-history of the species, which it is hoped to publish later.

Fishing experiments with a large purse-seine net for these fish are in progress at the time of writing, but so far have not met with success. It seems fairly clear now that there is little prospect of being able to capture this species in New South Wales waters except by night and under good weather conditions. Jervis Bay is probably one locality where a few small boats, operating lampara nets or small purse-seines at night, would have some prospect of success. Unfortunately, war-time lighting restrictions make further night trials impossible at present.

In Victoria, pilchards were fairly conspicuous in Port Phillip Bay in the warmer months of 1941-42. This was the first season for which they had been noticed in quantity since that of 1937-38. Apparently the occurrences of the species here are highly variable.

There is little to be said regarding pilchards in other waters, except that reliable details of pilchard occurrences are available for the first time from Western Australia. Large shoals of fish, which were mostly small, were present in the Albany region, in the outside waters, from about May to September, 1941.

(ii) *Sprat (Clupea bassensis).*—This species, which is apparently confined to Tasmania, has been further investigated and appears to have reasonable prospects for commercial exploitation. In 1940 and 1941 numerous shoals were discovered by the *Warreen* in the D'Entrecasteaux Channel, near Hobart, between March and June, and some catches were made with the lampara net. Similarly, in 1942, the fish were located during the same period by the *Warreen* and by the Tasmanian Fisheries vessels *Arcadiar* and *Allara,* and some catches were made with the lampara by the *Arcadiar*. These sprat schools are in general quieter and less easily disturbed than those of any other pelagic species so far investigated, and on this account are far easier to catch in surface seine nets. Catches have now been made fairly consistently over a period of at least two years with the lampara net, and it is considered possible that the fish could be caught on a commercial scale by small boats operating this type of gear. Small purse-seines would probably be more efficient, but would be more costly to buy and to operate. Trials of this latter type of net on sprats and other fish have been proceeding for some months in the Hobart region from the *Arcadiar,* though, owing to the unsuitability of this vessel for the purpose, no success has yet been achieved. Once the efficiency of this type of gear is demonstrated (which is felt to be only a matter of time) it should prove very well adapted to conditions in south-eastern Tasmania in particular, since this area not only possesses large areas of fairly sheltered waters, but has no less than three species of pelagic fish, which are numerous in season, and which could be captured by such nets, viz., sprat, salmon, and "mackerel" (*vide infra*). Although none of these three species would be suitable for live bait for developing the tuna fishery, all would be valuable for canning; and as regards live bait, it may be said that this type of net, once demonstrated to be a success, could probably be employed to catch pilchards and anchovies in certain New South Wales and Victorian waters, for use as live bait. Present indications are that private enterprise may soon begin to exploit the field of Tasmanian pelagic fisheries on these lines, although war-time difficulties in obtaining suitable boats, nets, and engines may delay this process.

(iii) *Anchovy (Engraulis australis).*—Some valuable additions to our knowledge of this species have been made, principally in respect of Victorian and Tasmanian inshore waters.

Particulars are now available regarding the anchovy fishery in Port Phillip Bay, in which about a dozen men, fishing mainly by hoop-nets suspended from piers, are almost wholly engaged. The catch is sold for bait. The fish may occur throughout the year, but as a rule the summer months are the most productive and the winter months the least. The fish seem to appear regularly from year to year.

In Tasmania, particular attention was given to two estuaries on the east coast, St. Helens and Hastings. Anchovies were present in both these places in December-January, 1941-42, and apparently for some months prior to that. They virtually disappeared from both places about the beginning of February. Apparently, the season on this coast extends from the late winter to the early autumn, with a peak about December-January, which is apparently a spawning season. At St. Helens a good number of anchovies was caught and placed in a floating experimental pen at the end of January; the majority of these survived until about mid-April, and some were still alive at the end of May, showing that it is quite possible

to hold this species in reserve for use (for live bait for tuna, &c.) out of season. Actually it is considered that by the exercise of more care of such pens (cleaning off marine growths, &c.) the fish could be held almost indefinitely in this manner. However, it is considered that a better live bait supply of anchovies could be built up in this manner at Port Phillip than at any Tasmanian locality. Probably pilchards could be caught and penned in the same way, say at Jervis Bay, for use as live bait out of season.

Regarding other waters, there is little to be noted. The anchovy season in the spring and summer of 1941-42 on the south coast of New South Wales was a poor one. The species seems to vary greatly in abundance from year to year in this area.

5. Tasmanian "Mackerel".

(*Trachurus novae-zelandiae*).

Although this species has not yet become the subject of biological investigation, several facts bearing on its geographical and seasonal distribution have been brought to light. Shoals are to be found in numbers off the coasts of south-eastern Tasmania between February and June; later in the year the fish move into shallow water along the beaches. In the early part of the year, the fish could therefore be caught in purse-seines and would constitute a valuable commodity, being a good-sized fish (10–12 inches is a common size) and very suitable for canning and smoking.

6. Mullet Investigations.

A first report embodying an account of the mullet fishery and a preliminary statement of the biology of *Mugil dobula* has been prepared and submitted for publication. This report sets out the economic and biological evidence upon which suggestions have been made for improvement of this fishery. These, in brief, were that the legal minima in the various States should be increased and, at the same time, should be supported by (1) adjustments of the restrictions on fishing operations, (2) a continuous statistical system and, (3) technical and biological research. Steps have been taken by the States concerned towards the implementation of some or all of these suggestions. This division has continued its research programme in support of the suggestions. It has been greatly assisted by the work of the State-employed market measures recently established in Western Australia, New South Wales and Queensland. The material from these workers, with other material collected in the field, permits an advance in the analysis of the composition of the stocks. This is being extended by the examination of the relationship between meteorological elements and fish yield. Tagging operations have been continued; returns are yielding indispensable factual information on the subject of migrations.

7. Australian Salmon Investigations.

The work conducted in Tasmania in 1941 definitely established the importance of the Tasmanian area as a nursery ground. Analysis of statistical material derived from the several State Fisheries Departments is being continued to determine whether or not large long-term fluctuations in stocks are discernible. General biological data are accumulating, and there is some slight evidence to hand which indicates that part at least of the spawning area of the Australian salmon lies within the ten fathom line along the south central coast of New South Wales. An attempt to exploit these shoals of salmon which travel the coast of New South Wales, outside the range of operations of beach seine fishermen, is being made. To this end, a large beach purse-seine, similar in many aspects to the Canadian salmon beach purse-seine, is being constructed at Eden by a team of professional fishermen working under the direction of the Division of Fisheries. This net will be operated from a modern Danish seine boat and the first tests will be undertaken in July.

Seasonal fluctuation in abundance is evident, due to the "lateness" of the winter "run", which occurred at least four weeks late in 1942. The failure of the Australian salmon to enter the estuaries was evident again in 1942 for the third year in succession. The relationship of this phenomenon to abnormalities in meteorological and hydrological conditions is being studied.

8. Barracouta Investigations.

Beyond the routine computation of biological and statistical data, barracouta have received little attention during the past year. Biometrical study has been intensified, and an examination of a series of larvae of up to 1½ in. long has revealed the presence in plankton catches and stomach contents of larvae of both the barracouta (*Thyrsites atun*) and the king barracouta or hake (*Rexea solandri*). A study of fishing methods has revealed that the fishery is relatively static in respect to gear, and the personnel engaged are unlikely to alter their methods unless a strong stimulus is given by the successful experimental operation of new types of equipment.

9. Oyster Investigations.

(i) *Spatfall.*—In order to obtain information on the time and the density of spatfall in Port Hacking, special sets of fibro-cement sheets have been laid down for regular observation. In addition, quantities of other materials, including wattle sticks, have been laid for comparison. Results are being observed.

(ii) *Fundamental Studies.*—(*a*) The regular sampling of commercial stock by means of large monthly samples was continued into 1942. These samples were submitted to the same metrological and biological analysis as had been employed in the previous year, with the same objectives. A quantity of oysters placed in an aquarium supplied with sea water, samples taken from oysters supplied to the Division of Food Preservation, and samples of another species (*Ostrea angasi*) were also examined.

(*b*) The gonad material taken from the oysters of the above samples has been sectioned and stained and studied in order to discover the cytological and histological bases corresponding to changes in gonad condition. This has yielded considerable information on the sex change of the oyster, and forms a basis to the studies on spawning and rate of gonad development

(*c*) The dried meats obtained in the above samples were analysed by the biochemist appointed to the staff of this laboratory by the New South Wales State Fisheries Department. The earlier work in this section has been published in the Council's Pamphlet No. 111.

(*d*) Many data were obtained from the experiments with the kymographic apparatus; these await analysis.

(*iii*) *Winter Mortality.*—During the winter of 1941, a considerable array of oysters set out in relation to level and density was examined twice weekly for the occurrence of oysters dead from winter disease. Although this work confirmed past finding that mortality is higher at low levels and low density, the losses over all were greater than generally experienced on neighbouring leases, and this phenomenon is at present attributed to the effect of the frequent handling. Further arrays of oysters have been set up on the lease in the current winter in order to pursue the same lines of investigation. The hydrological programme in relation to this work has been intensified.

(iv) *Canning.*—In collaboration with the Division of Food Preservation a programme of experimentation on the canning, freezing, etc., of oysters was designed and initiated. This Division's share of the programme consisted of providing the oysters and supplying biological specification of them, also of assisting in the assessment of the results. This work has been suspended.

(v) *Co-operation.*—The New South Wales State Fisheries Department provided funds for the appointment of an additional officer to this Division to work initially on oyster problems. The first appointee was a biochemist, part of whose work is reported above. This officer left the Division during March; the State Department decided not to continue the arrangement during the present critical period, but has continued to provide funds for the expenses of field experimental work.

10. Hydrological Investigations.

A hydrological cruise in the region Sydney to Cape Byron was carried out in January of this year. The results showed that some hitherto unknown influence was at work, giving rise to relatively high temperatures and salinities in the region. It was felt at the time that the magnitude of this development would render oceanic and coastal conditions over the East Australian region abnormal for quite some time. In March and April, coastal observations were taken between Sydney and South Tasmania, and the penetration and persistence of the high temperature-salinity water masses to the southern limit of this region were demonstrated. Observations in May showed that the coastal waters off the East Tasmanian coast were practically "normal" for the month, but that above Gabo Island there was a persistence of the high salinity-temperature water masses. It is obvious that abnormalities in hydrographic conditions have an effect on the course of the fisheries. The necessary graphs, charts, &c., for the presentation of the complete data from the last three years are being completed, and the writing up and analysis of the material is proceeding.

In the estuarine work the first year's data from George's River and Port Hacking have enabled certain hypotheses to be formulated concerning oyster distribution and biology. An estuarine programme has been formulated for the testing of these propositions, and the present unavoidable curtailment of the oceanic work should enable this work to be carried out actively.

11. Other Investigations.

(i) *Minor On-shore Species.*—The collection of data incidentally in the course of field-work has been continued. This includes data on blackfish, black bream, and whiting.

(ii) *Snapper.*—The biological studies of this fish (*Crysophrys guttulatus*) have been continued by a worker at Sydney University working in collaboration with this laboratory and in co-operation with the New South Wales State Fisheries Department. This work has not yet reached a definite stage, but interesting results have been obtained on growth rate, weight/length relation, gonad development (showing hermaphroditism), and the relationship between rainfall and yield.

(iii) *Netting Experiments.*—After discussions with the New South Wales State Fisheries Department on the question of specifying gear appropriate to the legal minima, it was agreed that experiments should be conducted to determine the relationships between mesh size, net construction, &c. and the size of the fish held and of those meshed. These experiments will need to be performed in large numbers before conclusions may be expected, although useful results have been obtained to date.

X. NATIONAL STANDARDS LABORATORY.

1. General.

As in the previous year, the activities of the Laboratory were directed largely to defence work, although considerable assistance has also been given to various industries in regard to production methods and the development of new products. Demands on the library have expanded considerably, and its facilities are being used to an ever-increasing extent by other Government Departments, industrial organizations, and research workers.

2. Metrology.

(i) *General.*—During the year most of the flow of work in the Metrology Section has come through one or other of the various Directorates of the Ministry of Munitions. The field has covered the examination of gauges and measuring equipment, the manufacture of measuring equipment, and the calibration of testing machines. Work on volumetric glassware is just commencing.

(ii) *Examination of Gauges and Measuring Equipment.*—During the year, 20,000 gauges have been examined. The equipment used for this purpose has, in general, been purchased from abroad, but deficiencies have been made up by the design and construction of equipment within the Laboratory workshops. The practice of the National Physical Laboratory, Teddington, strongly influences the work at this Laboratory, and special facilities were made available by the National Physical Laboratory to provide information, equipment, and instruction to the Australian staff. Some of the measuring equipment in course of construction is to National Physical Laboratory design.

All gauges made in New South Wales and Queensland to the order of the Ministry of Munitions are forwarded to this Laboratory for examination for compliance with drawing. In addition to gauges, the work has been extended to measuring equipment, jigs, fixtures, hobs, and machine tools. An important major activity of the Section is acting in an advisory capacity to firms engaged in the manufacture of gauges, measuring equipment, and various munitions stores. Assistance is given in the design and construction of measuring equipment, the manufacture and measurement of gauges, and the care and use of gauging equipment in the workshop. Staff from industrial establishments visit the Laboratory for such instruction, and girls are given a course to enable them to return to their gauge rooms the better equipped to undertake the factory inspection of gauges. Arrangements were made for some of the staff to give a series of lectures for inspectors and examiners in a course arranged by the Directorate of Ordnance Production. The Officer-in-Charge is a member of the Australian Advisory Committee on Aeronautics and of the Optical Munitions Panel.

(iii) *Manufacture of Measuring Equipment.*—A considerable amount of work has been carried out in developing the production of certain measuring equipment such as screw pitch measuring machines, slip gauges, and bench micrometers.

(iv) *Calibration of Testing Machines.*—The Laboratory holds Morehouse proving rings calibrated at the United States Bureau of Standards and accessory equipment made in the Laboratory workshops. On behalf of the Army, Navy, and Air Inspection Branches, testing machines, laboratories, and personnel are examined, and recommendations are submitted concerning the ability of these institutions to act as approved Test Houses. All the large organizations possessing testing machines in New South Wales and Queensland, as well as most of the small plants, have been visited and their testing equipment calibrated.

As a result of these periodical visits, it can be said that the general conditions for testing are now in a satisfactory state.

(v) *Volumetric Glassware.*—Considerable advice has been given to a firm about to embark on the manufacture of volumetric glassware. The work of the Laboratory, however, is seriously handicapped owing to its inability to obtain from abroad balances ordered over two years ago. As a complete cessation of delivery of volumetric glassware from abroad must be considered, it is expected that intensive demands will very soon be made on the Section.

3. Electrotechnology.

The only major item still outstanding on the initial orders, placed by officers of the Electrotechnology Section when in England, is the equipment for the magnetic testing of iron. Extensions have been made to the workshop to provide for a new electrical shop, which is now occupied by the electrical fitters. A dark room has been equipped for photography of experimental work, and is now ready for use. The installation of the electrical services in the Laboratory has been completed, and most of the services are in operation.

The D.C. laboratory has been very well equipped, and a number of tests have been undertaken on equipment and materials required for urgent war work. A considerable number of tests on potentiometers for use with thermocouples have been carried out in association with the Physics Section programme of tests on pyrometric equipment on behalf of the Ministry of Munitions. A limited amount of A.C. testing has also been carried out. Confidential investigations undertaken on behalf of the Services continue to occupy most of the time of the Section.

4. Physics.

(i) *General.*—The work of the Physics Section since its establishment at the end of December, 1940, has been concerned chiefly with those branches of physics included under the terms "heat" and "light", and with certain branches of electricity, and during the year 1941-42 has been devoted almost entirely to war problems. Two main branches of work have been undertaken—one, the calibration, testing, and inspection of pyrometry equipment in munitions factories in New South Wales, and the other arising out of problems associated with the manufacture in Australia of optical glass and optical munitions. The Laboratory has collaborated closely on the latter problems with the Optical Munitions Panel, of which the Officer-in-Charge of the Section is a member.

(ii) *Light.*—(*a*) *Optics.*—(1) *Testing of optical munitions instruments.*—The National Standards Laboratory is now recognized by the Department of Munitions as a reference and testing laboratory for optical munitions manufactured in New South Wales; as a result, assistance has been given to manufacturers in numerous phases of the construction of optical munitions. Tests were made on gun sighting telescopes manufactured in New South Wales during the period that elapsed before routine testing facilities were provided in the factories; the Laboratory now tests only a percentage of such instruments.

(2) *Optical glass.*—Measurements are being made at the Laboratory of the optical properties of all melts of optical glass manufactured in Australia. It has been established that this glass is equal in quality to that manufactured abroad. Other investigations have been on the effect and importance of striae in optical glass, the permissible residual strain allowable after annealing, and the production of neutral filter glass for optical instruments. A number of investigations for the fighting services have also been undertaken.

(*b*) *Photometry.*—The Laboratory is represented on a committee of the Standards Association of Australia concerned with the preparation of A.R.P. lighting specifications. Photometric equipment has been constructed and installed for the measurement of feeble intensities such as met with in blackout conditions, and for the measurements of the light transmission of blackout fabrics and papers. Some assistance has been given to the New Zealand Government in the establishment of photometric standards.

(iii) *Heat.*—In the period from January to June, 1941, the work in heat in the Laboratory was concerned principally with the setting up of equipment for the maintenance of the International Temperature Scale and the accurate measurement of temperature over a range from about —80° C. to 1600° C. This range has now been extended to higher temperatures. In the course of this and other work, furnaces have been built giving temperatures up to 2300° C.

(*a*) *Pyrometry Calibration for the Ministry of Munitions.*—As the accurate measurement and control of temperature is of great importance in many industrial processes, the Laboratory was requested by the Ministry of Munitions to undertake the testing, inspection, and calibration of all pyrometric equipment used in munitions factories and annexes in New South Wales. For this purpose it now maintains two teams for the inspection and test of furnace temperatures and pyrometric equipment at factories, and calibrates a wide range of equipment which includes substandard apparatus used by firms who have their own approved testing facilities; 107 visits have been paid to firms in the course of this work.

