1944.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

EIGHTEENTH ANNUAL REPORT

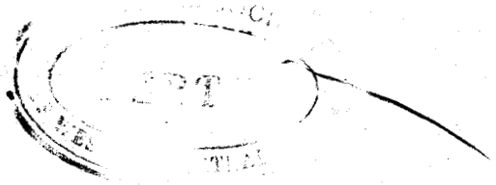
OF THE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH,

FOR THE

B. 1/1

YEAR ENDED 30TH JUNE, 1944.



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COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

EIGHTEENTH ANNUAL REPORT (FOR YEAR ENDED 30TH JUNE, 1944).

NOTE.—*A very considerable part of the Council's activities is now devoted to the solution of problems arising out of 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, Industrial Chemistry, and Radiophysics. 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.

1. GENERAL.

The Council for Scientific and Industrial Research was established in 1926 by the re-organization of the existing Institute of Science and Industry. The powers and functions of the Council are defined by the *Science and Industry Research Act* 1920-1939, and include the initiation and carrying out of research in connexion with, or for the promotion of, primary and secondary industries; the training of research workers; the making of grants in aid of pure research; the testing and standardization of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardization; and the establishment of a bureau of information relating to scientific and technical matters.

2. WORK IN RELATION TO THE WAR.

During the year, the Council has continued to concentrate on activities of immediate importance in the war effort. When possible these activities have been mentioned in the divisional reports that follow. The extension of military operational areas into the tropics has raised many new problems, including the utilization of local resources. For instance, there has been a great demand for information about timbers from the Northern Territory, New Guinea, and the Pacific Islands. Many other problems arising out of the campaigns in these areas have been investigated.

3. POST-WAR RECONSTRUCTION.

The Council is now giving much more attention than formerly to problems of post-war reconstruction. The work of the Division of Soils, in particular, has been turned more directly to the needs of land settlement in rural reconstruction. There has been a strong demand for soil surveys as a basic step in the consideration of new areas for subdivision as new farms and in defining problems of development.

4. RETIREMENT OF OFFICERS.

At the end of the year under review, Mr. G. Lightfoot retired from the position of Secretary of the Council. He was the first senior officer appointed to the Advisory Council of Science and Industry when that body was established in 1916, and has been the Secretary of the present Council ever since its formation in 1926. He has now been co-opted as a member of the Council, and is assisting in its administration at head office in a part-time capacity. He has been succeeded as Secretary by Mr. G. A. Cook.

Mr. I. H. Boas, who was the first Chief of the Division of Forest Products, and who had held that position since 1928, also retired during the year. He is continuing to assist the Division in a part-time consultant capacity. He has been succeeded as Chief of the Division by Mr. S. A. Clarke.

5. FINANCE.

Section XVI. of this report gives details of expenditure by the Council during the financial year 1943-44 of a sum totalling £682,849. Of this amount, £115,888 was contributed from sources other than the Commonwealth Treasury. It should be mentioned that certain other expenditure, involved in erection costs of buildings and in maintenance costs of secret war work, was also incurred on behalf of the Council. The Council is particularly gratified with the way in which contributory bodies continue to support it and with the marked interest evinced by, 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 Veneer and Woodworkers' Supply Company, the timber industry, and the pulp and paper industry.

II. PLANT INVESTIGATIONS.

1. GENERAL.

During the year, the Division of Plant Industry suffered the loss of two officers by death. Dr. Alexander McTaggart, who had been in charge of the Plant Introduction programme since its inception in 1930, died after a short illness on 16th May, 1944. He had brought to his work experience in New Zealand and Canada, and was a zealous officer. A noteworthy contribution was the preparation of the pasture map of Australia and the accompanying descriptive bulletin in the preparation of which he played a leading part. Mr. Marks, who had been on the Tobacco Investigation staff since 1931, died suddenly on 9th December, 1943. His chief contribution was the study of grade standards.

Because of the importance of vegetable investigations, a Committee on vegetable problems, representative of the Division of Plant Industry, the Merbein Research Station, and the Griffith Research Station

has been established. It is charged with co-ordinating all the Council's work on vegetable production problems and with maintaining contact with work in the several State Departments of Agriculture.

The Council is appreciative of the co-operation of the Department of Botany of Sydney University on studies of the anatomy of flax; of the Pharmacy Department of the University of Sydney, and the Physiology Department of the University of Melbourne in connexion with medicinal and drug plant investigations; of the Department of Agriculture and Stock of Queensland on drug plants; and the University of Adelaide on guayule rubber trials.

Numerous requests have been received urgently requesting that certain weeds investigations be undertaken, and that the causes of the depreciation of pastures be examined. It is abundantly evident that an early resumption of work on weeds control, and an adequate expansion of investigations on wool, dairy, and meat pastures, are necessary.

2. Pasture Investigations.

(i) *Agrostology.*

A. INVESTIGATIONS IN THE WINTER RAINFALL ZONE.

(*a*) *Canberra, A.C.T.*—(1) Pasture Management Experiment.—This experiment, which was commenced in 1939, was designed to compare the relative return from pastures grazed continuously and pastures grazed rotationally (one week in four and one week in eight). The pasture mixture, consisting of *Phalaris,* subterranean clover, and lucerne, was established on fallow. A wide range of seasonal conditions has been experienced during the four years of the experiment. Grazing commenced in 1940, and the average rate of stocking has been three Merino wethers per acre. The following criteria have been used in comparing the three systems of grazing—liveweight of sheep, wool returns and wool quality, pasture yields, botanical and chemical composition of the pasture, and the presence of internal parasites of the sheep. The data obtained over nearly four years have shown that there has been no difference between the effects of the three systems of grazing, with the exception that: (*a*) during the worst period of feed shortage in autumn-winter of 1942, the plots grazed one week in eight provided slightly greater amounts of harvestable pasturage, and during this period of decreasing bodyweights, the sheep on these plots maintained their weights at a slightly higher level (however, by the following summer, bodyweights on all treatments were again similar); and (*b*) lucerne has been practically eliminated by continuous grazing and has been reduced to a small proportion in the plots grazed one week in four, whereas in plots grazed one week in eight, lucerne made up 15 per cent. of the pasturage in 1943. As the sheep have maintained their weights equally well in those plots in which lucerne has been eliminated, the presence of this species does not seem to have been any advantage in this pasture mixture. This experiment will conclude this year, and details of the results are being prepared for publication.

(2) Soil Fertility Studies.—The importance of lime in the nutrition of lucerne and subterranean clover on soils of the Southern Tablelands was reported upon last year. Further pot experiments are being conducted to determine whether the effect is due to a change in pH or to additional calcium. *Phalaris* has also shown a response to lime and this effect is being further studied.

(3) Pasture Survey of the Hume River Catchment.—At the request of the Soil Conservation Board of Victoria, an agrostologist was detailed to survey and report upon the pastures of the Upper Hume Reservoir Catchment Area, with particular regard to soil stabilization. A report, with recommendations as to stocking and planting procedure, has been prepared and presented.

(*b*) *Western Australia.*—(1) Species and Mixture Trials.—These investigations are concerned with the sheep country in the South-west Division receiving 15-25 inches of rainfall per annum, and with the poor coastal sands having a rainfall in excess of 25 inches. In a two-year-old trial at Walebing (17½ inches rainfall), the yield of *Phalaris* has been unsatisfactory, and extraneous species have invaded the plots of this grass to a greater extent than those of perennial veldt grass (*Ehrharta calycina*) and Wimmera ryegrass. Although Wimmera ryegrass yielded well the first year, the instability of this annual was demonstrated by a very low yield during the second year. Veldt grass has yielded relatively well in both years. Its seasonal distribution has been good, its autumn yield exceeding that of the other grasses. On the other hand, the amount of clover present is least in the plots of this grass, and this point requires further consideration. Other investigations with this species have been continued. Selections having non-shattering seed heads have been carried on, and studies on the germination and viability of the seed of this grass have been made. Seed harvested late in the season has shown superior germination to that harvested early.

(2) Control of Capeweed.—*Phalaris* has proved to be unsuitable as a competing species, and it is evident that a more aggressive species is required. *Ehrharta* has been included in an experiment designed to give further information on the effect of time of sowing on the control of capeweed. Late sowings again showed considerably less capeweed, and this was accompanied by an increased amount of *Ehrharta.* Mowing at one and two monthly intervals, and mowing at the times of bud initiation, flowering, and maturity, decreased the growth of the capeweed, but neither encouraged nor depressed the sown species. Pot experiments have indicated that, although monthly defoliations depressed the total growth of the weed, it was still able to grow quite vigorously, and this possibly explains the lack of increase in the competing grass in the field mowing trials. The most important effect of mowing or other forms of defoliation may be through a depression in the reseeding ability of the species, and thus suitable mowing or grazing technique may be applied to reduce capeweed dominance in a natural pasture prior to sowing down pasture mixtures.

(3) Soil Fertility Studies.—The effect of the legume blue lupin (*Lupinus varius*) on soil fertility and the subsequent growth of grass has been studied. In one trial, the growth of natural grass species on land that had previously been sown to lupins and subsequently grazed, showed a substantial, although not statistically significant, increase, over adjacent grazed land not sown to lupins.

Investigations into the mineral deficiencies of the coastal sands indicate that, so far as subterranean clover is concerned, phosphate is a major deficiency. To supply the increased growth which follows the application of phosphate, additional potash is required. With *Ehrharta,* phosphate was required only when the growth had been substantially increased by the application of nitrogen.

B. INVESTIGATIONS IN THE SUMMER RAINFALL ZONE.

(*a*) *Gilruth Plains, Cunnamulla, Queensland.*—(1) Grazing Management Experiment.—This experiment, which has now been in progress for three years, has as its objects the comparison of several rates and

frequencies of stocking on Mitchell grass pastures with respect to their effect on wool production, and on the pasture, and also the observation of the practicability of predetermining systems of grazing on these pastures. The effects of the various grazing treatments have been interpreted in terms of liveweights of sheep, wool returns, pasture yield (grazing residue), botanical and chemical composition of the pasture. Dry conditions prevailed throughout 1943, and the sheep were maintained on the forage produced by 8 inches of rain which had fallen in December, 1942. Supplementary feeding was necessary on the heavy grazing treatment (one sheep to 2½ acres) towards the end of the year. The decline in bodyweight during the dry period has been slight at the light stocking rate, but heavier at the other rates. Fleece weights and fibre diameter have both varied inversely with the rate of stocking. The deleterious effect of heavy stocking was evident in the reduced amount of forage produced, following the December, 1942, rains, on those paddocks previously subjected to the heavier rates. During the subsequent twelve months, the grazing residue has been consistently less with the heaviest rate of stocking (one sheep to 2½ acres), but there has been no difference between the medium (one sheep to 5 acres) and the light rate (one sheep to 7½ acres). Since the commencement of the experiment, the proportion of Mitchell grass in the pasture has decreased at the heavier rates of stocking. The occurrence of miscellaneous (herbage) species and legumes appears to be governed mainly by seasonal conditions, and no effects of grazing in modifying the proportion of these in the pasture have yet been recorded. No major differences in chemical composition have resulted from different rates of stocking. The superiority of the miscellaneous species, as suppliers of protein, calcium and phosphorus, has been maintained irrespective of seasonal conditions. In general, with minor exceptions, there has been little difference between grazing sheep on one paddock continuously and grazing them on two paddocks alternately for six months.

(2) Other Investigations at Gilruth Plains.—A stand of spaced plants of barley Mitchell grass has been established to test the effects of various cutting treatments on the yield, chemical composition, and persistence, with respect to the conservation of Mitchell grass hay.

The role of birds in removing seed and diminishing the normal seed supply in the soil, with a possible effect on the regeneration of the annual and perennial grasses, has received consideration. The crop contents of galahs examined have contained up to 28,000 seeds of grass species common to the Mitchell grass plain. It is proposed to investigate the point further.

Lack of rain has delayed further studies on soil moisture relationships.

Preliminary studies on the development of a technique for quantitatively expressing the floristics of a vegetation association have been commenced on the mulga (*Acacia aneura*) association.

(*b*) *Lawes, Southern Queensland.*—The study of lucerne as a legume component in Rhodes grass pastures has been continued. Two pastures of Rhodes grass and lucerne have now been grazed and observed for a period of three years. The results of this preliminary work have led to a cattle-grazing trial in which the contribution of lucerne in such a mixture will be assessed, and commercial Rhodes grass will be compared with the introduced Kenya No. 1 strain. An experiment to investigate the theoretical and practical aspects of growing pasture species in rows has also been commenced.

(ii) *Pasture Plant Improvement.*

(*a*) *Canberra, A.C.T.*—Owing to the shortage of staff, the programme of medic improvement has been curtailed. Increase plots of several promising strains were grown at Canberra last year, and a preliminary trial of a number of species and strains has been commenced at "Cranmore Park" in Western Australia.

Sixty-four varieties of soybeans have been obtained recently from the United States of America and Canada and are being grown at Canberra for increase and observation, with a view to conducting a programme of trials, selection, and breeding in a suitable area, with particular regard to their value as fodder legumes.

Investigations with *Danthonia* have been continued on a restricted scale. A study of the flowering and seed-setting habits of the species, and the development of hybridization technique, is in progress. It is evident from field and glasshouse trials that *Danthonia* is fully self-fertile and is probably highly self-fertilized. A vigorous introduced species, *Danthonia californica*, having large seed almost devoid of "fluffiness", has been studied in detail. Selected material of a number of species is being maintained. Investigations on the germination and methods of sowing *Danthonia* seed, and on the ecology of the group in natural sown pastures, are in progress.

(*b*) *Lawes, Southern Queensland.*—Australian types of lucerne have maintained their superiority at Lawes. In a two-year-old survival test, the only material to exceed the check commercial variety in persistence has been derived from selections within Australian ecotypes. Disease resistance studies have been continued, and over 300 progenies segregating for rust resistance have been examined in the field during the year. Seed of selected *Phalaris* material has been increased.

3. Weeds Investigations.

Experiments on the control of galvanized burr (*Bassia birchii*), a native shrub species that has become a weed on certain natural pastures, have been continued. The main experiment consists of a grazing trial in which control of the weed is sought by encouraging vigorous competition from native forage species by stocking management. As reported previously, seasonal conditions are the dominant factor governing the increase or decrease of the burr, and their effect far outweighs that of stocking. Confirmation of this has been obtained from the last year's results. Drought conditions during the 1943-44 summer caused a high mortality among the burr (up to 79 per cent.) and this was general, irrespective of the stocking treatment. Where stock have been excluded for seven years, the burr population on both the sand and loam soils is now less than where stocking has been practised at the rate of a sheep to 2 acres, but there is no difference in the burr population under grazing at this rate and at a sheep to 5 acres. Detailed work on the germination requirements of this species and its general ecology is proceeding.

4. Plant Introduction.

(i) *Introduction and Exchange of Plants and Seeds.*—During the year, 326 introductions were brought in from abroad, making a total of 8,225 to date. The number of samples introduced was appreciably larger than in the previous two years, but still much smaller than was usual before war conditions cut off many potential sources of supply. A large proportion of the introductions were made for the use of specialists engaged in the study of particular crops, rather than for trial by officers of the Plant Introduction Section. As in previous years, there was a great diversity in

the types of plants introduced: particularly noteworthy, perhaps, were large collections of vegetables and of linseed varieties.

In exchange for these introductions, some 319 samples of seeds of Australian wild and cultivated plants were sent to institutions abroad. This exchange activity has developed considerably in recent years and is facilitated by the issue, in mimeographed form, of an annual list of seeds available for exchange, based on those harvested from the initial trial plots at Canberra and branch stations.

Apart from the introductions grown for trial at one or other of the Section's primary testing stations, 143 samples were sent out for trial by State Departments of Agriculture and others. The cessation of the issue of "Plant Introduction Inventories" in the war years has prevented adequate diffusion of information on the plants introduced, and it is proposed, as a substitute for the inventories, to make available mimeographed lists of the introductions at frequent intervals.

(ii) *Agronomic Studies at Canberra, A.C.T.*—(*a*) *Cereals and Linseed.*—The trials of introduced varieties of wheat, barley, and oats, using standard Australian varieties as controls, were continued during the year. Ten of the most promising introduced strains of *wheat* were grown in a randomized block trial with ten replications, using the varieties Ford and Waratah as controls. The best of the introduced varieties was C.P.I. 2955 (S635), a strain received from Portugal via New Zealand, which, with a yield of 47.9±5.5 bushels per acre was not quite significantly superior to Waratah, the best of the controls, which yielded 43.0 bushels per acre.

Twenty-three introduced *barley* varieties were grown in a randomized block trial, with the variety Trabut as control. Bolivia (C.P.I. 8315) was the outstanding variety, with a yield of 52.8±8.5 bushels per acre, as against 40.8 bushels for the control. Flynn (C.P.I. 7737), which had given the highest yield in the previous year, was intermediate with a yield of 46.9±8.5 bushels per acre.

In the *oat* trial, ten introduced varieties were grown in comparison with Mulga and Sunrise. Two varieties, Texas Red Rustproof (C.P.I. 7117) and one from Portugal (C.P.I. 8397), yielded better than the better control, but the differences were not statistically significant.

In a preliminary trial of nineteen *linseed* varieties, the best yield was given by Hindi (C.P.I. 8096), obtained from Egypt, which was significantly superior to Punjab, the variety most commonly grown in Australia. The cold, late spring was unfavorable to growth of this crop, of which a more extensive trial is now in progress.

(*b*) *Forage Plants.*—Work on sward trials of introduced forage plants was on a restricted scale during the year, owing largely to the cessation of work at Duntroon and difficulties experienced in establishing plots at the new field station at Dickson. These difficulties were caused by adverse climatic conditions and heavy weed competition. It has not yet been possible to obtain quantitative data from the new plots, but observation confirmed previous reports of the value of certain North African strains of cocksfoot (*Dactylis glomerata*). C.P.I. 6834, in particular, was conspicuously green and productive in autumn after a very long, dry spell.

The comparative trials of introduced lucerne varieties, conducted at Duntroon farm, were completed during the year, the results being described in an article which appeared in the Council's Journal (vol. 16, p. 124, 1943).

Preliminary trials are in progress with recently introduced species and strains of grasses and other forage plants.

(iii) *Agronomic Studies at Lawes, Southern Queensland.*—(*a*) *Forage and Green Manure Plants.*—On the basis of observations made during the year, the most promising grasses are, again, varieties of *Paspalum scrobiculatum*. The "Kabulabula" strain (C.P.I. 7949) was outstanding in all trials at Lawes, while on the Darling Downs, an earlier introduction (C.P.I. 2696) has shown greater vigour and bulk. An experiment designed to assess the relative value of the four available strains of this grass at all times of the year, and as components of a mixed pasture, has been begun.

Of the grasses grown for the first time this year, two strains of *Urochloa* (C.P.I. 8683 and 8684) show promise as pasture plants, being smaller and more leafy than previous introductions of this genus. Two introductions of *Setaria sphacelata* are also promising.

Green manure plants of the genera *Dolichos, Vigna,* and *Phaseolus,* noted in last year's report, continue to show promise, as do strains of the sword bean, *Canavalia ensiformis,* which have also been in demand as vegetables for cultivation in New Guinea.

(*b*) *Miscellaneous Introductions.*—Experimental plantings of guayule rubber suffered severely from weed competition in the wet weather of early summer, and those on the black soil, where cultivation was impracticable during rainy periods, were choked out. Plants on sandy ridge soil were successfully established and made good growth, especially during the drier weather of late summer.

Of a number of recently introduced vegetables under trial, Celtuce (C.P.I. 8467), New York Mammoth Lettuce (C.P.I. 8481), and a number of onion varieties appear promising.

(*c*) *Grazing Trials.*—An experiment planted in 1941 and designed to compare grass yields in swards, in rows, and in swards with nitrogenous top-dressing or with an admixture of legumes, under hay conditions, has been completed. Outstanding results are: (i) the great increase in the yield of grasses when top-dressed with ammonium sulphate, (ii) the increase in yield consequent on row-cultivation, (iii) the absence, under hay conditions, of any significant increase in the yield of grasses due to admixture of legumes, and (iv) the increase in total yield from plots due to the growth of lucerne.

Experimental row-cultivated pastures of *Paspalum scrobiculatum* and lucerne, established on the Darling Downs, are very promising, carrying four sheep to the acre when sheep on natural pasture on the same property were being hand-fed. Difficulties previously experienced in establishing pastures may have been due to a deficiency of zinc in the upper layers of the soil.

A new experiment has been planted this year designed—(*a*) to determine the comparative yields, vigour, and purity of stands of *Paspalum scrobiculatum* in rows and in swards, under grazing; (*b*) to determine the optimum row-spacing for the grass under local conditions; and (*c*) to compare, under grazing, grass yields from a mixed stand of grass and lucerne with those from pure grass stands with and without nitrogenous top-dressing. This experiment is being carried out as part of the programme of the Section of Agrostology.

(iv) *Agronomic Studies at "Fitzroyvale", Rockhampton, Central Queensland.*—(*a*) *Forage Plant Trials.*—Work was continued on the evaluation of a number of grasses and other forage plants found promising in previous years. An experiment designed to assess the relative productivity of *Brachiaria*

brizantha in swards and inter-cultivated rows was completed during the year, the cultivated rows having failed to show any advantage in total or seasonal yield.

A comparison is being made between five introduced strains of molasses grass (*Melinis minutiflora*) and a Queensland commercial strain under four cutting treatments. In the first harvest, covering the summer growth, one of the introductions out-yielded the control, but this is considered to be of doubtful advantage, because only a proportion of the growth would be eaten and trampling losses would be considerable. In a similar trial with introduced strains of Rhodes grass (*Chloris gayana*), "Kenya No. 1" has significantly out-yielded an improved Queensland strain used as control in a cut at the end of summer.

While these introduced grasses are undoubtedly much more productive than the natural spear grass pasture, it is recognized that their value must depend largely on their seasonal productivity, and on their ability to withstand grazing. In order to obtain a satisfactory standard of comparison, experiments are in progress to determine the productivity of the natural pasture under different systems of defoliation. Preliminary results suggest that the yield of natural pasture decreases when more than one cut per year is made, while some of the introduced grasses yield best with several cuts per year. Further work on grasses includes trials of *Digitaria* spp. from South Africa, some of which appear very promising, and comparative trials of introduced strains of *Panicum maximum, Pennisetum purpureum,* and *Sorghum* spp.

Several recent grass introductions are considered sufficiently promising to justify further trial in plots, and seed supplies are being built up with this object. They include *Panicum* spp., *Eragrostis barbinodis, Brachiaria stolonifera, Panicum coloratum, Paspalum notatum, Echinochloa pyramidalis,* and *Hyparrhenia rufa.*

The great value of *Stylosanthes guianensis* as a pasture legume for coastal Queensland has been shown in previous years. Further work on an experiment designed to study methods of establishment of the legume in natural pasture has confirmed previous indications that it can readily be established by burning and surface-cultivating, and that, once established, the yield of the pasture is almost doubled. Since the protein content of the legume is high, its value, particularly for the frost-free parts of coastal Queensland, is fully apparent.

The possible use of pigeon pea (*Cajanus Cajan*) as a protein-rich supplement was referred to in last year's report. Further work has shown that the heavy yield of seed from some of the introduced varieties is more than fully maintained in the ratoon crop, two varieties from India having yielded an aggregate of 47 and 46 bushels respectively during the two years. The grain is readily accepted by stock, and should form a very valuable supplement to the protein-deficient natural pastures from winter to early summer. A more comprehensive trial of sixteen introduced varieties has been begun.

(*b*) *Miscellaneous Introductions.*—Comparative trials of four rapeseed varieties from India, introduced as sources of vegetable oils, have given interesting results. One variety (C.P.I. 8538) gave a seed yield of 5.72 cwt. per acre, with an oil content of 36.8 per cent. Further work is in progress on these plants. Several introductions of *Dolichos lablab* and tropical varieties of garden peas are being tested to determine their usefulness as green leguminous vegetables for Queensland.

(v) *Agronomic Studies at Muresk, Western Australia.*—Work at this recently-established station was hampered by very adverse weather conditions, the summer being the longest and driest on record. The newly planted introductions were thus subjected to a very severe test, and, while many failed to survive the summer, it is encouraging to find that some of the grasses made good growth and produced a fair bulk of foliage. Among the best were some species of *Bromus,* especially a strain of *Bromus marginatus,* as well as *Agropyron semi-costatum* from Central Asia, and species of *Festuca, Lolium, Ehrharta, Panicum,* and *Phalaris.*

Of the leguminous forage plants, some strains of *Medicago* and *Onobrychis* showed promise, while the annual *Coronilla scorpioides* not only established readily and made good growth, but appeared to be repellent to the red-legged earth mite, a very serious pest on the station. The shrubby *Psoralea bituminosa* from the Mediterranean region showed promise as a browse plant. Of miscellaneous introductions, most of the linseed varieties under trial made poor growth, but varieties of the opium poppy developed well under adverse conditions. Trials of guayule rubber were hampered by germination difficulties and rabbit damage, but are being extended.

Co-operative tests with the State Department of Agriculture are in progress at other places, but are still in their early stages.

(vi) *Herbarium.*—Much work has been done in the Divisional Herbarium during the year; it is designed primarily to enable the increasing demands for plant identifications and information on systematic and economic botany to be handled more efficiently.

The collections have been largely re-sorted, duplicates removed, and the specimens numbered. During the year, 1617 new specimens have been mounted and incorporated in the Herbarium, bringing the total to 10,632, exclusive of large collections of marine algae and Papuan plants. These new specimens are in part a by-product of identifications carried out in the Herbarium, several hundred such determinations having been made for officers of this, and other, divisions, and for other Government departments. In part, they are derived from exchanges with other institutions and botanists within Australia and abroad, particularly interesting under this head being large collections of *Eriachne* spp. presented by Mr. S. T. Blake of the Queensland Herbarium, American and other grasses from the United States National Herbarium, and New South Wales plants collected by Mr. F. Day. Collections sent out include duplicates of marine algae to the University of Sydney, Australian grasses to the United States National Herbarium, and specimens of introductions to the Melbourne Herbarium.

Work has continued on a revised list of standardized plant names, and on a revision of the grass genus *Eriachne,* the latter in co-operation with Mr. S. T. Blake.

5. Wheat Investigations.

Take-all.—A short account of the influence of plant food depletion on the damage caused by take-all of wheat was published in the Council's Journal (vol. 16, page 18, 1943). In 1941, another pot experiment was begun out of doors to confirm and amplify the results of the earlier work. Among other things, compounds of some soil bases were added to a local soil to test the influence of such additions on take-all. One-half of the number of pots so treated was contaminated with one of the soil organisms associated with take-all; the others were controls. Notes on the results obtained in previous seasons have appeared in recent annual reports.

The experiment was continued in 1943, but the number of pots used in each treatment was reduced from nineteen to sixteen. Sodium nitrate was added

to four of the contaminated and four of the control pots in each series. This year's results indicate that in the third year of the trial the total weight of the plants and the weight of grain borne by the plants in the pots to which 250 g. of burnt lime was added were outstanding; plants with 250 g. of ground limestone and with 250 g. of ground magnesite were also well above the corresponding plants grown in the native soil as well as the native soil plus other chemical treatments. The roots of the plants in the three series just mentioned, particularly ground limestone, were also freer from rotting than those otherwise treated. There was no evidence of significant differences between any of the added chemical compounds on the number of pots containing plants with whiteheads or plants with small, pinched grain. Comparing the contaminated with the uncontaminated soil —excluding the pots without added chemical compounds—the total weight of plants, and to a less extent the total grain weight borne in the pots to which the organism was added, was significantly greater than those from the uncontaminated controls. This is the second reversal in the relative magnitude of the yields for these two treatments, the position in 1943 being the same as in 1941 and the reverse of 1942. There was no significant difference between the treatments in the number of pots with whiteheads or in the condition of the roots.

The effect of the addition of sodium nitrate in 1943 was to increase the total weight of the plants and their grain yield, but it was without influence on grain size, the number of pots with whiteheaded plants, or the health of the root system.

Comparing the pots containing only the native soil (no chemical compounds except superphosphate being added), there was no significant difference in the total weight of the plants, weight of grain, or condition of roots between those that were contaminated with the organism in 1941 and those that were not contaminated, but the average weight of grain from the inoculated plants was significantly higher. This is supported by a significant difference in the number of pots with whiteheaded plants in the uncontaminated pots. The pots to which neither inoculum nor chemical compounds (except superphosphate) were added were much more affected with take-all than any others. This appears to have been due to the inability of the native soil to make available to the plants food that is present in unavailable form. The addition of bases appears to facilitate the change from the unavailable to available form judging by the results of these experiments. Heavy applications of burnt lime are most effective. A full account of this experiment is to be published in the journal in the near future.

6. Fruit Investigations.

(i) *At Stanthorpe, Queensland.*—The investigations at Stanthorpe concerned with apple and pear rootstocks have been in progress for ten years. Effort has been devoted primarily to the problem of finding apple rootstocks which give a better performance under Australian conditions than the commonly used Northern Spy, are easily propagated, and are immune to attack by woolly aphis. Attention has also been given to a search for improved rootstocks for pears and plums.

Altogether, some 20,000 rootstocks and 4,000 worked trees have been raised for various experiments. Seven experiment plots have been established in the form of apple rootstock nursery trials in which the trees are planted from 3 feet to 4 feet apart in rows 5 feet distant, and two orchard trials with trees planted 20 feet by 20 feet. The area occupied by the experiment plots is approximately 9½ acres.

In the two nursery trials which have been established for eight years, the scion varieties Jonathan and Granny Smith have given a far better performance on certain stocks than they have on Northern Spy. Two rootstocks in particular are especially promising. These are Merton 789 and Merton 793, both of which are immune to woolly aphis and propagate readily by stooling. The vegetative vigour of Jonathan on both of the Merton stocks is greater than on Northern Spy and 75 per cent. more fruit was produced by the trees on the Merton stocks. In the other nursery trials the scion varieties Jonathan, Delicious, and Granny Smith are being tested on a range of Malling stocks, local selections, Merton stocks, and other types immune or resistant to woolly aphis.

In a pruning trial superimposed on one experiment, hard pruning has dwarfed the trees as compared with the Wickens non-tipping leader method. In order to ascertain whether any of the leading commercial scion varieties could be propagated satisfactorily on their own roots, propagation tests on some 30 varieties have been made, and the root systems of own-rooted trees carefully studied. The differences in rooting ability and in the nature of the root systems produced by different varieties were very great.

The investigations concerned with pears aim to discover: (*a*) one or more rootstocks which can be propagated vegetatively, are compatible with the more important scion varieties, and give orchard trees of better performance than those now produced on seedling pear stocks, and (*b*) whether any of the important scion varieties can be propagated satisfactorily on their own roots. Five clonal types were imported from East Malling, in England, and rootstocks were selected in the Stanthorpe district and in Victoria. They have been subject to propagation trials and a number of them to compatibility tests. Four of the East Malling stocks propagate successfully by layering and have proven compatible with the leading scion varieties. In a four-year-old trial, in which Williams Bon Chretien was grown on these four stocks and *Pyrus Calleryana*, the latter stock has given the most vigorous trees.

Some attention has also been given to the question of rootstocks for plums, several types having been selected in the Stanthorpe area; clonal types were imported from England and propagation tests have been made on these various types. During the course of the work, several mineral deficiency diseases have become evident, their nature being diagnosed by appropriate experiments and control measures successfully applied.

(ii) *In Tasmania.*—The investigation of physiological diseases of apples in the field, and disorders following storage, has been further curtailed, and all experiments on fresh apple problems with few exceptions are in abeyance. The officer responsible for these studies has been engaged on war emergency work concerned with the production of dehydrated apples and vegetables, and the examination of processed foodstuffs designed for use by the Services. This work is being carried out on behalf of the Department of Commerce and Agriculture.

The work on the "cork" of pears and "dimple" of Granny Smith and Cleopatra apples, and tree dieback, has been confined to observations on existing plots, and nothing has appeared to modify previous conclusions. Experiments on the wax coating of apples were restricted to a comparative test of a commercial preparation. Tests on storage disorders have been made on the fruit from two plots in order to preserve the continuity of the studies concerning the relation of storage disorders to climatic and crop factors. Other plots have been maintained on a purely observational basis.

(iii) *At Griffith, New South Wales.*—Investigations at the Griffith Research Station have been continued on rootstocks and shoot and root growth of citrus. Eighty-three rootstock types selected from old trees of outstanding vigour and performance in the local irrigation areas have been collected and nursery stock raised from root cuttings. The collection of imported stocks has been increased by the addition of a strain of *Poncirus trifoliata* from California, and of a bitter orange from Spain which is reputed to be very resistant to root rot and suitable for heavy wet soil conditions. Three nursery trials of rootstock types are now established in which the vigour of growth of some 13 types is being compared.

Plants raised from rough lemon seed from Norfolk Island which has been largely used by nurserymen for raising commercial citrus stocks exhibited considerable variation in growth habit. Four main types were differentiated. An upright-growing type appeared to develop a better root system than the others, but no difference in the growth of Valencias or Navels budded on the different types was apparent during two years' development.

The experiments concerned, in which declining trees were inarched with young rootstocks, have not yielded any positive results. Where sick trees have been pruned back severely, less growth has been made than by untreated control trees. The survey method of recording tree health has been continued in the experiment plots at the Research Station and project plots on growers' farms. Studies of the root development and distribution of citrus roots under various soil conditions have also been continued.

7. Drug Plant Investigations.

These investigations are the subject of co-operative work by the Council, the Department of Physiology, University of Melbourne, and the Department of Pharmacy, University of Sydney, and are being carried out under the aegis of the Medical Equipment Control Committee and the National Health and Medical Research Council. The Universities of Melbourne and Sydney have continued to carry out the analysis and testing of locally-grown material, and have been responsible for the methods of drug extraction. The Departments of Agriculture of the various States, and particularly the Department of Agriculture and Stock, Queensland, and the Sub-Department of Forestry, Queensland, have also continued to co-operate in the conduct of field experiment plots of the different drug plants.

(i) *Hyoscine and Atropine.*—It was necessary to concentrate effort during the past twelve months on the chemical work associated with the investigation of the opium alkaloids and quinine and, consequently, work on the chemistry of the *Duboisia* alkaloids had to be practically suspended. These latter studies are now being recommenced and will be concerned in the first place with the analysis of leaf from individual trees of *Duboisia myoporoides* and *D. leichhardtii.* This project aims to select from natural stands high-yielding types or strains most suitable for cultivation and for alkaloid extraction.

An experiment plot of *Duboisia myoporoides* and *D. leichhardtii* has been established at Nambour (South Queensland) to determine the most effective and economic methods of cultivation, including time, method, and frequency of harvesting. A start has also been made in propagating from those trees which have given the most promising results in the preliminary assays of the selection project. The investigation of methods of propagation are proceeding and a small observational plot of *Duboisia* has been established at Canberra. Studies are also being made of the effect of varying drying conditions upon the alkaloid content of the dried leaf.

Pests and diseases of *Duboisia* so far noted include potato moth (*Gnorimoschema operculella* (Zeller)), a flea beetle (*Psylliodes* sp.), a looper caterpillar (*Chloeres citrolimbaria* (Guenee)), all of which attack the leaf, a nematode (at Nambour), and a root rot (*Verticillium* sp.).

Seed of *Atropa Belladonna and Hyoscyamus niger* has been distributed to growers intending to produce material of these plants for the manufacture of galenicals containing hyoscyamine and hyoscine.

(ii) *The Opium Alkaloids.*—The development of a satisfactory method for estimating the morphine content of small samples of dried capsule and straw of the opium poppy (*Papaver somniferum*) has been effected. Experiment plots were grown at Canberra, Red Cliffs (Vic.), and Muresk (W.A.), and were designed to obtain information with respect to the relative value of some dozen different varieties, the effect of time of harvest on morphine content, and the effect of rain on the morphine content of semi-mature and mature crops. Results indicated considerable differences in the time of maturation, yield of dry matter, and morphine content of different varieties. In both yield of dry matter and percentage of morphine, one variety in particular gave significantly better results than the variety being used at present for production purposes. Seed increase plots of the most promising varieties have been established, and further variety trials, including additional varieties, seed of which was obtained from Russia, Turkey, and Persia, have been sown.

Time of harvest had only little effect on the morphine content of the capsules and straw between the time of petal fall and maturity. There was, however, evidence that the concentration of morphine tended to be greatest in the semi-mature capsule (i.e., about three weeks after petal fall). Results also indicated that rain on a standing mature (i.e., dry) crop may result in serious losses of morphine; the effect when the capsules are green and immature is not so marked.

Commercial scale plantings have again been made under the supervision of the Council.

(iii) *Quinine.*—The *Cinchona* trees established on the Atherton Tableland have not developed satisfactorily; particularly where not sheltered by adjacent forest, growth has been stunted and a high mortality sustained. Six plants of *C. Ledgeriana* and *C. hybrida*, sampled at the age of 2⅛ years,, averaged 3 ft. and 2 ft. 9 in., respectively, in height, weighed 275 grams and 193 grams per plant, and contained approximately 1 per cent. quinine alkaloids. Data were also obtained with respect to the distribution of the alakloids in the stem, leaf, and root. These results approximated those obtained in the U.S.S.R., where *Cinchona* is being harvested at a young stage and cultivated as an annual crop. Samples of prunings (whole shoot) contained 1.1 per cent. total alkaloids and the bark alone 1.75 per cent. alkaloids.

A small amount of seed from high-yielding trees of *Cinchona succirubra* and *C. Ledgeriana,* selected and raised in the Philippine Islands, and made available by Lieutenant-Colonel Fischer, of the United States Army, was sown at the Bureau of Tropical Agriculture at South Johnstone, together with some seed of high-yielding *C. Ledgeriana* from Guatemala made available by the U.S.D.A. Some 15,000 seedlings were successfully raised and transported to New Guinea for establishment in plantations by A.N.G.A.U.

(iv) *Ephedrine.*—The plots of *Ephedra gerardiana, E. nebrodensis,* and *E. intermedia* established at Canberra and Griffith have continued to make good growth. *Ephedra gerardiana* seeded freely and a considerable quantity of seed was harvested. Samples for assay have been taken systematically at monthly intervals throughout the season, but results are not yet available. Previous results indicated a total alkaloid content of approximately 1 per cent. for *E. nebrodensis* and *E. intermedia,* and 1.3 per cent. for *E. gerardiana.* A sample harvest of 2-year-old plants of *E. gerardiana,* planted at the rate of 7,000 per acre, gave a yield of approximately 1 ton of dry *Ephedra* per acre; for *E. intermedia* the figure was approximately 1½ tons per acre.

(v) *Santonin.*—Trial plots of *Artemesia maritima* at Canberra, Griffith, and Merbein have been moderately successful. Samples were taken at various stages from immature buds to open flowers and dried in different ways. Santonin content varied from 0.5 per cent. in the very young immature bud stage to 2.7 per cent. when the sample consisted of flowers and buds just about to open.

(vi) *Pyrethrum.*—During the 1943-44 season, plots of approximately one acre in extent were established of the open-pollinated seed progeny of five strains of *Pyrethrum cinerariifolium* at Canberra. These five types were selected from 24 which were present in the original plots and were chosen primarily on the basis of vegetative characters deemed desirable for mechanical harvesting. Some 20,000 seedlings of these types were raised for planting in the pyrethrum production project being carried out by the Department of the Army.

Smaller experiment plots of the open-pollinated seed progeny of all the 24 original types have been established, and plots of vegetatively propagated material of a number of selected types at Canberra. Small plots have also been established of several selected types in each of a number of different locations to determine which places produce the best quality pyrethrum.

Trials of different methods of harvesting were carried out and data obtained on their relative cost and efficiency. It was found that an ordinary wheat stripper will harvest the flowers reasonably satisfactorily. A certain percentage of stalk is obtained in the material so harvested. Trials are in progress to determine whether the inclusion of this stalk in the material raises any processing difficulties and, if so, whether they may be overcome.

(vii) *Miscellaneous.*—Small plots of *Atropa Belladonna, Hyoscyamus niger,* &c., have been grown to maintain fresh seed supplies, and the propagation of a number of medicinal plants of minor importance such as *Urginea maritima* and *Dryopteris Filix-mas* has been continued. It was not possible to continue the search for, and study of, native plants of possible medicinal and insecticidal value during the past twelve months. Arrangements have now been made for this work to proceed.

8. Tobacco Investigations.

The system of leaf grades for the flue-cured tobacco approved by tobacco officers of the Council and of the States, was given a practical test on a farm in Victoria. Although the crop was poor, no insurmountable difficulties in using the approved grading system were experienced. Growers, and also manufacturing organizations generally, approve the proposals, but do not wish the existing appraisal grades to be altered during the war. Under the new scheme, flue-cured tobacco grown in Australia would be classified into four main types—(1) North Queensland; (2) Dumaresq Valley (Queensland-New South Wales border districts); (3) North-east Victoria; (4) Manjimup (Western Australia). The leaf of each type would be graded on leaf position on the stalk, leaf qualities, and colour, thus ensuring that leaf with similar characteristics was included in the one grade. This system of grading is facilitated when tobacco with similar characteristics and qualities is placed in the same bulk after curing. It is believed that this classification, based as it is on the same fundamental principles used in most tobacco growing countries, could with advantage be adopted in Australia. An article on the classification and grading of flue-cured tobacco grown in Australia appeared in the *Journal* (Vol. 16, page 245, 1943).

9. Vegetable Investigations.

(i) *General.*—Emphasis is placed on the important kinds, viz. potatoes, tomatoes, beans, peas, cabbage, carrot, red beet, and onions. Particular attention is paid to the development of suitable varieties for large-scale production and processing.

(ii) *Potatoes.*—Breeding for resistance to the potato viruses A, X, Y, and leaf roll is being continued, and it is hoped eventually to combine a high degree of field resistance to these four viruses into a number of new varieties adapted to the different major potato areas of Australia.

(iii) *Tomatoes.*—Replicated field trials under differing environments in Australia and embodying all the promising varieties available are elucidating those suitable for canning, juice, and sauce manufacture. In addition, these trials indicate deficiencies in existing varieties. Hybrids combining desirable agronomic characters and resistance to Fusarium wilt and leaf mould are being developed.

(iv) *Beans.*—Replicated field trials in several districts with varieties commonly grown in Australia, and with the most promising United States of America canning varieties, have provided valuable agronomic data. This information is being used to develop suitable canning varieties for the large centres of production. Hybrids combining desirable agronomic characters with resistance to Fusarium, bean mosaic, halo blight, and anthracnose are being developed.

(v) *Peas.*—Agronomic studies of all available varieties are being made. Varieties are being tested for resistance to Ascochyta blight. The relationship between field emergence and organic fungicidal seed dressings is being investigated on large numbers of samples of canning and garden pea seed grown in different localities.

(vi) *Cabbage.*—Studies on varietal variation are in progress. The variety Succession is being subjected to intense selection with the object of producing a uniform line which will give a high percentage of marketable cabbages per acre.

(vii) *Red Beet and Carrot.*—Studies on varietal variation under several environmental conditions are being carried out. The influence of genetical factors as opposed to environmental on the development of white rings in beetroot and red core in carrots is being considered particularly.

(viii) *Onions.*—Comparative agronomic studies of all available varieties are being conducted in several localities.

(ix) *Seed Production Trial at Lawes, Southern Queensland.*—A seed production trial has been conducted at Lawes, with 21 varieties of vegetables, planted on six occasions during a twelve-month period. Carrots, silver beet, turnips, swede turnips, and cabbage (two varieties) failed to produce seed at any plantings. Cauliflower (four varieties), beetroot, celery, leek, and two varieties of onions produced small or negligible

quantities, while one variety of onion, parsley, broccoli, parsnip, and lettuce produced fair or good yields at at least one planting. February and April plantings were most successful, excepting in the case of lettuce, in which the December planting was the only high yield successfully harvested. Whether conditions from flowering to harvesting are erratic, and of major importance in this locality.

10. Potato Investigations.

(i) *FX Potato Stocks.*—During the year, arrangements were made for the permanent maintenance and multiplication of the stocks of Up-to-date and Bismarck potatoes free from virus X, which is responsible for considerable losses to potato-growers throughout Australia. The scheme is being operated by the Commonwealth Department of Commerce and Agriculture through the State Departments of Agriculture. All stocks of potatoes incorporated in the scheme are to be given the label FX (free from X virus) to distinguish them from ordinary certified seed potatoes. The essential feature of the scheme will be the permanent maintenance of nuclear stocks of the selected varieties under technical supervision at a government potato station, and the regular renewal of commercial seed stocks by multiplication from the central nucleus. Selection and testing of the nuclear stocks will be continued as a routine practice, so that there will be no loss of health and vigour. The nuclear stocks of the varieties Up-to-date and Bismarck are being held by the Tasmanian Department of Agriculture at the Tewkesbury Potato Station; also the first stages of multiplication are being performed there. The produce from these multiplication plots is being distributed to State Departments of Agriculture, who will place it with chosen farmers for further multiplication. Final distribution will be made through the established seed certification schemes.

The Snowflake potatoes free from virus X, which were obtained during the previous season, are being multiplied by the Victorian Department. Extensive surveys and tests of Carman potatoes, made in co-operation with that Department, did not yield any virus-free plants or tubers. Selections of the modern American varieties, Katahdin and Sebago, were found to be free from virus X. Stocks of another variety, Houma, were found to be infected.

During the season, a series of yield trials was made in co-operation with departmental officers in New South Wales and Tasmania to test the various strains of FX Up-to-dates. Strain differences in yielding ability and reaction to environment were demonstrated, but whether these are permanent and characteristic remains to be determined. Further trials will be made next season.

(ii) *Aphis Survey.*—Studies of the technique of sampling populations of the aphids that disseminate potato virus diseases were continued. These involved further investigations on the development of the foliage of potato plants. Attempts were made to determine the proportion of a whole plant that was sampled at different stages of growth when single leaves were picked and the aphids on them counted. A closer approach was made to methods by which reasonable estimates of the population of aphids per plant could be made from this form of sampling. Routine aphis counts and further experiments on the field transmission of potato leaf roll were made.

11. Vegetable Fibres.

(i) *Flax.* — The statistical examination of the morphological data obtained at the University of Sydney showed that because of the variability inherent in the material, very large numbers of stems would have to be examined in order to establish differences, if any, due to variety or treatment. Furthermore, seasonal effects were such that the work would have to cover a range of seasons. It has not been possible, so far, to establish any satisfactory linkage of the results of anatomical examination with quality and yield data. To obtain evidence on this aspect, the three varieties Blue Riga, Concurrent, and Liral Crown, grown at Canberra in 1943, were harvested at four different stages of growth. Samples were taken for anatomical work while yield and quality will be determined by retting, &c., in the usual manner. During the early stages of growth, it was evident that, despite efforts made to establish a uniform stand of plants in all plots, there was considerable variability, both within and between plots. This is a common feature of flax crops and is to be investigated further.

Seed increase plots were maintained, the objective being to increase pure seed supplies of each variety to several pounds weight so that a reserve is available for experimental work.

(ii) *Flax Retting.*—Research on dew retting, on a modification of ordinary warm water retting, and a combination of fungal and bacterial retting was continued throughout the year. All the experiments on dew and water retting demonstrate that, provided the ret is stopped at the right time, the main factor that determines the quality and quantity of the resultant line fibre is the quality of the straw. Therefore, until a new and better technique of retting is evolved, improvement of fibre will depend on the soil and climatic conditions under which the straw is grown. Experiments to determine the effects of some soil and climatic factors in straw quality are in progress.

In the course of experiments on a method of retting in which fungal action was followed by bacterial action, a factor in the environment that appeared slightly to improve the grade of fibre was noted. This factor was subsequently used in a modification of the ordinary warm water ret at one of the flax mills with results that appear to be satisfactory to all concerned. Because it was necessary to plan the experiment in a way that would not slow down mill operations, the final results will not be available until next spring.

The discovery of a factor that in the two preceding years was responsible for a considerable reduction of quality and quantity of fibre at one of the mills, and the adoption of a simple means of control, has resulted in an increase of 50 per cent. of line fibre of greatly improved quality.

12. Disease Investigations.

(i) *Tomato: Spotted Wilt.*—The main work in hand has been the continuance of selection and purification of the component strains of tomato spotted wilt virus. The great variability of symptoms of this disease has been adequately explained by the demonstration of the existence of these strains. This marks an important step in the study of the virus and should be of considerable help to workers breeding for resistance to it. A large field plot of tomatoes was set out in October, 1943, to study the possibility of using the mild strain of virus for protective inoculation. The yield of each of 400 plants was recorded separately throughout the season. The results showed that protective inoculation had distinct possibilities, but that it would be necessary to purify the mild strain absolutely before it could be used to the best advantage. This was necessary because the balance of the component strains varied rapidly within the plant, and even though a plant were inoculated with a mild strain of virus containing mere traces only of the other strains, it might well develop severe symptoms as a result of the other strains rapidly building up in concentration. Attempts to purify the mild strain completely have so far been unsuccessful, but are being continued.

(ii) *Potato: Virus Studies.*—Co-operation in the potato virus work has been continued. From June-December, 1943, visits were paid to Gatton Agricultural College, Queensland, to supervise the planting, roguing, and harvesting of six acres of virus-free Factor potatoes, part of the scheme for rapid multiplication of this stock to enable it to be passed out to farmers. At Canberra, routine potato aphis population surveys have been maintained throughout the summer in co-operation with the Division of Economic Entomology.

(iii) *Cauliflower: Virus.*—During the 1943 winter, an investigation of a virus disease affecting cauliflower in Canberra gardens was made in co-operation with the Division of Economic Entomology. This virus was identified as broccoli mosaic, a common disease causing considerable losses in England. Observations of the incidence of this virus are being continued.

(iv) *Peas and Beans: Diseases.*—A programme of investigation on legume diseases of major economic importance in Australia has been begun. Ascochyta blight of pea and Fusarium wilt of bean, both responsible for great crop losses, are receiving immediate attention. Tests of large numbers of varieties to find resistant material suitable for breeding work are under way. A study is also being made of the incidence of seed-borne Ascochyta in seed from a large number of sources.