(*b*) *Examination of Prototype Pyrometric Instruments.*—Owing to the shortage of pyrometric instruments in Australia, the problem of local manufacture is important. The Laboratory has assisted various firms in the development of pyrometric instruments, some of which are nearing the state in which they can be put into industrial use.

Other work in which the Laboratory has assisted is: (*a*) temperature control of blood serum desiccation investigations at the Prince Henry Hospital, (*b*) the influence of heat flow in stored wheat in the control of insect pests, and (*c*) a hot wire method for the cutting of hessian for camouflage purposes.

(iv) *Electrical Standards.*—During the past eighteen months the establishment of the essential equipment for the maintenance of the electrical standards of resistance and voltage has been completed.

(v) *Jewel Bearings.*—In view of the possible shortage of bearings for electrical indicating meters required in large numbers by the services, the knowledge which officers of the Laboratory had obtained abroad of the manufacture of bearings and the possible use of substitutes was applied in an investigation into the possibility of moulding glass bearings. With the assistance of certain information from abroad, a satisfactory moulding technique has been developed. Wear tests on these substitutes are now in progress. Details of processes used abroad for the production of sapphire jewel bearings have been supplied to firms developing the manufacture of jewel bearings.

XI. AERONAUTICAL INVESTIGATIONS.

1. General.

The number of the Division's staff has increased considerably during the past two years and an increase in workshop accommodation has become necessary. The area of workshops has therefore been doubled and, in addition, the small and large engine test houses have been built. The Division of Industrial Chemistry is now in occupation of its building and shares the workshops and library with this Division. A joint Metal-

lurgy Section has been set up and an officer to take charge of this obtained on loan for the duration of the war from a commercial company.

The Division is also closely co-operating with the Australian Advisory Committee on Aeronautics recently set up by the Government.

2. Structures and Materials Section.

(i) *Use of Australian Timber for Aircraft Construction.*—The entry of Japan and United States of America into the war has caused a greater realization of the value of wood for aircraft construction. Since its formation, the Division has devoted much effort, in co-operation with the Division of Forest Products, towards—(1) the determination of Australian species suitable for aircraft work; (2) the collection of design information relating to the use of Australian timber in aircraft; (3) the development of new methods of wooden construction using synthetic resin adhesives. Though work is being continued by the Division of Forest Products, the first objective is virtually reached in that a sufficient number of species suitable both in strength characteristics and quantities available have been selected.

(*a*) *New Methods of Construction.*—The development of methods of construction with synthetic resins is proceeding satisfactorily. A small experimental autoclave 5 ft. long by 2 ft. 6 in. in diameter has been acquired in which moulded wood veneer components may be formed under heat and pressure, so producing parts of what is known popularly as the "plastic" aeroplane. Synthetic resins have great advantages over the organic glues which they are replacing as they are not subject to bacterial attack, are much more water-resistant, and their strength with age is more dependable.

The development of "compregnated" (laminated, resin-impregnated, and compressed) wood was suggested by this Division to the Division of Forest Products some two years ago and a satisfactory material has now been produced.

(*b*) *Design Information.*—The first section of the investigation into methods of design of wooden box spars has been completed, and data in the form of design curves are available for one timber and in part for another. A project of considerable magnitude on which little work has so far been done is the determination of the strength and stiffness of plywood boxes.

Before the new moulded veneer methods with synthetic resins can be used by designers, it is necessary to collect design information on the strengths of Australian timbers used in this way. Two projects are now being commenced with this objective in view.

(ii) *Testing.*—A large number of tests have been made for the aircraft industry and Government Departments during the past year.

(iii) *Equipment.*—A considerable amount of miscellaneous equipment for general testing and for use in connexion with specific investigation has been designed by the Section. The design and construction of a small testing machine of 1,000 lb. capacity for fabric, plywood, and rubber tests have been completed within the Division, and the design of a 300,000 lb. universal testing machine is well advanced.

(iv) *Metallurgy.*—No separate Metallurgy Section was envisaged in the original plans for the Division of Aeronautics; however, owing to the war, it has recently been found necessary to set up such a section in conjunction with the Division of Industrial Chemistry. Aeronautical work is specially catered for and is closely associated with the work of the Structures and Materials Section of the Division of Aeronautics.

The Bausch and Lomb metallographic microscope has arrived and has been in continuous use, and a great number of miscellaneous examinations and tests have been carried out. In addition to all the current test work going on, there are three major investigations in hand. One concerns the significance of the Izod or notched bar impact test. An exhaustive bibliographical survey has been made to determine the full significance of the test if possible. An investigation into the "hardenability" of steels is in hand as part of a larger investigation into the mechanical properties of Australian steels related to the Izod test. Finally, in conjunction with the Department of Aircraft Production and private manufacturers, attention is being given to the development of a sintered bronze suitable for oil-impregnated bearings.

3. Aerodynamics Section.

(i) *Wind Tunnel.*—The wind tunnel has been completed and is now fully occupied on testing work. The tunnel, which has a 9-ft. by 7-ft. working section, and a maximum speed of 300 feet per second, was wholly designed, including the fan, aerodynamic balance, and subsidiary equipment, by the staff of the Division. The 550-h.p. electric motor and other electrical gear, and the six-bladed fan, were made in England; the tunnel and aerodynamic balance were built by a Melbourne firm. Instrumental equipment was constructed by the University of Melbourne. Some delay was experienced in obtaining the electrical equipment from England, but by the end of November, 1941, it was found possible to have a test run. Calibration was completed by the end of January, and both tunnel and balance were found to be as efficient and as accurate as the best examples of their type abroad.

Since calibration, the tunnel has been continuously engaged on tests of immediate importance for the aircraft industry. In addition to local problems of immediate importance, a programme of research into problems the solution of which would be more widely applicable is in hand.

(ii) *Theoretical Work.*—(*a*) *Fan Design.*—During tests of a fan for engine cooling designed on existing theory, unexpected difficulties due to the rotation of the flow were experienced. It was found that the simplifying assumptions which had been made did not apply to high pressure fans producing large rotational effects. A more exact theory has been developed, and, instead of the previous method of successive approximation, it is now possible to use a method of direct design. A report on the subject has been written.

(*b*) *Wind Tunnel Corrections.*—Octagonal wind tunnels, which shape was the one adopted for the Division's tunnel, have become increasingly popular. Though the influence of the walls of wind tunnels of rectangular, circular, and elliptic cross-sections on the behaviour of a model is well known, the same work had not been done for octagonal tunnels. This work has now been completed and is also the subject of a report.

(iii) *Flight Testing.*—The establishment of an organization for determining the performance characteristics of aircraft designed and constructed in Australia has now been accomplished.

4. Engines and Fuels Section.

(i) *Testing Equipment.*—The situation in regard to engine testing equipment has improved since the last annual report was made, when it was stated that only one out of four of the dynamometer plants ordered from England had arrived. This was the 120-h.p. DPX 2 hydraulic dynamometer for automobile engine testing. Since then the 400-h.p. DPXR 4 combined electric and hydraulic dynamometer has arrived

and installation is nearly completed. This plant is particularly required for single-cylinder testing, which, up till now, has been done on a simple rig constructed in the Laboratory. Though this was intended only as a temporary expedient until the more elaborate plant arrived, it has functioned satisfactorily and done well over 1,000 hours of testing. The amount of work in hand is evidence that this, as well as the new plant, will be needed permanently for single-cylinder work.

The large engine test plant (2,000-h.p. DPYR 6 hydraulic dynamometer with 500-h.p. cooling fan) which has been on order for two years from England, is now arriving in sections. The building has been completed and installation of the plant is under way. Special precautions have been taken to sound-proof the control-room, and double walls throughout have been provided, each being on a separate foundation. The building has been so designed that sound-absorbing tunnels on the air intake and outlet can be added if it is necessary to reduce the noise heard outside the building.

It has been found that certain types of engines are too powerful to be tested on the 400-h.p. plant and have too high a rate of rotation for the 2,000-h.p. plant. A suitable intermediate size of dynamometer, the Heenan and Froude DPY 5, of 700 h.p. and 3,500 r.p.m. capacity, has been obtained from England for this purpose.

(ii) *Rotary Valve Engine.*—If the rotary valve can be successfully applied to the internal combustion engine, it will give an increased ratio of power to fuel consumption. So far, mechanical troubles have stood in the way of the development of this type of valve, but the design of an Australian inventor offers hope of avoiding these. At the time of the last annual report a six-cylinder automobile engine with this valve had been tested, and a four-cylinder air-cooled aero engine was being redesigned to incorporate the valve. The engine has now been completed and tests are in progress. Up to now the valve has only been applied to liquid-cooled engines, and air cooling has introduced many problems. It is believed that the problems will be successfully solved.

The severe design limitations found when applying the rotary valve to an existing engine have stressed the need for fundamental design data. This is most conveniently obtained on a single cylinder engine. The design of such a unit has been completed by the Division and construction is almost complete.

(iii) *Tests of Ignition Equipment.*—Locally made starting booster coils have been tested at the request of the Department of Air and equipment for the type-testing of magnetos has been installed.

(iv) *Sundry Tests.*—In addition to the work described above, many tests have been performed on behalf of firms and government departments. Among these have been tests on samples of fuel, flexible fuel and oil tubing, samples of self-sealing tank coverings, a form of exhaust nozzle, and a small automobile engine.

5. Instruments Section.

This Section has been functioning a shorter time than any of the others, the officer-in-charge having been appointed only some fifteen months ago. The construction of special research instruments was at first the main activity, but latterly a number of tests have been done.

(i) *Special Research Instruments.*—Instruments which have been designed and constructed include a noisemeter, a recording accelerometer, and resistance strain gauges. An amplifier and cathode-ray oscillograph for use with the Standard Sunbury engine indicator have also been made. Items of equipment made for the existing wind tunnel are the warning and indicating lights (operated by photo-electric relays) and torque-measuring attachments for use with the small electric motors for driving the air-screws in models.

(ii) *Testing.*—Two production models of an Australian electric engine tachometer have been tested against the Air Board's specification. A magnetic drag tachometer, made by the same firm, has also been tested. Both these instruments are Australian designed and manufactured. Other instrument tests have been made on an electric fuel pump, a fuel pressure gauge, and flexible drivers for tachometers.

XII. INVESTIGATIONS IN INDUSTRIAL CHEMISTRY.

1. General.

The Division of Industrial Chemistry moved into its own laboratory early in 1942 and can now be said to be well established. Initial shortages of laboratory equipment have mainly been overcome, but deliveries of special apparatus and of pilot plant have been slow. The staff of tradesmen is being augmented as accommodation and machine tools become available, with the object of fabricating more equipment in the Council's own workshops. Time will be saved thereby and tradesmen will become experienced in a class of work which must become more important as laboratory investigations reach a stage where trial on a larger scale becomes necessary. It is the aim of the Division gradually to acquire a complete set of pilot-plant equipment for the various unit operations of industrial chemistry: gases, liquids, and solids will have all to be provided for. This plant will be available to assist industry in the development of new processes and the setting-up of established processes based on Australian raw materials.

The staff of the Division has increased substantially during the year, and additional appointments have recently been authorized in order to cope with a rapidly expanding field of activities. Difficulty has been experienced, however, in finding suitable candidates for some positions, especially among technicians. An analytical section has been established whose functions will be: (*a*) To undertake analytical work for the other sections within the Division, and for certain other Divisions of the Council; (*b*) to develop methods of analysis to meet specific problems from other sections, and (*c*) to undertake independent analytical research. It is important to develop the third function to attract men and women with the capacity for independent work so essential if this Section is to be of maximum service to the Council and to industry. A section of Physical Metallurgy has also been established, jointly with the Division of Aeronautics. Cement investigations have recently been commenced, the Cement Manufacturers' Association of Australia having undertaken to provide half the costs for a period of five years.

At the instigation of the Division, a conference was called by the Minister in charge of the Council to consider the methods to be adopted for rubber conservation. One result was the formation of a Rubber Advisory Committee, which is playing a prominent part in the formulation of plans for increasing the life of rubber goods and for conserving supplies. Another result was that the Division has been asked to act as technical advisory body to various Government and Service departments. It will also be responsible for the analysis of a number of Australian plants submitted for consideration as sources of rubber, for certain aspects of rubber technology in connexion with trials of imported plants, and for technical advice in discussions concerning the production of synthetic rubber in Australia. Collaboration with other scientific

institutions and with the rubber industry has already been arranged.

At the request of the Minister for Supply and Development, the technical feasibility and the economics of several processes suggested for the production of alumina are being examined, and a report will shortly be submitted. This has been one of the major activities of the Division during the latter half of the year under review: officers from several sections have taken part in the investigation.

The demands on the Division in connexion with the war have been so great that projects not immediately connected with the national effort have all been put aside. The Associated Woollen and Worsted Textile Manufacturers of Australia have been informed that no new work on wool technology can be undertaken until after the war, but that investigations on shrinkage reduction of clothing for the Services will be continued. Work has been deferred in certain fields, such as ceramics and paints and varnishes, to which the Division is committed.

2. Dairy Products.

The Division's officers have worked as a joint team with the Council's Section of Dairy Research. Their work is described in the report of that Section.

3. Wool Investigations—Shrinkage Reduction Processes.

(i) *Freney-Lipson Process.*—Further investigations on the Freney-Lipson process have been undertaken in the laboratory in order to determine a greater range of conditions under which it may be satisfactorily applied in practice. The results are now being published. The process has been in commercial operation for many months, and thousands of pounds of socks have been shrinkproofed for the Services. A description of the plant is also being published.

A pilot plant has been designed and ordered which may be expected to facilitate closer control of operating conditions than has hitherto been possible outside the laboratory. It should also indicate means by which greater throughput and lower costs can be attained.

(ii) *Woolindras Process.*—The Woolindras plant that had been obtained on loan from the Wool Industries Research Association was erected in Melbourne. After experience had been gained in shrinkproofing of socks and flannel, the method of operation of the plant was demonstrated before a representative gathering from the woollen industry. As a result, this particular plant has been taken over by a Tasmanian company for treatment of goods for the Army.

(iii) *Fundamental Studies.*—The results of certain fundamental studies of the nature of felting shrinkage will be published in the near future; work of this type was set aside early in 1942 until conditions became more nearly normal.

4. Fellmongering and Leather.

The attention of the Section has been concentrated on fellmongering. This in itself consists of a number of different operations of which the more important are soaking, burring, sweating, and "pulling". Following the pulling operation, which separates the wool from the pelt, the latter passes through additional operations for conversion to leather. Studies on several of the operations have been continued during the period under review and studies on new phases have been commenced.

(i) *Removal of Oxygen from Soak Water.*—When freshly burred green sheepskin is immersed in water, the dissolved oxygen is gradually removed from the water until, after four to six hours, none remains. Wool alone only depletes it slowly, whereas pelt has an extremely rapid effect. Tests have shown that oxygen removal is probably due to the multiplication of bacteria on the nutrients dissolved out of the skin tissues.

(ii) *Physical Method of Following the Depilation of Sheepskins.*—In order to study the effect of various factors on the sweating and painting processes, a method was developed for measuring the ease of depilation. The pull necessary to detach the wool from a small area of skin is measured by a spring balance; after scouring, the weight of 1-in. length of the detached staple is also measured; the pull required to remove a sample weighing 5 mg. is then calculated; the average of six such determinations is termed the "depilation load". This load falls from an initial value of several hundred grammes to zero during the sweating process, or after application of a depilatory paint. The method is therefore satisfactory for following the course of depilation.

(iii) *Effect of Temperature on Rate of Sweating.*—By measuring depilation load and bacterial count on samples of skin during storage at various temperatures, the relationship between temperature and rate of sweating has been revealed. Although increasing the temperature in the vicinity of 10 deg. C. or 15 deg. C. increases the rate of sweating very considerably, increments above 25 deg. C. have very little effect.

(iv) *Mechanism of Sweating.*—It has been observed that when sheepskin is sweated slowly by storing at a low temperature, the depilation load falls in two phases separated by a lag phase. It has also been noted that if the skin be sterilized with ammonia or with certain other antiseptics, the initial phase proceeds without interruption, but the last phase is inhibited and the depilation load does not reach zero even after prolonged incubation. It is suspected, therefore, that the initial phase is due to enzyme action, and the last phase to bacterial action.

(v) *Chemical Sterilization of Sheepskin.*—Before the effects of given types of bacteria can be accurately investigated, it is necessary to have available sterile sheepskin. One of the first investigations was, therefore, concerned with chemical sterilization of sheepskins, and, following many experiments with a wide variety of antiseptics, a satisfactory sterilization technique has now been developed. The treatment does not influence the subsequent response of the skin to fellmongering processes.

(vi) *Identification of Bacteria Capable of Depilating Sheepskins.*—Many different species of bacteria have been identified on sheepskins, but of these only a few have any influence on the sweating process. The depilatory action of a strain of *Proteus vulgaris,* first demonstrated with foetal lambskin, has been confirmed with adult skin, sterilized as before mentioned. Two new bacteria, recovered from sweated skins, and designated Nos. 28 and 42, have also been found capable of depilating sterilized skin. No. 28 is a species of *Flavobacterium,* which is recovered from less than one in five of the skins examined, and has depilatory activity about equal to that of *Proteus.* No. 42 is a gram-negative bacillus, as yet unidentified, which occurs on the majority of skins and, while possessing greater depilatory activity than No. 28, also has the advantage of producing less skin damage.

A survey of the bacterial flora of sheepskin and soak water from various fellmongeries in Sydney, Melbourne, and Adelaide, has shown that, in general, the types of bacteria present are independent of the source of the material.

(vii) *Proteolytic Enzymes from Bacteria Responsible for Sweating.*—Experiments with *Proteus vulgaris,* the bacterium must commonly responsible for sheepskin depilation, have shown that its proteolytic

enzyme production can be promoted by aeration. Multiplication of the organism is also favoured by plentiful air supply, but not sufficiently to account for the additional enzyme produced. Thus, improved enzyme formation is not a direct function of bacterial growth. It must, therefore, be associated with the adoption of a new type of metabolism particularly suited to high oxidation potential. A practical implication of this work is that fellmongery sweathouses should be well ventilated so that proteinase secretion by the depilating bacteria can attain its optimum.