13. Rubber Plant Investigations.

(i) *Guayule Rubber.*—As mentioned in last year's report, about 16.9 acres were planted with guayule rubber plants at Dickson Station, Canberra, Australian Capital Territory, the plants being spaced 3 feet by 3 feet. Transplanting was completed by the end of May, 1943, but with the onset of cold weather, the transplants showed no signs of active growth until the middle of the following October. A survival count made towards the end of November showed approximately 40,000 surviving plants on the area, which, allowing for small additional plantings made in the spring, indicated a mortality of about 55 per cent. This heavy mortality was fully paralleled by experience in South Australia and elsewhere. While undoubtedly enhanced by the long spell of cold weather following transplanting—the cold damp conditions of September being particularly unfavorable—the heavy mortality is due, in part at least, to other causes, for only slightly better establishment was obtained from the spring plantings which were made under apparently favorable weather conditions. The influence of seasonal and other factors on plant establishment is being further studied. It has become clear from the year's results that the potential growth period at Canberra is limited to the six summer months, and that the plants will only make satisfactory growth during this period if adequate moisture is available. Accordingly, seed has been supplied to Lawes for trial in southern Queensland, where climatic conditions should enable the plants to enjoy a longer growth period. Trial plantings will also be made in northern New South Wales during the coming season.

Seedlings transplanted from a shade house have been used for replacements on part of the guayule area at Dickson Station and on this part experiments are in progress to study the effect of lime and fertilizers on yield and seed production, the influence of cultural treatments on weed control, and the effect on yield and rubber content of different harvesting methods.

In South Australia, further investigations have been made at the Waite Institute on various factors influencing germination and establishment of guayule. The nursery technique has been intensively studied, and the best conditions of soil, moisture and temperature have been fully determined. Considerable difficulties have, however, been experienced in obtaining satisfactory field establishment of the transplanted seedlings, the percentage of surviving plants being rarely higher than 60, even under the most favorable circumstances. Under more adverse conditions, particularly where weed competition was severe, establishment has been as low as 5 per cent. The whole problem of field establishment is receiving further study.

Small-scale trial plots planted at a number of localities in South Australia during the previous year are yielding useful information on soil and other requirements. Best results have been obtained from irrigated plantings on light, friable soils: these made vigorous growth during the summer months and produced seed liberally. The plants in the regional plots are also being sampled at intervals to determine the rubber content, knowledge of which, co-ordinated with information on general growth, enables a complete picture to be drawn of the potentialities of the crop in different parts of the State.

(ii) *Kok-saghyz.*—Both field and pot experiments have been conducted with *Kok-saghyz* (*Taraxacum kok-saghyz*), during the year. Difficulties have been met in field establishment. Germination trials under controlled soil conditions have shown that at 18° C. approximately, *Kok-saghyz* requires a soil moisture content equal to field capacity or more, for a period of seven to ten days. Seed treatment studies have confirmed that the rate of germination of new seed is increased considerably by pre-soaking in a ½ molar solution of KNO_3 for four days at 17° C. Contact with superphosphate in the soil has been shown to decrease germination. Pot trials with three soil types and with various fertilizer treatments have indicated that, in general, the plant requires a rather high degree of soil fertility for satisfactory growth. Preliminary attempts to produce polyploids by the use of colchicine have shown promising results. Seed production has been studied. Analyses of roots, for rubber content, have shown that field-grown material has averaged about 14 per cent. per dry weight of rubber.

(iii) *Asclepias erosa.*—Seed of *Asclepias erosa,* one of the milkweeds of America, was received last year. Plants in the field have not made satisfactory growth. Pot experiments have been commenced to determine the effect of fertilizer on yield of rubber, but no harvest has yet been made.

III. ENTOMOLOGICAL INVESTIGATIONS.

1. General.

Attention has continued to be given mainly to problems of special importance in wartime. In association with the Army, important advances in the control of disease-carrying insect pests have been made. Effective methods for controlling moths in stored raw and scoured wool have been evolved. New methods suitable for the fumigation of bagged and bulk-stored wheat to protect it against insect pests and mice have also been evolved, these methods being particularly useful for the treatment of wheat stored under temporary conditions. Many vegetable pests, notably the potato moth, have been studied and important advances have been made in their control. Intensive investigation of the cattle tick has yielded promising results. Methods which it is anticipated will bring the buffalo-fly under effective control in dairy herds have been worked out. The long range investigation of the Australian plague locust continues to produce results of importance. Parasites of the potato moth, the green vegetable bug, and citrus scales have been imported from overseas and some have become established in the field. Insects liberated some years ago to attack St. John's wort and lantana continue to flourish in the field and are already exercising some degree of natural control.

2. Insect Pests of Stored Wheat.

(i) *Control of Bulk Infestations.*—In Victorian bulk-wheat depots, in which the principal pest is *Rhizopertha dominica,* effective control of insect infestation has been secured by treatment with inert dusts and fumigation. The function served by the dust (magnesite or dolomite) is to reduce the number of infestations, and the elimination of these is obtained by local fumigation. The fumigant employed is usually carbon bisulphide. This is used at a dosage of 16 fluid ounces per square yard of wheat surface. After the application of the fumigant, the wheat surface is covered by a bitumen-impregnated paper. Ethylene dichloride mixed with trichlorethylene (3:1 respectively) gives an equally good result when applied in the same manner at a dosage of 40 fluid ounces per square yard. Fumigation is followed by a rapid fall in wheat temperature to a normal level if the infestation is fumigated at a fairly early stage; otherwise, the temperature remains above normal and a recurrence of infestation at the same place is more likely. The cost of carbon bisulphide fumigation is extremely low, and the fumigation of the whole wheat surface several times a year (in order to eliminate the sparsely scattered insects and so prevent the appearance of hot-spots) was contemplated. However, it was found that in cool (uninfested) wheat such surface fumigation did not give a high kill of *Rhizopertha,* apparently because of the low rate of evaporation.

The dust (dolomite or magnesite) is applied to the surface of the wheat at a dosage of 35 ounces per square yard—equivalent to 5 tons of dust per million bushels of wheat. Of this dosage, 21 ounces is first applied and raked in, and then 14 ounces is scattered over the wheat surface. Such dosages do not prevent the expansion of an existing infestation (which must be fumigated) though they retard the rate of expansion. The surface dusting does, however, make it more difficult for the insects to establish fresh colonies, and the aim is to produce a continuous dust barrier, at the wheat surface, against the entry of insects dispersing by flight. In experiments in which extensive wheat surfaces were dusted at dosages of 7, 21, 43, and 57 ounces of dolomite per square yard, it was found that the lower two dosages did not greatly inhibit the appearance of *Rhizopertha* infestations, but the areas treated at the higher dosages showed a lower level of infestation and a higher percentage of dead adults than the controls. In an experiment in which *Rhizopertha* infestations were treated with dolomite at 84 ounces per square yard, the density of living adults decreased slightly and the percentage of dead adult insects increased from 11 to 86 in four months. In the control, the density of living insects doubled and the percentage of adults dead increased from 21 to 31 in six weeks. All the field experiments so far carried out indicate that the dusting of the wheat surface substantially reduces the rate of insect increase. The result of the large-scale application of this dust-cum-fumigation technique is that wheat stored for over two years is being loaded out in excellent condition.

From observations made in the Victorian depots it is clear that heating of the general body of the wheat does not occur. Heating is attributable to two causes—outbreaks of insect pests, and an increase in the moisture-content of the wheat, leading to bin-scald, at points where the depot floor is not water-tight. The first only can be controlled.

Special attention has been given to investigating the reason for the virtual restriction of insect infestation to the surface of bulk-depot wheat. It has been shown that a lethal factor is involved, and that the phenomenon is not explicable in terms of non-lethal factors such as tropisms. The lethal factor appears with the infestation itself and increases in effectiveness with the increase in insect density. In a well-developed infestation, insects rapidly die when placed at a greater depth than one foot in the wheat, and there is a marked increase in the mortality rate from the surface downwards. There appear to be two possible explanations only. First, that the temperature-moisture-content conditions become unsuitable for insect development. At the moment, this explanation seems unlikely to cover the observed facts. Secondly, that a lethal gas or vapour is produced by the insects or, less probably, by the wheat itself. Analysis of air drawn from the lethal zone has so far given only negative results. The increase in carbon dioxide (up to about 3 per cent.) and the corresponding decrease in oxygen are unlikely explanations. Carbon monoxide, aldehydes, ammonia, and quinones are apparently absent. Hydrocarbons are apparently present in low concentrations and these are being further examined.

(ii) *Control of Weevil and Rodents in Bag Stacks.*—An increase in the number of bag stacks infested with insects (principally *Calandra oryzae*) and rodents (principally *Mus musculus*) in South Australia and Victoria necessitated the development of a simple technique for the fumigation of stacks *in situ.* A series of experiments was carried out on experimental stacks of normal commercial height to determine the conditions under which effective fumigation could be secured. Carbon bisulphide was usually employed because this is the only fumigant, excepting hydrocyanic acid, available in adequate quantities. The following points were demonstrated:—(*a*) The fumigant when liberated on the top penetrates satisfactorily to the bottom of the stack. (*b*) A dosage of 1 gallon per 1,000 cubic feet under suitable conditions of enclosure, gives an excellent commercial kill of insects and rodents. (*c*) The fumigation of an infested portion of a stack, by partial stack-enclosure, is impractical. (*d*) Given air-tight walls only, the rate of diffusion from the top of the stack is so slow that a good kill is obtained throughout the stack except in the top few layers of bags, and a good kill is obtainable in these layers by making the enclosure about 3 feet higher than the stack itself. In practice, however, infestations are usually restricted to the lower half of the stack.

The results of these experiments are now being applied commercially. The walls of infested stacks are draped with an airtight fabric, and the fumigant roughly distributed over the top face of the stack which is then covered with hessian. The fumigation period is 24 hours. Stacks containing as much as 90,000 bushels of wheat have already been fumigated, and there is no limit to the amount which can be fumigated as a single unit. The total cost of fumigation in the commercial trials was less than a farthing per bushel, and the results appear to be entirely satisfactory. It was found in tests on the experimental stacks that a mixture of ethylene dichloride and trichlorethylene (3:1) used at a dosage of 3 gallons per 1,000 cubic feet was rather less effective than carbon bisulphide used at 1 gallon per 1,000 cubic feet.

(iii) *Treatment with "Inert" Mineral Dusts.*—The detailed investigation of the effectiveness of certain mineral dusts for the control of grain pests has been continued and standardized. The efficacy of a dust is determined from tests in which it is used at two levels of concentration, viz. 0.5 per cent., and 1 per cent. by weight of the wheat, at two different relative humidities, 45 per cent. and 65 per cent., against the two important species *Calandra oryzae* and *Rhizopertha dominica.* From time-mortality curves based on these tests, it is possible to compare the relative efficiencies of the various dusts. During the past twelve months, tests have been made on magnesites from all the mainland States; dolomites from New South Wales, Victoria, and South Australia; a number of industrial residues including

cement kiln dust, blast surface dust, pyrites cinters, and zinc concentrate; and activated alumina of English and Australian origin. The most outstanding material was the imported activated alumina, which is the only dust so far tested that has produced a complete kill of *R. dominica* more rapidly than of *C. oryzae*. In contrast, the Australian activated alumina gave an efficiency below that of the best magnesites. Both the magnesites and dolomites were in general comparable with similar dusts already in commercial use. None of the industrial residues showed any promise.

(iv) *Biological Studies.*—A study is in progress on the effects of various combinations of temperature and humidity on the longevity and reproductive potential of *Rhizopertha dominica*. Results to date indicate that 44 per cent. R.H. is more suitable than 32 per cent., and that at both humidity levels more progeny are produced at 85° F. than at either 80° or 90° F. Individual insects may live at least seven months, but most of the oviposition takes place during the first eight to ten weeks of adult life.

3. Insect Pests of Stored Wool.

(i) *General.*—The investigation of the infestation of stored wool by clothes moths, which was begun in 1941, has been successfully concluded. Methods of control have been devised for use with both scoured and greasy wool, and fairly accurate estimates of their efficiency and cost have been made. The decrease previously reported in the degree of infestation of an untreated store in Brisbane has been maintained and is ascribed to the operation of three distinct factors: namely, an increase in the numbers of a hymenopterous parasite *Apanteles carpatus;* a disease of the larvae; and an increase in the numbers of a spider, *Uloborus geniculatus,* which was ultimately catching the majority of the adult moths that emerged. It appears that increase of the moth population to a maximum, followed by a very considerable decline, would occur in any untreated and undisturbed store.

(ii) *Spray Tests.*—Two liquid sprays, one known as "middle oil 43", and the other a proprietary preparation, had been shown previously to be the most promising out of a series tested in the laboratory for their fumigative toxicity to clothes moth larvae in greasy wool. These two materials have now been compared under more practical conditions by applying equal quantities of each to isolated bales and counting the number of dead and live larvae found on opening the bales after a suitable interval. It was found that the percentage of larvae remaining alive after treatment with middle oil was only one-fifth of the percentage remaining alive after treatment with the proprietary spray. Other evidence indicated that middle oil would not be inferior in persistency to the proprietary spray which confers a very high degree of protection against reinfestation for a period of up to two years.

Trapping of moths in comparable wool stacks, one of which had been sprayed, together with the whole of the store containing it, and the other left unsprayed in an unsprayed store, was continued. It revealed that, even after ample time had been allowed for larvae that had survived the spraying to emerge as moths, the population in the treated stack did not exceed 3 per cent. of its level before the treatment was carried out. The spray used in this case was the proprietary preparation. In view of the superiority of middle oil over this preparation, a considerably better result could be anticipated by the use of the former.

Tests against isolated dumps of scoured wool were carried out along the same lines as those described above, in which greasy wool was used. Three sprays were compared, which had shown up best in laboratory tests of fumigative toxicity, namely, (*a*) 90/190 solvent naphtha saturated with naphthalene at 70° F., (*b*) orthodichlorbenzene saturated with naphthalene at 70° F., and (*c*) a mixture of equal parts of orthodichlorbenzene and lighting kerosene, saturated with naphthalene at 70° F. All three had the required property of evaporating completely from treated wool without leaving any stain or any residue that would interfere with subsequent dyeing. All three sprays gave a 100 per cent. kill of larvae in the treated bales after three weeks.

(iii) *Recommendations for Control.*—In the light of the above experiments, and other described in previous reports, the following recommendations were drawn up for the treatment of infested stores: (*a*) For greasy wool, "middle oil 43" should be applied to the standing stacks, at the rate of 1 pint per bale, by means of spraying equipment which has been designed for the purpose. This should preferably be done soon after stacking. (*b*) For scoured wool, 90/190 solvent naphtha, saturated with a pure grade of naphthalene at about 70° F., should be applied in the same way and at the same rate. (*c*) For both greasy and scoured wool, commercial "whizzed" naphthalene should be spread on top of each tier of bales in the course of construction of the stack, at a rate of about 1 lb. per double dump.

The estimated cost of these treatments varies from 2d. per bale for the cheapest, to 5d. per bale for the most costly.

4. Insect Control of Noxious Weeds.

(i) *St. John's Wort* (*Hypericum perforatum*).—Inspection during November, 1943, showed that colonies of *Chrysolina hyperici* at Orange, Sodwalls, Mudgee, Piambong, and Rylstone were all making satisfactory progress. The most spectacular progress was at one site near Piambong, north of Mudgee. In December, 1943, a further liberation of approximately 10,000 adult insects was made at Mannus, near Tumbarumba, as earlier liberations of *C. hyperici* in this area had not made the progress that was expected.

In Victoria, further very satisfactory progress was noted throughout the Ovens Valley and German Creek areas in the vicinity of Bright, where the insects have now spread naturally for a distance of some 10 miles, and in restricted areas the weed has been brought under control. At Ovens Vale, near Myrtleford, where a colony was established during 1940 in a State pine plantation, the progress has also been very satisfactory, and the insects have now dispersed over a wide area. Good colonies are also developing at Harrietville, Tawonga, and in the Dargo district to the south, where several colonies are making satisfactory progress.

Early in December, 1943, large consignments of *C. hyperici,* collected at Bright, were sent by air to South Australia. In all, some 20,000 adult insects were forwarded. These were later liberated in the South Australian National Park. Approximately the same number of insects was sent to Tasmania. During the same month about 30,000 *C. hyperici* were sent to New Zealand. Reports stated that the consignment arrived in very satisfactory condition and that, as a result, large numbers had been liberated in two localities in New Zealand where heavy infestations of St. John's wort occur.

Chrysolina gemellata is now well established at Baker's Gully, near Bright, as a result of liberations made during 1939.

In November, 1943, the sites where the root-boring Buprestid, *Agrilus hyperici,* had been released at Piambong and Mudgee were again examined. The various colonies were found to be making progress, and to have spread steadily from the initial liberation points. Three colonies have been established in New

South Wales; one on the Mudgee Catchment Area and two at Piambong, about 10 miles distant. Victorian liberation sites where these insects are established at Baker's Gully, Bright, were also visited during December, 1943. Colonies there, numbering four in all, were found to be making steady progress, and showed evidence of spread at a satisfactory rate.

(ii) *Lantana (Lantana camara).*—Although there have been no recent reports concerning the work of *Teleonemia scrupulosa* in the coastal areas of north Queensland, the general position there appears to be satisfactory, and there are indications of further improvement. Recent reports from various centres in south-eastern Queensland indicate that there is a distinct improvement in the position in this region. A colony liberated at Withcott, below Toowoomba Range, in December, 1940, has now survived three winters. Populations near the liberation site are high, while infestation extends over a distance of about two miles. At Mt. Bauple, north of Gympie, where a colony was liberated about the same time, the bugs are reported to be breeding freely, and infested lantana has a dry yellowish appearance, with few flowers present. At one point, some bushes are reported to be almost completely defoliated. Early this year, the colony at Mt. Bauple provided considerable numbers of bugs which were distributed to other centres of lantana infestation throughout south-eastern Queensland.

5. Sheep Blowfly.

Work has been carried out on the sheep blowfly problem during the year whenever the generally very urgent medical entomology investigations have permitted. B.K.B., a modification of B.T.B. blowfly dressing, and possessing extremely rapid killing power when it comes in contact with maggots, has now been recommended, and is in use in the field.

A detailed analysis of results obtained in earlier experiments has been made for the purpose of collating information on the density of the natural population of the sheep blowfly, *Lucilia cuprina,* and the mechanism whereby it is selectively attracted to sheep. On the basis of this information, the possibility of reducing strike by such means as traps, poison baits, carcass disposal, and destruction of maggots in strike wounds, is being critically examined. This is the main field of entomological investigation into crutch strike of sheep which still requires examination. Several publications on this work are being prepared.

6. Medical Entomology.

In its capacity as research centre for army medical entomology, this laboratory has carried out many investigations during the year with the aim of establishing effective control measures against mosquitoes and flies, the two most important groups of insect vectors of disease in Australia and the islands.

The mosquito control problems fell into three categories: (*a*) repellents for application to exposed skin surfaces and clothing, (*b*) insecticidal sprays for killing adult mosquitoes, and (*c*) larvicidal oils for treating their breeding grounds. Work on repellents in Australia and New Guinea confirmed and extended the results obtained previously. However, for security reasons it is not desirable to indicate the nature of the results beyond saying that there have been very great advances. Laboratory experiments with mosquito sprays were supplemented by a large number of tests in New Guinea against the principal malaria mosquito. As a result of this work it is now possible to select the effective concentration of a number of toxic substances for use in sprays and also to standardize on the dosage of spray required. Work on mosquito oils was governed at first by the necessity to reduce the number of 44-gallon drums required for the transport to New Guinea of oils blended in Australia. By using oils which were already available in bulk in New Guinea, a blend of distillate, creosote, and furnace oil was produced which was as effective as Malariol. As an alternative, a proprietary spreader plus furnace oil to a total extent of 2 per cent. was found to render distillate satisfactory. Although the spreader would have to be sent over from Australia, its comparatively small bulk would not present a serious problem.

There have been several advances in the field of fly control. Owing to the extreme shortage of pyrethrum since the outbreak of war, it has been necessary for Allied Nations to restrict its use to mosquito control. In view of plans for increased pyrethrum production, and the possibility that some pyrethrum might become available for fly control, an investigation was undertaken into various means of increasing the effectiveness of pyrethrins by means of activators. Many Australian essential oils were tested as activators and the following were found to be most effective:—Oils of *Backhousia myrtifolia, Zieria smithii, Melaleuca bracteata,* and Huon pine (*Dacrydium franklinii*). These oils were the same as those found last year to be effective as mosquito repellents. Oil of *Backhousia* was many times more effective than sesame oil which is used at present on a large scale as a pyrethrin activator in America and India. Valuable information has been obtained on the chemical composition of the effective essential oils. None of the activators for pyrethrum found to be effective against flies were effective against mosquitoes. Fly sprays containing 0.03 per cent. or more of D.D.T. are highly toxic to houseflies, but their knockdown effect is slow. This can be remedied by the addition of low concentrations of pyrethrum. For at least nine months after application, surfaces treated with D.D.T. will kill houseflies resting on them. Paralysis takes place slowly and flies may still be able to fly for about an hour after first contact, while death may not occcur until several hours later. This confirmation of overseas work opens up new possibilities in the control of flies in hospitals and kitchens and should revolutionize domestic fly control after the war. Information on the mechanism of action of this extremely effective poison is being obtained. For the treatment of hospitals and kitchen refuse to prevent fly breeding in areas where incineration cannot be practised, sodium arsenite used at the rate of ½ lb. dissolved in 3 gallons of water and applied to 10 cu. ft. of refuse was found to produce complete mortality. This treatment is now recommended by the Army.

7. Cattle Tick.

Further studies have been made on the effect of temperature on the incubation of eggs and the longevity of larvae. At all temperatures larval longevity increases with increasing humidity until close to saturation. Newly emerged nymphs and adults experimentally transferred from one host to another reached maturity. The maximum parasitic period for male ticks was found to be about 70 days, which is twice the maximum for females. The mean parasitic period for females was found to be 22.9 days, and the maximum and minimum periods 35 and 18.9 days respectively. The natural mean mortality of parasitic stages in the field was determined as 26.2 per cent. Nymphs and adults migrate freely following ecdysis before becoming attached. Unfavorable conditions assist this movement.

Bacteriological studies of dipping fluids were made and some oxidizing organisms were isolated. It was found that the oxidation of sodium arsenite to sodium arsenate which takes place in used dips is due to an active system which can be destroyed by autoclaving or by the use of bacteriostatic agents. In the laboratory, oxidized dips tend to reduce when contact with air is prevented.

Spraying with arsenical solutions at fourteen-day intervals was found to allow some females to engorge and lay viable eggs. This appears to be due to the demonstrated fact that ticks in the early nymphal stage show resistance to arsenic. When sprays at seven-day intervals were used no ticks developed beyond the unengorged nymphal stage. Some unattached larvae survived treatment with arsenic. Arsenic gives practically no period of protection against reinfestation. Numerous preliminary experiments were made with the use of D.D.T. sprays and promising results were obtained. It was found that the most susceptible stages are the larva and the newly emerged adult, the least susceptible being the semi-engorged nymph. Protection against reinfestation varied from 2 to 13.5 days with concentrations varying from 0.5 per cent. D.D.T. in alcohol to 2 per cent. in emulsion.

8. Buffalo-fly (*Lyperosia exigua*).

Research into the control of this pest has been conducted at Malanda, the Atherton Tableland dairying centre. The similarity of the buffalo-fly to the horn fly (*Lyperosia irritans*) suggested that a trap which has been found effective against the latter pest in the United States would also serve to control the buffalo-fly. On dairies the trap is built into the fence of the milking yards, so that the cows pass through it each milking time. The trap has a roofed passageway approximately 11 feet long, 6 feet high, and 3 feet wide. As the cows pass through the passage the flies are brushed from their bodies by canvas screens, and are collected in gauze traps lining the sides of the passageway. It was found at Malanda that on a milking herd using such a trap twice a day the numbers of flies per beast were reduced to less than 10 per cent. of what they were before trapping commenced. The flies remaining were so few that any worry they caused the cattle was negligible.

Herds in which all beasts were sprayed with 4 per cent. solution D.D.T. in lighting kerosene remained virtually free from flies for periods of from two to three weeks. After this it appeared that the material had all gone from the hide, so that flies settling on the cows were no longer killed; but the population of flies did not reach the pre-treatment level for a further period of about two weeks.

Those parts of the hide normally kept free of flies by the switching of the tail need not be sprayed with D.D.T., as flies alighting there are driven off and, in order to feed, must settle on a part of the beast that has been sprayed. It has been found, too, that when only half of the cows in a herd is treated, the cows selected being most attractive to the flies, control is almost as effective as when all the cows are treated. This indicates that within a herd the flies travel around from beast to beast to a considerable extent. As an alternative to complete treatment of only a proportion of the cows, one may treat only those parts of the hide of each beast where the flies congregate in greatest numbers, namely the shoulders and flanks, and still achieve very effective control. By these means economy of labour and material can be effected.

If applied in sufficient quantity, kerosene is injurious to the skin of cows. For this reason spraying with kerosene solutions must be done so that the spray does not penetrate to the skin. As this is difficult in practice whilst still applying adequate dosage, alternative methods of preparation of the spray are desirable. Considerable promise is shown by an aqueous emulsion of kerosene solution of D.D.T. incorporating a proprietary wetting agent. By the use of this emulsion a substantial reduction in the quantity of kerosene applied to each beast is possible.