(viii) *Causes of Pelt Damage in the Sweating Process.*—In the course of studies of the factors responsible for pelt damage, large numbers of nematodes were recovered from sheep pelts after sweating, but, contrary to the opinion now prevailing that contamination of the pelts occurs in the sweating chamber, it has been shown that they are present on merino skins even before entry into the chambers. However, the possibility of skin damage by bacteria alone cannot be excluded.

(ix) *Improvements in the Pie-ing Operation.*—The recovery of wool from skin pieces by the operation known as "pie-ing" has also received some attention. Normally, the lugs, shanks, and skin pieces are spread in a thin layer on the ground until putrefaction of the skin has proceeded so far that the wool can be easily recovered by hand picking. Objections have been raised to this method, firstly, on the score of the labour needed for hand picking, and, secondly, because of the obnoxious nature of the operation. An alternative method sometimes used involves recovering the wool by dissolving the skin in boiling water, but this produces severe discoloration and damage of the wool. Development of an alternative method is being attempted, utilizing the hydrolytic action of hot water on collagen, but superimposing on this the proteolytic action of a suitable enzyme.

(x) *A New Proteolytic Enzyme from a Victorian Noxious Weed.*—The latex of the weed *Euphorbia lathyris* (Caper Spurge), which grows in Victoria and New South Wales, has been found to possess marked gelatinase activity. Acetone powder preparations possess activity comparable with that of samples of pepsin, trypsin, and papain. Thus a new member has been added to the half-dozen known plant proteolytic enzymes, and an additional source of proteinase has been revealed which might well prove to be of industrial importance to Australia. Already such enzymes are used for desizing textiles, depilating and bating in the leather industry, clearing beer, tenderizing meat, and pre-shrinking wool.

(xi) *Production of a New Moulding Powder from Scrap Leather.*—A new moulding powder has been prepared by mixing finely-ground vegetable-tanned scrap leather with two other components, and drying the mixture under specified conditions. When placed in moulds and pressed at an elevated temperature, this powder yields a material resembling bakelite. However, it is softer than bakelite, and can be readily cut with a saw. It also has the useful property of being practically unaffected by immersion in either water or petrol.

5. Minerals Utilization.

(i) *Chemical Treatment of Monazite.*—Monazite sand from Byron Bay, or elsewhere, is the raw material for the production of cerium-iron pyrophoric alloy used in sparking lighters and metallurgical processes. The chemical treatment necessary to convert the sand to anhydrous rare earth chlorides has been worked out and some notable improvements introduced. Advice has been given to several commercial firms, one of which has produced cerium-iron pyrophoric alloy for the first time in Australia, and improvements in technique are likely to follow as the result of further collaboration.

(ii) *Chlorination Tests on Refractory Minerals.*—Experimental investigations were continued, and the chlorination method was applied to the decomposition of monazite for the direct production of anhydrous rare earth chlorides. Chlorination of zircon was also investigated as a means of decomposing the mineral or freeing it from ferruginous impurity. Chlorination of chromite in presence of carbon led to the production of mixed anhydrous chlorides of iron and chromium. The conditions for separating these two salts by differential sublimation were examined and lilac-coloured anhydrous chromic chloride was obtained. This compound has important potential uses. In all this work the contamination of the product with carbon may, if necessary, be avoided by the introduction of carbon tetrachloride into the chlorine stream. This technique was applied to the chlorination of monazite.

(iii) *Decomposition of Chromite.*—The direct sulphuric acid decomposition of chromite has been investigated in some detail, using various catalysts. Under optimum conditions for the reaction, 97 per cent. of the chromite is attacked. Several methods of separating the various products of this reaction were tried. It is considered that a useful commercial method for the preparation of a variety of industrially important chromium derivatives might be founded on this process. The investigation is being continued.

(iv) *Tests of Bauxite by Bayer Process.*—Tests are being made with Gippsland bauxite to ascertain its suitability for commercial alumina production by the Bayer process. Bauxite ores from other parts of Australia will also be tested. The preparation of "seed" alumina has received some attention as has also the production of an easily filterable trihydrate of alumina. Owing to an automatic disintegration of the bauxite in the soda it was found that the original state of subdivision of the bauxite was of very little importance. A continuation of this work is planned to include a study of the desilication of the aluminate liquors.

(v) *Synthesis of Cryolite.*—The conventional methods for the manufacture of synthetic cryolite were reviewed, and it was considered desirable to investigate an alternative method based primarily on the interaction of fluorite and alunite in acid solution. Experimental work indicated that considerable difficulties might be encountered in obtaining appreciable yields of cryolite by this method, but it was considered worth while to explore the possibilities to the fullest extent, in view of the importance of the problem, and the restricted availability of certain of the more usual intermediates used in this synthesis.

(vi) *Beneficiation of Graphite.*—The Minerals Committee of the Department of Supply and Development has asked that chemical methods of beneficiation of South Australian graphite ores should be attempted. Ore dressing processes, developed in other laboratories of the Council, yield a concentrate containing about 86 per cent. of graphitic carbon, which is unsuitable for certain purposes. Preliminary experiments of this Division have shown promising results and have yielded a flake product almost devoid of impurities. Such material has special uses in lubricants, powder metallurgy, oil-less bearings, commutator brushes, &c. Other grades of graphite which require varying degrees of chemical beneficiation involve material for dry cell manufacture, inert paints, metallurgical electrodes, foundry facings, &c.

(vii) *Beneficiation of Pyrolusite.*—A general programme on the chemical beneficiation of Australian manganese ores has had as its focal point the preparation of a grade of pyrolusite suitable for use as a depolarising agent in the manufacture of electrical dry

cells. This work is aimed at avoiding the importation of special battery grades of pyrolusite and has been recognized as urgent by battery manufacturers. The general hydrometallurgy of manganese ores is also involved in this programme.

(viii) *Alunite Investigations.*—Two officers of the Division have assisted for eighteen months with the investigations of the University of Western Australia into the production of potash fertilizer from alunite. These investigations have led to the decision to establish a new and important industry in Western Australia. The investigations have been extended to determine whether it is practicable to produce highly refined alumina for aluminium production from the residues after extraction of the potash salt. Should it prove possible to produce both alumina and potash salts from the extensive alunite deposits they may well be regarded in the future as one of Western Australia's most valuable assets.

(ix) *Miscellaneous.*—A number of miscellaneous investigations have also been undertaken. Thus, the effect of superheated steam on the decomposition of ilmenite by sulphuric acid has suggested that autoclave treatment for non-reactive titaniferous iron ores may perhaps be dispensed with in some cases. Throughout the period under review, many industrial contacts were made and maintained.

6. Cement Investigations.

In close collaboration with the Cement Manufacturers' Association of Australia, which is to share the cost, investigations are being initiated into certain aspects of cement manufacture and concrete mixing. The field for possible work has been closely surveyed and a programme for investigational work submitted for consideration by the Association.

7. Producer Gas Investigations.

Methods of analysis of charcoal developed by officers of the Division, working in the Department of Engineering at the University of Melbourne, formed the basis of the Standards Association of Australia's specifications for the methods of testing charcoal, and the results obtained by these officers on Australian hardwood charcoal form the basis for the specifications adopted. Analyses of some 30 brown coal charcoal briquettes have just been completed; they should enable the State Electricity Commission of Victoria to determine the optimum conditions of the production of what may well be a much improved fuel for gas producers.

8. Physical Metallurgical Investigations.

The work of this Division in the field of physical metallurgy began only towards the close of the year under review. Attention was confined to certain matters of importance with respect to conservation of tin.

9. Physico-chemical Investigations.

(i) *Flotation of Sulphide Ores.*—Oxidation of sulphide ores of copper, lead, and zinc, such as occurs in mining storage, crushing, and grinding is generally thought to be responsible for difficulties in the preparation of high grade concentrates. Methods have been developed to determine the degree of oxidation and its dependence on certain variables. It has been shown that both major and minor constituents of the ores may be responsible for some difficulties, but the investigation —admittedly a difficult one—has not yet reached the stage that deductions of practical value are possible.

(ii) *Flotation of Non-Sulphide Ores.*—This investigation is of considerable breadth. Attempts are being made to determine the fundamental chemical and physical principles underlying the use of certain proposed new types of chemical reagents in flotation, and to apply these principles to the separation of certain strategic minerals from those with which they are commonly associated in Australian ores. The introduction of new flotation reagents is fraught with difficulty, but the benefits that would accrue for certain important minerals are such as to justify the attempt to develop their use.

A method akin to flotation is being applied to separate two materials of plant origin, one of which is required for an essential drug. Thus studies in one field are likely to find useful application in an entirely different field.

10. Foundry Sands Investigations.

The laboratory is now equipped with almost a complete range of modern sand-testing equipment. Sands from many foundries have been tested, involving over a thousand separate tests. Research on methods of testing has been undertaken, and sands from all the major pits near Melbourne have been examined. Foundries faced with the problem of casting unfamiliar alloys required for the production of munitions have been advised as to the correct grades of sands to employ in cores and moulds. More attention has been given to core sands and cores than formerly, and a trade circular on this subject is being published.

11. Organic Chemistry.

(i) *Ethylene and its Derivatives.*—An investigation of ethylene as starting material for the synthesis of commercially valuable organic chemicals has been initated. The method of production from ethyl alcohol has been examined, particularly with respect to the most suitable catalyst. Although a thorough examination was not made, a suitable clay catalyst was found which at 380°–390° C., gave an ethylene of 92 to 96 per cent. purity in yields exceeding 90 per cent. of the theoretical and often reaching 96 per cent.; the ethylene contains 1 to 2 per cent. of butylene. A generator is in operation which has a production of 250–300 litres per hour, and a larger pilot plant apparatus is under construction.

This ethylene has been used, first, to discover its value as a source of formaldehyde. In addition to formaldehyde, another valuable product of the oxidation was ethylene oxide, which was readily removed by transformation to ethylene glycol.

The production of ethylene chlorohydrin from ethylene has been examined on a laboratory scale, and from the results obtained an apparatus has been designed and operated to produce the amount of this chemical that is required in synthesizing novocaine sufficient for Australia's requirements. In the United States of America and Canada, the oxidation of ethylene to give mainly ethylene oxide has been developed. From ethylene oxide a number of organic chemicals, now required in Australia, can be prepared. The investigation of this oxidation has been started.

Parallel with the work on ethylene, work has been commenced upon the oxidation of methane to formaldehyde. The rate of conversion to formaldehyde and the percentage yield of formaldehyde are not expected to be so high as with ethylene, but the process seems to have certain compensating advantages.

(ii) *Synthetic Resins.*—A commencement has been made with some investigations in the field of synthetic resins. The main investigation, so far, has concerned the production of synthetic adhesives for the manufacture of "compregnated" woods. This work is being carried out in collaboration with the Division of Forest Products, which impregnates the woods with resins supplied by this Division and tests their properties. The adhesives already supplied have shown some

advantages. Cresylic acid of local manufacture has been carefully analysed and a method developed for the partial analysis of the cresol-formaldehyde resins. It is hoped that this method may be of value in controlling resin production. This method is being perfected; it is now sufficiently reliable to act as a guide in resin preparation.

An examination of resins of the phenol-furfural and cresol-furfural class has recently been commenced. Use of furfural in resin production would relieve the demand on supplies of formaldehyde and, since it can be produced relatively simply from waste materials such as oat hulls and bagasse, its production in Australia seems desirable. Samples of furfural obtained from bagasse by the Australian Estates Co. Ltd. and from flax shives by the Division of Forest Products, have been found to be of sufficient purity for use in resin production.

The causes of cracking and crazing of transparent methyl methacrylate sheets during moulding and working have been examined. As a result of the investigation carried out, recommendations were made as to precautions to be observed in using these materials.

XIII. LUBRICANTS AND BEARINGS.

1. General.

The work on the building up of a research organization for dealing with friction, lubrication, bearing, and wear problems has been continued. In order to deal with the numerous problems that the war has made urgent, some expansion, the construction of more apparatus, and the development of new lines of work were necessary. The Section is collaborating with the Services, Government Departments, and commercial organizations concerned with war production; in fact, the main part of its activities is devoted to war work, and since much of this is confidential an account of it is not given here.

The University of Melbourne is continuing its cooperation, and the work is being greatly assisted by Professor E. J. Hartung, who has provided additional laboratory accommodation in the new chemistry school. Professor A. Burstall and the staff of the Engineering School are assisting with the construction of apparatus, and the Departments of Natural Philosophy and Metallurgy are helping with other aspects of the work.

2. Friction.

Investigations of the physical processes that occur during the sliding and seizure of surfaces are being made.

(i) *The Theory of Metallic Friction and the Role of Shearing and Ploughing.*—According to the theory of metallic friction put forward earlier, the frictional resistance is due, primarily, to the shearing of the metallic junctions which are formed at the points of contact, and to the work of dragging or ploughing the surface irregularities of the harder metal through the softer one. An attempt has been made to put this theory on a more quantitative basis. The frictional force F may be written as $F = S + P$ where S is the force required to shear the metallic junctions and P the force required to displace the softer metal from the path of the slider. For sliders of different shapes and sizes a theoretical calculation of F, S, and P is made in terms of shear strength, and the "flow pressure" of the softer metal. An experimental investigation of these relations has been made for steel sliding on indium which is a very soft metal. The experiments were made with cylindrical, hemispherical, and plane sliders, and S and P were evaluated separately. It was found that the experimental results were in reasonable agreement with the general theory. The friction between the metals is determined primarily by the real area of contact: the load is important mainly in so far as it affects this area. Indium adheres strongly to clean steel, so that when sliding takes place the shearing of the junctions occurs in the indium itself, and the shear strength is approximately equal to that of pure indium. Since pure indium flows readily, the area of contact between the metals may be large and the friction between the metals may be high. If, however, the indium is in the form of a thin film on the surface of a harder metal the frictional resistance is very small.

(ii) *The Friction of Thin Metallic Films.*—An investigation has been made of the frictional properties of thin films of indium, lead, and copper, deposited on to the surface of other metals, and the results are in agreement with the above theory. For all three metals, the frictional resistance to the movement of a curved slider is determined primarily by the real area of contact between the metals, whether they are present as a thin film or are used in bulk. When the different metals are present as thin films, their frictional resistance is directly proportional to their shear strength. The friction decreases as thinner films are used. There is, however, a limit to this, and for indium on finely ground steel the frictional force is a minimum when the film thickness corresponds to a few hundred molecular layers. Films of thickness less than about 50 atomic layers cease to be effective on this surface. The friction of indium films and of lead films falls steadily as the temperature is raised and reaches a minimum when incipient melting begins. A measurement of the rate at which indium films are worn off the surface by continued sliding shows that, although the metal films are resistant to wear, they are less so than stearic acid films of the same thickness.

3. Manufacture and Development of Aircraft Bearings.

Work on the development and manufacture of aircraft bearings has been continued. The work has been simplified by the formation of the Bearing Control Committee and has been greatly helped by the action of the Department of Aircraft Production in setting up a Pilot Bearing Annexe to work in close association with the Council. New techniques of manufacture have been worked out for a number of major aircraft bearings used in Australia. The general procedure has been to manufacture prototype bearings in the Council's laboratories, test the methods on a larger scale in the Bearing Annexe, and, when they are known to be successful, to hand over the technique to local bearing manufacturers.

4. Investigation and Testing of Bearing Metals and Bearings.

(i) *X-ray and Micro Examination of Bearings and the Testing of Bond Strength.*—The general work on the examination of bearings by microscopic and X-ray methods and the correlation of the results with known defects in the bearings have been continued and have been applied to a large number of experimental, locally made, and imported bearings. The Aeronautical Inspection Directorate and Munitions Supply Laboratories are collaborating in this examination, and certain standards of acceptance and rejection have been arrived at.

(ii) *Bearing Testing Machines.*—Two bearing testing machines have been constructed. The first is designed primarily for investigating the performance of the master rod aircraft bearing in a radial engine. The second machine is for less specialized bearing and lubricant testing, and is designed to study the performance of sleeve bearings under widely varying conditions of speed, load, and lubrication. Both these machines are being applied to practical problems.

(iii) *The Theory of the Action of Bearing Metals.*—The main function of a bearing metal is to reduce the friction, wear, and seizure, between the sliding surfaces. If the friction is to be small, however, the area of contact A, and the shear strength s of the metal must be as small as possible. Unfortunately, if the metal has a low shear strength, it is usually soft with a low flow pressure, giving a comparatively larger area of contact. The double condition of small s and small A may be achieved, however, by depositing a thin film of a soft low melting metal on a hard one. This may be carried out by direct deposition, or by selecting an alloy of suitable structure and composition, so that the film is spread during the sliding process. A series of experiments has been carried out on pure metals, on alloys, and on thin films of soft metals deposited on to hard metallic substrates. The results show that the friction of the different metallic alloys is considerably less than that of any of the constituent metals. The lowest friction of all, however, is obtained with the thin films of soft metal deposited on to a hard one.

If the alloy consists of a soft metal dispersed throughout a harder matrix, it is shown that its frictional properties resemble very closely those of a hard surface (consisting of the matrix material) over which a thin film of the softer metal has been spread. The actual value of the friction is the same, the temperature-coefficient of friction is the same, and the increase of friction with wear is also very similar. It is suggested that for a large class of bearing metals, the extrusion and smearing of a soft constituent over a harder matrix, plays an important part in reducing the friction, wear, and seizure between the sliding surfaces.

(iv) *Sintered Metal Bearings.*—Work on the frictional and wear properties of sintered metal bearings and their suitability for various purposes is being carried out.

(v) *Economy of Tin.*—The Section is acting in an advisory capacity to the Controller of Non-ferrous Metals on the conservation of tin in bearings and is carrying out experiments on various low tin bronzes, white metals, and other alloys.

5. Lubrication.

Additional apparatus has been constructed for the physical and chemical investigation of lubricants, and a number of investigations are in progress.