The research with D.D.T. has not yet reached the stage when it is possible to recommend its general use against the buffalo-fly. Further study of methods of preparation and application of sprays is necessary.

Information is required on the extent to which flies travel from one property to another, and hence the rate of reinfestation of treated farms from surrounding properties where fly-control measures are not practised. The method has been adopted of liberating marked specimens on properties adjoining that on which the buffalo-fly trap is situated, and examining the catch of the trap for the presence of marked specimens. However, the technique of marking the flies without injury has not yet been perfected, and results so far obtained are inconclusive.

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

The more important part of the investigation has been that carried out in the Trangie area. Observations have been continued on the fluctuations of the local population of *Chortoicetes,* with special reference to the nature of the country in which swarm formation can take place; work on possible methods of rendering conditions less favorable to swarm production by ploughing, revegetation of scalds, and planting of trees, has been carried a stage further; and additional experiments on poisoning sparse populations with bran bait have been conducted.

(i) *Population Studies.*—Very favourable weather conditions during the spring months led to a high survival rate, and numerous swarms were produced by the concentration of the population in the late nymphal instars. Convincing evidence was obtained that this concentration had taken place in the type of situation that had already been assigned a swarm-producing role on the basis of earlier, less complete, observation, i.e. in the supposed outbreak *centres.*

The quantitative studies of population fluctuations in relation to changes in vegetation factors (described in earlier reports) provided evidence as to the type of pasture that is most favorable to survival and breeding of the active stages of the locust. To check the conclusions reached in this way an experiment has been carried out in which adult locusts were confined in large cages over pasture artificially maintained in various extreme and medial conditions. The pasture within the cages was differentiated by cutting and/or watering, and its species-cover, shelter-status, and green-feed-content were determined by the same methods as had previously been applied to naturally occurring pastures. Mortality of the caged adults was found to be highest at extremes of bareness and of tall dense pasture, and lowest under intermediate conditions of cover and shelter.

(ii) *Ecological Control Experiments.*—Observations have been continued on the condition of the pasture on fenced portions of outbreak centres that were ploughed two years ago in the hope of inducing a type of plant cover that would be less favorable for locust oviposition. Although minor changes have occurred, there has been no significant improvement. Since the soil is steadily compacting and the plough furrows disappearing, it appears that ploughing and fencing alone constitute an inadequate means of destroying the favorable features of the oviposition habitat. Fencing alone is still more inadequate.

Some two-thirds of the trees and shrubs which it was planned to plant on selected outbreak centres, with a view to preventing free movement of locusts between their oviposition and food-shelter habitats, have now been planted. Much information on the best methods of culturing these plants and establishing them in the field has been accumulated, and the majority of those planted are now established and doing well. The effect of the treatment on the locust population of the outbreak centres cannot yet be estimated.

(iii) *Poisoning Experiments.*—Further poisoning of non-swarming populations of hoppers has been carried out, using standard bait at dosages of 30 lb. and 15 lb. to the acre, i.e. dosages respectively one-half and one-quarter of those recommended for use against swarms. Inconclusive results were obtained.

10. Termites.

Owing to shortage of staff, investigation had to be confined to the continuation of test of timbers and treated timbers under field conditions. Details for the 15th Progress Report of the International Termite Test were forwarded to the United States of America.

11. Potato Moth (*Gnorimoschema operculella*).

It has been estimated that upwards of 20 per cent. of the tubers dug in Australia during the 1943-44 season were lost owing to attack of the potato moth. In a field experiment at Canberra the yield of potatoes was doubled by protecting the foliage with phenothiazine. Although in normal potato-growing districts the loss due to potato moth attack on growing plants is unlikely to be as high as this, there is clearly a great reduction of yield due to attack of this kind, the importance of which was not previously appreciated.

Tests were made with a number of spray materials for the protection of growing plants. The best results under experimental conditions were obtained with phenothiazine and derris, but synthetic cryolite, lead arsenate plus sodium aluminium sulphate, and basic copper arsenate gave appreciable control. Small-scale tests with 33 varieties were made to study the susceptibility of different varieties, and it was found that there is a considerable variation in the degree of attack of tubers according to variety.

Five species of parasites of the potato moth were imported from California during the year. Stocks of four of these have been successfully reared in insectaries, and one species, *Chelonus phthorimaeae,* has become established in the field in the Canberra district.

12. Cabbage Butterfly (*Pieris rapae*).

Because of the seriousness of this pest on many vegetables, comparative field tests were made with a number of different toxic dusts. A result of particular interest obtained was that magnesite containing 6 per cent. nicotine sulphate gave as good results as arsenical dusts and derris dusts, and therefore may prove a desirable substitute for these, particularly as it also controls the cabbage aphis.

The parasite *Apanteles glomeratus,* introduced about two years ago, was recovered from the field in the Canberra district in appreciable numbers. Consignments of this parasite have been sent to Queensland, Victoria, and South Australia.

13. Green Vegetable Bug (*Nezara viridula*).

Preliminary laboratory and field tests indicate that D.D.T. is a very promising insecticide for the control of this pest, which is most resistant to control by sprays in general use up to the present. Several further consignments of the parasite *Trichopoda pennipes* were received from Florida. Adults were liberated in the Canberra district and there have been indications that at least one generation has bred in the field.

14. Citrus Red Scale (*Aonidiella aurantii*).

Colonies of the Chinese race of the parasite *Comperiella bifasciata* have been maintained since its introduction in 1942 and consignments have been distributed to most States. During the past year the bulk of the liberations were made on the Murrumbidgee Irrigation Area where conditions for establishment were best. Indications that the parasite has become established there and in South Australia have been obtained.

15. Brown Olive Scale (*Saissetia oleae*).

Laboratory colonies of the parasite *Metaphycus helvolus* have been maintained since its introduction in 1942, and further small distributions have been made, chiefly in the eastern States, in areas where brown olive scale and other host scales are of economic importance.

16. Light Brown Apple Moth (*Tortrix postvittana*).

A preliminary study has been made of the damage this pest causes to vine fruits in the vine-growing areas in the Murray Valley. The main damage is caused by the larvae which feed in the developing bunches. Damage to the berries is frequently followed later by mould.

17. Meat Ant (*Iridomyrmex detectus*).

Preliminary experiments indicated that solvent naphtha and crude naphtha used at the rate of one pint to every eight entrance holes may form efficient substitutes for carbon bisulphide. They are cheaper and less dangerous to use. Paradichlorbenzene, which has been stated to be effective against ants, was also tried, but it proved impossible to affect a nest seriously with as much as 2 lb. per nest.

18. Insect Vectors of Plant Virus Diseases.

(i) *Broccoli Mosaic.*—A virus disease of cauliflower and swede turnip has been recorded from the Australian Capital Territory, and it is considered to be the same as broccoli mosaic described from England and cauliflower mosaic recorded in the United States of America. It has been found that the vector is the cabbage aphid, *Brevicoryne brassicae* L.

(ii) *Potato Virus Diseases.*—The detailed survey, begun in 1941, on the abundance of the green peach aphid, *Myzus persicae* Sulz., and the potato aphid, *Macrosiphum gei* Koch, vectors of leaf roll and mosaic viruses of potato, was continued at Black Mountain and Dickson, Australian Capital Territory.

Eggs of the green peach aphid were laid on peach trees in Canberra in the autumn and some viviparous reproduction took place throughout the winter on cabbages. The main flight in spring took place on the 8th October, 1943, six days later than in 1942, and aphids appeared on potatoes on the experimental plots at this time. The peak of population in potatoes again occurred at the end of October, and the numbers then decreased and disappeared for four months from early December. A small autumn generation appeared on potatoes in March, 1944, and produced winged migratory individuals.

Throughout the winter the potato aphid again bred on a number of host plants, the most common of which was sow-thistle, *Sonchus oleraceus* L. Invasion of potatoes began in the spring about the same time as green peach aphid, rose to a peak of population in the first week of November, and then disappeared until the middle of March, 1944. Winged migratory individuals were produced at this time.

19. Systematic and General Entomology.

As in the past, considerable numbers of insects have been identified for institutions and individual workers throughout Australia and New Zealand. Assistance has also been given in dealing with various systematic and taxonomic problems.

Further additions, mainly of insects of economic importance, have been made to the collection, either as a result of material secured on field trips or by exchange with other entomologists or institutions. The Australian and Allied services have been assisted, on occasions, with information concerning the control of various insect pests, and the supply of material for instructional purposes.

Following the publication of the monograph "The Termites of the Australian Region" by Mr. G. F. Hill, reference collections consisting of material used in the preparation of this work have been distributed to various institutions in Australia, and to one in the United States of America. Three more collections will be sent to important museums in other countries when conditions become favorable for their transport.

IV. ANIMAL HEALTH AND NUTRITION INVESTIGATIONS.

1. General.

The work of the Division of Animal Health and Nutrition has continued during the year very much along the same lines as in the previous year.

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 (Queensland), Badgery's Creek (New South Wales), and at Werribee (Victoria). Co-operative work with the State Departments of Agriculture has continued. Links with other divisions in work on entomology and agrostology have been maintained through the Veterinary Entomological Committee and the Inter-divisional Committee for Agrostology, respectively. The Biochemistry Section of the Division of Industrial Chemistry and an officer of the Division of Food Preservation have been housed and given facilities at the Laboratory, Parkville (Victoria).

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

2. Animal Health Research Laboratory, Melbourne.

(i) *Pleuro-pneumonia of Cattle.*—Further progress was made in assembling and preparing the groups of vaccinated cattle for the experiment designed to determine the influence of nutritional stresses on the maintenance of immunity against pleuro-pneumonia. Laboratory investigations of the correlation of virulence of strains of the causal organism with cultural changes have continued but without success. Attempts to infect very young mice of 5 g. weight after ether anaesthesia were unsuccessful. During the year 465,000 doses of vaccine were distributed to centres in Queensland and the Northern Territory mainly. Antigen for the complement-fixation test was supplied to Kenya as in the past. The possibility of preparing a standard dried antigen was investigated.

(ii) *Entero-toxaemia of Sheep and other Diseases due to Clostridia.*—The investigation, mentioned in the last report, of the optimal conditions for formaldehyde toxoiding of the toxin of *Cl. welchii* type D was extended to whole cultures. The results obtained were very similar. Study of the haemolysins of the *Cl. welchii* group was continued. Some of the results were published (*Aust. J. Exp. Biol. Med. Sci.*, Vol. 21, pp. 79-88, 1943).

(iii) *Caseous Lymphadenitis of Sheep.*—Study was continued of the antigenic make-up of variants of *C. ovis*. Some of the variants which were not agglutinated by anti-serum against the parent strain were agglutinated after treatment with sodium lauryl sulphate, which presumably removes masking layers. The vaccination experiment referred to in the last report was continued.

(iv) *Myxomatosis.*—Investigations into the use of the virus of myxomatosis for the control of rabbit populations was concluded during the year and a short report on the results was published in the Council's Journal (Vol. 17, pp. 79-93, 1944).

(v) *Mastitis in Dairy Cattle.*—During the year observations have continued on the cows in the experimental herd and on the control of the spread of infection in the milking shed. It was determined that the epidemic type of *Str. agalactiae* can spread with comparative ease in the milking shed even when the usual precautions are taken. However, when the precautions were tightened and care was taken to use a hypochlorite solution in sufficient strength, viz. 1,000 p.p.m., the spread was prevented. Examination of the data on the first epidemiological experiment was continued but was not concluded. The cows in the second epidemiological experiment are expected to come into production in the near future. During the year some attention was given to the treatment of mastitis, and sulphanilamide in oil was found to overcome early infections of the quarter. No study of the value of preparation in chronic infections was made but soluble preparations of sulphanilamide were tried and they failed to give uniformly good results. With eradication of the infection as the criterion of success, many other preparations failed to give the desired results.

(vi) *Toxaemic Jaundice in Sheep.*—Observations were continued on the experimental flock at Barooga in co-operation with officers of the Veterinary Research Station, Glenfield, New South Wales. Of the 300 ewes which constituted the flock in 1940, only 132 remained alive at the beginning of 1944. The death rate in 1943 was 50 per cent. and a heavy death rate recurred in 1944. It was determined that what had been regarded as the typical manifestation of the disease, viz., haemoglobinuria and haemolytic jaundice, was indeed only the manifestation of what may be called an acute form of the disease. The manifestations of the more chronic form, which in the last report was regarded as distinct from toxaemic jaundice, are associated with chronic liver damage and the occurrence in a proportion of cases of an obstructive jaundice. Both manifestations are believed to be, on the evidence, indications of copper poisoning. Another flock of 300 young ewes was placed on the experimental farm in November, 1943. The experimental study of copper assimilation and of copper poisoning was continued in the laboratory during the year.

(vii) *Peg-leg of Cattle.*—This investigation was terminated during the year and the results are being examined with a view to publication.

(viii) *Contagious Abortion of Cattle.*—During the year about 9,000 doses of "Strain 19" vaccine were prepared and supplied to the Victorian Department of Agriculture. The vaccine was used for injecting calves and non-pregnant adult cattle in herds suffering wastage from contagious abortion. The success or otherwise of the vaccine will be determined by an examination of the results when they become available. Studies have continued on the standardization of the vaccine and earlier difficulties were overcome. The viable count of the vaccine in buffered saline was found to remain unchanged for about 20 days at room temperature. Thirty calves were vaccinated and they are to be exposed to natural infection along with unvaccinated calves during pregnancy in order to test the degree of resistance produced. The response of adult cows was investigated under conditions of decreasing dosage of vaccine injected subcutaneously, intradermally, and into the tip of the tail. The results were measured by the agglutination test, but the investigation is not completed.

(ix) *Study of the Mechanics of Hand-feeding of Sheep.*—The experiment, mentioned in the last report, was concluded. No effort was made to give protection to the sheep after shearing, and as the weather became very cold deaths occurred off-shears. The mortality

rate was greater in the weekly-fed group. Apart from this, the weekly-fed group was maintained approximately in as good condition as the daily-fed group.

(x) *Toxicity of Wheat for Stock.*—The experiment was continued but the horse was used as the experimental animal, as it reacts with greater regularity to consumption of wheat than does the sheep. The histamine hypothesis of the cause of distress and death was examined. An appreciable rise in histamine in the blood of horses, suffering with laminitis or other acute illness after the consumption of 20-30 lb. of wheat, could not be demonstrated. Relatively large amounts of histamine were found in the stomach contents of horses after large feeds of wheat compared with stomach contents after hay or pasture has been consumed. A similar relationship was found with contents of the small intestine. Tests were carried out *in vitro* with wheat, pepsin, hydrochloric acid, and a small inoculum of stomach contents of a "case". After incubation at 37° C. an appreciable concentration of histamine was demonstrable, whereas the controls showed no such development. Histamine could not be demonstrated in the wheat itself. The investigation is being continued.

(xi) *Miscellaneous.*—A pure strain of *Anaplasma centrale* has been maintained in cattle for some years. An attempt was made to determine if this micro-organism could be maintained in a frozen state with fewer passages through cattle. Blood from an inoculated beast at the height of the infection was quickly frozen to and kept at —80° C. It was found to be infective after quick thawing when tested nine months later.

3. The McMaster Animal Health Laboratory.

(i) *Parasitological Investigations.*—(*a*) *Study of Anthelmintics against Haemonchus Contortus.*—For the purpose of this study the substances under investigation were injected directly into the rumen or into the abomasum, and sometimes they were given by mouth. Soluble arsenical compounds and insoluble arsenical compounds were investigated in this way. Of seven arsenites used, all were effective under the conditions of the test, and of eleven arsenates five only were effective. Other insoluble inorganic compounds of strontium, barium, fluorine, zinc, lead, bismuth and chromium, were found to be ineffective under the conditions of the test.

(*b*) *Study of Anthelmintics against Trichostrongylus spp.*—Further studies on the effect of phenothiazine on the immature forms of the parasite showed that the usual dose was ineffective against the immature worms ten to fifteen days old. However, a dose of 40 g. injected directly into the rumen was found to be effective. A dose of 15 g. every 21-28 days directly into the rumen of young sheep receiving 2,000-7,000 infective larvae was effective in keeping the worm burden at a low level. The variable results obtained by single doses of from 5 g. to 10 g. of phenothiazine were confirmed in other experiments. Preliminary trials have failed to show that the efficiency of phenothiazine depends upon the degree of worm infestation. By injections directly into the rumen or into the abomasum it was found that the efficiency against *Trichostrongylus* supp. was not controlled by the destination of doses given by the mouth. Further trials confirmed the anthelmintic efficiency of carbon bisulphide when injected into the abomasum.

(*c*) *Study of Anthelmintics against Oesophagostomum columbianum.*—Enemas containing arsenic pentoxide were found to have less efficiency than those containing sodium arsenite. The effect of age on suspensions of phenothiazine stored for 12 to 15 months was found to be negligible.

(*d*) *Epidemiology.*—The epidemiological studies which have been in progress at Armidale, New South Wales, for several years have been extended to include areas in Queensland. So far, the results following seasonal changes have been similar to those observed at Armidale.

(*e*) *Administration of Phenothiazine in a Lick.*—A group of sheep was given access to a mixture containing phenothiazine and the results were compared with those obtained from another group drenched with phenothiazine at intervals of about a month, and with a group receiving no treatment. At first the phenothiazine was mixed with stock salt and later with linseed meal in an attempt to obtain a consumption of about 0.5 g. phenothiazine per day. Consumption of the salt lick was irregular and fell from 7.5 g. containing 0.4 g. of phenothiazine to 0.7 g. and 0.035 g., respectively. Linseed meal was added, but consumption was not improved until the phenothiazine was added to a mixture of linseed meal and salt in about equal proportions. For about four months there was no effect on the worm burden, but with increase in the consumption of phenothiazine to 0.5 g. per head per day the egg counts decreased. The effect was more pronounced on *H. contortus* and *Oe. columbianum* than on *Trichostrongylus* spp. In the other group regular administration of phenothiazine as a drench brought about a marked reduction in worm burden, and the gain in body weight was 9.4 kg. compared with 5.0 kg. for the "lick group". Under the conditions of the experiment a daily consumption of 0.5 g. of phenothiazine was not as valuable as a single dose of 15 g. once a month.

(*f*) *Miscellaneous.*—In addition, work has been carried out on field trials conducted in South Australia from the Animal Nutrition Laboratory and in Canberra from the Division of Plant Industry, on the anthelmintic efficiency of carbon bisulphide against Ascaris in pigs, and on the control of helminthiasis in the general flock at the McMaster Field Station.

(*g*) *Parasitological Studies at Armidale.*—The epidemiological studies were continued and the results of the last five years are being examined. Studies on the value of rotational grazing for the control of parasitism were continued. Further study was made of the value of supplementary feeding in the control of worm parasites, but so far no ration has been found to give economical returns. Observations on the treatment of haemonchosis under outbreak conditions showed that phenothiazine is superior to carbon tetrachloride, copper sulphate, and copper sulphate-arsenite mixture, but that all anthelmintic treatment lacks efficiency under outbreak conditions. Phenothiazine was used to treat a flock of 800 sheep early in May, early in July, and late in August when, under the climatic conditions, reinfestation is not expected. This winter treatment reduced worm burdens considerably, but did not eliminate any species of helminth parasite. *Haemonchus contortus* infestation was reduced to a very low level and the usual spring outbreak of haemonchosis did not occur.

(ii) *External Parasites of Sheep.*—Studies on the contact toxicity of arsenic, rotenone, and D.D.T. were started. Further studies of lime-sulphur or polysulphide sulphur dips were made to determine their stability during dipping procedures and to determine the optimal amount of wetting agent to be used. Some determinations were made of the absorption of arsenic by sheep dipped in 0.2 per cent. sodium arsenite solution. From 50 to 90 mg. of arsenic was absorbed by sheep weighing from 70 to 100 lb.

(iii) *The Blowfly Strike Problem.*—(*a*) *Breech Operation.*—Experimental and field investigations led to the development of a modified Mules operation

which, by removing a definite pattern of skin from each side of the breech, aims at stretching the whole skin of the breech thus removing wrinkles and increasing the size of the woolless bare area around the vagina. Experimental and field results have shown this modified operation to be much superior to the earlier procedure.

(*b*) *Optimal Tail Length.*—During the year six trials were started to obtain further information on the effect of tail length on fly-strike. The trials are being carried out on widely separated properties under several pastoral and climatic conditions. The main results will become available during the spring and early summer of 1944.

(*c*) *Tail Strike.*—Primary strikes occur frequently on the tail, and an investigation was started to determine if the tail could be rendered less susceptible after operative procedure aimed to pull the wool from the sides and tip of the tail.

(*d*) *Head Strike in Rams.*—Methods of dehorning rams as a control of head strike were brought under investigation.

(iv) *Biochemistry.*—(*a*) *Studies on Mineral Metabolism of Sheep.*—Studies were continued on the calcium metabolism of sheep fed on cereal grains. One experiment continued over a period of four years was completed and the data have been partly examined. The effect of various grades of ground limestone as a calcium supplement was studied. Studies of phytic acid phosphorus utilization by sheep indicated that sheep utilize it more efficiently than do non-ruminants. Under the conditions of the experiment not more than 2 per cent. of the total phosphorus present as phytic acid could be recovered from the faeces of the experimental animals. Limited observations on urinary calculi of sheep showed that at least four distinct chemical types of calculi may be found. The calculi consisted mainly of calcium magnesium carbonates, calcium magnesium phosphates, calcium magnesium ammonium phosphate, or silica.

(*b*) *Losses of Rams during Transit.*—The losses, in some instances at least, appeared to be associated with loss of appetite as a result of periods of fasting. In experimental observations rams fed generously on good-quality roughage and concentrates for about a fortnight before trucking were able to be sent long distances without untoward results.

(*c*) *Prussic Acid Poisoning from Linseed.*—It was determined that the feeding of linseed nuts to sheep that have fasted for several days may result in death of the sheep from prussic acid poisoning. The same quantity of linseed consumed by sheep that have not fasted gave no harmful results. Analysis of the nuts showed 0.05 per cent. of "available" prussic acid.

(*d*) *General.*—Work was continued on certain aspects of pregnancy toxaemia. Chemical analyses were made on plants for oxalates, on pasture samples from several sources, on feedstuffs, and on soil found to be attractive when licked by sheep.

(v) *Chemical Studies of the Fleece.*—Studies on the chemistry of the fleece of sheep under several experimental conditions were continued.

(vi) *Wool Biology.*—(*a*) *Biological Analysis of the Fleece.*—Ten Merino ewes representing four diverse strains were studied under experimental conditions. A divergence in capacity to utilize food for wool production was determined. The effects of pregnancy and lactation on food consumption and wool production were studied. Under the experimental conditions food consumption remained approximately steady during pregnancy but wool production fell. Food consumption and wool production increased appreciably during lactation. Analysis of the fleece constituents during these several experimental periods is being made.

(*b*) *Fleece Testing and Progeny Testing.*—Studies were continued on the methods of measuring differences in quantity and quality of wool produced by sheep, and on the methods of statistical analysis of the results. Special methods of measurement are required to meet the requirements for speed with large numbers of samples, especially for the application of the methods in the field of progeny testing. Instruments for the collection of small samples of fleece from defined areas of skin and for the estimation of compactness of fleece are under investigation and working models have been constructed.

(*c*) *Study on the Skin and Wool Follicles.*—Studies have been continued by the use of histological sections of the skin to determine fibre and follicle population density, ratio of primary follicles, the functional activity of the follicle, the population density and relative number of sweat glands, relative size of primary and secondary fibres, and the source of variability in fibre diameter. Miss Margaret Hardy has been working in the section as Walter and Eliza Hall Fellow in Economic Biology of the University of Queensland and has taken up the particular study of the sudoriferous glands of the sheep.

(*d*) *Fleece Moisture Determinations.*—A study was started on the affinities of the raw fleece and of clean wool for moisture over a range of humidities at constant temperature. The results with the raw fleece are correlated with the results of chemical analysis of the fleece.

(*e*) *General.*—The study of the effects of internal parasitism on wool production was continued. Co-operative work was carried out with officers of the Animal Nutrition Laboratory on the study of the effects of nutrition during the growing period on wool production.

4. The F. D. McMaster Field Station.

(i) *General.*—Seasonal conditions continued to be very dry at the Field Station. The number of livestock carried during the year was approximately the same as in the previous year and included at the beginning of May, 1944, 668 adult sheep and 179 lambs. The staff remained in the same depleted condition, the Officer-in-Charge being the sole research officer remaining.

(ii) *Zebu Hybridization.*—No further data of any consequence were added during the year to those already collected.

(iii) *Fertility in Sheep.*—The results of several years of observation on the periodicity of oestrus were summarized and published as Bulletin No. 166.

(iv) *Inheritance of Skin Wrinkles in Sheep.*—The investigation of the inheritance of wrinkling and its association with fibre population was continued during the year. Plain-bodied Border Leicesters and wrinkled Merinos were used as parental types. First and second generation progeny have been secured and matings have been arranged to give "come-backs" (back-cross). Appropriate wool samples have been taken from all the sheep in the experiment for the determination of number of fibres per unit area of skin surface. Conclusions will be delayed until further generations of sheep, particularly back-crosses to parental types, are developed, but the available evidence suggests that both characters are polygenic and that "plain body" is dominant over "wrinkled".

(v) *Inheritance of Horns in Sheep.*—Matings designed to provide homozygous polled types were continued. They were based on the hypothesis or criterion that only males and females which have cup-shaped depressions at the horn sites are truly polled.

(vi) *Faults of Merinos.*—Following the observations of leading studmasters that "hair", "hollow-back", and "grip" are common faults, matings have been

made to investigate the inheritance of these conditions. The planned inbreeding of Merino groups is also proceeding to determine what faults, if any, will be disclosed within the groups.

5. The Animal Nutrition Laboratory, Adelaide.

(i) *Energy Metabolism.*—Since few quantitative data were available on the energetic requirements of the sheep and of the capacity of various fodders to provide the energy necessary for its maintenance, the detailed study of the subject has been a major project of this laboratory for a number of years. The results of a comprehensive series of investigations extending over this period have provided the information which, besides being fundamental to scientific studies of the nutrition of this animal, is of value in the solution of many of the main problems associated with support of flocks by hand-feeding in times of prolonged drought.

(ii) *Drought Feeding.*—(*a*) *Energetics.*—During the last year an intensive study has been made of the efficiency with which the Merino sheep utilizes energy at different levels of feeding, especial attention being given to the energy required for the maintenance of this animal. The former investigations have provided the necessary data for computation of feeding levels essential for most efficient production, and the latter have established the final bases for the calculation of the energy requirements of Merino sheep. The results have provided answers to problems of nutritional energetics hitherto incompletely understood, and have rendered it possible now to formulate a system which allows the minimum rations necessary for the maintenance of flocks during drought to be computed with ease and considerable precision. The findings are in the course of preparation for publication as a scientific monograph. The practical implications, and the system of drought feeding based on the information, will be dealt with in another bulletin suitable for general distribution to the industry.

(*b*) *Vitamin A.*—As a part of the drought-feeding project the study of the sheep's requirements of vitamin A has been continued during the year. The investigation has taken two main courses. On the one hand, an intensive study is being made of the effects of vitamin A deficient rations on sheep confined in pens, and, on the other hand, observations are being made on flocks grazing under various natural conditions. It is already obvious that, during the periods when the pastures are green and rich in vitamin A precursors, sheep store sufficient of the vitamin to provide their requirements during dry feeding periods of usual duration. In times of drought, however, vitamin A deficiency is likely to become a serious limiting factor. Sufficient vitamin A to meet the requirements of the sheep should thus be present in rations used for hand feeding.

(*c*) *Inorganic Nitrogen as Protein Substitute for the Sheep.*—The investigations concerned with the factors which influence the synthesis of protein from simple nitrogenous compounds through the agency of the micro-organisms of the rumen have been continued. Elaborate mixtures of inorganic salts fed together with the urea have not favorably influenced the very small response in wool growth obtained when urea is added to protein-deficient rations composed of straw chaff mixed with a small proportion of dried lucerne. Thus urea, when fed alone or with inorganic adjuvants, is not likely to prove an efficient substitute for the protein supplements which previously have been demonstrated to increase wool production during periods when the protein content of the available pastures is low. The influence of starch on the synthesis of protein in the rumen is being investigated.

(iii) *Influence of the State of Nutrition on Wool Production.*—Subsidiary experiments arising from the main investigation of the effect which the state of nutrition during the growing period exerts on the subsequent conformation and wool-growing propensity of the Merino sheep, have been continued. The data arising from the main experiment are in the course of preparation as a scientific monograph. As mentioned previously, the results have provided quantitative answers to many outstanding problems of sheep husbandry. The broad general conclusions from these studies suggest that most, if not all, of the sheep grown under natural grazing conditions in Australia, never express their full hereditary capacity as wool producers; they become modified and their inherent propensity is limited by the nutritional environment in which they develop.

(iv) *Plant Proteins.*—Work on plant proteins has been continued. Large samples of the protoplasmic protein have been prepared from leaves of four pasture species (*Phalaris tuberosa, Hordeum murinum, Medicago sativa,* and *Medicago denticulata*). It is considered that these satisfactorily represent the "whole" proteins present in the leaves. Detailed analytical study of the amino-acid distribution of these samples is proceeding. Study of sulphur distribution in the proteins from legume seeds has shown these to be low in methionine content.

(v) *Physiological Studies.*—The main activities during the past year have been devoted to work with the enzyme systems responsible for the transport of oxygen in living matter. This work has been undertaken in conjunction with the studies of physiological function of minor elements. A series of studies involved with the development of techniques suitable for continuous intravenous injection of glucose into the sheep was undertaken in connexion with the energy metabolism programme. The investigations along both lines are being continued.

(vi) *Minor Element Deficiencies.*—(*a*) *General.*—The development of the research on this subject since the original discovery of the importance of cobalt in ruminant nutrition has been outlined in previous reports. Large areas of South Australia having a mean annual rainfall in excess of 12 inches are limited in productivity by the lack of sufficient available minor elements in the soils. In certain limited areas the addition of the missing elements to the superphosphate utilized for top-dressing has rendered possible the establishment of splendid permanent pastures and the support of healthy flocks and herds on what was previously considered hopeless country. The degree of limitation of production by minor element deficiency under natural conditions varies from the obvious effects suffered by the flocks and herds and by the pastures themselves on the frankly deficient terrain, to the more subtle effects on the incipiently deficient areas. The deficient terrain is by no means confined to South Australia.

(*b*) *Copper Status of Sheep on Copper-dressed Pastures.*—At Robe, the investigation of the ability of copper-dressed improved pastures to fulfil the copper requirements of the grazing sheep has shown again that, although their general health is apparently normal and their wool is of good quality, additional supplements are essential for optimal wool production on this calcareous littoral. The investigations have been extended to other types of deficient terrain at Keith and at Borrika where experimental flocks are being treated and observed.

(*c*) *The Reaction of Sheep to Excessive Intakes of Copper.*—The first series of field experiments designed to study the difference in behaviour between Merino and Border Leicester sheep when subject to copper deficiency and copper excess has been completed. A comprehensive study of the physiological state of the animals has shown that the two breeds differ in their ability to deal with an excessive intake of copper.

During the course of this experiment, observations of the influence which increasing copper intakes had on the nature of the wool indicated that the character of the fleece was favorably influenced by copper intakes far in excess of that normally present in natural fodders. This phenomenon is being studied further.

(*d*) *Copper Deficiency and Wool Production.*—The fleeces from the experimental flocks which were supplemented with different levels of copper were collected at the end of the third year of treatment. These fleeces, which grade from the seriously affected steely wool of the control groups to the splendidly crimped wool of the animals which received high quantities of copper, provide valuable experimental material for the determination of the influence that crimp exerts in the manufacturing performance of wool. They have been sent to the laboratory of the Wool Industries Research Association at Torridon, Leeds, for specialized experimental study.

(*e*) *Mapping of Areas Affected with Minor Element Deficiency.*—The wide distribution of minor element deficiency has been proven unequivocally by the results from field stations dispersed throughout suspected areas in South Australia. The findings at these sites have provided the necessary data for the more complete mapping of the affected areas and have indicated the order of response to proper treatment. The difference between the monetary value of the fleeces from treated and untreated animals is always considerable. In seriously affected areas this exceeds 4s. per head. The costs of treatment are little in excess of 2d. per head. It is already clear that terrain which is deficient in copper is much more extensive than that in which cobalt deficiency is a serious limiting factor. The experimental investigations, however, show that cobalt deficiency is certainly much more widely distributed in South Australia than was first suspected when it was considered to be confined to the calcareous littoral.

(*f*) *Cobalt Deficiency.*—The investigations of the role of cobalt in ruminant nutrition are being continued, and studies of problems associated with the control of the deficiency under natural conditions have been extended.

(vii) *Agrostological Investigations.*—Nine pasture experiments initiated during the period 1938-1941 have been maintained for quantitative determinations of the persistence of species under different fertilizer treatments, the changes in botanical composition supervening on the vigorous growth of legumes over this period and the residual effect of various fertilizer treatments. These experiments have been concerned with the minor element deficient calcareous sands, those of Robe being characteristic. In May, 1944, six new experiments involving 323 plots were started in this area. Extension of the findings to the different soil types which comprise the heath sands of the Ninety Mile Desert was begun in May, 1944, with the sowing down of 300 plots designed to provide information concerning the problems involved. Areas at other centres are also under observation.

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

Climatic conditions have been dry since December, 1942. Up to 8th June, 1944, the total rainfall since 1st July, 1943, was only 7.52 inches. Since 1st January, 1943, the total rainfall has been 11.31 inches. The stock have maintained their condition well during this dry period. Lamb-marking was completed in November. At a general muster 2,684 ewes were counted and 1,979 lambs were marked. This gives a net lambing percentage of 73.7. Shearing for 1943-44 season commenced on 22nd May. The wool was very clean but light. In all, 6,164 sheep were shorn for a total of 130 bales.

(i) *Observations on the Control of Crutch Strike.*—Little blowfly strike has been experienced during the dry period. A more radical breech operation was evolved and this so-called modified Mules operation has given better results in field trials. Further investigation was started on the length of tail to be left to give optimal results. All the experiments so far have given results favouring the longer tail. Tail-length in relationship to the modified Mules operation has not yet been determined. Further experiments were made on the technique of docking, on the efficiency of the breech operation carried out on lambs and on weaners, on the control of tail strike by surgical methods, and on the control of head strike in rams.

(ii) *Observations on Sheep Classing.*—Two persons independently classed all the ewe portion of the 1942 spring drop of lambs at about six and eight months of age in 1943 and at about eighteen months of age in 1944. Individual fleece weights and classing data were obtained on all these sheep at shearing in June, 1943, and again in May, 1944. These data are to be analysed.

(iii) *Periodicity of Oestrus.*—Observations were continued on two groups of ewes. One group was kept continuously associated with the ram and the other group consisted of new ewes each month which were joined with the rams after about a year's isolation. The results showed again a period of lowered sexual activity in ewes during the spring months. The reduction was very much less in the second group of ewes which had been separated from the rams for some months.

(iv) *Investigation of Poisonous Plants.*—During the year feeding tests were conducted on *Myoporum deserti*, turkey bush or Ellangowan bush. The plant was found to be definitely poisonous and to cause death after the sheep had exhibited some drowsiness followed by collapse, some oedema of the mandibular area, some transient haemoglobinuria, and some jaundice.

V. SOILS INVESTIGATIONS.

1. General.

The work of the Division of Soils in the past year has turned more directly on the needs of land settlement in rural reconstruction. It has become increasingly apparent that the Division is faced with a strong demand for surveys as a basic step in the selection of new lands for subdivision as new farms and for defining the problems of development. Requests have come in steadily for soil investigations from Government and private sources.

The physics of the soil in relation to engineering construction has continued as a major line of investigation, particularly in defence projects. Shortage of experienced staff has prevented the full implementation of the field and laboratory research programme, but the reorganization of the Division during the year has given it a sound basis to build on.

The Division of Soils has its head-quarters at the Waite Agricultural Research Institute, University of Adelaide, and its staff has been associated freely with University colleagues engaged on allied agricultural research. Co-operation with State Departments of Agriculture, Lands, Forestry, and Irrigation has continued smoothly as in past years in the various States where the Division has been active. Work in connexion with rural reconstruction has brought the Division into contact with the State Committees set up for that purpose. It is very gratifying to find both Government and private agencies relying on the fundamental soil survey as the initial move in tackling land problems. The principle of correlating soil and land use and leading on from this to experimental work by specialist workers on problems in production, is becoming recognized more widely.

The Division has been reorganized during the year into three large units—soil surveys, soil physics and mechanics, and soil chemistry, each with a responsible senior officer in charge, and a small section of soil bacteriology. The staff has been enlarged to cope in part with the increasing work. The policy of setting up regional bases, for dealing with long term investigations removed from close contact with head-quarters, has been adopted.

2. Soil Surveys.

The activities of the Rural Reconstruction Commission have resulted in the Division of Soils undertaking on its behalf preliminary inspection of areas submitted by various authorities as suitable land for settlement. The aim of the inspections has been to determine which areas are worthy of further survey and to place them in some order of priority. Consideration has been given to areas in Western Australia, Tasmania, and South Australia, and the surveys have in some cases entered the second stage as reconnaissance or detailed types. Similar work has not yet been commenced in the other States, but in two of them investigations in hand are relevant to the problem of more intensive settlement.

(i) *Western Australia.*—In the latter part of 1943 the preliminary inspection of areas was completed, and five units were selected for survey in the higher rainfall districts in the south-west of the State. The survey of the first of these at Margaret River was begun in March and the first portion completed in May. Traverses were made extensively through large adjoining areas. Plans for the continuation of the surveys have been made for next spring in co-operation with Departments of Agriculture and Lands. An officer has also been sent to assist in a survey in the Kimberley region being conducted by these Departments.

(ii) *Tasmania.*—Discussions were held on various occasions in 1943 with the Post-War Land Development Committee of Tasmania. An officer has now been stationed in a regional centre at Hobart to be responsible for the survey programme. The field work has been completed on a detailed survey of the Waterhouse portion (55,000 acres) of the North-East Coast and on a reconnaissance examination of the soils of the Montagu, Welcome and Dismal Swamps in the far north-west of the State. The soils of the nearby reclaimed Mowbray and Britton's Swamps have been used as yardsticks in evaluating the densely vegetated virgin swamps.

(iii) *South Australia.*—A survey of 25,000 acres of unimproved heath-mallee land in the Hundred of Wanilla, Eyre Peninsula, has been completed in anticipation of experimental work designed to precede subdivision and settlement. The field experiments are now under way with proper agronomic supervision to determine the possibilities and requirements of pasture to be used for fat lamb production.

A survey of 8,000 acres in the Hundred of Glengarry was also made at the request of the State Land Board. It is at present a forest reserve but following the survey is being considered for agricultural development.

Considerable attention has been given to possible sites for new irrigation areas on low and high lift along the Murray River in South Australia. Many preliminary inspections made have narrowed the sites to a small number and those are to be surveyed in some detail later this year. At the request of the Irrigation Branch of Lands Department, a detailed soil survey was made of an area of 1,200 acres at Cobdogla, as a suggested extension of an existing irrigation system. The survey indicated the unsuitability of a large portion because of soil type or salinity. A virgin area of 1,000 acres proposed for development on high lift adjoining the Renmark settlement was examined from the soil aspect, and a large part appeared very suitable for the purpose.

Small areas for irrigation development to supply the requirements of the greatly increased township of Whyalla were examined in detail and recommendations made as to orchard, garden and parkland sites.

(iv) *New South Wales.*—A soil survey mapping soil groups has been completed over the 600,000 acres of the Berriquin Irrigation District. When the staff and aerial photographs become available it is proposed to survey in the necessary detail portions of this area and of the Deniboota Irrigation District which was covered in reconnaissance last year. Until then the surveys are providing a good basis for discussion regarding use of land and irrigation water in these areas.

An area of 2,000 acres was surveyed at Barham to determine its suitability for citrus, which is grown to a small extent locally. The soils are good sandy types suitable for citrus, if water can be brought economically to them.

(v) *Victoria.*—By arrangement with the Soil Conservation Board of Victoria, a survey to define the erosion position has been commenced in the Dookie-Benalla district over an area of about 1,000 square miles. Reconnaissance traverses have been carried out and detailed surveys of the soils and their erosion status have been begun on the first of three unit areas covering in all about eight parishes in the district. As the erosion factor is negligible, over the balance of the area the soil types only will be mapped on broad lines.

(vi) *Queensland.*—A survey of an experimental area at the Cunnamulla Research Station was made for the Division of Plant Industry as a basis for further ecological investigations.

(vii) *Divisional Reports.*—A total of fifteen Divisional Reports dealing with field investigations on new areas or with various aspects of land development were put out for consideration by the appropriate authorities.

3. Soil Physics and Mechanics.

The greater part of the work in soil physics has been concentrated in the study of engineering properties of soils, largely in connexion with defence projects. Testing of soils for air-field construction has continued, and one officer has been seconded full time for this purpose to the U.S. Army Services of Supply. The testing of materials for a hard standing at an aerodrome in South Australia was undertaken.

Various materials have been tested for their power to waterproof soils. The stability of a paved surface, as on airstrip or roadway, often depends on the degree of saturation of the underlying soil base, and failures may result under waterlogged conditions. When incorporated in the soil in small quantities, certain resins have proved extremely efficient as waterproofing agents in preventing permeation of water into a compacted soil mass. This may prove of value in dam and channel construction as well as preventing failure of pavements.

Soil cement investigations into the effect of cement on the colloidal properties of the soils were begun last year. It appears on present data that portland cement does not materially alter the nature of the soil colloids but rather reduces their influence by aggregating the soil particles. Work on the density and durability of soil cement blocks prepared at different time intervals after mixing and wetting has been concluded and is being prepared for publication. Five soil types of widely different nature were used with the standard "wet-dry" and "freeze-thaw" tests.

A study has been made for the South Australian Department of Mines of the permeability, porosity and compaction properties of soft rocks from a proposed metropolitan dam site. The material proved less permeable and more dense than indicated in the

field examination, and leakage would be greater through fissures than through the natural rock. The suitability of the rock for crushing and compacting was considered.

Some soils concerned with a building failure were examined, and it was shown that the original foundation rested on a layer with high clay content and high shrinkage and expansion properties. Tests in the laboratory indicated suitable depths for a better foundation footing.

A series of soil samples taken by the engineers of the South Australian Highways Department from several main routes were tested for their suitability for road sub-grades and construction materials.

The use of spray irrigation is generally regarded as very desirable on the light soils subject to waterlogging or over-irrigation. The physical properties of soils on an experimental site at Berri, South Australia, are being studied with a view to later work on water movements under different types of spray treatment. The work is in collaboration with the South Australian Lands Department and the Engineering and Water Supply Department.

The effect of cultivation and crop rotation on stability of soil structure has been studied on a field at the Waite Institute. Long periods of cultivation caused a notable decline in stability of soil aggregates.

4. Soil Chemistry.

During the year a joint department of soil chemistry has been established to cover the work carried out by the Waite Institute and the Division of Soils. The organization of this department is proceeding so that it can undertake the routine testing of the large number of soil samples collected by the survey section as well as chemical research into specific soil problems.

Since the establishment of the department, technical assistants have been trained, and it is now possible to handle the more urgent analyses as the samples come in. It will, however, be necessary to develop a more rapid method for the determination of exchangeable cations, and it is proposed to examine spectrochemical methods for this purpose as soon as staff and equipment become available.

The soils examined have included twenty samples for the Department of the Army and reports on these have assisted in the establishment of Army farms in Central and North Australia.

In connexion with the shortage of phosphatic fertilizers in Australia, a pot experiment was carried out to determine the fertilizer value of certain local deposits of rock phosphate. St. John's rock phosphate, even when finely ground, was found to have no immediate value as a source of phosphoric acid, either in terms of yield of crop or phosphorus uptake. Studies on the phosphate question are being continued to obtain more precise knowledge on the status of Australian soils in available phosphate.

At the request of the Scientific Liaison Bureau, several samples of kieselguhr filter-aid of Australian manufacture were examined and compared with the standard American grades used by the Army for water filtration. Standard specifications were drawn up and adopted by the Army to cover the supply of this material. Suggestions were also made to assist Australian producers in improving the quality of their product.

Spectrochemical studies of soils have been continued throughout the year. A series of ironstone gravels derived from various soils has been examined for the less common metallic constituents. These gravels resulted from the concentration of iron in the profile but it is probable that cobalt, copper, manganese and nickel are not similarly concentrated. On the other hand, gallium, molybdenum, lead, vanadium and zinc appear to be concentrated with the iron. During this investigation considerable attention was given to technique, and a convenient method for the preparation of the hydrochloric acid extract of a soil for spectrochemical examination was worked out. Spectrochemical investigations are now being extended to cover an examination of the more important soil types of south-east Australia for their minor metallic components, especially those known to be essential for normal plant and animal growth.

The influence of molybdenum on the growth of subterranean clover and lucerne on a soil deficient in this element has been studied in co-operation with the Department of Agronomy of the Waite Institute. By spectrochemical analysis it has been possible to determine the increased amounts of molybdenum in plants resulting from the application of 0.25 oz. molybdenum per acre in the fertilizer. Applications of lime to the soil increased the availability of molybdenum whereas superphosphate lowered the availability.

A series of 50 soils from areas associated with outbreaks of toxaemic jaundice were examined, on behalf of the Division of Animal Health and Nutrition, for copper in connexion with field surveys. In addition a number of soil, plant, and fertilizer samples have been examined, particularly for trace elements, at the request of other departments.

Spectrochemical determinations carried out to assist the war effort have included a survey of 38 samples of galena and five samples of pyrites in an attempt to correlate their known electrical properties with the traces of the minor metallic constituents present. The composition of certain tool steels has also been determined.

5. Bacteriology.

Symbiotic nitrogen fixation continues to be the major subject under investigation because it affects pasture practice in South Australia. Existing pure cultures of strains of *Rhizobium* have been maintained and their "effectiveness" tested at regular intervals.

An experiment to study the possible benefit derived by different species of grasses growing in association with legumes when the latter are periodically clipped has been concluded. Although clipping of the legume resulted in loss of nodules, no substantial benefit to associated grasses resulted from this treatment, and all grasses were extremely nitrogen-deficient.

Work has continued on an investigation into the role of the trace element, molybdenum, in the nutrition of grasses and legumes. Results have shown that molybdenum increases the nitrogen-fixing capacity of *Rhizobium*; under the conditions of the experiment, no effect was obtained with grasses.

The supply of bacterial cultures to farmers has been carried on, with the same demand as in the previous year. In some pastoral areas where inoculation has been practised over the past few years, populations of Rhizobia should be well established in the soil and continue to give the pastures every chance of success.

Since last July, bacteriological examination of foodstuffs canned in South Australian factories has been carried out on behalf of Commonwealth Food Control. More than 400 cans have been examined, the products being chiefly vegetables and fruit juices. Where contamination with viable bacteria has been found, the organisms causing spoilage have been isolated and identified.

VI. IRRIGATION SETTLEMENT INVESTIGATIONS.

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

1. General.

The staff reductions due to the war still dominantly affect the programme of work at the Commonwealth Research Station, Merbein. Pre-war investigations related to the method and frequency of irrigation, soil

preservation and reclamation, horticulture, and fruit processing had reached the stage where the results of the investigations had been incorporated in rural practice. While it is recognized that further research would result in useful refinements in practice, there were no outstanding problems during the year apart from those associated with new products required for the war effort, and modifications in rural practice necessitated by shortages in man-power and supplies.

Fruit-drying investigations have now been extended to cover practically all dried fruits required by the Department of Supply; they include the end-point of processing, the percentages of preservatives required to give keeping qualities, and the general specifications necessary for high quality products. In connexion with plants for which the Commonwealth undertakes the financial responsibility of production, the Station has assisted in the development of land brought under irrigation since the advent of the war, for the growth of vegetables at military establishments, grass covers for aerodromes, and drug plants.

The curtailment of certain requisites for dried fruit production and the provision of substitutes for substances not now obtainable, necessitate alteration in production and processing methods, and the staff of the Station assists in an investigational and consultative capacity in these re-adjustments.

2. Viticulture.

Long-dated experiments in connexion with the application of fertilizers to vines have been continued to the extent that the treatments have been applied, though it has not been possible to measure yields in two of the three plots. It is considered that the cumulative effects, if any, of the fertilizers can be measured in subsequent years, and that the present omission is not a matter of great concern, owing to the regularity of the results previously obtained.

Investigations on the effects of different manurial treatments on the pH of the soil, the total cation exchange capacity, and the exchangeable cations, were commenced on soil samples from the Woorinen manurial plot. Manurial treatment appears to have an effect on both the pH and total cation exchange capacity of the surface soil.

Crop estimates, based on the proportion of fruit buds at the September sprouting, were made at the request of the industry, and maturation studies were also carried out as a guide to the date of harvest, engagement of labour, and contingent routine operations including irrigation.

The oil spray trial on frost protection by delaying bud burst was continued, and yields were recorded. Bud burst can be delayed by about a fortnight, but the cumulative effect on yield after several years' treatment is serious. All treatments significantly reduced the yield, and in the case of the heaviest treatment it was reduced by about 50 per cent.

3. Irrigation.

After a period of consolidation, during which the economic stability of the settlers and the preservation of the soils were major considerations, the necessity for additional products has resulted in irrigation expansion during the war years. The Station has assisted in the selection of sites suitable in soil types and general environment to the required products; and in the irrigation design necessary to give the required service. Such assistance has applied to military and Royal Australian Air Force establishments, to land temporarily acquired by the Commonwealth for special crops, and to private individuals producing crops under special contracts for Commonwealth Departments. An interesting feature of the Middle and Lower Murray areas is the increased popularity of spray irrigation, which represents the maximum economy and efficiency in the usage of irrigation water.

A check was kept on the quality of the water used for irrigation purposes in various parts of the district by the regular analysis of samples taken at selected sites.