(i) *The Mechanism of Lubrication.*—Investigation is being made into the mechanism by which the boundary lubricant film reduces the friction between moving surfaces. Experiments have shown that the action of polar hydrocarbons is very specific, and that, alone, they are ineffective on the surfaces of certain metals. They may, however, be rendered effective by the addition of certain non-polar hydrocarbons. The results are of interest both from the fundamental and from the more practical point of view. Special apparatus has been made for measuring and analysing friction and for studying the boundary lubrication properties of oils and lubricants over a wide temperature range. This is being used for investigating the suitability of a number of lubricating oils and greases for various purposes and for the development of substitutes.

(ii) *Development of Lubricants for Drawing and Pressing.*—A laboratory investigation has been made into some of the physical processes which occur during drawing of metals, and of the effect which various lubricants may have in reducing the friction and seizure during drawing. Work is being carried out on the development of drawing fluids for various special purposes.

(iii) *Extreme Pressure Lubricants.*—When the load between moving surfaces is very high, for example in the lubrication of heavily loaded gears, and the ordinary lubricants may fail, it is customary to add to the mineral oil active ingredients which may attack the surfaces chemically and form a protective film which reduces the extent of the metallic seizure. These compounds are specific, and their action is modified by the high local temperatures developed at the points of contact. An investigation into the effect of various active compounds has been made and the work is being continued.

(iv) *Cutting Fluids.*—At the outbreak of war large quantities of cutting fluids were imported into Australia for high-grade machining work in the aircraft and other industries. Work has been carried out to assist in the development of locally made fluids. A series of laboratory experiments combined with standardized practical tests have shown that an important property of a cutting oil is its ability to lubricate steel surfaces under severe conditions of load and temperature. Using these laboratory experiments as a basis, certain improved fluids were developed in collaboration with others. These fluids proved successful in practice and are now widely used.

(v) *Fluids for the Grinding and Cutting of Glass.*—The local optical companies were experiencing trouble in grinding the edges of lenses and in cutting grooves in borosilicate glass. Since it was no longer possible to obtain the imported grinding fluids, a short investigation of this was made and some experimental grinding fluids were made up. These proved suitable for the purpose.

6. Wear.

(i) *The Lubrication and Wear of Piston Rings and Cylinders.*—Experiments into the nature of the lubrication between the piston ring and cylinder wall of a running engine have been continued. An electrical method is used to follow any momentary breakdown of the oil film. It is found that the transition from fluid to boundary lubrication may be a sudden one, and that it is very sensitive to small changes in the viscosity and temperature of the oil and to the conditions of engine operation. The observations have an interesting bearing on both the theoretical and the practical problems of cylinder lubrication and wear.

(ii) *Wear of Aircraft Cylinders.*—Laboratory measurements have been made of the basic wear properties of various steels and cast irons used in the manufacture of aircraft cylinders and piston rings. The influence of the structure, and of certain defects in the steel on its wear properties, have been studied.

(iii) *The Wear and Oil Contamination of Producer Gas Vehicles.*—A series of wear measurements has been completed on a number of vehicles operating on charcoal producer gas. The measurements showed that, with some of the early models of gas cleaners, excessive abrasive wear of the cylinders and piston rings occurred. With later cleaners of better design, however, which reduced the amount of dust entering the engine to a low value, the wear was no greater than that observed with petrol. Analyses of the lubricating oil from the sump showed that under these conditions the oil contamination and deterioration was also no greater than that frequently observed with petrol vehicles.

(iv) *The Measurement of Surface Finish and Surface Damage.*—Information about the mechanism and the extent of wear under various practical conditions may be obtained by an investigation of the contours of the worn surfaces and of the distortion immediately below the worn portion. The normal method of microexamination of a section cut at right angles to the surface does not reveal very fine irregularities. The technique of cutting a section at a very oblique angle is, therefore, used. This gives a contour of the surface

with its vertical component magnified about ten times. The method is being applied to various wear and frictional problems. The results obtained provide strong evidence that a minute local welding of the surfaces can occur during the sliding of metal surfaces.

7. Impact of Colliding Surfaces.

Experiments on the nature of contact between colliding surfaces are being continued and the results applied to a study of the mechanism of detonation of explosives by impact and friction, and to other problems.

8. Miscellaneous.

Work is in progress on a number of other problems such as the friction and wear of brake bands, the replacement of ball and roller bearings, the electroplating of bearings, the physical and chemical examination of lubricants from various sources, &c. Members of the Section are acting on technical committees, and are assisting and advising government departments and other organizations which are concerned with war work.

XIV. OTHER INVESTIGATIONS.

1. Dairy Research.

(i) *General.*—During the year, the Section moved from the School of Dairy Technology, Werribee, where facilities had been generously made available by the Victorian Department of Agriculture. The work is now centred in laboratories provided by the Division of Industrial Chemistry. Close co-operation is maintained with the Division, and three of its officers are now fully employed on the dairy research work of the Section. Most of this work has been on problems associated with the transport and storage of dairy products under war-time conditions.

(ii) *Survey of the Properties of Australian Butters.*—The survey mentioned in the last annual report was continued during the year. Monthly records showing the conditions of production, methods of butter manufacture, and properties of the butterfat over a period of two years are now available for many producing districts in Australia. The task of collating the large amount of information obtained has not yet been undertaken. The growing importance of the manufacture of pure butterfat adds importance to this work. Obvious variations in the properties of this product have already been observed which can be correlated with the conditions of production..

(iii) *Tinned Butter.*—Tinned butter normally constitutes only a small proportion of the total Australian production, but its importance has been increased considerably by present war-time conditions. These have also served to emphasize the inherent instability of the product compared with other tinned foodstuffs. The comparative lack of keeping quality is due largely to the virtual impossibility of sterilizing butter, and the development of tallowy flavours due to fat oxidation. An investigation into the problem of keeping quality in tinned butter has been initiated, and collaboration has been arranged with the Department of Agriculture, and commercial organizations in New South Wales, who are conducting experiments towards the same end. It has been found possible to control the development of micro-organisms by incorporating a suitable concentration of salt and processing the butter in such a way that a very fine texture is obtained. This has resulted in a definite improvement in keeping quality, and the problem of fat oxidation is now the limiting factor to further progress in this direction. Early experiments involving the reduction of air content, and the heat treatment of cream, have not yielded promising results so far, but other lines of approach to the problem are under consideration.

(iv) *Preparation of Pure Butterfat from Butter (Dehydrated Butter).*—Pure butterfat is not susceptible to bacterial action and, when properly packed, keeps well at room temperatures. Moreover, a good quality product can often be made from second-grade butter, so that conversion of such butter to the dry butter-fat will release considerable refrigerated space for other purposes. During the year, experiments on the large scale peparation of the dry fat have been made. This was possible because of a generous grant by the Australian Dairy Produce Board, and the ready co-operation of the Longwarry Co-operative Dairy Company, who made plant available. The experimental plant was capable of treating about 1 ton of butter per hour. Briefly, the process consists of melting the butter, adjusting the pH of the serum in order to facilitate separation, separating the serum centrifugally, and boiling off the last traces of water and deodorizing in a vacuum before filling into tins. Conditions for the satisfactory operation of the plant were worked out, and a trial shipment forwarded to Great Britain. This travelled well as unrefrigerated cargo, and there appeared to be little if any deterioration in quality during transport. Fat in completely filled and sealed tins has also been kept at room temperatures for a period of twelve months without deterioration. If desired, the fact can be reconstituted to butter by re-emulsifying to a cream and churning, or more directly by methods used in margarine manufacture.

A commercial plant capable of treating over 100 tons of butter a week and based on the experimental one is now in operation, and another plant is being erected. Large stocks of second grade butter which had accumulated are being treated to produce a satisfactory quality butterfat.

(v) *Cheese.*—During the year the manufacture of a quantity of cheese which was shipped as unrefrigerated cargo was supervised. Various modifications in manufacture, which it was hoped might improve the keeping quality at comparatively high temperatures, were tried. Unfortunately, none was found effective, and the cheese did not travel well. Further work is being done on the small scale on the factors influencing the loss of fat from cheese at high temperatures.

(vi) *Compressed Whole Milk Powder.*—In order to increase the shipping density of milk powder, and to avoid the use of tinplate containers, whole milk powder has been compressed into block form. The blocks were compressed to the point where free fat began to appear on the surface so as to reduce as far as possible the oxygen content. Conditions of pressing roller and spray-dried milks were worked out. The blocks contain about 8 per cent. of air, and the packing density of the milk powder is increased from about 0.6 to 1.15. Small 1.25 lb. blocks representing a gallon of milk, and large 9-inch cubes weighing 33 lb. were produced. The blocks are hard, although somewhat friable. They do not dissolve readily in water without previously powdering, and this would present some difficulty on the domestic scale, although it can be readily accomplished with suitable equipment. Unsuccessful attempts were made to produce a block which would disintegrate when placed in water, but it was found that the addition of 20 per cent. cane sugar gave a block that could be easily ground to a powder, for instance with a rolling pin.

An experimental shipment of 11 cwt. was forwarded to Great Britain, and preliminary reports have been favorable. Experiments here showed that, when properly wrapped, blocks stored for 26 weeks under atmospheric conditions, and also at 32° C. and 80-90 per cent. relative humidity kept well, and were only slightly inferior to the controls which were tinned in an atmosphere of nitrogen.

2. Radio Research Board.

During the year under review the work of this Board, which is carried out with the co-operation of the Postmaster-General's Department, the University of Sydney, and the Commonwealth Solar Observatory, has been confined to studies of the ionosphere. The results obtained are proving of considerable practical value in many Australian radio activities.

3. Mineragraphic Investigations.

Twenty-nine investigations have been carried out into the mineral association of valuable minerals in ores and mill products submitted by mining companies and institutions. Each of these investigations was complete in itself and directed to some specific problem such as the mode of occurrence of gold and other valuable minerals in an ore, a concentrate, or a tailing, particularly in relation to losses during treatment. Fourteen of these investigations have been concerned with ores that have been subjected to experimental treatment in the ore-dressing laboratories or with the examination of test concentrates and tailings obtained thereby.

The more extensive investigations included the examination of mill products from zinc lead ores at Captain's Flat and North Broken Hill mine. In these, quantitative expressions of the nature and combination of the various minerals have been developed, and the method has proved successful in clearly distinguishing the mineral features of each product and in being informative as to the degree of separation accomplished by the grinding practice and the efficiency of the separations by mineral flotation.

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

4. Ore-dressing Investigations.

Co-operative investigations on ore-dressing have been continued in the Laboratories at the Kalgoorlie School of Mines, the South Australian School of Mines and Industries, and the Metallurgical School of the University of Melbourne. In past years, this work has been practically confined to gold ores and has materially assisted in increasing Australian gold production. A feature of the year under review, however, has been a change-over to the examination of ores of much-needed base metals and to the so-called "strategic" minerals required for war production.

At Kalgoorlie, attention has been given to the treatment of Whim Creek copper ore by the segregation process, the preparation of pyritic ores for utilization in the manufacture of sulphuric acid, the blowing in of small copper smelting furnaces, and the treatment of drosses formed in the galvanizing of wire netting. Work is also being undertaken on the recovery of wolfram and scheelite from the mill residues of a gold mine. In addition, investigations have been undertaken into certain gold problems, particularly the use of charcoal instead of zinc as a precipitant of gold in the cyanide process and an investigation of the methods of assay of roaster calcines.

At Adelaide, particular attention has been given to ores of copper and manganese, and to rutile, barytes, and graphite.

At Melbourne, ores of manganese, copper, zinc, antimony, chromium, bismuth, and graphite have been examined. Work on an oxidised copper ore from Western Australia resulted in the development of a process whereby a shipping grade of concentrate can be produced directly from the coarse ore with a recovery somewhat exceeding 60 per cent. of the total copper. A further successful investigation was conducted with a view to recovering base metals from scrap and rumbler discharge produced at an ammunition factory; as a result of this work, a method of separating brass and cupro-nickel was developed.

5. Biometrics.

(i) *General.*—Early in 1941 the Biometrical Section was partially re-organized to meet the demands of the Council's expanding organization and the increasing scope of the work. The principal move in this change was the establishment of the Sectional head-quarters staff at the Council's Head Office, Melbourne. Other officers were retained in those divisions in which biometrical work demanded their full time. Under this arrangement the Section has, throughout the past year, continued to be actively engaged in co-operation with officers of the Council's divisions and also with various external organizations. There have been several staff changes, the most important of which was the secondment of one officer to assist in civil defence.

(ii) *Division of Plant Industry.*—Early in the year, new investigations were designed to test the effects of spacing and fertilizers on vegetable seed production, and the results of these trials have recently been analysed. The sampling of pastures has received further consideration, and an extensive examination has been made of data derived from particular subsampling techniques designed to determine the botanical composition of pasture samples. Multiple regression analyses have been made to relate the percentage incidence of potato virus to various factors, including climatological factors. A scoring system has also been developed for rating the estimated size of potato plants in order to determine the spread of virus disease from infected plants.

Analyses of fertilizer trials in forestry plantations have been made, and considerable attention has been given to such questions as the nature and number of sampling measurements that must be taken in order to estimate volumes of timber with reasonable accuracy. Investigations into take-all of wheat included an examination of data on the relation of ear and tiller development to root condition in diseased and healthy plants, the planning and analysis of a series of glasshouse experiments designed to determine the influence of mineral additions to soils on the incidence of the disease, and a further series to determine the influence of soil moisture on plants inoculated with the disease.

Other work involved the analysis of (i) data from a number of field and variety trials, (ii) data relating to the time interval between the opening and tripping of flowers of *Medicago* spp., and (iii) further investigations of the mode of transmission of yellow dwarf disease of tobacco and of potato virus.

(iii) *Division of Economic Entomology.*—In this Division statistical work included a comparison of the rates of increase of *Rhizopertha* populations under conditions of varying temperature and time interval between sievings of infested grain, the analysis of dosage—mortality data for a variety of insects and insecticides, the analysis of a number of insecticidal field trials, the correlation of climatological factors and the occurrence of grasshopper swarms, the analysis of data relating to catches in fly-traps and the action of repellents, and the development of a theory of random movement for a technique used to determine the density of flies in the field.

(iv) *Division of Animal Health and Nutrition.*—The Section has undertaken an extensive study of data derived from the parasitological field trials being carried out at Armidale (N.S.W.). Throughout the past year work has been continued on the reduction of a number of climatological factors from the primary

data in order to relate them to variations in worm burden. Epidemiological studies have also been continued and the analysis of seven years' data from the bacteriological examination of a herd of cows has been completed. Secular graphs of the incidence of various organisms and mastitis have been prepared and life tables calculated showing the probability of infection at various stages of herd-life.

Other work included the analysis of data from a trial designed to determine the influence of state of nutrition on wool production, the analysis of body weights, fleece weights, and fleece characteristics of offspring from different rams, the analysis of field trials at Gostwyck and Mihi, and further investigation on the development of a technique for estimating numbers of eggs of parasitic worms in faecal material.

(v) *Division of Forest Products.*—During the period under review the Section has continued the calculation and reduction of data for the several sections of this Division. Statistical work has been principally concerned with the analysis of data obtained in studies of the mechanical properties of Australian timbers suitable for use in the production of aircraft, and with the planning of investigations and the analysis of experimental data relating to the manufacture and testing of paper pulp. Many thousands of routine calculations have also been completed.

(vi) *Division of Industrial Chemistry.*—In connexion with the foundry sands investigations being conducted by this Division, further advice has been given in the planning of experiments and assistance with the analysis of data relative to the standardization of sieving practice, the calibration of sets of sieves, and the comparison of different test pieces (continuation of work previously reported). A new series of experiments has been designed to determine specifications for the standardization of dry sand testing practice, and a further series to compare methods of moisture testing, and the re-calibration of the Speedy moisture teller.

(vii) *National Standards Laboratory.*—The Section has begun the preparation of a set of tables for use with certain optical equipment recently acquired by the Physics Section.

(viii) *Commonwealth Research Station, Merbein.*—In the last report it was stated that the Section was working on the problem of devising methods for the analysis of data obtained in the drainage investigations being carried out by officers of this Station. This work was completed early during the period covered by the present report and the methods were then successfully applied in an analysis designed to determine the optimum depth and spacing of drains for the several soil types of the Murray Irrigation Area, from observations on drainage effluents, rates of fall of watertable, &c. The methods developed have also been applied to four other large-scale trials in the Murray Irrigation Area. Considerable assistance has also been given to officers of this Station in the analysis of viticultural, wine-grape, and reclamation trials.

(ix) *Irrigation Research Station, Griffith.*—The Section has completed the analysis of the data from the Griffith Horticultural Survey and is at present engaged in writing the report in collaboration with officers of the Station.

6. Standards Association of Australia.*

The Association has continued during the past year to devote practically the whole of its energies to standardization projects associated with defence. The total number of specifications of this character published since the outbreak of war is approximately two hundred. In addition to continued work on the series of aircraft standards, and emergency standards for munitions, much attention has been given to specifications for materials and equipment required for civil defence purposes. A series of standards for A.R.P. materials and requirements has been issued, and specifications for camouflage paints of different types and standard camouflage colours have been prepared. A code for the illumination of buildings was completed in tentative form to serve as the basis of regulatory action for the improvement of industrial lighting.

The hazards imposed by enemy action have created difficulty in supplying to Australia stocks of many British and some American specifications required by Australian defence industries. To meet this situation, the Association in all appropriate cases has arranged for the reprinting of the publications in Australia from individual copies available. This activity is now on an established basis.

The library information service in regard to specifications and related technical data is now in such demand that in many quarters the Association is known best by the assistance given in this form. With the outbreak of war in the Pacific and the extension of Australian-American co-operation, there has been a particularly strong demand for information available in the library for data concerning American industrial practice.

The increased financial assistance received by the Association has been fully utilized in providing the technical staff necessary to deal with the volume of work which the Association has been called upon to undertake, and the results have amply justified a continuance of this expenditure.

XV. INFORMATION SECTION.

1. General.

The demand for the services of the Information Section by industrialists, business organizations, and their scientific investigators, and investigators of the Council's own staff, reported last year, has steadily continued. Especially in the preparation of extensive summaries and bibliographies on particular aspects of certain technical products, the Section has made many worthwhile contributions to the war effort, and the value of having a specially trained staff for this work has been further demonstrated. The searching for, and summarising of, information spread throughout the voluminous technical literature of the world is becoming more and more a specialist's job and it is not too early to predict that the laboratory research worker will soon call upon the trained information officer in connexion with all problems which he might be considering or even actually undertaking; and to help effectively the information officer in his turn must be soundly trained and kept up to date in the subjects of his search.