4. Drug Plants.

The Mildura district and adjacent irrigation areas have been utilized for a considerable proportion of the programme in drug-plant experimentation and production under the direction of the Division of Plant Industry. One variety of the opium poppy is grown in commercial quantities, and other varieties are being tried. Considerable areas of pyrethrum have been established and have matured to the stage of commercial production. An interesting phase of pyrethrum and poppy production has been the modification of Australian harvesting machinery to harvest these crops. The harvester header for wheat has been successfully adapted for the poppy crop, and further alterations to this machine are being made with a view to harvesting pyrethrum flowers.

5. Vegetable Production.

The expansion of vegetable production in Australia, and the production by growers without previous experience, created a demand for more definite information regarding vegetable culture, and also necessitated investigations into the kind of vegetables and the strains suitable under Murray River irrigation conditions. Root crops, comprising carrots, parsnips, beet, and onions, were sown at monthly intervals, and the growth rate measured by taking the diameter of the root at the crown. Preliminary measurements showed a high correlation between the diameter of the root and its weight. The results showed the periods of the year over which marketable size could be obtained without unduly prolonging the growing period; the possibilities of off-season production; and also the periods during which seed production was successful, from plants left *in situ* and from resetting of roots.

A variety trial of tomatoes, including strains recently introduced from the United States of America, was carried out embracing twelve different varieties. In this, the first year of the trial, certain varieties introduced from the United States of America showed to marked advantage compared with the best of the Australian tomatoes, and similar indications were noted in the introduced varieties of field beans.

In producing lettuce seed, it does not appear necessary to grow the plants for seed at a period of the year when the edible portion of the plant grows best. One variety (Imperial 615) produced quite a good seed after a short growing period during which the body of the lettuce developed very little. It is necessary to select parent plants true to type in the previous generation, as selection from the off-season plants producing seed is not possible.

6. Fruit Processing.

The shortage of edible oil supplies has become more acute during the course of the war. Last season adequate supplies of cotton-seed oil were not available for the manufacture of the usual cotton-seed oil emulsion used in dipping sultanas and other vine fruits. Fortunately trials carried out in recent years had shown that a "self-emulsifying" mixture consisting of paraffin oil, cotton-seed oil, and a suitable sulphonated oil could be used as a satisfactory substitute.

Further dipping trials with sultanas were carried out last season, particular attention being paid to the use of emulsions of sulphonated oil and paraffin oil, and sulphonated oil and cotton-seed oil. Some of the latter

have given very good results. Investigations on the wetting and spreading properties of various oil emulsions used in dipping sultanas have also been carried out.

Burning properties of American sulphur with and without added sodium nitrates have also been investigated, since such sulphur has proved somewhat inferior to pre-war Sicilian in sulphuring tree fruits. The addition of 3 per cent. sodium nitrate markedly improved the burning properties of American 99.5 per cent. S, speeding it up five-fold, with higher concentrations of sulphur dioxide in the chamber during the burning period, and with no ill-effect on the colour of the fruit. Further work has been carried out on the sulphuring of peeled clingstone peaches and peeled pears prior to dehydration, by immersion in sulphite solutions of varying pH. The retention of sulphur dioxide has been found to be dependent on the pH value of the dipping solution, as also are the pH and flavour of the dried product.

Moisture tables for use with the electrical moisture meter have been prepared for prunes and apples. Tables showing the calculated loss on dehydration were prepared at the request of the industry for partially dried sultanas and lexias, and have come into general use in the Mildura district. These tables are used in conjunction with the electrical moisture meter and show estimated deductions (moisture plus losses due to caramelization, &c.) which should be made from packing house door weights, in order to give the net weight after dehydration when the fruit is fit for packing.

A limited amount of work was carried out for the Department of Commerce on the resulphuring of Tasmanian dried apples. The manufacture of dipping oil for the 1944 dried vine fruits season was supervised for the Mildura Packers Association. General technical assistance was given in the production of canned citrus juices and dried potatoes. A limited number of maturity and quality tests were carried out on navel oranges.

7. Entomological Pests.

Control measures for dried fruit pests are still in operation without alteration. One field pest, the light brown apple moth (*Tortrix postvittana*) occurred during the 1943-44 seasons in numbers not hitherto experienced. Observations made throughout the growth period for vines disclosed the larvae on vine shoots only a few days old. The development of the larvae indicated that early feeding and development must have been on some other plant. Subsequently an officer of the Division of Economic Entomology located the larvae on tick beans. Observations at the time of setting of the grapes showed a large and well distributed population at this stage. During the periods of late maturation and ripening of the grapes, surveys showed a widespread and damaging distribution of larvae on grapes throughout the Mildura district. These larvae almost invariably were those of the light brown apple moth, though isolated specimens of other pests were noted.

8. Financial Assistance.

The Merbein Station has been relatively highly subsidized by organizations which benefit directly from the results of the investigations. Staff reductions have necessitated reduced grants by mutual consent of the Council and the contributing bodies. The Australian Dried Fruits Control Board, one of the principal contributors, has agreed that dried fruits production has reached a high standard of efficiency and that diversion of officers to work more directly connected with the war effort is justified, with a reduction in the grant to approximately £600, one-third of the amount originally allocated. The subsidy from the Mildura Packers Association has been maintained at £1,000, principally for the work described under (6) above. Minor subsidies, for special investigations in the Wakool and Curlwaa districts, New South Wales, have been reduced.

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

1. General.

The work of the Station has been expanded considerably during the past year to cope with the pressing problems presented in maintaining production of fruit and increasing the production of vegetables.

The New South Wales Water Conservation and Irrigation Commission, which provided the land and co-operated in the establishment of the Station, again provided £2,000 towards the cost of the investigations during the year. The various settlers' organizations and co-operatives, through the Advisory Committee, have again been very active in their interest in the work of the Station and have maintained their contribution of £1,100 for the express purpose of bringing the results of the investigations more quickly to the irrigation community.

2. Orchard Cover-crop Investigations.

As previously reported, plots to study the effect of various cover-crop treatments have now been established for a few years. These plots are located at the Research Station, and on peach and citrus plantings on settlers' farms covering a wide range of soil, slope and managerial conditions. The treatments include cover-crops such as lucerne and subterranean clover, and a winter crop of tick beans followed by summer clean cultivation.

Experiments on these plots deal with irrigation methods and technique, infiltration characteristics, salt content, soil moisture and watertable fluctuations. Tree response is measured by health, yield, the amount and distribution of roots.

These plots have already yielded useful information concerning the effect of the various cover-crop treatments on the nitrogen relationship of the soil, and on the permeability and structure of the soil. Much useful information concerning the best irrigation methods to adopt for various soil conditions and crops has been obtained.

3. Other Field Experiments.

Other permanent field experiments with orange trees include treatments to investigate the following factors: methods of irrigation and water requirements of the trees, including such questions as the best frequency of irrigation; fertilizer requirements, including both major and minor elements; cultural treatment; and various minor studies. Fuller details have been given in previous reports.

4. Irrigation Investigations.

Experiments are in progress to determine the best methods of watering declining citrus groves. These deal with restricted area watering, including alternate bay or furrow irrigation, and with the effect of various degrees of wilting on tree health and yield. A large number of infiltration tests have been carried out on several soil types, and these have been used in drawing up recommendations on irrigation practices. Investigations are continuing on hydraulic principles involved in furrow and other surface methods of irrigation.

Particular attention has been given to the irrigation of vegetables. Vegetables demand that the surface of the soil be thoroughly wetted, but excessive applications of water must not be made; otherwise high watertables are formed, the soil becomes waterlogged and salting of the soil occurs. Best irrigation is obtained by using

very flat grades, so that the problem is one of designing the irrigation layout to permit this and at the same time permit easy and economical working of implements.

A special problem is the irrigation of very permeable soils which are very liable to salting. Satisfactory progress in the elucidation of the problem is being made.

5. Drainage Investigations.

High watertables, due to years of irrigation augmented by recurrent wet winters, have made underdrainage an important problem on the Murrumbidgee Irrigation Areas. The decline in tree health, especially citrus, over the last few years is closely related with high watertables and excessive soil moisture conditions. The problem of under-drainage is being approached in four ways: (i) the laying of experimental drainage plots under controlled conditions; (ii) investigations on farms where settlers have already installed drainage systems; (iii) a survey of farms where drains have been installed for varying periods under different soil conditions (the report on this survey will supply information to settlers desirious of laying drainage systems immediately); and (iv) tests with short lengths of drains to test the drainage capacities of soil types under investigation (*see* Land-use Studies). Records are kept of irrigation applications, drainage effluent, watertable fluctuations, salt, tree health, yields, size of fruit, and cultural operations. Methods of reclaiming salted land are being investigated.

6. Vegetable Investigations.

Problems of vegetable culture include crop rotations, fertilizer requirements, irrigation requirements, tillage methods, seed germination, weed control, and nutrient constituents of vegetables. Extensive factorial field experiments are being carried out to test the effect of various fertilizing elements, soil moisture as controlled by irrigation, tillage methods, time of planting, and other cultural factors and these interactions on the growth, yield, and food value of the more important vegetable crops. Investigations to date point to the importance of a good fallow period to bring the soil to a high nitrogen status. The placement and time of application of fertilizers is found to be very important. If fertilizers are used correctly maximum yields are obtained by comparatively light dressing.

With root crops it is difficult to be sure of a satisfactory germination of the seed, and poor germination is often the cause of serious loss. The appropriate sowing and irrigation technique to obtain the best germination has been investigated. The drilling in of superphosphate near the seed improves the germination. Other methods of improving the germination, such as pre-germination, have been investigated with promising results.

The carotene, ascorbic acid, sugar, calcium, and phosphate contents and other characteristics of the vegetables important from a nutritional standpoint are determined as well as the yields of the various plots. The use of selective sprays for weed control is being investigated.

7. Land-use Studies.

Following the orchard survey (*see* previous reports) and the soil survey (carried out by the Division of Soils), the Station is co-operating with the New South Wales Rural Bank, the New South Wales Water Conservation and Irrigation Commission, and the New South Wales Department of Agriculture, in land-use studies. Land-use maps are being prepared. These show the classification of the land according to its suitability for various crops, and are based on the soil and slope of the land. The studies are useful for future development, including post-war reconstruction.

8. Soil Reconditioning Investigations.

The average life of orchards is about twenty years, and as most of the plantings on the Murrumbidgee irrigation areas are now 20 to 30 years old the areas have passed through the first cycle of development, and what to do with old orchard lands is now a major problem. In many cases the soil has undergone structural changes for the worse. Investigations have been begun to determine the best use to which old orchard lands can be put and whether soil reconditioning is necessary and, if so, the best methods of carrying this out.

9. Soils and Irrigation Extension Work.

In order to bring the results of investigations of soil-water relationships and irrigation methods to the irrigation farmers, a programme of educational work has been inaugurated. For this purpose a staff of irrigation specialists is being trained. The extension work embraces field days, extension schools, wireless talks, press articles, and pamphlets as well as direct contact with settlers to advise on their soil and irrigation problems. Close co-operation is maintained with the New South Wales Department of Agriculture. The programme is for three years in the first place, after which the organization will be reviewed. The scheme is working satisfactorily and very harmonious relations have been established with the irrigation community and the settlers' organizations, and already good progress in the educational work has been made.

VII.—FOREST PRODUCTS INVESTIGATIONS.

1. General.

The activities of the Division have continued to be directed almost entirely towards immediate problems associated with the war effort. An increased difficulty has been the changing of operational areas and variation in the supply position. Close and continued scrutiny of priorities of work and adjustment of staff as a result have been necessary.

Much of the work carried out cannot be recorded here, but an effort has been made to include in this report all activities which can be disclosed without affecting security. It must be remembered, however, that in many cases, although the civilian application of the work is stressed the reason for carrying it out was a defence one and has been withheld.

2. Wood Structure.

(i) *Timbers of the South-west Pacific Area.*—During the year the Division has built up considerable information on the timbers of New Guinea and the surrounding islands. An original handicap was the paucity of authentic specimens from New Guinea, although specimens from Malaya, Dutch East Indies, and the Philippines covering some New Guinea species were available for examination. This lack of New Guinea specimens was to a very large extent made good by the courtesy of Mr. C. E. Lane-Poole, Inspector-General of Forests, who made available specimens collected by him on his trip to New Guinea and Papua in 1924. Other authentic specimens have also been obtained. With this material to work on, knowledge has been gained of more than 100 different timber species. Methods for the identification of these timbers have been developed, and the identification keys prepared have been most essential because of the number of New Guinea timbers received for identification. These keys have been based on the card-sorting principle and in one of them the 100 timber species have been included in the standard set of timber identification cards maintained in the Division. In the other card-sorting keys, however, macroscopic features only have been used, and a very effective key employing hand lens examination of the wood has now been completed.

Numerous sets of these card-sorting keys have been prepared and approximately 90 already distributed. With each set are included directions for use, colour chart for matching timber colours, and a sorting needle, while on the back of each card is attached a low-power photograph of the cross section of the timber represented. In addition a mimeographed report on the properties, uses, distribution, and identification of 22 of the more important New Guinea timbers has been prepared and 250 copies distributed.

(ii) *Timbers of the Northern Territory.*—Specimens (160) of Northern Territory timbers supplied to the Division through the Allied Works Council for identification and report on properties, have been examined. All except eleven of these have been identified with the assistance of the National Herbarium, Melbourne.

(iii) *Identifications.*—Timber identifications numbering 537, not including the Northern Territory timbers referred to above, have been carried out during the year, the majority of these being timbers from the New Guinea area. In addition over 1,600 identifications have been made for the Section of Timber Mechanics. Other identifications included specimens of wood flour, paper, fibres, and glue-lines in plywood.

(iv) *Compression Wood.*—(*a*) Experiments were carried out to determine the value in the detection of compression wood of the examination of rotary cut hoop pine veneer over a strong source of light. In spite of numerous tests no satisfactory results could be obtained.

(*b*) Further work on specimens from a number of trees of hoop pine in which compression wood was observed again indicated the high correlation existing between the presence of compression wood and abnormally high longitudinal shrinkage.

(v) *Investigations of Structure in Relation to Properties.*—(*a*) Following the examination of shear failures in material made from 1/16-in. veneer, an examination was commenced of shear failures in the standard 2 in. cube shear specimens (solid wood) from the same species. In the tests so far completed the failures appeared to be again associated with definite anatomical features of the timber concerned.

(*b*) The routine examinations of test material from the two species of silver ash, namely *Flindersia pubescens* and *F. bourjotiana,* have now been almost completed. In neither species was tension wood an important feature, and there was no correlation between properties and the frequency of the parenchyma bands (indicative of growth rings).

The distribution of "brittle heart" varied somewhat in the two species. In the samples of *F. bourjotiana* examined, it was of comparatively rare occurrence, but in the samples of *F. pubescens* it was more common although not an unduly serious feature. In both species localized minute compression failures were detected.

(vi) *Structure of Improved Wood.*—The microscopic examination of various specimens of improved wood has been continued. In one series, the effect on the structure of the improved wood, caused by degree of advancement of the water-soluble phenol resin used, was investigated. It was observed that, as the stage of resin advancement was increased, there was a corresponding change in the microscopic structure of the improved wood.

(vii) *Fibre Structure.*—Considerable attention has been paid to fibre investigations during the year, the work being carried out in co-operation with the Wood Chemistry Section.

(*a*) Eucalypt kraft pulp fibres were examined after various stages in the Clark-Kollergang laboratory beater, and the effect of beating on the fibres was studied. Variations in beating technique were accompanied by changes in fibre appearance, and certain conclusions regarding beating in this type of beater could be drawn.

(*b*) To investigate fibre structure further, matched samples of unbleached eucalypt kraft fibres were subjected to various pretreatments (acid and alkaline) using reagents known to have some chemical action on the fibre constituents. After each pretreatment the fibres were washed and beaten in the usual way in the laboratory Lampen mill. Again some very interesting results regarding the response of fibres to beating were obtained, and of particular interest was the development of broken fibres on beating the pulp which had been pretreated with boiling 3 per cent. sulphuric acid.

(*c*) Following the results obtained after sulphuric acid pretreatment, considerable attention was paid to the examination of fibres isolated from normal wood and brittle heart of *E. regnans,* both before and after acid treatment. It was hoped to obtain some information bearing on the formation of broken fibres, when fibres from brittle heart areas isolated by the holocellulose process were so treated. These experiments have yielded results of considerable interest.

(viii) *Photography.*—The large volume of photographic work handled by the Division has been maintained during the year, the individual prints numbering well over 130,000.

3. Wood Chemistry.

(i) *General.*—During the past year, the Wood Chemistry Section has continued to devote much of its attention to the study of fundamental problems on behalf of the Australian pulp and paper industry. The scale of the work has been somewhat limited because of the difficulty in securing personnel of the desired calibre to replace officers who have been seconded by the Division to other Divisions and Departments. The Section has also been actively concerned with tropic packaging problems on behalf of the fighting Services. A very successful Paper Industry Conference, which was attended by technical representatives from the three operating companies, was held at the Division of Forest Products during the year.

(ii) *Wood and Pulp Analysis.*—A number of methods for wood and pulp analysis which were developed by the Section and recently revised, have now been adopted as standard methods for use by the Australian pulp and paper industry. Other methods, which were critically examined at the most recent Paper Industry Conference, are being further investigated preparatory to their adoption as standards.

(*a*) The lignin determination is subject to a solubility factor in that a fraction of the lignin and particularly that which has the greater methoxyl content, is soluble in hot 3 per cent. sulphuric acid. It appears that it may be necessary to develop a regression equation to correct for this solubility factor. Recent investigations have also revealed that the times involved in the lignin determination may be substantially reduced.

(*b*) A new and simpler method which depends on the reaction between calcium acetate and carboxyl groups and on the release of acetic acid is being explored for the determination of carboxyl groups. These are assuming increasing importance, not only in the preparation of bleached and high-alpha pulps but also in connexion with their influence on pulp properties and especially freeness. They appear to be connected with the influence of dissolved salts on the freeness of pulps and on the physical properties of the resulting sheets.

(iii) *Lignin.*—The procedure for extracting lignin from wood by means of dry methanol, at elevated temperatures and pressures, has been exhaustively explored. The yields have been found to increase with time up to four days, after which they become steady. Of the total material so extracted from the wood, only about 80 per cent. may be accounted for as Klason lignin. There is evidence that some furfural-yielding material is also extracted. For the recovery of lignin from the methanol extract, a satisfactory procedure which produces the lignin as a light-coloured fine powder has been developed. It has been established that the "native lignin" is methylated before it is dissolved in methanol, and that only that lignin with a methoxyl content in excess of a certain value is soluble in this reagent. This introduction of methoxyl groups means that the isolated lignin is not identical with "native lignin". In view of this, some alternative solvents are being considered. Sufficient methanol-lignin is being accumulated to permit a detailed study of its constituent groups, molecular weight, and chemical reactions.

(iv) *Carbohydrate Fraction.*—Investigations on the carbohydrate fraction of eucalypt wood have been interrupted on account of lack of staff. In view of the importance which these materials will assume in the post-war period in connexion with the manufacture of regenerated cellulose and cellulose derivatives, the study of their chemistry is gradually being resumed. To date the work has been mostly concerned with the training and building up of new personnel.

(v) *Pulp Evaluation.*—(*a*) *Lampen Mill.*—With the conclusion of a comprehensive study of all the variables of the Lampen mill, the first stage of instrumentation studies, as applied to pulp evaluation, has been brought to a successful conclusion with the formulation of a standard method, endorsed by the industry, for operating the Lampen mill. It is proposed, when time permits, to publish the results of this work. The Section has assisted the Laboratory Pulp Evaluation Committee of Australian Paper Manufacturers Limited in the preparation of a brochure setting out, in detail, the procedure to be followed for pulp evaluations in all the laboratories of that company.

(*b*) *Clark-Kollergang Beater.*—Laboratory work on the second stage of pulp evaluation instrumentation studies involving the Clark-Kollergang beater, has been temporarily interrupted following the discovery that the instrument in use was off-standard.

(*c*) *Stock Divider.*—The Section has, in the past, given considerable attention to precise methods of stock sampling for laboratory sheet-making. This has resulted in the development of two types of "stock divider". During the year, many data relevant to the performance of these were obtained and presented at the annual Paper Industry Conference. These results were so convincing that several units of one type of stock divider have been manufactured for installation in the various laboratories of the industy.

(*d*) *Freeness.*—An interesting property of eucalypt kraft pulps is the amazing influence which small quantities of dissolved salts have on their properties. This applies particularly to freeness but is, naturally, reflected in the sheet properties. During the year, considerable attention has been given to the influence of dissolved salts on freeness, and it has been established that this influence is a function of the cation and that it increases with valency of this ion. The one exception is hydrogen-ion which gives effects comparable with the tervalent cations. It is interesting to note that the influence of cations on freeness closely corresponds to the influence of cations on the electro-kinetic potential of cellulose as found by Heymann and Rabinov.

As the salt effect is bound to affect laboratory pulp evaluations, especially where results obtained in different laboratories having different water supplies are to be compared, it has become of paramount importance in formulating pulp evaluation procedure. It may become necessary to supply all laboratories with dosed or de-ionized water. With this end in view, the Section has been giving consideration to the influence of salts at the various stages of pulp evaluation. Since the greatest amount of water is consumed in the actual sheet-making process, the investigation has been initiated at this point. Owing to the limited facilities for providing de-ionized water for this purpose (distilled water in this case) progress in the work has been rather slow but, nevertheless, some very useful data are being accumulated.

(*e*) *Paper Testing.*—Instrumentation studies related to paper testing have been concerned with the measurement of internal tearing resistance and with the determination of basis weight. Various methods for increasing the number of readings with the same number of sheets have been investigated. It has been demonstrated that it is not possible to achieve this without automatically disqualifying some of the individual tests. The results have indicated that in the standard methods which are employed overseas, various replicate readings are complementary to one another and by no means independent. Consequently, they cannot be regarded as true replicates.

Precise basis weight determinations are essential, particularly as they are used to adjust all the values for all other physical properties. It has been shown that the two recommended methods are inaccurate. One of these involves an assumption of the sheet area. A method, which employs a precision guillotine, has been used to determine true basis weights and, with the aid of this, it has been shown that the recommended methods can be subject to an error of at least 20 per cent.

(vi) *Tropic Packaging.*—The Section has given considerable practical assistance to inter-service committees which are concerned with tropic packaging problems. This assistance has involved physical testing of, and the drafting of specifications for, wrappings and moisture barriers. The Section has undertaken the responsibility for measuring the water-vapour permeability and water resistance of moisture barrier materials. A special chamber, which is maintained at high relative humidity and temperature, has been designed and constructed within the Division for use in this work. Special apparatus in the form of exposure dishes, masks, and templates and a special device for creasing specimens under standard conditions, have also been designed and manufactured, and the equipment is ready for use in water-vapour permeability tests on behalf of the fighting Services and food authorities. Various water resistance tests on different types of containers have been undertaken on behalf of certain sections of the Services. Numerous inquiries relative to the war effort have been handled during the course of the year.

4. Timber Physics.

(i) *Physical Properties of Australian Timbers.*—The work of collecting detailed information on the more important physical properties of Australian timbers has now been in hand for many years. During the past year the work has been extended to material from New Guinea and the Northern Territory. It is proposed shortly to determine just what blanks remain in our information and to make arrangements for filling them.

(ii) *Physical Properties of Improved Wood.*—Amongst the properties of improved wood of particular

interest at the present time are those of thermal expansion and damping capacity. Determinations of these properties have been made on numbers of different samples.

(iii) *The Effect of High and Low Temperatures on the Strength of Wood, Plywood, and Glued Joints.*—Work on this project has been continued. The preliminary investigation was confined to material at 15 per cent. moisture content (*J. Coun. Sci. Ind. Res.*, Vol. 16, page 263, 1944) but these tests are being repeated at 8, 12, and 20 per cent. moisture content, much of the work already being completed. Results emphasize the desirability of applying temperature corrections as well as moisture content corrections in structural designs, particularly of solid wood.

(iv) *Battery Separators from Australian Timbers.*—Specification tests on separators are made from time to time as requested by various manufacturers and users. Storage trials on batteries built up with treated and moist separators are in hand. Further work on the pretreatment of kauri separators is planned with the object of improving the mechanical properties of this species. To this end, a wear tester has been designed and constructed. Methods of drying treated separators are also being tested.

(v) *Compressed Wood.*—Some progress has been made in an investigation concerned with the manufacture and properties of compressed wood. In a preliminary survey various temperatures at time of compression, moisture contents, species, and compression across and along the growth rings have been tried. It is hoped to expedite the work next year.

(vi) *High-frequency Electrical Heating.*—The Division's high-frequency heating equipment has been rebuilt by the State Electricity Commission of Victoria and installed in a properly screened room in the basement of the laboratory. The equipment has a rated power output of 400 watts at a frequency range from 14 to 28 megacycles; it is now being used for experimental work on synthetic resin gluing.

(vii) *Improved Instrumentation.*—One of the functions of the Timber Physics Section is to afford assistance to other Sections in improving their instrumentation technique. Examples of this are the vibrating reed speed indicators and water level indicator in the pulp and paper laboratory and the use of valve relays for various temperature controls, thus reducing the wear and tear on mercury contact thermometers.