2. Information for Council.

During the year the Section has experienced a considerable demand for its services from the various Divisions of the Council. This demand is a healthy sign, for the Section can often save much time of Laboratory investigators and can frequently suggest likely sources of information that are not always obvious. Experience has shown that the demand for information is heaviest in the early stages of the consideration of an investigation. Once it has been decided to undertake laboratory work on a particular problem it is best for the laboratory investigator to

* 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.

make his own thorough, detailed study of the literature, but even here the Section can generally afford some valuable assistance.

Much information has been prepared for the Division of Industrial Chemistry. For instance, a study has been made of the utilization of scrap leather including the relevant patent literature. Another study has related to a suitable means of determining mixtures of aliphatic amines and ammonia, for the investigation of the volatile amines liberated in the fellmongery sweating process. In the field of minerals, a complete search of the literature has been made in regard to both the beneficiation of manganese ores and the chemical beneficiation of graphite ores, and summaries and reports prepared on zirconium, beryllium, and aluminium. In connexion with the investigations into the failures of cement and concrete undertaken by the Division, assistance has been rendered by the preparation of a complete summary of the information available on the chemistry, mineralogy, and failures of, and notes of alkalies and other compounds in, cement and concrete. Other matters dealt with have related to the possibilities of using silver-lead, cadmium-lead, and calcium-lead alloys for certain high-tin solders and bearing metals, phosphatising and other processes for minimising the use of tin in the plating of food containers, and the use of cadmium-lead alloys. A further more comprehensive report has been prepared on the poisonous nature of cadmium, the industrial hazards associated with the metal, and the precautions to be taken for its safe handling. Summaries have also been prepared on electroplating. To give assistance in the investigational work being carried out on the separation of minerals, a comprehensive report was prepared on electrostatic separators, attention being directed to apparatus and equipment, mineral conductivities, and costs.

On the organic chemistry side, summaries have been prepared covering the literature and patents on urea-formaldehyde glues, and on aniline-formaldehyde glues and resins to assist in research into the manufacture of resin-bonded plywood. A summary of patents relating to phenol-furfural resins has also been prepared as a preliminary to work being undertaken on the development of these resins to relieve the demand for formaldehyde in resin manufacture.

Extensive bibliographies on both meat and vegetable canning were prepared for the Division of Food Preservation, and they have proved of value in connexion with the rapid development of these industries in Australia. Furthermore, the references compiled with regard to vitamin stability are being used in the carrying out of experimental work on dietary deficiencies.

A summary, including bibliography, on powder metallurgy has been of assistance in the investigations being carried out by the Division of Aeronautics. A bibliography on self-locking nuts has been of help in the workshop.

In connexion with the experimental work being carried out by the Division of Soils on cement stabilization of soils and on dust control for aerodromes, summaries and bibliographies have been prepared, and, in addition the Division has been advised of all likely sources of information.

3. Information for Manufacturers, Government Departments, &c.

In addition to the above-mentioned demand from within the Council, the usual demand from manufacturers, government departments, and private individuals has been experienced. A selection of the matters concerning which requests have been received is given below:—

Synthetic resins: Furfural-type resins, polymethyl methacrylate resin for manufacture of aircraft parts, urea-formaldehyde glues, aniline formaldehyde resins, and tego film. *Industrial hazards*: Aluminium dust explosions, toxicity of lead, cadmium, and silver, danger from sodium cyanide, combating oil fires, shatterproofing glass. *Cement and concrete*: Chemistry, mineralogy, and failure of cement and concrete, quick setting cements—ciment-fondu, concrete tanks for petrol storage, cement stabilization of soil for roads. *Minerals*: Zirconium, beryllium, beneficiation of manganes ores, graphite, carbon black, sulphur from pyritic concentrates, alumina from bauxite. *Utilization of waste products*: Scrap steel, wood waste, blood, wool fat in paints, by-products in sugar industry, ox horns. *Foundry and engineering problems.* Casting magnesium alloys, casting manganese bronze, titanium-aluminium alloys, zinc base for die casting, gaseous equilibria in copper, cadmium and chrome plating, black nickel plating, degreasing light alloys, diamond-mounting in tools, permanent magnets, moulded brake-linings, fluorescent-lighting, heat loss in buried pipes. *Preparation of chemicals.* Ammonium persulphate, phosphorus oxychloride, sodium fluosilicate and fluosilicic acid, silica gel, guanidine carbonate, methyl chloride, acetaldehyde, menthol and thymol from piperitone, chlorine, salt by solar radiation, polythionates. *Miscellaneous*: Electrostatic separators, katadyne water-sterilization, deodorizing power kerosene, turpentine substitutes, carotenoid pigments, pectin, crystallized cherries, stencil paper, dry cells, catgut sutures, bimetal thermometers, rennet.

4. Committees, Abstracts, &c.

Officers of the Section have also acted on various special committees. Thus one member of the staff was Chairman of the Standards Association Committee on the Rotproofing of Materials. Subsequent to the work of this Committee a survey was made of rot and waterproofing methods applicable to cotton duck or flax canvas for use as army covers and tarpaulins. Many methods have been used for this purpose but on account of shortages of supply and restricted plant facilities, these methods were not readily applicable to Australian conditions. In co-operation with the Munitions Supply Laboratories suggestions were made and investigations were undertaken with the result that a new and satisfactory method has now been developed; it is pleasing to report that this method has been adopted by the Department of the Army as standard practice for covers and tarpaulins. The rotproofing chemicals used are of Australian origin and utilize considerable proportions of a war by-product, available in excess quantities. Incidentally, the treatment has reduced by one-third the quantity of waterproofing chemical previously imported.

Officers of the Section have for some time past been preparing "Australian Chemical Abstracts" published by the Australian Chemical Institute and confined to reports and articles published in Australia and to Australian patents. These abstracts are used by the majority of Australian chemists in keeping track of the results of local work.

5. Miscellaneous.

Apart from the above work the Section has prepared and issued to members of the Council, its committees, senior members of its staff, and corresponding bodies in other parts of the Empire and in United States of America, statements summarizing the reports received on the Council's work, prepared and issued press statements on the work of the Council, and edited, published, and distributed the Council's *Journal*, bulletins, pamphlets, annual report, and other publications. The mechanization of the Council's mailing list has now been completed and, in addition, the addressograph machine has been utilized for the preparation of salary returns, with a saving of man-power and paper.

6. Library.

The work of the Head Office Library has continued along the same lines as in previous years. Owing to the war it is becoming increasingly difficult to obtain the references required from overseas publications, but this, to a certain extent, is being overcome by the use of photographed microfilm in obtaining material from abroad. With the establishment of new departments dealing with war activities, the need for specialized libraries has greatly increased. Some of the departments have found it necessary to have small libraries of current periodicals and a few of the essential text-books of their own, but they are able to obtain assistance from the Council's library for many of the references they require. The advice of the library staff is also being continually sought in regard to the best methods of organizing and maintaining these small libraries which, in many cases, cannot be staffed by trained librarians.

During the year, the librarian of the New Zealand Department of Scientific and Industrial Research spent three months in the Council's library making a first-hand acquaintance with the general systems of cataloguing and classification which are in use, and with the relationship which has been set up between the Head Office and the Divisional libraries. Such welcome visits will facilitate future co-operation.

Ever since the publication of the Catalogue of Scientific and Technical Periodicals in the Libraries of Australia, the Council's library has come to be considered by other libraries rather in the light of a central bureau for information on scientific periodicals; this function is being developed and efforts are continually made to record library holdings of all journals not mentioned in the catalogues.

7. Photographic Copying.

Experience during the year has demonstrated still further the great value of the small sized camera in disseminating information. An increasing number of scientific workers in government, University, and private laboratories are using this service to obtain copies of scientific articles or reports that are inaccessible to them. Work in this field has also considerably increased as a result of the establishment of scientific liaison officers in England and America. Many libraries and organizations continue to afford most helpful co-operation by lending the Council their special literature for photographing.

XVI. FINANCIAL MATTERS, STAFF, AND PUBLICATIONS.

1. Finance.

The statement of expenditure from 1st July, 1941, to 30th June, 1942, is as follows:—

	£	£	£
1. Salaries and contingencies	..	..	37,740*
2. Remuneration of Chairman and Members of Council	..	..	2,348†
3. Investigations—			
(i) Animal Problems—			
(*a*) Sheep diseases: foot-rot, black disease, preputial disease, caseous lymphadenitis, entero-toxaemia, pregnancy disease and equine navel ill (at Animal Health Laboratory, Parkville, Victoria)	..	6,508	..
(*b*) Mastitis (Victoria)	3,954	..	..
Less contribution from Australian Cattle Research Association and part Berwick Farm Revenue	3,954	..	..
		..	..
(*c*) Rabbit myxomatosis (at Animal Health Laboratory, Parkville, Victoria, and Point Pearce, South Australia)	503	..	..
Less contribution from Australian Wool Board	300	..	..
		203	..
(*d*) Tick and tick fevers, pleuro-pneumonia, &c. (at Animal Health Laboratory, Parkville, Victoria, and Field Stations at Tooradin, Victoria, and Helenslee, Queensland)	8,579	..	..
Less contributions from Queensland Government, part proceeds from sale of vaccine, and C.P.P. Revenue Fund	6,151	..	..
		2,428	..
(*e*) Haematuria (Victoria and South Australia)	..	127	..
(*f*) Toxaemic jaundice (at Animal Health Laboratory, Parkville, Victoria, and Field Station, Barooga, New South Wales)	612	..	..
Less contributions from Toxaemic Jaundice Revenue Fund, Australian Wool Board and Australian Meat Board	443	..	..
		169	..
(*g*) Fertility and Blood Parasites at Werribee Field Station, Victoria	..	759	..
(*h*) Parasitology (at McMaster Laboratory, University of Sydney)	10,058	..	..
Less contributions from George Aitken Pastoral Research Trust, and Australian Wool Board	1,403	..	..
		8,655	..
(i) Bacteriology (at McMaster Laboratory, University of Sydney)	1,500	..	..
Less contributions from University of Sydney, George Aitken Pastoral Research Trust, and Australian Wool Board	450	..	..
		1,050	..
(*j*) Biochemical problems (at McMaster Laboratory, University of Sydney)	1,310	..	..
Less contributions from Australian Wool Board	800	..	..
		510	..
(*k*) Parasitology and genetics (at F. D. McMaster Field Station, St. Mary's, New South Wales)	3,419	..	..
Less contributions from Australian Wool Board, Thorpes Ltd., and Infertility Revenue Fund	827	..	..
		2,592	..

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

† Provided from Consolidated Revenue Fund.

3. Investigations—*continued*—	£	£	£
(*l*) External parasites (at McMaster Laboratory, University of Sydney)	454	..	..
Less contributions from Australian Wool Board	454	..	..
		..	..
(*m*) Wool research (at McMaster Laboratory, University of Sydney) ..	..	504	..
(*n*) Wool biology (at McMaster Laboratory, University of Sydney) ..	1,765	..	..
Less contributions from Australian Wool Board	1,631	..	..
		134	..
(*o*) National Field Station, "Gilruth Plains", Cunnamulla, Queensland	5,546	..	..
Less contributions by Australian Wool Board, Commonwealth Bank, George Aitken Pastoral Research Trust, and Station Revenue Account	5,546	..	..
		..	..
(*p*) Entero-toxaemia (braxy-like disease), Moora (Gingin) disease, ataxia in lambs, &c. (Western Australia)	..	511	..
(*q*) Biochemical and Agrostological Studies (at Animal Nutrition Laboratory, Adelaide, and Field Stations, Robe, South Australia) ..	11,148	..	..
Less contributions from George Aitken Pastoral Research Trust and Nutrition Revenue Account	506	..	..
		10,642	..
(*r*) Feeding Experiments (at Waite Agricultural Research Institute, Glen Osmond, South Australia)	1,269	..	..
Less contributions from George Aitken Pastoral Research Trust	100	..	..
		1,169	..
(*s*) Field Experiments on Mineral Supplements (at Robe Field Station and other minor centres in South Australia)	1,243	..	..
Less contributions from George Aitken Pastoral Research Trust	300	..	..
		943	..
(*t*) Drought Feeding, Nutrition and Wool Production (at Animal Nutrition Laboratory, Adelaide)	1,980	..	..
Less contributions from Australian Wool Board	1,980	..	..
		..	..
(*u*) Blowfly School	47	..	..
Less contribution from Australian Wool Board	47	..	..
		..	..
(*v*) Suspense account	..	355	..
(*w*) Central office	..	4,398	..
	..	41,657	..
Less contributions from Commonwealth Bank (Rural Credits Development Fund)	..	9,000	..
	..		32,657
(ii) Plant Problems—Division of Plant Industry—			
(*a*) Central Laboratory—			
Annual	5,249	..	..
Capital	374	..	..
		5,623	..
(*b*) Experimental plots	..	588	..
(*c*) Plant pathology	..	4,019	..
(*d*) Plant genetics	..	5,919	..
(*e*) Herbarium	..	352	..
(*f*) Fibre investigations	..	1,101	..
(*g*) Plant introduction	..	4,519	..
(*h*) Apple rootstocks, Stanthorpe, Queensland	..	1,050	..
(*i*) Fruit problems	..	2,995	..
(*j*) Agrostology	7,287	..	..
Less contributions from Australian Wool Board	1,500	..	..
		5,787	..
(*k*) Field Experiment Station, Dickson, Canberra	1,730	..	..
Less contribution from Tobacco Trust Fund	480	..	..
		1,250	..
(*l*) Tobacco investigations	2,589	..	..
Less contributions from Tobacco Trust Fund	2,589	..	..
(*m*) Water weeds and hoary cross, Victoria	453	..	..
Less contributions from New South Wales Water Conservation and Irrigation Commission, and Victorian State Rivers and Water Supply Commission	410	..	..
		43	..
(*n*) Medicinal Plants	680	..	..
Less contributions from Department of Supply and Development	680	..	..
(*o*) Suspense account	..	70	..
	..		33,316
(iii) Entomological Problems—Division of Economic Entomology—			
(*a*) Central Laboratory—			
Annual	4,386	..	..
Capital	393	..	..
		4,779	..
(*b*) Museum and technical services	..	716	..
(*c*) Biological control (Australia)	..	574	..
(*d*) Biological control (America)	..	251	..
(*e*) Oriental Peach Moth	..	512	..
(*f*) Locust investigations	..	2,362	..
(*g*) Earth mite investigations	..	916	..
(*h*) Termite investigations	..	2,097	..

3. Investigations—*continued*—	£	£	£
(*i*) Physiology and toxicology	..	613	..
(*j*) Cattle tick	..	748	..
(*k*) Blowfly investigations	..	2,133	..
(*l*) Insect infestation of stored wool	290	..	..
Less contributions from Central Wool Committee	290	..	..
(*m*) Wheat infestation	604	..	..
Less contributions from Australian Wheat Board	602	..	..
		2	..
(*n*) Prickly Pear investigations	261	..	..
Less contributions from Commonwealth Bank	261	..	..
(*o*) Cotton investigations	131	..	..
Less contributions from Ministry of Agriculture, Egypt	131	..	..
(*p*) Suspense account	..	39	..
	..		15,742
(iv) Horticultural Problems of the Irrigation Settlements—			
Citricultural—			
(*a*) Research Station, Griffith—			
Salaries and incidentals	7,408	..	..
Capital	1,979	..	..
	9,387	..	..
Less funds provided from Station Revenue	1,683	..	..
	7,704	..	..
Less contributions by New South Wales Water Conservation and Irrigation Commission and Griffith Producers Co-op. Coy. Ltd.	2,092	..	..
		5,612	..
Viticultural—			
(*b*) Research Station, Merbein—			
Salaries and incidentals	6,089	..	..
Capital	276	..	..
	6,365	..	..
Less funds provided from Station Revenue	577	..	..
	5,788	..	..
Less contributions by Dried Fruits Control Board and Nyah-Woorinen Dried Fruits Inquiry Committee	1,315	..	..
		4,473	..
(*c*) Ripening, processing, &c., of vine fruits, Mildura District	848	..	..
Less contributions by Irymple Packing Pty. Ltd., Mildura Co-op. Fruit Co., Red Cliffs Co-op. Fruit Co. Ltd., and Aurora Packing Pty. Ltd.	848	..	..
			10,085
(v) Soil Problems—			
(*a*) Investigations at Waite Agricultural Research Institute, Glen Osmond, South Australia—			
Annual	9,689	..	..
Capital	93	..	..
		9,782	..
Less contributions from Commonwealth Bank (Rural Credits Development Fund)	..	2,500	..
			7,282
(vi) Food Preservation and Transport—			
(*a*) Central Laboratory, Homebush, New South Wales—			
Annual	3,690	..	..
Capital	560	..	..
	4,250	..	..
Less contributions from L. Berger & Sons and Wm. Angliss Ltd.	108	..	..
		4,142	..
(*b*) Meat investigations, Homebush, New South Wales	2,226	..	..
Less contributions by Australian Meat Board and Metropolitan Meat Industry Commissioner, New South Wales	1,075	..	..
		1,151	..
(*c*) Fish investigations, Homebush, New South Wales	..	1,690	..
(*d*) Non-tropical fruits, Homebush, New South Wales	2,163	..	..
Less contributions from New South Wales Department of Agriculture	1,000	..	..
		1,163	..
(*e*) Physics and Transport, Homebush, New South Wales	..	1,939	..
(*f*) Citrus preservation	..	397	..
(*g*) Microbiology	..	1,734	..
(*h*) Meat investigations, Brisbane Abattoir	1,333	..	..
Less contributions by Queensland Meat Industry Board	850	..	..
		483	..
(*i*) Egg investigations	1,516	..	..
Less contributions from Egg Producers' Council	758	..	..
		758	..