5. Timber Mechanics.

(i) *Box and Crate Design.*—The problems in this branch of the work have been entirely those arising from the packaging of goods for defence and essential services. Laboratory work was devoted mainly to the improvement of details of munitions boxes such as lid fittings and screws. Assistance was given to manufacturers in the design of boxes and crates for machinery and equipment for forward areas. Tests made on a new type of processed cement-coated nails showed that they have about 50 per cent. higher efficiency than smooth nails as at present manufactured, but it was found that smooth nails made at the present time have considerably lower holding power than those made about ten years ago, presumably due to improved wire-drawing enabling smoother nails to be produced (see *J. Coun. Sci. Ind. Res.*, Vol. 17, p. 156, 1944).

(ii) *Timber Structures.*—Although the volume of work is decreasing, timber is still being used extensively as a structural material by the Services and the Allied Works Council.

(*a*) A development of particular interest has been the use of nailed arches for such purposes as stores, workshops, and hangars. This type of construction is very light and comparatively cheap, and although it was generally considered that nailed joints would not be very satisfactory with green hardwoods these structures have given good service and this type of construction will undoubtedly persist after the war. Unfortunately, there is little or no information on the strength, stiffness, and behaviour of nailed joints in Australian timbers. Tentative data were published in Supplement No. 1 to the *Handbook of Structural Timber Design*, but the experience of the Allied Works Council has been that the safe loads given in the Supplement are probably on the conservative side, and a series of tests on nailed joints is now being planned.

(*b*) It was found that the Council for Scientific and Industrial Research column formula, in which allowance is made for the lower strength of columns subjected to dead loads as compared with those subjected to live loads only, is the best available. It has been shown that, assuming Hooke's law applies for dead loads as well as for live loads and that there is a limiting value of creep, the formula is mathematically correct. It is realized that the basic assumptions are probably over-simplified, but until experimental data are obtained from creep tests they are probably the best available.

(*c*) Tests on the strength and stiffness of wall panels made up with corrugated iron and fibro-cement sheets have shown that fibro-cement-covered panels have little strength (mainly due to the bending of the nails or screws by which the sheets are fastened to the framework) but that corrugated iron can take shear loads equivalent to those in a medium-sized building. Quantitative data cannot yet be given, as the results of the tests to date have been very erratic and it has been necessary to expand the investigation beyond that initially planned.

(*d*) A survey was made of the damage caused by a disastrous fire which swept the bayside suburb of Beaumaris in January, 1944, destroying or damaging 66 houses. This showed that the resistance of a house to an external fire is more dependent on details of construction than on the material used in the walls. Most of the houses were destroyed or damaged because of the entrance of sparks and burning debris under the roofs or floors, and if this can be prevented, for instance, by boxing the eaves, the danger is greatly reduced.

(iii) *Creep.*—Comprehensive tests on the phenomenon of "creep" in timber have been planned. Progress has been slow because of the difficulty in having the rather elaborate equipment made. However, the prototypes are now practically ready and it is hoped that the full programme of tests will be under way before long.

(iv) *Timber Connectors.*—(*a*) Early in 1938, a series of tests was started to determine the relative efficiency of sixteen different types of anti-corrosion treatment for split-ring timber connectors. The connectors were inserted in green karri, which is a corrosive timber, and subjected to conditions conducive to corrosion for a period of five years. The tests showed clearly that hot-dip galvanizing was the best treatment and was thoroughly effective, the galvanized rings losing no weight over the five years, whereas untreated controls lost up to 35 per cent. of their initial weight (see *J. Coun. Sci. Ind. Res.*, Vol. 17, p. 162, 1944).

(*b*) Preliminary tests on the effect of duration of loading on the strength of timber-connector joints in green hardwood indicated that, under loads of a few days' duration, joints are liable to fail at not more than 60 per cent. of the live load strength. Plans have been prepared, and the prototype equipment tested, for a large-scale investigation for the purpose of obtaining quantitative data on the relation between the strength and slip of joints and the duration of loading.

(*c*) Valuable data on the behaviour of the numerous timber structures built in Australia in the last three years have been obtained as a result of a survey by an officer of the Allied Works Council extending over twelve months. The Division co-operated in planning the survey.

(v) *Mechanical Tests.*—(*a*) A large number of tests were carried out on species with special mechanical properties. One feature of interest disclosed by the tests was that the strength/weight ratio of Tasmanian mountain and alpine ash is considerably lower than that of the same species growing in Victoria.

(*b*) An investigation of the Izod impact test has been made as part of a general survey of impact testing of wood. This has involved the testing of some 10,000 Izod specimens in a study of the variation of the Izod value due to such factors as variation in size of specimen and length of moment arm, notching, and shape of notch. Variation with width of specimen has been shown to be linear, which agrees with the simple theory. However, the variation with depth of specimen does not appear to be predictable from simple bending theory, for the analysis showed it to be best represented by a cubic equation.

The variation with length of moment arm was studied by varying the moment arm from 1 to 2½ inches at ¼-in. intervals for specimens varying in depth from ⅛ to ⅝ inch. With the thinnest specimens the Izod value was constant over a range of moment arms, with a rapid rise in value as the length was reduced beyond a certain point. As the depth of specimen was increased, the range over which the Izod value remained constant was reduced until a depth was reached for which the results showed a definite minimum value. The weakening effect of notching was marked in the case of brittle timbers such as hoop pine and King William pine, but in the case of the tough timbers such as mountain ash, spruce, and Queensland maple no significant effect due to notching was observed.

A start has been made to investigate the Denison impact test, and so far results have indicated that the variation of toughness value with width and depth of specimen is very similar to the Izod.

(*c*) An investigation to determine the influence of duration of loading (as distinct from rate of loading) on the strength of timber gave very erratic results, and it will be repeated on a larger scale when opportunity offers. The results indicated, however, that when the full load is applied for ten seconds, the strength is about the same as that obtained in the standard testing procedure where the load is increased at a constant rate until failure occurs.

(*d*) At the request of the Allied Works Council, tests are being made on samples of Northern Territory timbers. Samples from 160 trees representing 30 species have been tested, thus enabling the local timbers to be used to best advantage by the constructing authority in the Territory. At the request of the Army, similar tests are being made on samples of New Guinea timbers to provide data essential to the best utilization of local timbers in operational areas.

(vi) *Veneers and Plywood.*—(*a*) Tests to determine the variation in strength properties of hoop pine plywood with moisture content have been completed. It has been found that the compressive strength increases considerably with decreasing moisture content but that there is little change in tensile strength with changes in moisture content. The type of glue used (phenol formaldehyde, urea formaldehyde, and casein) did not appear to influence the results to any appreciable extent. However, there was a marked variation in the equilibrium moisture content of the plywood made up with the different glues, the equilibrium moisture content of the phenol formaldehyde glued material being up to 4 per cent. lower than that of the casein bonded plywood, the urea formaldehyde glue giving intermediate values.

(*b*) An investigation on the strength and stiffness of veneer at varying angles to the grain was completed, the experimental results checking the theoretical values (based on the complete theory of elasticity of orthotropic materials) very closely.

(*c*) An investigation, which is still in progress, has indicated that the type of grip has a pronounced influence on the results obtained in tensile strength tests on plywood. Badly fitting fixed grips give results up to 33 per cent. lower than completely self-aligning grips. Even with apparently similar grips, different machines of the same make give somewhat different strengths. A survey is now being made of the results obtained from twelve machines in four testing laboratories as a first step in the elimination of a serious source of error.

(*d*) Tests on the strength and elastic properties of hoop pine plywood panels subjected to shear loads have been made during the year, particular attention being paid to the determination of the true elastic limit (as distinct from the limit of proportionality). Electric resistance strain gauges have been widely used in this investigation. These gave considerable trouble at first, but a satisfactory technique for manufacture and use has now been developed.

(*e*) The determination of the modulus of rigidity of plywood by means of tubes loaded in torsion has given satisfactory results.

(vii) *Felloe Manufacture.*—Shortage of petrol and later of rubber resulted in an increased demand for horse-drawn vehicles. Supplies of seasoned felloes for new construction and repair work were soon exhausted. As felloes are made from eucalypt timbers in thicknesses requiring several years to season, a serious position developed. Investigations were started on the bending of suitable timbers in 1-in. thicknesses and subsequent combining of these into laminated felloes with suitable glues. The results were very satisfactory, and felloes of this type are now in production. Tens of thousands have been produced mainly from mountain ash, with less than 1 per cent. failures.

6. Timber Seasoning.

(i) *General.*—The Division continued to give a wide service to the industry in the solution of seasoning and allied problems. A number of veneer and timber drying plants in Tasmania, Victoria, New South Wales, and Western Australia were visited during the year. Kilns were tested, appropriate recommendations made for improvement where necessary, and specific drying problems discussed. Numerous minor inquiries were received. These included requests for information on kiln schedules for various species; the burning of sawdust as an auxiliary fuel; the suitability of and method of seasoning Australian timbers for smoking pipes; the suitability of Australian timbers for textile rollers; kiln maintenance; moisture meters; the prevention of mould on packed case shooks; the removal of taint from wooden barrels; timber for household fittings, and the like.

(ii) *Kiln Schedules.*—Work associated with the development of special drying schedules designed to avoid loss of mechanical strength in timbers during kiln drying was continued as one of the major projects of the Section during the year. Since the commencement of this investigation particular attention has been given to ten timber species, namely, alpine ash, hoop pine, King William pine, mountain ash, northern silver ash, Queensland maple, silver quandong, white birch, and sassafras. Some 25 kiln schedules, covering the drying of the above species in thicknesses of 1 inch and 2 inches, have been established. A limited amount of

work on the chemical seasoning of 6-in. spruce, and 4-in. Queensland walnut and white birch, was carried out.

(iii) *Kiln Design.*—Numerous requests were received from the timber trade and associated bodies throughout Australia during the year for plans covering the construction of timber seasoning kilns, veneer driers, special conditioning cabinets, and miscellaneous driers. Designs including detail drawings, for slightly more than 30 installations were issued during the year.

The number of timber and veneer drying kilns and drying rooms in Australia has now reached a figure well in excess of 800 individual units. Slightly more than 75 per cent. are devoted to the drying of solid timber (including case timber) some 11 per cent. are used in the drying of veneers and the redrying of plywood; approximately 7 per cent. are used for redrying timber for core stock or for the conditioning of veneers; and the remainder are specialty kilns for such purposes as the curing of improved wood and the drying of woodwool. Of the total given above, it is safe to say that some 70 per cent. were constructed to designs prepared by the Division.

(iv) *Boxes and Cases.*—A considerable proportion of the time of officers of the Section was devoted to trade contact work associated with the kiln drying of case timbers for defence and civilian requirements. This work has included the preparation and issue of numerous designs covering the construction of drying kilns for case stock, advising on details of construction and costs, testing kiln units for performance, and the training of operators.

One of the principal factors affecting the rate of corrosion of metal containers packed in wooden cases is the moisture content of the wood. At relatively low moisture contents no corrosion takes place, whereas at high moisture contents appreciable corrosion can occur. It would appear that the transition occurs in the vicinity of the moisture content range of 17 to 21 per cent.—possibly towards the higher part of the range for softwood species, and towards the lower part of the range for hardwood species containing appreciable quantities of acetic acid. Although this range may appear to be fairly close, a much more accurate knowledge of the limiting moisture content is desirable. This is especially important from aspects of plant capacity, and work on this project was commenced using several Australian hardwood and softwood species commonly used as case timbers.

(v) *Shipbuilding.*—To ensure good construction in the building of wooden ships, a knowledge of the correct moisture content required in the various parts is essential. With the object of determining the equilibrium moisture content reached in ships' planking in service, experimental work was carried out with six timber species (comprising both softwoods and hardwoods) in the form of 2-in. planks having one face in contact with water and the other face in contact with air. The moisture content conditions was measured after a period of twelve months. It was found that a very high moisture gradient existed across the thickness of the timber, ranging from under 20 per cent. near the dry face to over 100 per cent. near the wet face; and that in this thickness the average moisture content of the planking varied from 27 to 45 per cent. depending on species (see *J. Coun. Sci. Ind. Res.*, Vol. 17, p. 133, 1944).

For the guidance of contractors constructing wooden ships, an article covering the seasoning and shrinkage of ship-building timbers was prepared and a survey of a number of ship-building yards in New South Wales was made to advise ship-building contractors concerning proper timber seasoning technique where this was found necessary.

(vi) *Correspondence Course.*—The correspondence course in timber seasoning and kiln operation, conducted for the training of kiln operators and others, was continued. An additional sixteen students, including a number of service personnel, were enrolled during the year.

7. Preservation.

(i) *General.*—Early in the war the policy adopted for the Preservation Section was that, owing to the necessarily long-term nature of most of its experimental work, inspections of established projects would be continued but no new projects would be undertaken and staff would be devoted to more pressing war-time problems. The demands on the Section from the Services have, however, increased steadily, largely owing to the war in the Pacific areas. Numerous inquiries have been attended to, lectures have been delivered, by request, to selected service personnel, a visit has been made to the Northern Territory to report on termite problems encountered there, and assistance has been given on problems dealing with tropic-proofing and the underwater protection of wooden craft.

(ii) *Service Tests.*—Shortage of staff has limited inspection of field tests to a few in which information was most required.

(*a*) *Fluorized karri sleepers.*—The sixth inspection of the test, the installation of which commenced in Western Australia in 1929, carried out towards the end of June, 1944, confirmed previous inspections in indicating that the fluorizing treatment is not as effective against decay as against termite attack.

(*b*) *Treated sleepers, Victoria.*—In order to extend sleeper resources a study of the effects of preservative treatment on less durable timbers was commenced in 1941, and up to the inspection in January, 1944, there was no difference between treated and untreated sleepers.

(*c*) *Fence posts, Western Australia.*—The posts were installed in 1930, and the seventh inspection was carried out in June, 1944. The report of the inspection is not yet available, but treated posts are standing up well, although most of the controls have now been destroyed.

(*d*) *Arsenic pole treatments, Mt. Jamberoo, New South Wales.*—Tests with arsenious oxide collars and crude oil plus arsenic treatment were commenced in 1930. As reported previously, the collar treatment was not effective in preventing termite attack. The fourth inspection was made in 1944. The crude oil and arsenic treatment is still effective, but because of decay of the sapwood attention to the test poles is necessary. This will be carried out when man-power becomes available.

(*e*) *Jarrah sleepers.*—Jarrah contains pockets of rot which are regarded as a cause for rejection in sleepers. Test pieces installed in three localities in 1938-39 under conditions similar to those of sleepers, were inspected in June, 1944. Few of the rot types had developed so that reduction in the cause for rejection in sleepers will be possible. In 1932, the Western Australian Forests Department installed jarrah sleepers showing defects. The third inspection made by the Division at the end of June, 1944, indicated the desirability of relaxing the present specification in some respects.

(iii) *Borers.*—The shortage of timber has encouraged the use of sapwood susceptible to lyctus attack. The result has been an increase in the requests for information on behaviour and treatment of this borer in a wide range of materials, from cases and casks to structural members.

Marine borer exposure tests of plywood bonded with urea formaldehyde glue and phenol formaldehyde glue respectively have been commenced in co-operation with

the Queensland Forest Service. Results so far indicate that tego and urea formaldehyde bonded plywood will not withstand attack by *Nausitora*. The urea formaldehyde bonded material, however, appears to be more resistant than the tego bonded.

(iv) *Preservative Treatments.*—Laboratory tests showed the practicability of impregnating with a hot and cold bath treatment plywood bonded with phenol formaldehyde glue, but plywood bonded with urea formaldehyde glue gave patchy penetration.

This year has seen the almost complete installation of the first commercial pressure-preservation plant to be built in Australia. This has a cylinder approximately 30 ft. long by 7 ft. 6 in. diameter and accessory equipment including an incising machine. The Division, which supplied initial information, has acted in an advisory capacity throughout the erection, and will exercise a general supervision over the operation of the plant. It is hoped that this will serve to introduce pressure treatment as a practical procedure to be adopted on a much wider scale in the future.

8. Veneering and Gluing.

(i) *General.*—During the year, an officer of the Division completed a visit to the United States of America and Canada to study the "plastic moulding" of plywood with particular reference to its application in the fabrication of aircraft and marine structures. Complete details of the various procedures were obtained, but it was recommended that research work should not be commenced on this aspect of plywood manufacture at the present time. Other matters studied were the latest developments in adhesives and the use of infra-red, resistance strip, and high frequency heating in gluing.

(ii) *Peeling.*—The following species have been peeled, &c., during the year:—brush box (*Tristania conferta*), hoop pine (*Araucaria cunninghamii*), leatherwood (*Eucryphia billardieri*), mountain ash (*Eucalyptus regnans*), radiata pine (*Pinus radiata*), satinay (*Syncarpia hillii*), scented satinwood (*Ceratopetalum apetalum*), Sydney blue gum (*Eucalyptus saligna*), yellow gum (*Eucalyptus leucoxylon*). A considerable quantity of this veneer was peeled dried, and made up into plywood for use by other sections of the Division, and by the Division of Aeronautics.

Previous work on karri has resulted in the establishment of a plywood factory in Western Australia to utilize this timber. An officer of the Division spent some time in Western Australia assisting in the initial stages of the establishment of the industry. Previous work on mountain ash as a timber for match splints has resulted in the extensive use of this species for this purpose and has assisted in practically eliminating the use of imported splints.

(iii) *Glues and Gluing.*—(*a*) Preliminary tests have been completed on locally made Beetle A cement and hardeners. Assistance has been given to manufacturers in changing over from casein to urea formaldehyde glue.

(*b*) Laboratory and commercial tests have been carried out on the locally manufactured resin glue film similar to the imported tego film. It was shown that this material was equal to the imported article for the bonding of hoop pine.

(*c*) Tests have been carried out and are continuing on a tropic-proofing material developed for the protection of casein-glued plywood. This material has been recommended for trials under field conditions.

(*d*) Efforts are being made to find a substitute for casein for use in the plywood and allied industries. Casein is unprocurable at the present time owing to the general shortage of milk products and the demand for cheese and condensed milk, &c. Peanut meal appears to be the best possibility for plywood manufacture, while a starchy waste product from dehydration plants offers possibilities for the gluing of insulating boards which previously were glued with casein.

(*e*) Tests have been carried out on various types of adhesives, mainly casein, urea formaldehyde, and phenol formaldehyde, to determine their properties and to check their suitability for gluing wood and the reasons for difficulties being experienced in their use. Considerable time has been devoted to advisory work to the trade and Government bodies in connexion with special uses for adhesives, sources of supply, &c.

(*f*) Work has been carried out in conjunction with the Division of Industrial Chemistry on the development of synthetic adhesives for the bending of veneer.

(iv) *Plywood.*—Experiments are progressing on the manufacture of plywood for use in watercraft from veneer which has been impregnated with various preservatives, e.g., creosote, copper naphthenate, and trichlorphenol. It has been shown that it is possible to bond such veneer with both tego film and a range of urea formaldehyde glues. Practical difficulties associated with commercial manufacture militate against the use of this technique, however.

9. Improved Wood.

(i) *Variable Density Planks.*—For certain purposes, improved wood is required with different mechanical properties at the two ends of a plank. Material of this type was successfully made by a new procedure. In this method, the long veneers were impregnated with the resin at one end by soaking, and the inter-leaving veneers, which are of varying length and which are necessary to give the high density at one end of the plank, were completely impregnated with the resin solution. In assembling the veneers before pressing, the unimpregnated portions of the long veneers were interleaved with tego film. The bundles of veneers so made up were pressed to a uniform thickness giving a high density improved wood at one end and a comparatively low density improved wood at the other.

Experiments were also carried out in the manufacture of variable density planks from scented satinwood veneer using tego-film throughout instead of impregnating with the resin solution.

(ii) *Gluing.*—Considerable progress has been made in these investigations, which have been largely in co-operation with the Division of Industrial Chemistry. These have as the objective the development of hot and cold press resin adhesives suitable for the bonding of improved wood and other plastic surfaces.

A series of preliminary tests gave information on the effect of various factors on the joint strength of a cool press (160° F.) cast phenolic type of resin adhesive. This type of adhesive has been variously modified before commencing a large-scale factorial experiment to select the final type for the cool press gluing of improved wood. This experiment has been planned to cover the comparative testing of 126 cool press cast phenolic resin adhesives variously modified and supplied by the Division of Industrial Chemistry.

Some preliminary tests have indicated that when specimens of tego-bonded scented satinwood are glued together, it is preferable that no tego face is exposed, as in such cases the joint strength is reduced roughly by 50 per cent.

(iii) *Type of Resin.*—This co-operative project with the Division of Industrial Chemistry has been continued, and in one experiment the influence of degree of advancement of the water-soluble phenol formaldehyde resin on the properties of the improved wood was investigated. With the degree of advancement investigated, namely, (i) very lightly condensed, (ii) lightly condensed, (iii) medium to lightly condensed, and (iv) medium condensation, it was shown that

there was a significant drop in shear strength parallel to the grain and parallel to the laminations and a significant though small increase in Izod. From a practical view-point it was decided that the second stage was that most generally useful.

The influence of the phenol-formaldehyde ratio in a lightly condensed water-soluble resin on the properties of the improved wood was also investigated. Eight resins representing eight different ratios were used in the impregnation of matched veneers from four different trees. Results of mechanical tests on the improved woods made from these resins suggested that the use of a low ratio (e.g. around 1.0) was desirable if high Izod as well as high shear properties were essential.

(iv) *Electrical Properties.*—Further tests on specimens of improved wood made with a water-soluble phenol formaldehyde resin were carried out for the Division by the Electricity Commission of Victoria. These tests showed that for telephone terminal boards and for other similar duties operating at 20-30 volts direct current, the improved wood made with the above resin and to a thickness of ¼ in. could be recommended. These ¼ in. specimens had electrical properties which complied with the requirements of S.A.A. Specification No. C108-1937P; however, it was considered that close control and frequent testing during manufacture were essential to maintain the uniformity of the product.

(v) *Textile Equipment.*—Whilst only a small amount of wood is used for this purpose, the performance of textile machines depends on the reliability of wooden components such as picking sticks. Since 1941, shortage of supply of hickory from America has grown progressively worse, and the position in the United States of America is now acute. Attempts to use Australian timbers have not been altogether satisfactory, so that the Division arranged for the preparation of sticks from special improved wood and their testing out in service. The results have been entirely satisfactory, the improved wood sticks giving a life of 1,500 hours as against the 6 to 30 hours previously being obtained from substitute materials. The best results were given by sticks made from a high density (86 lb./cu. ft.) tego-bonded spotted gum improved wood. In other wooden components of looms, equally satisfactory results have been obtained.

10. Utilization.

(i) *General.*—The work in this section has been greatly hampered by lack of staff. The two senior officers of the section were still under secondment to Timber Control, while the remaining officer spent six months in New Guinea. The work has been carried on with the assistance of other sections of the Division. Advice and information on the utilization of timber for munitions and for the essential requirements of the service and civilian population form the major part of the work.

(ii) *Liaison.*—Liaison with Australian Government departments, including Navy, Army, Air, Munitions, Supply and Shipping, and Interior, was maintained, as was also contact with the United States Forces in Australia. Information was supplied to the Australian Council for Aeronautics, Army Design and Experimental Directorate, Army Inventions Directorate, Navy, Army, and Air Inspection Branches, Controller of Timber, Ordnance Production Directorate, Foodstuffs Committee, Contract Board, Department of Aircraft Production, Trade and Customs and others.

The Division was represented at conferences to discuss tropic-proofing of materials and equipment to be used in New Guinea, portable prefabricated huts, the revision of aircraft timber standards, the preparation of a standard for imported plywood, production of small watercraft, and the use of timber in aircraft construction. The secretarial work for the Timber Sectional Committee for the Standards Association of Australia and for the Timber Panel of the Australian Council for Aeronautics was continued.

(iii) *Timber Uses.*—Advice has been given to inquirers seeking information on timbers for the manufacture of agricultural machinery, aircraft plywoods, ambulance stretchers, ammunition boxes, axe handles, battery separators and boxes, boat construction, bobbins, boot lasts, bridging equipment, bridge and wharf construction, buildings, butter boxes, cable drums and reels, camp tables, cargo barges, children's playgrounds, clog soles, containers (including boxes, cases, drums, and barrels for food, clothing, machinery, &c.), crossarms, derricks, dockyard construction, explosives factory equipment, flooring, furniture, laminated wooden construction, mauls and mallets, matches, mining timber, motor boats, oars, picking sticks, pickling vats, pike poles, plywood for various purposes, pontoons, portable prefabricated huts, propellers, railway carriages, railway sleepers, rifle and machine-gun furniture, scaffold planks, ships' decking and masts, shuttles, slide rules, marine slipways, teasing rollers, telegraph poles, tent poles, tent pegs, textile rollers, torch cases, wheels for industrial trucks and perambulators, &c., wooden ships, wooden stave tanks, wooden tubs and buckets, woollen mill equipment.

11. Flax.

(i) *General.*—The production of flax in Australia has continued on the basis of some 60,000 acres per year. Yields and quality of scutched fibre have shown considerable improvement and costs have been reduced. To these results the Division has contributed in no small measure. The work of the Division will be facilitated by the installation of a scutching machine on loan from the Flax Production Committee.