3. Investigations—*continued*—	£	£	£
(*j*) Non-tropical fruits, Melbourne		513	
(*k*) Fruit juice investigations, Homebush, New South Wales		2,049	
(*l*) Apple juice certification	264		
Less contributions from Apple and Pear Board	264		
(*m*) Drying and canning of foods, Sydney University		59	
(*n*) Adviser on food preservation		131	
(*o*) Suspense account		44	
		16,253	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)		2,000	
			14,253
(vii) Forest Products—			
(*a*) Central Laboratory—			
Annual	11,978		
Capital	1,015		
		12,993	
(*b*) Seasoning		2,518	
(*c*) Preservation		1,563	
(*d*) Chemistry	2,335		
Less contributions from Australian Paper Manufacturers Limited, Associated Pulp and Paper Mills Ltd., and Australian Newsprint Mills Pty. Ltd.	1,375		
		960	
(*e*) Creosote investigations	713		
Less contributions from Tar Distillers' Research Committee	713		
(*f*) Aircraft timber		5,315	
(*g*) Flax processing	840		
Less contributions from Department of Supply and Development	792		
		48	
(*h*) Wood structure	3,475		
Less contributions from Bureau of Forestry, Canberra, and Queensland, New South Wales, Victorian and Western Australian Forests Services	90		
		3,385	
(*i*) Mechanics		2,729	
(*j*) Utilization		1,044	
(*k*) Physics		1,166	
(*l*) Fibres		1,099	
(*m*) Plastics and wood constructed aircraft		321	
(*n*) Veneer and gluing		1,622	
(*o*) Wood taint in butter	9		
Less contributions from Australian Dairy Board	9		
(*p*) Suspense account		97	
		34,860	
Less miscellaneous contributions		566	
		34,294	
Less contributions from Commonwealth Bank (Rural Credits Development Fund)		1,500	
			32,794
(viii) Mining and Metallurgy—			
(*a*) Mineragraphic investigations		812	
Less contribution by Australasian Institute of Mining and Metallurgy		368	
			444
(ix) Radio Research—			
(*a*) Melbourne and Sydney Universities		4,298	
Less contributions by Postmaster-General's Department		3,223	
			1,075
(x) Information Service, including Library			4,885
(xi) Gold Mining—			
(*a*) Mineragraphic investigations, Melbourne University		863	
(*b*) Ore-dressing, Melbourne University		1,505	
(*c*) Ore-dressing, South Australian School of Mines		806	
(*d*) Ore-dressing, Kalgoorlie School of Mines		591	
			3,765
(xii) Fisheries Investigations—			
(*a*) Administrative—			
Annual	5,328		
Capital	114		
		5,442	
(*b*) Marine biology		4,167	
(*c*) Marine bacteriology		879	
(*d*) Chemistry (including fish and by-product analyses) and hydrology		663	
(*e*) Investigations at sea		7,236	
(*f*) Fish liver oils		108	
(*g*) Co-operative investigations with New South Wales	325		
Less contribution from New South Wales Government	311		
		14	

	£	£	£
3. Investigations—*continued*—			
(*h*) Other investigations (including Canning, Smoking, and Agar experiments)	..	366	..
(*i*) Suspense account	..	28	..
	..		18,903
(xiii) Apple and Pear Investigations—			
(*a*) Waxy coating of apples	..	215	..
(*b*) Waxy coating of apples and pears	..	310	..
	..	525	..
Less contributions from Department of Commerce	..	525	..
(xiv) Aeronautical Research—			
(*a*) Administrative—			
Annual	6,424	..	..
Capital	4,595	..	..
	..	11,019	..
(*b*) Workshop	..	7,731	..
(*c*) Instrument Section	..	1,093	..
(*d*) Structure and materials	..	7,337	..
(*e*) Engine and fuels	..	5,105	..
(*f*) Aerodynamics	..	4,348	..
(*g*) Plastics and wood-constructed aircraft	..	404	..
(*h*) Aeronautics Advisory Committee	..	282	..
(*i*) Suspense account	..	38	..
			37,357
(xv) National Standards Laboratory—			
(*a*) Administrative—			
Annual	9,261	..	..
Capital	976	..	..
	..	10,237	..
(*b*) Physics	11,191	..	..
Less contributions	2,187	..	..
	..	9,004	..
(*c*) Electrical	8,485	..	..
Less contributions	1,714	..	..
	..	6,771	..
(*d*) Metrology	24,112	..	..
Less contributions	13,216	..	..
	..	10,896	..
(*e*) Calibration of testing machines	..	842	..
(*f*) Workshop	..	7,952	..
(*g*) Suspense account	..	252	..
			45,954
(xvi) Industrial Chemistry—			
(*a*) Administrative—			
Annual	11,394	..	..
Capital	3,152	..	..
	..	14,546	..
(*b*) Cement	..	226	..
(*c*) Wool	..	1,387	..
(*d*) Minerals and metals	..	2,503	..
(*e*) Dairy products	..	1,232	..
(*f*) Foundry sands	..	729	..
(*g*) Producer gas	..	93	..
(*h*) Alunite	..	843	..
(*i*) Organic	..	3,123	..
(*j*) Flotation	..	968	..
(*k*) Fellmongery	..	2,241	..
(*l*) Analytical	..	840	..
(*m*) Suspense account	..	695	..
			29,426
(xvii) Miscellaneous—			
(*a*) Tomato wilt	..	276	..
(*b*) Mineral deficiency in pastures	..	885	..
(*c*) Dairy research	3,302	..	..
Less contributions from Dairy Produce Control Board	457	..	..
	..	2,845	..
(*d*) Statistical Section	..	3,271	..
(*e*) Air Raid Precautions	..	1,798	..
(*f*) Lubricants and bearings	8,170	..	
Less contribution from University of Melbourne	519	..	
	..	7,651	
(*g*) Scientific survey	..	290	
(*h*) Rubber research	..	130	
(*i*) Various	..	59	
	..		
Total of Item 3—Investigations	..	..	..

2. Contributions.

The following statement shows the receipts and disbursements during the year 1941-42 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled "The Specific Purposes Trust Account":—

	Receipts 1941–42 and balances brought forward from 1940–41.	Expenditure 1941–42.
	£	£
Commonwealth Bank (Animal Health and Nutrition, Horticultural, Food Preservation and Transport, Prickly Pear, and Forest Products Investigations)	15,871	15,761
Australian Wool Board (Animal Health and Nutrition Investigations—Sheep Research)	12,813	9,336
Australian Cattle Research Association (Mastitis Investigations)	3,750	3,750
George Aitken Pastoral Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,000	2,000
Queensland Government Cattle Research (Animal Health and Nutrition Investigations)	1,000	1,000
University of Sydney (Animal Health and Nutrition Investigations)	350	250
Australian Meat Board (Toxaemic jaundice investigations, Barooga, New South Wales)	135	135
Thorpes Ltd., F. D. McMaster Field Station (Animal Health and Nutrition Investigations)	27	27
New South Wales Water Conservation and Irrigation Commission (Cumbungi Investigations)	192	192
Victorian State Rivers and Water Supply Commission (Cumbungi Investigations)	217	217
Victorian Central Citrus Association—Citrus Problems (Plant Industry Investigations)	100	..
Tobacco Trust Fund—Prime Minister's Department—Tobacco Problems (Plant Industry Investigations)	13,223	3,070
Department of Supply and Development—Medicinal Plants (Plant Industry Investigations)	680	680
Commonwealth Bank—Bee Research (Entomological Investigations)	92	..
Ministry of Agriculture, Egypt, Cotton Investigations (Entomological Investigations)	255	176*
Australian Wheat Board—Wheat Infestation (Entomological Investigations)	604	604†
Central Wool Committee—Wool Infestation (Entomological Investigations)	303	289
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	2,500	2,000
Murrumbidgee Irrigation Area Co-op. Society (Maintenance of Griffith Research Station)	100	92
Mildura Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	216	212
Irymple Packing Company (Dried Vine Fruits Investigations, Merbein)	216	212
Red Cliffs Co-operative Fruit Company (Dried Vine Fruits Investigations, Merebein)	216	212
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	216	212
Dried Fruits Control Board (Dried Fruits Investigations)	1,300	1,255
Carried forward ..	56,376	41,682

	Receipts 1941–42 and balances brought forward from 1940–41.	Expenditure 1941–42.
	£	£
Brought forward ..	56,376	41,682
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	60	60
Victorian State Rivers and Water Supply Commission (Soils Investigations)	73	73
Victorian Department of Agriculture (Soils Investigations)	40	40
Australian Meat Board (Meat Investigations)	546	546‡
Metropolitan Meat Industry Commissioner of New South Wales (Meat Investigations)	546	546‡
Queensland Meat Industry Board (Meat Investigations)	850	850
Apple and Pear Marketing Board—Apple Juice Certification (Food Preservation Investigations)	268	264
New South Wales Department of Agriculture (Food Investigations)	1,000	1,000
A. Lawrence & Co. (Division of Food Preservation and Transport)	500	..
W. Angliss Ltd. (Division of Food Preservation and Transport)	100	83
L. Berger & Sons (Division of Food Preservation and Transport)	25	25
Batlow Packing House Co-op. Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations)	10	..
Lewis Berger & Sons Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations)	25	..
Egg Producers' Council (Division of Food Preservation and Transport—Egg Investigations)	771	758
Egg Producers' Council (Watery Whites in Eggs)	2	..
Australian Paper Manufacturers Limited (Paper Pulp Investigations)	375	375
Associated Pulp and Paper Mills Limited (Paper Pulp Investigations)	500	500
Australian Newsprint Mills Pty. Ltd. (Paper Pulp Investigations)	500	500
Bureau of Forestry, Canberra, and Forest Services of Queensland, Victoria, New South Wales, and Western Australia—Wood Structure (Forest Products Investigations)	110	90
Tar Distillers Research Committee (Cresosote Investigations)—Division of Forest Products	734	713
Sundry Contributors (Forests Product Investigations)	2,050	566
Australian Dairy Council (Wood Taint in Butter Investigations)	20	9
Department of Supply and Development—Flax processing (Forest Products Investigations)	791	791
Brisbane Timber Merchants' Association (Division of Forest Products—Veneer and Gluing Work)	8	..
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	368	368
Postmaster-General's Department (Radio Research)	3,461	3,399§
New South Wales Government (Fisheries Investigations)	314	314‖
Department of Commerce (Apple and Pear Investigations)	798	525
Ministry of Munitions	19,702	17,445¶
Carried forward ..	90,923	71,462

* Includes £45 on account 1940–41 expenditure. † Includes £2 on account 1940–41 expenditure. ‡ Includes £8 on account 1940–41 expenditure.
§ Includes £116 on account of 1940–41 expenditure. ‖ Includes £3 on account 1940–41 expenditure. ¶ Includes £327 on account 1940–41 expenditure

	Receipts 1941–42 and balances brought forward from 1940–41.	Expenditure 1941–42.
	£	£
Brought forward ..	90,923	71,462
Sundry Contributors (Council for Scientific and Industrial Research) (Publications) ..	7	..
Amalgamated Textiles (Aust.) Ltd. (Division of Industrial Chemistry)	35	..
F. Walton & Co. (Division of Industrial Chemistry)	10	..
Associated Woollen and Worsted Textile Manufacturers of Australia (Division of Industrial Chemistry	500	..
University of Melbourne (Friction Research)	518	518
Dairy Produce Control Board (Dairy Research)	457	457
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Nutrition Investigations) ..	92	22
Revenue Fund—Contagious Pleuropneumonia Investigations (Animal Health and Nutrition Investigations)	1,868	1,576
Revenue Fund—Oestrus Experiment (Animal Health and Nutrition Investigations)	75	..
Revenue Fund—Oonoonba Research Station—Sale of Vaccine (Animal Health and Nutrition Investigations)	3,575	3,575
Revenue Fund—Anaplasmosis Investigations (Animal Health and Nutrition Investigations) ..	26	..
Revenue Fund—Parkville Laboratory (Animal Health and Nutrition Investigations)	207	..
Revenue Fund—Werribee Farm (Mastitis Investigations) ..	1,832	204
Revenue Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations)	3,572	3,560
Reserve Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations)	382	..
Revenue Fund—Bacteriological Investigations (Animal Health and Nutrition Investigations) ..	38	..
Revenue Fund — Parasitological Investigations (Animal Health and Nutrition Investigations) ..	178	..
Revenue Fund—Infertility, F. D. McMaster Field Station (Animal Health and Nutrition Investigations)	1,030	300
Revenue Fund—Nutrition Laboratory (Animal Health and Nutrition Investigations)	662	6
Revenue Fund—Toxaemic Jaundice Investigations, Barooga, New South Wales (Animal Health and Nutrition Investigations) ..	598	151
Revenue Fund—Plant Industry Investigations	111	..
Revenue Fund—Entomological Investigations	432	..
Revenue Fund—Griffith Research Station (Citricultural Investigations)	3,691	1,683
Revenue Fund—Merbein Research Station (Viticultural Investigations)	5,810	578
Revenue Fund—Citrus Preservation Investigations	102	..
Revenue Fund—Division of Food Preservation and Transport ..	101	..
Revenue Fund—Egg Investigations, Egg Producers' Council (Division of Food Preservation and Transport)	80	..
Carried forward ..	116,912	84,092

	Receipts 1941–42 and balances brought forward from 1940–41.	Expenditure 1941–42.
	£	£
Brought forward ..	116,912	84,092
Revenue Fund—Mining and Metallurgy	3	..
Revenue Fund—Ore-dressing Investigations	717	..
Revenue Fund—Division of Aeronautics	51	..
Revenue Fund—National Standards Laboratory	60	..
Revenue Fund—Dairy Investigations	4	..
	117,747	84,092

3. Staff.

The following is a list of the staff of the Council as at the 30th June, 1942. 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.R.S., F.A.C.I.

Deputy Chief Executive Officer—A. E. V. Richardson, C.M.G., M.A., D.Sc.

Secretary—G. Lightfoot, M.A.

Assistant Secretary and Officer-in-Charge, Information Section—G. A. Cook, M.Sc., B.M.E., F.A.C.I.

Assistant Secretary (Finance and Supplies)—M. G. Grace, A.I.C.A. (*vice* H. P. Breen, A.I.C.A., seconded).

Information Section—
J. E. Cummins, B.Sc., M.S., F.A.C.I.
J. S. Hosking, M.Sc., A.I.C., A.A.C.I. (seconded from Division of Soils).
F. G. Nicholls, M.Sc., A.A.C.I. (seconded).
N. C. Hancox, M.Sc., A.A.C.I. (seconded from Division of Industrial Chemistry).
Miss M. E. Hamilton, B.Sc.
Miss J. Dunstone, B.Sc.

Library—
Librarian and Scientific Assistant—Miss E. Archer, M.Sc.
Assistant Librarian—Miss A. L. Kent.
Assistant Librarian—Miss F. V. Murray, M.Sc.

Accounts, Stores—
Accountant—D. J. Bryant, A.F.I.A. (*vice* M. G. Grace, A.I.C.A.).
R. W. Viney, A.I.C.A., A.A.I.S.
M. A. Elliott.
V. Leonard.
C. Munro (on service leave—R.A.N.V.R.).
F. Butler.
J. Farey (on military leave—A.I.F.).
F. J. Whitty (on military leave—A.I.F.).
R. Bennett (on military leave—A.I.F.).
J. Bourne (on military leave—A.M.F.).
C. Garrow, A.F.I.A. (on service leave—R.A.N.V.R.).
C. Cole (on service leave—R.A.N.).
K. Gamble (on service leave—R.A.A.F.).
B. Gaynor (on military leave—A.M.F.).
H. Lee (on service leave—R.A.A.F.).
J. M. Short (on service leave—A.M.F.).
K. J. Fogarty (on service leave—R.A.N.).

Orders and Transport—
J. M. Derum.
L. Graham (on service leave—R.A.A.F.).

Staff—
R. D. Elder.
J. Smithwick (on service leave—R.A.A.F.).

Records—
P. Domee-Carre.
P. Knuckey.
R. McVilly, A.F.I.A.
B. Gooley (on service leave—R.A.A.F.).
M. Coombe (on service leave—R.A.A.F.).
M. Reynolds (on military leave—A.M.F.).
Miss W. Livingston.
Miss N. R. Johns.
D. Yarr (on service leave—R.A.A.F.).

Head Typiste—
Miss B. M. 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.
Senior Clerical Officer, Sydney—R. F. Williams.
Architect—W. R. Ferguson, B.E., A.R.A.I.A.

2. Secretaries of State Committees.

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

Victoria—
G. A. Cook, M.Sc., B.M.E., F.A.C.I., 314 Albert-street, East Melbourne.

Queensland—
Miss H. F. Todd, 113 Eagle-street, Brisbane.

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

Western Australia—
R. P. Roberts, B.Sc., Institute of Agriculture, University of Western Australia.

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 (half-time)—Mrs. E. Crawley.
Clerk-in-Charge (half-time)—D. Banyard (acting).
Clerk, Records—K. J. Prowse (on military leave—A.I.F.).
Pathology—
Principal Research Officer—H. R. Angell, O.B.E., Ph.D.
Research Officer—J. G. Bald, M.Agr.Sc., Ph.D.
Research Officer—W. V. Ludbrook, B.Ag.Sc., Ph.D.
Assistant Research Officer—N. H. White, M.Sc.
Assistant Research Officer—D. O. Norris, B.Sc. (Agric.).
Genetics—
Principal Research Officer—J. R. A. McMillan, D.Sc.Agr., M.S.
Assistant Research Officer—F. W. Hely, B.Sc.Agr.
Assistant Research Officer—E. M. Hutton, B.Ag.Sc., M.Sc.
Assistant Research Officer—S. G. Gray, B.Sc.Agr.
Plant Introduction—
Senior Research Officer—A. McTaggart, B.S.A., M.S.A., Ph.D.
Research Officer—W. Hartley, B.A., Dip.Ed.
Horticultural and General Botany—
Senior Research Officer—C. Barnard, D.Sc.
Vegetable Fibre Investigations—
Research Officer—J. Calvert, D.Sc., F.L.S.
Agrostology—
Senior Research Officer—J. G. Davies, B.Sc., Ph.D.
Research Officer—C. M. Donald, M.Ag.Sc. (seconded).
Assistant Research Officer—R. Roe, B.Sc. (Agric.).
Assistant Research Officer—R. M. Moore, B.Sc.Agr.
Assistant Research Officer—N. Shaw, B.Agr.Sc. (seconded).
Assistant Research Officer—T. Wilkinson, B.Sc. (on military leave—A.I.F.)
Assistant Research Officer—W. M. Willoughby, B.Sc.Agr.
Technical Officer—E. H. Kipps, B.Sc.
Technical Officer—Miss N. Barrie, B.Sc.Agr.
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. (on service leave—R.A.N.).
At Waite Agricultural Research Institute—
Technical Officer (tobacco physiology)—Miss J. McPherson, B.Sc.
At Moss Vale, New South Wales—
Research Officer (genetics)—K. L. Hills, B.Agr.Sc.
At Griffith, New South Wales—
Assistant Research Officer (horticultural physiology)—Miss J. Hearman, B.Sc., Ph.D.
At Queensland Agricultural High School and College, Lawes—
Research Officer (genetics)—C. S. Christian, B.Agr.Sc., M.Sc.
Research Officer (plant introduction)—T. B. Paltridge, B.Sc.
At Stanthorpe, Queensland—
Research Officer (horticultural investigations)—L. A. Thomas, M.Sc.
At Fitzroyvale, Central Queensland—
Assistant Research Officer (plant introduction)—J. F. Miles, B.Agr.Sc.
Assistant Research Officer (plant introduction)—E. T. Bailey, B.Sc.
At University of Melbourne—
Assistant Research Officer (weeds investigations)—R. W. Prunster, B.Sc. (Agric.) (seconded).
At Huonville, Tasmania—
Research Officer (fruit investigations)—D. Martin, B.Sc.
At University of Western Australia, Perth—
Research Officer (agrostology)—A. B. Cashmore, M.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer (agrostology)—R. C. Rossiter, B.Sc. (Agric.).

5. Division of Economic Entomology.

At Canberra—
Administration—
Chief—A. J. Nicholson, D.Sc.
Librarian (half-time)—Mrs. E. Crawley.
Clerk-in-Charge (half-time)—D. Banyard (acting).
Clerk, Records—K. J. Prowse (on military leave—A.I.F.).
Clerk—T. Lewis.
Wheat Pest and Termite Investigations—
Senior Research Officer—F. N. Ratcliffe, B.A.
Assistant Research Officer—F. J. Gay, B.Sc., D.I.C.
Technical Officer—T. Greaves.
Wool Pest Investigations—
Research Officer—K. H. L. Key, M.Sc., Ph.D., D.I.C.
Assistant Research Officer—K. R. Norris, M.Sc.
Veterinary Entomology—
Principal Research Officer—I. M. Mackerras, B.Sc., M.B., Ch.M. (on military leave—A.I.F.).
Assistant Research Officer (blowfly investigations)—Mrs. M. J. Mackerras, M.Sc., M.B. (on extended leave).
Assistant Research Officer (blowfly investigations)—D. F. Waterhouse, M.Sc., A.A.C.I.
Assistant Research Officer (blowfly investigations)—D. Gilmour, M.Sc.
Agricultural Entomology and Museum—
Assistant Research Officer—T. G. Campbell.
Technical Officer (photography)—W. J. James (on service leave—R.A.A.F.).
Insect Vectors of Virus Diseases—
Assistant Research Officer—G. A. Helson, M.Sc.
Locust Investigations—
Assistant Research Officer—K. H. L. Key, M.Sc., Ph.D., D.I.C.
At Warren, New South Wales—
Assistant Research Officer (locust investigations)—L. R. Clark, M.Sc.
Technical Officer (locust investigations)—D. L. Hall, Dip.Agr.
At Melbourne, Victoria—
Assistant Research Officer (wheat investigations)—F. Wilson.
At School of Veterinary Science, Brisbane—
Senior Research Officer (cattle tick investigations)—L. F. Hitchcock, M.Sc.

6. Division of Animal Health and Nutrition.

At Animal Health Research Laboratory and Divisional Headquarters, 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., O.B.E.
Senior Research Officer (pathology, bacteriology, dairy cattle)—D. Murnane, B.V.Sc. (on military leave).
Senior Research Officer (pathology, bacteriology)—C. G. Dickinson, B.V.Sc.
Senior Research Officer (serological investigations)—A. D. Campbell, B.V.Sc.
Research Officer (immuno-chemistry)—A. T. Dann, M.Sc., A.A.C.I.
Research Officer (bacteriology, dairy cattle)—E. Munch-Petersen, M.Sc., Ph.B., M.I.F.
Research Officer (bacteriology—biochemistry)—A. T. Dick, M.Sc., A.A.C.I.
Assistant Research Officer (bacteriology, anaerobic infections)—A. W. Rodwell, M.Sc.
Assistant Research Officer (field studies, dairy cattle diseases)—L. Duckett, Dr.Med.Vet. (Brno).
Technical Officer—Miss C. E. Eales, B.Sc.
Technical Officer—Miss M. J. Monsbourgh, B.Sc.
Technical Officer—E. Wold.
Technical Officer—A. E. Wright.
Technical Officer—J. J. Spencer (on military leave—A.I.F.).
Libararian—Miss F. V. Murray, M.Sc. (part-time).
Clerk—J. Foley (on military leave—A.I.F.).

At F. D. McMaster Animal Health Laboratory, Sydney—
Officer-in-Charge—D. A. Gill, M.R.C.V.S., D.V.S.M. (seconded).
Principal Research Officer (bacteriology)—T. S. Gregory, B.V.Sc. (on military leave—A.I.F.).
Senior Research Officer and Acting Officer-in-Charge (parasitology)—H. McL. Gordon, B.V.Sc.
Senior Research Officer (biochemistry)—M. C. Franklin, M.Sc., Ph.D. (Cantab.), A.I.C.
Senior Research Officer (bacteriology, sheep diseases)—W. I. B. Beveridge, D.V.Sc. (seconded).
Research Officer (parasitology)—G. Kauzal, Dr.Vet.Med.
Research Officer (field investigations, ectoparasites)—N. P. H. Graham, B.V.Sc.
Research Officer (chemistry of wool)—M. R. Freney, B.Sc., A.A.C.I. (seconded).
Research Officer (wool biology)—H. B. Carter, B.V.Sc.
Research Officer (parasitology, field studies)—I. W. Montgomery, B.V.Sc. (on military leave).
Assistant Research Officer (blowfly strike, field studies)—I. L. Johnstone, B.V.Sc.
Assistant Research Officer (parasitology, field studies)—F. H. Ward, B.V.Sc.
Assistant Research Officer (biochemistry)—C. R. Austin, B.V.Sc. (part-time).
Technical Officer—E. Parrish.
Librarian—Miss B. Johnston, B.Sc. (part-time).
Clerk—H. H. Wilson (on service leave—R.A.A.F.).

At Animal Nutrition Laboratory, Adelaide—
Chief Nutrition Officer and Officer-in-Charge—H. R. Marston, F.A.C.I.
Secretary—J. Ward Walters.
Senior Research Officer (metabolism)—E. W. Lines, B.Sc. (on military leave).
Research Officer (ruminant physiology)—R. H. Watson, B.Sc.Agr.
Research Officer (biochemistry)—J. W. H. Lugg, Ph.D., D.Sc., F.I.C., A.A.C.I.
Assistant Research Officer (biochemistry)—A. B. Beck, M.Sc., A.A.C.I.
Assistant Research Officer (agrostology)—D. S. Riceman, B.Ag.Sc. (on military leave).
Assistant Research Officer (mineral deficiency, field investigations)—H. J. Lee, B.Sc.
Assistant Research Officer (metabolism)—F. V. Gray, B.Sc. (on military leave—A.I.F.).
Assistant Research Officer (biochemistry)—Frau Ella Flaum, D.Sc.Agric. (Budapest).
Assistant Research Officer (metabolism)—T. A. F. Quinlan-Watson, B.Sc.
Technical Officer—J. O. Wilson.
Technical Officer—F. C. Farr.
Technical Officer—I. G. Jarrett, B.Sc.
Technical Officer—A. F. Pilgrim, B.Sc. (on service leave—R.A.N.).
Technical Officer—D. W. Dewey.
Statistical Recorder—G. W. Bussell.

At Waite Agricultural Research Institute, Adelaide—
Research Officer (studies in experimental nutrition)—A. W. Peirce, M.Sc., A.A.C.I.

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

At National Field Station, "Gilruth Plains," Cunnamulla, Queensland—
Research Officer-in-Charge—J. H. Riches, B.Sc. (Agric.), Ph.D.
Station Manager—W. S. Firth.

At Institute of Agriculture, University of Western Australia—
Assistant Research Officer (biochemistry)—S. T. Evans, B.Sc., A.A.C.I.

7. Mineral Deficiency of Pastures Investigation.

At Waite Agricultural Research Institute—
Assistant Research Officer (chemist)—R. E. Shapter, A.A.C.I.

8. Division of Soils.

At Waite Agricultural Research Institute—
Chief—J. A. Prescott, D.Sc., A.A.C.I. (part-time).
Principal Research Officer (soil surveys)—J. K. Taylor, B.A., M.Sc., B.Sc.Agr.
Research Officer (soil surveys)—T. J. Marshall, M.Ag.Sc., Ph.D.
Research Officer (soil surveys)—C. G. Stephens, M.Sc., A.A.C.I.
Research Officer (soil chemistry)—J. S. Hosking, M.Sc., A.I.C., A.A.C.I. (seconded).
Research Officer (soil chemistry)—A. Walkley, B.A., B.Sc., Ph.D., A.I.C., A.A.C.I. (seconded).
Assistant Research Officer (spectrography)—A. C. Oertel, M.Sc., A.A.C.I.
Assistant Research Officer (microbiology)—T. H. Strong, M.Agr.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer (soil surveys)—J. G. Baldwin, B.Agr.Sc., B.Sc. (on military leave—A.I.F.).
Assistant Research Officer (soil surveys)—G. D. Hubble, B.Ag.Sc. (seconded).
Assistant Research Officer (soil surveys and ecology)—R. L. Crocker, M.Sc. (seconded).
Assistant Research Officer (soil surveys)—B. E. Butler, B.Sc. (Agric.) (on service leave—R.A.A.F.).
Assistant Research Officer (soil surveys)—R. Smith, B.Sc. (Agric.).
Assistant Research Officer (soil surveys)—R. G. Downes, M.Agr.Sc.
Assistant Research Officer (soil surveys)—E. J. Johnston, B.Sc.Agr. (R.A.A.F. Reserve).
Assistant Research Officer (soil surveys)—T. Langford Smith, B.Sc. (R.A.A.F. Reserve).
Assistant Research Officer—R. Brewer, B.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer—Miss M. P. Thomas, B.Sc.
Technical Officer (surveys and cartography)—P. D. Hooper.
Technical Assistant (soil chemistry)—H. R. Skewes (seconded).

9. Irrigation Settlement Problems.

At Irrigation Research Station, Griffith—
Officer-in-Charge—E. S. West, B.Sc., M.S.
Chemist—A. Howard, M.Sc., A.A.C.I.
Research Officer—R. R. Pennefather, B.Agr.Sc.
Assistant Research Officer—O. Perkman, B.Sc.Agr.
Assistant Research Officer—V. J. Wagner, B.Agr.Sc.
Orchard Superintendent—B. H. Martin, H.D.A.

At Commonwealth Research Station, Merbein—
Officer-in-Charge—A. V. Lyon, M.Agr.Sc.
Senior Research Officer (chemist)—E. C. Orton, B.Sc., A.I.C., A.A.C.I.
Assistant Research Officer (irrigation and viticulture)—D. V. Walters, M.Agr.Sc.
Assistant Research Officer (drainage)—A. L. Tisdall, M.Agr.Sc. (on service leave—R.A.A.F.).
Technical Officer—J. E. Giles.
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).
Senior Research Officer—C. S. Elliot, B.Sc.
Librarian and Records Clerk—Miss M. I. Hulme.
Chemistry Section—
Officer-in-Charge—W. E. Cohen, D.Sc., A.A.C.I.
Research Officer (chemist)—Miss T. M. Reynolds, M.Sc., D.Phil., A.A.C.I. (seconded).
Assistant Research Officer (chemist)—E. A. Hanson, Dr.Phil. (Leiden).
Technical Officer—A. G. Charles, A.A.C.I.
Technical Officer—A. J. Watson, A.A.C.I.
Wood Structure Section—
Officer-in-Charge—H. E. Dadswell, D.Sc., A.A.C.I.
Assistant Research Officer—H. D. Ingle, B.For.Sc. (N.Z.).
Assistant Research Officer—Miss A. M. Eckersley, M.Sc.
Assistant Research Officer—Miss D. J. Ellis, B.Sc.
Seasoning Section—
Officer-in-Charge—G. W. Wright, B.E. (acting).
Assistant Research Officer—A. C. Pond, B.E. (Hons.) (seconded).
Technical Officer—J. T. Currie.
Technical Officer—H. D. Roberts.
Timber Physics Section—
Officer-in-Charge—W. L. Greenhill, M.E., Dip.Sc.
Assistant Research Officer—P. H. Sulzberger, B.Sc.
Timber Mechanics Section—
Officer-in-Charge—I. Langlands, B.E.E., M.Mech.E., A.M.I.E. (Aust.).
Assistant Research Officer—R. S. T. Kingston, B.Sc., B.E.
Assistant Research Officer—N. H. Kloot, B.Sc.
Technical Officer—B. Whitington, B.Sc., B.E.
Technical Officer—A. L. Gunn.
Preservation Section—
Officer-in-Charge—S. F. Rust, B.Sc., M.S.
Assistant Research Officer—H. B. Wilson, B.Sc., A.A.C.I.
Assistant Research Officer—N. Tamblyn, M.Sc. (Agric.).
Creosote Research Officer—D. E. Bland, M.Sc., A.A.C.I. (co-operative investigation with Tar Distillers).
Veneering and Gluing Section—
Officer-in-Charge—S. F. Rust, B.Sc., M.S.
Technical Officer—R. Deeble.
Technical Officer—M. W. Mules (seconded from Division of Animal Health and Nutrition).

Timber Utilization Section—
Officer-in-Charge—R. F. Turnbull, B.E.(Hons.) (seconded).
Research Officer—A. J. Thomas, Dip.For.
Assistant Research Officer—A. Gordon, B.Sc.
Technical Officer—A. Rosel.
Flax Processing—
Officer-in-Charge—W. L. Greenhill, M.E., Dip.Sc.
Research Officer—A. M. Munro, M.A.(Oxon.), A.I.C., F.C.S.
Assistant Research Officer—Miss J. F. Couchman, B.Sc., A.A.C.I.
Technical Officer—C. N. Pickering.
Technical Officer—M. Tisdall.
Photography—
Technical Officer—E. S. Smith.
Technical Officer—Miss A. M. Lightfoot.
Maintenance Section—
Technical Officer—S. G. McNeil.
Technical Officer—G. Seal.

11. Division of Food Preservation and Transport.

At State Abattoir, Sydney—
Chief—J. R. Vickery, M.Sc., Ph.D., A.A.C.I.
Librarian—Miss B. Johnston, B.Sc. (part-time).
Physics Section—
Officer-in-Charge—E. W. Hicks, B.A., B.Sc., A.A.C.I.
Assistant Research Officer—M. C. Taylor, M.Sc.
Fruit Storage Section—
Officer-in-Charge—S. A. Trout, M.Sc., Ph.D.
Research Officer—F. E. Huelin, B.Sc., Ph.D., A.A.C.I.
Canning and Fruit Products Section—
Officer-in-Charge—L. J. Lynch, B.Agr.Sc.
Assistant Research Officer—J. F. Kefford, M.Sc., A.A.C.I.
Technical Officer—Mrs. I. M. Stephens, B.Agr.Sc.
Dried Fruits Section—
Research Officer—Miss T. M. Reynolds, M.Sc., D.Phil., A.A.C.I. (seconded from Division of Forest Products).
Assistant Research Officer—A. Howard, M.Sc., A.A.C.I. (seconded from Irrigation Research Station, Griffith).
Assistant Research Officer—H. S. McKee, B.A., D.Phil.
Assistant Research Officer—C. R. Austin, B.V.Sc. (part-time).
Technical Officer—A. J. Watson, A.A.C.I. (seconded from Division of Forest Products).
Technical Officer—Mrs. N. B. Adderley, B.Sc.
Meat, Fish and Egg Technology Section—
Senior Research Officer—W. A. Empey, B.V.Sc.
Microbiology Section—
Officer-in-Charge—W. J. Scott, B.Agr.Sc.
Assistant Research Officer—A. M. Olsen, B.Sc.
Technical Officer—P. R. Maguire.
At Division of Animal Health and Nutrition, Melbourne—
Assistant Research Officer (bacteriologist)—J. M. Gillespie, B.Sc., A.A.C.I., A.M.T.C.
At Brisbane Abattoir—
Research Officer—A. R. Riddle, M.A., M.Sc.
At Fisheries Research Laboratory, Cronulla—
Assistant Research Officer (chemist)—C. G. Setter, B.Sc.
Technical Officer (fish curing and canning)—R. Allan.
At Australia House, London—
Assistant Research Officer—N. E. Holmes, B.E.E.

12. Division of Fisheries.

At Port Hacking, Sydney—
Chief—H. Thompson, M.A., D.Sc.
Research Officer (bacteriologist)—E. J. Ferguson Wood, M.Sc., B.A.
Research Officer (biologist)—D. L. Serventy, B.Sc., Ph.D.
Assistant Research Officer (biochemist)—C. G. Setter, B.Sc., A.A.C.I., A.M.T.C. (seconded).
Assistant Research Officer (biologist)—G. L. Kesteven, B.Sc.
Assistant Research Officer (biologist)—M. Blackburn, M.Sc.
Assistant Research Officer (biologist)—A. Tubb, M.Sc.
Assistant Research Officer (chemist and hydrographer)—D. Rochford, B.Sc.
Assistant Research Officer—G. P. Whitley (seconded from Royal Australian Museum).
Technical Officer—A. Proctor (laboratory).
Technical Officer—K. Sheard.
Technical Officer—Mrs. M. G. M. Kesteven, B.Sc. (part-time).
Technical Officer—H. M. Peddie (m.v. *Warreen*).
Technical Officer—Mrs. M. Roger, B.Sc.
Master—m.v. *Warreen*—Captain A. Flett.
At Melbourne—
Fisheries Officer—S. Fowler.

13. Australian National Standards Laboratory.

Administration—
Officer-in-Charge—N. A. Esserman, B.Sc., F.Inst.P.
Senior Clerical Officer—R. F. Williams.
Clerk—W. J. Gillespie, A.F.I.A., A.A.I.A. (seconded from Division of Fisheries).
Draughtsman—A. G. Chinnery.
Draughtsman—R. H. Furniss.
Draughtsman—C. M. Williamson.
Librarian and Technical Recorder—Mrs. E. L. Eastman, B.A.
Assistant Librarian—Miss M. Barnard, B.A.
Assistant, Female (Technical Records)—Miss B. V. Mortlock, B.A.
Foreman-Supervisor of the Laboratory Workshop—J. Hanna.
Instrument Maker—A. H. Masters.
Toolmaker—W. Hyett.
Toolmaker—L. T. Mills.
Maintenance Engineer—D. J. Harper.
Plumber-Tinsmith—W. D. Palmer.
Patternmaker-Carpenter—A. Taylor.
Maintenance Electrician—N. Wunderlich.
Electrotechnology Section—
Officer-in-Charge—D. M. Myers, B.Sc., D.Sc.Eng., A.M.I.E.E., F.Inst.P.
Assistant Research Officer—W. K. Clothier, B.Sc., M.E., A.Inst.P.
Assistant Research Officer—B. V. Hamon, B.Sc., B.E.
Assistant Research Officer—A. M. Thompson, B.Sc.
Technical Officer—J. W. Porter.
Assistant, Female—Miss G. J. Levy, B.A.
Metrology Section—
Officer-in-Charge—N. A. Esserman, B.Sc., F.Inst.P.
Assistant Research Officer—G. A. Bell, B.Sc.
Assistant Research Officer—P. M. Gilet, B.Sc., B.E.
Assistant Research Officer—C. G. Greenham, M.Sc. (seconded from Division of Plant Industry).
Assistant Research Officer—M. F. Lamrock, B.Sc., B.E.
Assistant Research Officer—Miss P. M. Yelland.
Assistant, Female—Miss H. Muir, B.A.
Stores Clerk—B. G. Davis (seconded from State Taxation Department).
Physics Section—
Officer-in-Charge—G. H. Briggs, D.Sc., Ph.D.
Assistant Research Officer—N. A. Faull, B.Sc.
Assistant Research Officer—R. V. Giovanelli, M.Sc.
Assistant Research Officer—A. F. A. Harper, M.Sc.
Technical Officer—J. E. Thompson.
Instrument Maker—F. G. Boland.
Instrument Maker—D. A. Greenwood.

14. Division of Aeronautics.

Chief—L. P. Coombes, D.F.C., B.Sc. (Eng.), A.F.R.Ae.S., A.F.I.Ae.S.
Structures and Materials Section—
Principal Research Officer—H. A. Wills, B.E., A.F.R.Ae.S.
Research Officer—F. S. Shaw, B.E.
Assistant Research Officer—H. W. Maley, B.E.
Assistant Research Officer—W. W. Johnstone, B.E.
Assistant Research Officer—W. I. B. Smith, B.Sc.
Technical Officer—J. P. O. Silberstein.
Technical Officer—F. A. Dale.
Metallurgy Section—
Officer-in-Charge (on loan)—G. B. O'Malley, B.Met.E., M.Aust.I.M.M., M.Inst.M., M.A.I.M.E. (part-time).
Assistant Research Officer—J. B. Dance, B.Met.E.
Assistant Research Officer—A. R. Edwards, B.Met.E.
Assistant Research Officer—H. L. Wain, B.Met.E.
Aerodynamics Section—
Senior Research Officer—G. N. Patterson, B.Sc., M.A., Ph.D., A.F.R.Ae.S.
Assistant Research Officer—T. F. C. Lawrence, B.Sc., B.E.
Assistant Research Officer—G. K. Batchelor, M.Sc.
Assistant Research Officer—J. B. Willis, M.Sc.
Assistant Research Officer—R. W. Cumming, B.E.
Technical Officer—F. Redlich, Dipl. Ing.
Technical Officer—G. J. Dailey.
Technical Officer—H. J. Major.
Technical Officer—G. F. Gerraud.
Technical Officer—L. T. Watson.
Engines and Fuels Section—
Senior Research Officer—M. W. Woods, D.Phil., B.Sc., B.E.
Assistant Research Officer—W. B. Kennedy, B.Mech.E.
Assistant Research Officer—W. H. Clements, B.Sc.
Assistant Research Officer—J. C. Wisdom, B.Mech.E.
Instruments Section—
Assistant Research Officer—A. A. Townsend, M.Sc.
Drawing Office—
Senior Draughtsman—D. W. Eaton.
Workshops—
Supervisor—H. McCarthy.
Photography—
Technical Officer—Miss E. F. Lightfoot.

15. Division of Industrial Chemistry.

Administrative and General—
Chief—I. W. Wark, Ph.D., D.Sc., F.A.C.I., M.A.I.M.E.
Divisional Secretary—L. Lewis, B.Met.E.
Clerk—A. Patterson, A.F.I.A.

Leather and Fellmongery Section—
Research Officer—F. G. Lennox, D.Sc., A.A.C.I.
Assistant Research Officer—W. J. Ellis, A.S.T.C., A.A.C.I.
Assistant Research Officer—Miss M. Maxwell, M.Sc.
Minerals Section—
Senior Research Officer—R. G. Thomas, B.Sc., A.A.C.I.
Research Officer—A. Walkley, B.A., B.Sc., Ph.D., A.I.C., A.A.C.I. (seconded from Division of Soils).
Assistant Research Officer—A. Wylie, M.Sc., Ph.D., A.I.C., A.A.C.I.
Assistant Research Officer—P. Dixon, M.Sc., A.A.C.I. (seconded from Commonwealth Research Station, Merbein).
Assistant Research Officer—G. B. Gresford, B.Sc., A.M.T.C., A.A.C.I.
Assistant Research Officer—F. K. McTaggart, M.Sc., A.A.C.I.
Technical Officer—K. L. Elliot.
Dairy Products Section—
Research Officer—G. Loftus Hills, B.Agr.Sc.
Assistant Research Officer—J. Conochie, B.Sc.(Agric.).
Technical Officer—W. G. T. Laffan, H.D.D.
Organic Section—
Senior Research Officer—H. H. Hatt, B.Sc., Ph.D., A.I.C.
Research Officer—J. S. Fitzgerald, M.Sc., Ph.D., A.A.C.I.
Assistant Research Officer—N. C. Hancox, M.Sc., A.A.C.I. (seconded).
Assistant Research Officer—K. E. Murray, B.Sc., A.I.C., A.A.C.I.
Assistant Research Officer—R. G. Curtis, M.Sc.
Assistant Research Officer—R. J. L. Martin, M.Sc., A.A.C.I.
Technical Officer—L. K. Dalton, D.S.T.C., A.A.C.I.
Physical Chemistry Section—
Assistant Research Officer—K. L. Sutherland, M.Sc., A.A.C.I.
Assistant Research Officer—J. Rogers, M.Sc., A.A.C.I.
Assistant Research Officer—Miss E. Plante, B.Sc., A.A.C.I.
Foundry Sands Investigations—
Assistant Research Officer—H. A. Stephens, B.Sc.
Chemical Engineering Section—
Principal Research Officer—E. J. Drake, A.A.C.I. (seconded).
Assistant Research Officer—E. H. Waters, M.Sc. (seconded).
Assistant Research Officer—D. R. Zeidler, M.Sc., A.A.C.I.
Designing Draughtsman—C. Simpson.
Analytical Section—
Research Officer—A. Lench, B.Sc., Dip.Ed., A.A.C.I.
Technical Officer—H. C. C. Rasmussen.
Cement Section—
Research Officer—A. R. Alderman, M.Sc., Ph.D., F.G.S.
Metallurgical Section—
Officer-in-Charge (on loan)—G. B. O'Malley, B.Met.E., M.Aust.I.M.M., M.Inst.M., M.A.I.M.E. (part-time).
Assistant Research Officer—H. W. Worner, M.Sc., A.A.C.I., Assoc. I.S.I. (part-time).
At University of Western Australia—
Alunite Investigations—
Assistant Research Officer—G. H. Payne, B.Sc., A.A.C.I. (on service leave—R.A.A.F.).
Assistant Research Officer—W. E. Ewers, M.Sc.

16. Section of Biometrics.

At Melbourne—
Senior Research Officer—E. A. Cornish, M.Sc., B.Agr.Sc.
Assistant Research Officer—E. J. Williams, B.Com.
At Canberra—
Assistant Research Officer—G. A. McIntyre, B.Sc., Dip.Ed.
At Sydney—
Assistant Research Officer—Miss H. A. Newton Turner, B.Arch. (seconded).

17. Radio Research.

At University of Sydney—
Investigator—F. W. Wood, B.Sc.
Investigator—L. S. Prior, B.Sc.
Investigator—C. B. Kirkpatrick, B.Sc.

18. Ore-dressing Investigations.

At University of Melbourne—
Investigator—J. G. Hart.
Investigator—F. D. Drews.
At School of Mines, Adelaide, South Australia—
Investigator—K. S. Blaskett, B.E.

19. Lubricants and Bearings Section.

Officer-in-Charge—F. P. Bowden, Sc.D. (Cantab.), D.Sc., Ph.D.
Research Officer (Physics)—D. Tabor, Ph.D. (Cantab.).
Assistant Research Officer (Physics)—J. S. Courtney-Pratt, B.E.
Assistant Research Officer (Chemistry)—A. Yoffe, M.Sc., A.A.C.I.
Assistant Research Officer (Chemistry)—L. T. Wilson, B.Sc., A.A.C.I.
Assistant Research Officer (Chemistry)—J. N. Gregory, B.Sc.
Assistant Research Officer (Engineering)—A. E. Ferguson, B.E.E.
Assistant Research Officer (Engineering)—J. G. Brookman, B.E.E.
Assistant Research Officer (Metallurgy)—H. W. Worner, M.Sc., A.A.C.I.
Assistant Research Officer (Metallurgy)—A. J. W. Moore, B.Sc.

20. Other Investigations.

Dairy Products Investigations—
Officer-in-Charge—W. J. Wiley, D.Sc., A.A.C.I.
Research Officer—E. J. Pont, M.Sc.Agr.
Assistant Research Officer—C. C. Thiel, B.Sc.(Agric.), Ph.D.
Mineragraphic Investigations—
Investigator—F. L. Stillwell, D.Sc.
Research Officer—A. Edwards, B.Sc., Ph.D.

4. Publications of the Council.

The following publications were issued by the Council during the year:—

(i) Bulletins.

No. 141.—A Soil Survey of the Waikerie Irrigation Area, South Australia, by R. I. Herriot, B.Ag.Sc., and E. J. Johnston, B.Sc.Agr.

No. 142.—A Soil and Land Use Survey of the Hundreds of Riddoch, Hindmarsh, Grey, Young, and Nangwarry, County Grey, South Australia, by C. G. Stephens, M.Sc., A.A.C.I., R. L. Crocker, M.Sc., B. Butler, B.Ag.Sc., and R. Smith, B.Ag.Sc.

No. 143.—Production of Dried Grapes in Murray Valley Irrigation Settlements. 1.—Viticulture, by A. V. Lyon, M.Agr.Sc., and D. V. Walters, M.Agr.Sc.

No. 144.—Interference in a Wind-Tunnel of Octagonal Section, by G. K. Batchelor, M.Sc.

No. 145.—Friction and Lubrication, Report No. 1. 1.—The Theory of Metallic Friction and the Role of Shearing and Ploughing. 2.—The Friction of Thin Metallic Films, by F. P. Bowden, Sc.D., Fellow of Caius College, Cambridge, and D. Tabor, Ph.D. (Cantab.).

No. 146.—An Analysis of the Outbreaks of the Australian Plague Locust (*Chortoicetes terminifera* Walk) during the Seasons 1937-38 and 1938-39, by K. H. L. Key, M.Sc., Ph.D.

No. 147.—Enzootic Ataxia and Copper Deficiency of Sheep in Western Australia, by H. W. Bennetts, D.V.Sc., and A. B. Beck, M.Sc.

No. 148.—Studies in Fertility in Sheep. 2.—Seminal Changes Affecting Fertility in Rams, by R. M. C. Gunn, D.V.Sc., B.Sc.Agric., M.R.C.V.S., and R. N. Sanders, B.V.Sc., and W. Granger, B.V.Sc.

(ii) Pamphlets.

No. 108.—Studies on Some Ectoparasites of Sheep and their Control.
(1) Observations on the Bionomics of the Sheep Ked (*Melophagus ovinus*), by N. P. H. Graham, B.V.Sc., and K. L. Taylor, B.Agr.Sc.
(2) Chemical and Biological Studies on Certain Arsenical Dipping Fluids, by M. R. Freney, B.Sc., M. Lipson, B.Sc., and N. P. H. Graham, B.V.Sc.
(3) Chemical Observations on Commercial Powder Sheep Dips with Special Reference to their Arsenic Content, by M. Lipson, B.Sc.

No. 109.—Studies of the Physiology and Toxicology of Blowflies.
(8) Rate of Ammonia Production by Larvae of *Lucilia cuprina* and its Distribution in this Insect, by F. G. Lennox, M.Sc., A.I.C.
(9) The Enzymes Responsible for Ammonia Production by Larvae of *Lucilia cuprina*, by F. G. Lennox, M.Sc., A.I.C.

No. 110.—The Main Virus Diseases of the Potato in Victoria, by J. G. Bald, M.Agr.Sc., Ph.D., and A. T. Pugsley, B.Agr.Sc.

No. 111.—The Biology and Cultivation of Oysters in Australia.
(2) A note on the Calcium Content of Some East Australian Waters, by G. Humphrey, M.Sc.
(3) Biochemistry of the Proximate Constituents, by G. Humphrey, M.Sc.

No. 112.—Building-Frames, Timbers and Sizes, by A. J. Thomas, Dip.For., and Ian Langlands, M.Mech.E., B.E.E., A.M.I.E.Aust.

No. 113.—Drainage Investigations in the Horticultural Soils of the Murray Valley, by A. L. Tisdall, M.Agr.Sc.

No. 114.—Plant Introduction.
(1) A Review, with Notes on Outstanding Species, by A. McTaggart, Ph.D.
(2) Preliminary Selection and Evaluation of Pasture Species at Lawes (Queensland), by T. B. Paltridge, B.Sc.

No. 115.—Studies on the Shrink-proofing of Wool.
(1) The Industrial Development of the Freney-Lipson Process at Holeproof Limited, Melbourne.
(2) Further Studies on the Prevention of Shrinkage in Woollen Goods, by M. Lipson, B.Sc., A.A.C.I., and Carmel J. Clyne, B.Sc.
(3) Experimental Work on the Treatment of Wool by the Woolindras Process, by D. R. Zeidler, M.Sc.

(iii) TRADE CIRCULARS.

No. 20.—(Revised Edition).—Collapse and the Reconditioning of Collapsed Timber.

(iv) FOOD PRESERVATION CIRCULARS.

No. 4-P.—Notes on the Application of Refrigeration to the Australian Fishing Industry.

(v) QUARTERLY JOURNAL.

Vol. 14, No. 3, August, 1941.
Vol. 14, No. 4, November, 1941.
Vol. 15, No. 1, February, 1942.
Vol. 15, No. 2, May, 1942.

(vi) ANNUAL REPORT FOR THE YEAR ENDING 30TH JUNE, 1941.

(vii) "HANDBOOK OF STRUCTURAL TIMBER DESIGN" (REVISED EDITION).

XVII. ACKNOWLEDGMENTS.

In various sections of this Report reference has been made to the valuable assistance afforded by many State Departments and other 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. The Council also wishes to acknowledge the assistance it has received from its State Committees and other Committees, the members of which have placed their knowledge and experience so freely at its disposal.

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

G. LIGHTFOOT, Secretary.
September, 1942.

APPENDIX.

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

COUNCIL (AS AT 30TH JUNE, 1942).

EXECUTIVE.

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

CHAIRMAN OF STATE COMMITTEES.

Professor I. Clunies Ross, D.V.Sc. (New South Wales).
Russell Grimwade, C.B.E., B.Sc., F.A.C.I. (Victoria).
Professor H. C. Richards, D.Sc. (Queensland).
Hon. E. W. Holden, B.Sc., M.I.E.Aust., M.L.C. (South Australia).
E. H. B. Lefroy (Western Australia).
P. E. Keam, M.B.E. (Tasmania).

CO-OPTED MEMBERS.

N. K. S. Brodribb, C.B.E., F.I.C., A.A.C.I.
G. S. Colman, C.B.E.
R. J. Donaldson, D.S.O., B.C.E., M.Aust.I.M.M., M.I.E.Aust.
M. T. W. Eady.
J. P. Tivey, B.A., B.Sc., B.E., M.I.E.Aust., A.M.Inst.C.E.

STATE COMMITTEES (AS AT 30TH JUNE, 1942).

NEW SOUTH WALES.

Professor I. Clunies Ross, D.V.Sc. (*Chairman*).
Professor E. Ashby, D.Sc.
Professor Sir Henry E. Barraclough, K.B.E., V.D., B.E., M.M.E., M.Inst.C.E., M.I.Mech.E.
Professor W. J. Dakin, D.Sc., F.L.S., F.Z.S.
Professor J. C. Earl, D.Sc., Ph.D., F.I.C., F.A.C.I.
W. R. Hebblewhite, B.E.
L. St. J. Jones.
Hon. Sir Norman W. Kater, M.L.C., M.B., Ch.M.
Sir Frederick McMaster.
J. Merrett.
R. J. Noble, B.Sc.Agr., M.Sc., Ph.D.
A. R. Penfold, F.I.C., F.A.C.I.
Professor J. D. Stewart, F.R.C.V.S., B.V.Sc.
E. H. F. Swain, Dip. For.
J. P. Tivey, B.A., B.Sc., B.E., M.I.E.Aust., A.M.Inst.C.E.
F. J. Walker.
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