(ii) *Water Retting.*—In the laboratory, water retting investigations have been concerned with such problems as the effect of the storage of straw on retting, the effect of leaving the seed on the straw, the use of iron filings in the retting liquor, and the effect of prolonging the rinse period of the ret up to 48 hours. In no case did the results of these tests show that any advantage could be obtained by departing from the present standard technique. Mill tests were also made on the so-called "iron ret", using two different types of straw, but no significant difference could be found between this and the normal ret. Spinning tests on the iron retted fabric and controls also failed to show any difference.

An increasing amount of work is reaching the Division year by year in the form of samples from agricultural field trials in Victoria, South Australia, and Tasmania. The work involves sorting and preparing the straw, retting, scutching, and arranging for the grading of the fibre. Tensile tests are also made on most samples.

(iii) *Chemical Retting.*—Fairly extensive tests have been made at the pilot plant at Ballarat and a technique developed which has been applied to a wide range of straw types with general success. Recent spinning tests on chemically retted fibre have given very encouraging results. Work outstanding on this project is concerned with the economics of chemical retting as compared with other methods.

(iv) *Dew Retting.*—No new tests have been made, but an investigation started last year into the effect of storage of dew retted straw on the yield and grade of the fibre has been concluded. Storage was found to have no significant effect.

(v) *Physical Tests.*—Physical means of evaluating flax fibre are still being investigated with the object of removing the personal element associated with

present methods of grading. Factors such as tensile strength, hackling yield, fineness of hackled fibre, and ultimate fibre dimensions all appear to influence the spinning quality of the fibre, but are only some of the properties involved.

(vi) *Chemical Tests.*—Information on the chemical composition of flax straw is leading to a much better understanding of the maturing of the straw and of the process of retting. Analysis of the fibre may serve as a means of evaluating spinning quality. In particular the percentage of uronic acids appears to play an important part.

VIII. FOOD PRESERVATION INVESTIGATIONS.

1. General.

The activities of the Division continue to be almost entirely on problems of direct importance in the war effort. Advisory work and minor investigations required for this work now form a major part of the activity of most sections of the Division. Close liaison exists between the Division and the Services and other Commonwealth Departments, particularly the Department of Commerce and Agriculture, and it is in close touch with the food industries. These contacts help greatly in concentrating efforts on the most urgent problems.

Officers of all sections of the Homebush laboratory participated in the instruction given to the first of a series of Army Schools of Food Technology, and some assistance has been given in later schools of the series. The *Food Preservation Quarterly* has been continued and its circulation has increased during the year.

The work of the Division continues to be greatly assisted by many outside bodies. The Australian Meat Board, the Sydney Metropolitan Meat Industry Commissioner, the Queensland Meat Industry Board, and the Egg Producers' Council have again given very substantial financial assistance; Horitz Fruit Drinks Pty. Ltd. provided a contribution towards the cost of fruit products investigations, and valuable pieces of equipment have been presented by J. W. Earnshaw Pty. Ltd. and John Heine & Son. Many canners, food manufacturers and others have assisted the work of the Division by supplying information, materials, and facilities for conducting factory-scale tests.

2. Meat Investigations (Brisbane).

(i) *General.*—Consultation work, covering a wide field of problems related to food preservation and transport, has increased in volume during the year under review. It has often necessitated chemical, physical, and microbial surveys, work in the laboratory, and sometimes the design of apparatus. Requests for assistance have come from Service authorities, both United States and Australian, from government departments, both State and Commonwealth, and from representatives of many phases of the food industry.

(ii) *Plant and Equipment.*—The overhaul, adjustment, and improvement of plant and equipment has been necessary. Much new equipment, especially that needed in connexion with studies on the compression of dehydrated beef, was specified and fabricated. This included accessory apparatus for use with a Brinell hardness tested which had been borrowed from the Engineering School of the University of Queensland.

(iii) *Dried Beef.*—Investigations have been made into processing procedures prior to the drying of beef, with especial attention to the possibility of improving flavour by using lower cooking temperatures. Work on the return of extractives to the beef prior to drying was continued, and the value of doing so was strikingly confirmed by tasting tests. The tests were carried out on a wide variety of dishes made up with the dried beef both with and without the extractives returned to it. Assistance in this matter was given by the chef at a large Brisbane hotel, and by other interested persons.

Considerable work was done on the compression of dehydrated beef, with the object of finding (i) the reason why the material often loses its particulate character during compression and is so easily powdered, and (ii) ways and means of overcoming this. Runs have been made to study the effect of different particle sizes. The difficulty is probably associated with the structural muscular elements, namely, collagen fibres. It appears probable that they are digested to gelatin in the course of cooking. Histological studies on the material, from the raw beef employed to the finished product both before and after compression, have therefore been started.

(iv) *Moisture Content of Meat Extract.*—Papers on the nature of moisture content and a quick density method for its determination are being prepared for publication in connexion with a series of studies on the moisture content of meat extract.

(v) *Substitute Wrapping for Bacon.*—An investigation into a suitable substitute for the bitumen-wrap of bacon destined for the tropics was concluded. Unfortunately, weight loss due to evaporation could not be determined because of damage wrought by insects. Sufficient information was obtained, however, to suggest that the chances of finding a satisfactory substitute for bitumen were good if it was needed for trade to the tropics.

(vi) *General Microbiological Work.*—Microbiological work was done in relation to problems referred by various meat, canning, and milk concerns; much of it related to meat extract. At the request of a United States Army officer, cultures of all yeasts isolated from meat, which form part of the microbiological collection maintained by the Division, were prepared and despatched to the Osborn Botanical Laboratory at Yale University for use in connexion with studies on vitamin B_1. The whole of the reference collection of micro-organisms was recultured twice during the year.

3. Canning and Fruit Products Investigations.

Advisory and extension work in the canned foods industry has been actively maintained and the section is in continuous consultation with the Departments of the Army and of Commerce and Agriculture on day-to-day problems. Laboratory staff and facilities were extended during the year to cope with an expanded volume of work. Several items of new equipment have been purchased, and a can flip tester, a vacuum can tester, and a Campden type manometer have been generously donated.

(i) *Vegetable Canning.*—In co-operation with the New South Wales Department of Agriculture, varietal trials have been carried out on various vegetables, to determine their suitability for canning. Tomatoes from Bathurst Experimental Farm, sweet potatoes from Grafton Experiment Farm and from several commercial growers, and carrots, have been examined for canning quality.

The Griffith Research Station supplied material for a comprehensive canning trial of tomatoes. Several pickings of each of sixteen varieties were forwarded. Experimental packs of peeled tomatoes and juice were put up and certain chemical characteristics determined, e.g. vitamin C content, total soluble solids, pH. An attempt was made to correlate "wholeness" in the canned fruit with the proportion of pulp to carpel and placenta in the raw fruit. Colour standards have been prepared and used for studying the relation between maturity and canning quality.

The application of calcium chloride blanching in canning potatoes, a process developed by the Campden Research Station, England, was investigated. This blanch effects notable improvements in the quality of canned potatoes. The canning of broccoli has been studied with particular attention to vitamin C retention at various stages of the canning process. Canned broccoli shows considerable promise as a palatable pack with a useful vitamin C content, and it would fill a real need in present service rations for an attractive canned "green" vegetable. Canning trials have been carried out on a number of varieties of cabbage and on carrots of different maturities and period of storage before canning. A problem of surface discolouration of canned carrots was successfully overcome by double lye treatment.

(ii) *Meat Canning.*—Experiments have been carried out with the object of improving the quality of canned packs such as meat and vegetable ration, corned meat, and tripe and onions. Two interesting examples of chemical swells in meat cans have been recorded, one due to the use of excessive concentration of sodium nitrite and the other to the development of hydrogen.

(iii) *Fish Canning.*—In co-operation with the Division of Fisheries a satisfactory formula and method of processing has been developed for the preparation of a fish loaf from Australian salmon (*Arripis trutta*), which has undesirable characteristics when canned by the usual commercial method.

(iv) *Fruit Canning.—Pears.*—A report was received from New Zealand that extensive wastage had occurred in canned Packham pears, which was attributed to hydrogen swelling. The possible occurrence of this wastage in Australian packs has been investigated. Preliminary examinations of incubated packs suggest, however, that a heavy incidence of hydrogen swelling will not be encountered. Slight acidification and spicing with clove and cinnamon oils greatly enhance the palatability of canned pears.

(v) *Fruit Juices.*—General supervision on behalf of the Controller of Food was maintained over the production of citrus juices from all plants in Australia. As a result of information and experience gained in the United States of America, and investigational work at Homebush, further modifications in plant equipment have been incorporated into existing commercial citrus juice layouts.

(*a*) *Deaeration.*—Owing to increased demands for citrus juices it was found necessary to develop a deaerator nozzle capable of giving efficient deaeration at higher flow rates. Satisfactory deaerators are now available for flow rates in the ranges 100 to 140 gallons per hour and 250 to 315 gallons per hour.

(*b*) *Oil in Commercial Citrus Juices.*—The practice of steaming fruit before mechanical extraction was found to reduce the oil content by comparison with juice from untreated fruit. The results were not appreciably different when fruit was held for several days prior to extraction. Work was carried out on variation in rumbling times, rumbler charges, and washing of the fruit for mechanical extraction. Smaller charges and longer times gave considerable reduction in oil content of juice.

(*c*) *Juice Concentration.*—Investigations were continued into concentration of orange juice, particular regard being paid to vitamin C retention and the effect of concentrates on the enamel lining of cans.

(*d*) *Fruit Nectars.*—A palatable fruit "nectar", retaining the characteristic fresh flavour, was prepared from mangoes submitted by a north Queensland grower.

(vi) *Can Enamels and Lacquers.—(a) Citrus Enamels.*—Tests on citrus enamels followed two main lines, viz.. the testing of cans already coated by manufacturers and testing of enamels supplied by lacquer firms and applied in the laboratory by spray-coating can bodies and ends. Several of the lacquers contained more readily available constituents than the approved lacquer. Alternative enamel formulations submitted for test did not prove satisfactory. Suitable internally enamelled citrus juice cans are being manufactured in Australia using the citrus enamel originally approved by this Division.

(*b*) *Citrus Enamel Breakdown.*—Breakdown of internal enamels in cans of mechanically extracted citrus juices was found to be due to excessive oil in the juices. A number of experiments were carried out to determine the critical level of oil. It was found that percentages even lower than the limit set by Food Control caused stripping of the enamel. The effect of varying oil levels on enamel breakdown was critically investigated and recommendations for the amendment of standard specifications were made.

(*c*) *External Lacquers.*—A study of lacquering and other treatments to restrict external corrosion of cans has been started.

(vii) *Examination of Commercial Canned Food Samples.*—Examination of contract and tender samples of canned foods from New South Wales canneries was continued on behalf of Commonwealth Food Control until 1st January, 1944.

(viii) *Container Investigations.*—A survey, covering three years investigational work on food containers examined in this laboratory, has shown an unduly high proportion of leaky double seams in food cans. Numerous instances of extensive spoilage due to leaky cans have been reported, and several of these have been investigated. The methods employed for examination and testing of cans have been subjected to further study. Certain improvements in equipment and in technique have materially aided the diagnosis of can-making and can-closing faults causing leaky cans. The information obtained has been made available to can-makers, canners, and others through personal contacts, correspondence, and also through the medium of a series of articles published in the Division's Food Preservation Quarterly. Preliminary tests have been carried out to determine the efficiency of can-sealing compounds containing less rubber than those used prior to the shortage of rubber.

Several examples of overfilling due to the use of cans with internal volumes which were too low have come to the Division's notice. Proof of this was obtained in some instances by measurements of the internal volumes of cans and the volumes of the contents, using a Nicholson's hydrometer. This equipment provided a useful means for the measurement of headspace in cans containing semi-solid material. Where necessary, canners have been advised to use cans of sufficient internal value to allow for the density of the particular product being canned.

(ix) *Chemical Work.*—(*a*) *Fruit Juices.*—Two lots of navel orange juice were concentrated to half volume, filled into lacquered cans and stored. There was some loss of flavour and development of bitterness during processing, but practically no loss of ascorbic acid. Subsequently, the juice was kept for six months at 68° F. without further deterioration. At 86° F. loss of quality and ascorbic acid and slight attack on the can occurred after five months, and at 99° F. after two months.

Experiments were carried out on the fortification of canned Granny Smith apple juice with synthetic ascorbic acid to a level of approximately 28 mg. per 100 g. The best results were obtained by adding the requisite quantity of ascorbic acid to each can before sealing. With minimum headspace (4/16 in.), the subsequent loss of ascorbic acid was about 1 mg. per 100 g. per month at 68°-86° F. and 2 mg. per 100 g. per month at 99° F.

(*b*) *Jams and Jellies.*—An investigation was carried out on the retention of ascorbic acid during the preparation of marmalade mixture from citrus residues. The tests covered losses in the original residues on standing and in the preparation of the pulp and final jam. With minimum loss of ascorbic acid about 15-20 mg. per 100 g. was obtained in the marmalade mixture. Jellies were made from orange rind with or without added juice. Palatable jellies containing up to 70 mg. per 100 g. of ascorbic acid were prepared. Some preliminary tests were carried out on the preparation of jellies from fruit juices using pectin or sodium alginate.

(*c*) *Pectin.*—Investigations on the preparation of concentrated pectin extracts from apple and citrus residues were continued. Powdered pectin was prepared by precipitation with alcohol or aluminium chloride. The optimum conditions for precipitation with aluminium were determined.

(*d*) *Determination of Ascorbic Acid in Canned Foods.*—Canned foods may contain dissolved tin and iron, which under certain conditions interfere with the determination of ascorbic acid. The effect of various extractants was investigated, and a suitable technique for minimizing this interference was developed. A report is being prepared.

(*e*) *Cured Meats.*—Curing ingredients have been determined in a number of samples of bacon and other cured meats in connexion with canning and bacteriological investigations. Work is in progress on the determination of fermentable sugar in pork and bacon.

(*f*) *Metals in Canned Foods.*—Many samples of canned foods have been analysed for their content of tin and iron. The technique of determination has given some attention. The relation between bacterial growth and the level of total tin and various tin fractions is being investigated.

4. Dehydrated Foodstuffs.

(i) *General.*—During the year the section concerned has moved into new laboratories. The additional space and equipment has already made it possible to increase the scope of the work being done even though certain major items of equipment have not yet been received. Close contact has been maintained throughout the year with the section of the Department of Commerce and Agriculture responsible for the erection of vegetable dehydration plants and a considerable amount of investigational work has been done in dehydration plants. The section co-operated with the Department of Commerce and Agriculture during part of this year in the examination of samples of dehydrated vegetables from commercial plants.

(ii) *Dehydrated Vegetables.*—(*a*) *Processing Investigations.*—The aim of this work is to determine the factors affecting the initial quality of dehydrated vegetables. This involves a study of the effect of the quality of the raw material on the final product as well as a study of the various manufacturing processes. Varietal trials on cabbage and carrot have been carried out in co-operation with the Griffith Research Station. Investigations are now in progress on potatoes, carrots, and parsnips grown in Tasmania. The Tasmanian Department of Agriculture is supervising the collection of material. The effect of growing conditions, particularly the effect of soil type, is being investigated. In processing, attention has so far mainly centred on the effects of varying blanching time, sulphite treatment, drying temperature, and drying time. In all this work changes in the ascorbic acid and carotene contents of the material have been followed.

(*b*) *Storage Investigations.*—Studies have been made and are still continuing of the main factors affecting the storage life of dehydrated vegetables. It is already well established that the life of these products decreases fairly rapidly with increasing storage temperatures, and attention is now being centred on the effects of different processing treatments on the storage life at tropical temperatures. Experiments are also in progress to determine the storage life of average commercial products under various conditions.

(*c*) *Investigation of Analytical Methods.*—The main work on the development and standardization of the analytical methods used has been on the determination of carotene. A paper has been published summarizing the results. Other procedures which have received some attention during the year are the determination of moisture, reducing sugars, and sulphur dioxide.

(*d*) *Investigations in Commercial Plants.*—The main work has been concerned with the operation of dehydrators. This has involved air-flow, temperature, and weight loss measurements. The Division of Aeronautics has co-operated in this work.

(*e*) *Revision of Brochure.*—Work on the revision and enlargement of the brochure on the dehydration of vegetables issued in December, 1942, has been proceeding for some time, and it is expected that a number of sections will be issued shortly.

(iii) *Dehydrated Meat.*—Experiments have been carried out on various methods of pressure cooking of mutton for dehydration. Trial runs have also been made on the processing of boned-out carcasses. This work has been combined with a study of the suitability of different grades of carcass for dehydration. The quality of the products has been assessed on the basis of palatability and suitability for compression. The use of certain anti-oxidants to retard deterioration in storage has been studied. The use of electrical moisture meters for the determination of the moisture content of the product has been studied in collaboration with the Physics Section.

(iv) *Dehydrated Egg.*—Experimental runs with a small spray drier have been carried out in co-operation with the Physics Section. Various chemical methods for determining the quality of dried egg powder have been investigated with a view to improving their precision and obtaining a better correlation with palatability scores. The use of electrical moisture meters for the determination of the moisture content of dried egg has been studied in collaboration with the Physics Section.

5. Microbiological Investigations.

(i) *General.*—Work on canned foods continues to be the major activity of the Microbiology Section. For the first half of the year routine examinations of canned food submitted by the Controller of Defence Foodstuffs were continued, but these examinations have since been taken over by the laboratories of the Department of Commerce. Consequently, more time has been made available for the prosecution of research on canning problems and work on several such projects is now in progress. During the year instruction in the methods for the bacteriological examination of canned foods was given to visitors from all States, and lectures and demonstrations were also given to an Army School in food technology. Little further work has been done on the storage of shell eggs, but studies on the variations in quality of Australian egg pulp were continued in several States.

(ii) *Egg Investigations.*—(*a*) *Shell Eggs.*—The only experiments on shell eggs were made in co-operation with four producers in New South Wales. The regular addition of disinfectants to the cleaning machines was tested on the farms in an attempt to discover the most suitable concentration for controlling rotting in the stored eggs. While significant reduction

in wastage was achieved on all four farms, the minimum concentration found to be effective was not considered suitable for widespread use by producers. Further attempts to improve the efficiency of the method are contemplated. A report on shell egg investigations over the past five years is being prepared for publication.

(*b*) *Egg Pulp Bacteriology* (*Melbourne*).—Studies on the bacterial contents of egg pulp were extended to plants in the four principal egg-producing States. The results of these trials showed that the resazurin reductase test, which was developed for egg pulp in these laboratories, affords a simple and rapid method which is reliable for assessing the bacteriological quality of Australian egg pulp.

Representative strains of bacteria isolated from eggs have been studied in some detail to determine their ability to reduce resazurin. Some types of organisms have much greater reducing activities than others, but none of the cultures studied showed reducing activities as great as the mixture of organisms present in commercial pulp samples. Arrangements have been made for the test to be introduced at pulping plants during the coming season and it may be expected that this will facilitate general improvement of quality in Australian egg pulp.

(iii) *Canning Bacteriology.*—(*a*) *Examination of Canned Foods.*—This work continues to make heavy demands on the resources of the laboratory, the number of cans examined being within 5 per cent. of the number tested last year. The position has been eased during the latter half of the year by the routine examinations passing to other laboratories. However, a considerable number of problems of spoilage or suspected spoilage continue to be submitted by various government departments and processing firms.

(*b*) *Clostridium botulinum Experiments.*—Work has been continued on *Cl. botulinum* which constitutes the most important health hazard in inadequately processed canned foods. Several strains of the organism have been isolated from Australian soils, including some of type A which was not previously known to occur in this country. The resistance to heat of the spores has been studied. None of the Australian strains isolated produces spores of such high resistance as has been found in California.

In the course of studies on the growth of these organisms in canned vegetables, it was found that some vegetables dissolved sufficient tin from the unlacquered tin plate container to inhibit the growth of the organisms. When the dissolution of tin was retarded by the use of internal lacquers growth always occurred. As many products are packed in unlacquered containers, this finding is of considerable importance in canning investigations. The results of experiments with beetroot and carrots have been published in the Council's Journal (Vol. 17, pp. 16-22, 1944), and further studies on other vegetables and on the mechanism of inhibition are now in progress. An investigation of the destruction of botulinum toxin by heat has been commenced.

(*c*) *Heat Resistance of Bacterial Spores.*—During the past year the full time of one investigator has been applied to this work which is of vital importance in determining adequate heat processes for canned foods. It was discovered that for many types of spores, including those of *Cl. botulinum* there was a definite interaction between the nutritive requirements of the spores and the amount of heating to which they had been exposed. This finding stressed the importance of using media which would be reliable for determining the true number of spores which survive various periods of heating. The preparation of media adequate in this respect has proved more difficult than was expected, and it was time before it was found that the addition of small amounts of starch was important. It is believed that a firm basis for these studies is now in sight, and some useful results should be available during the forthcoming year.

6. Fruit Storage and Dried Tree Fruits Investigations.

Experiments on the storage of fresh and dried fruits have been carried out in conjunction with the New South Wales Department of Agriculture.

(i) *Skin Coatings for Apples.*—During 1943 further experiments were conducted on the use of skin coatings for increasing the storage life of apples in unrefrigerated storage and also in cool storage. The coatings used were emulsions of various oils and waxes and a solution of castor oil and shellac in alcohol. Experiments at Orange indicated that fruit of commercial picking maturity gave the best results after treatment; less mature fruit was lacking in flavour, and more mature fruit was more susceptible to mould and skin disorders.

The solution of castor oil and shellac was generally the most effective treatment for all varieties, although it sometimes caused lenticel spotting and the development of abnormal alcoholic flavours. Wax emulsions were most effective in controlling weight loss but caused injury to the calyx of the fruit and were not as effective as oil emulsions in controlling colour changes.

Effective treatments considerably increased the storage life of Jonathan, Delicious, Granny Smith, and Democrat apples in unrefrigerated storage and reduced the incidence of Jonathan Spot and other senescent disorders in cool storage. Wrapping alternate layers of Granny Smith apples in oiled wraps was the only way in which superficial scald could be completely controlled, but its incidence was considerably reduced by treating the apples with an emulsion of peanut oil prior to cool storage. The injurious effects which are sometimes caused by treating fruit with emulsions have been largely due to the concentration and nature of the emulsifier. During 1944 attention has been directed to emulsions prepared with low concentrations of oleic acid soaps and with other emulsifying agents. Satisfactory wax and oil emulsions which appear to be non-toxic have been prepared and good control of wilting and colour has been obtained with an emulsion of a viscous medicinal paraffin oil. Storage experiments are being conducted with the various varieties and the effect of skin coatings is being compared with that of gas storage.

(ii) *Skin Coatings for Vegetables.*—Certain wax emulsions reduced weight loss in vegetables by approximately 50 per cent., and further experiments are being conducted to determine their effect on changes in nutritive value.

(iii) *Dehydrated Apple Rings.*—Dehydrated apple rings prepared from Sturmer Pippin apples grown in Tasmania were sulphured by dipping in solutions of sodium metabisulphite, and dried in a tunnel dehydrator. Samples ranging in moisture content from 3-25 per cent. and in sulphur dioxide concentration from 500 to 2,000 parts per million were prepared and stored in sealed lacquered cans at 65°, 86°, and 98° F.

There was a gradual fall in sulphur dioxide content during storage until a minimum value was reached when the fruit developed a light brown colour and a burnt caramelized flavour. The rate of loss of sulphur dioxide was increased 2-2.5 times when the storage temperature was increased by 10° C. The storage life of the apple rings measured by the time taken to develop a light brown colour was the same over the range 15-25 per cent. moisture, but was considerably increased when the initial water content was reduced to 10 per cent. or lower. The storage life showed a direct relationship to the initial sulphur dioxide concentration.

Under the present specifications the moisture content of dried apples is fixed at 18 per cent., and to obtain a reasonable storage life under tropical conditions, fruit of this moisture content should contain from 2000-4000 parts of sulphur dioxide per million at the time of packing.

For various reasons the major portion of Australia's dried apples have a low residual sulphur dioxide content after drying, and resulphuring is necessary. Various methods of resulphuring dried apples were investigated and dusting with sodium metabisulphite seemed to give the most satisfactory results. This method is now being used commercially.

(iv) *Improved Methods of Dehydrating Pears, Apricots, and Peaches.*—(*a*) *General.*—Pears, apricots, and peaches are usually sun-dried, because in the past the dehydrated product was dull in appearance, of poor colour and texture, and commanded a lower price than the sun-dried. It was generally contended that exposure to the sun was necessary to fix the colour, but recent experiments in North America, confirmed by experiments at Homebush, have shown that dehydrated fruits at least equal and sometimes superior to the sun-dried in colour and texture can be obtained by steam blanching the fruit prior to sulphuring. The fruit is blanched until it is cooked through and the time of blanching is longer than is necessary to inactivate the oxidase systems. The blanching treatment reduces sulphuring and drying times, overcomes case hardening, and thus allows drying to be carried out at higher temperatures. The blanched fruit is translucent in appearance and of bright colour while the unblanched fruit is opaque and of poor colour.

(*b*) *Pears.*—There are limited facilities for shipping pears from Tasmania to the mainland, and dehydration would conserve fruit which would otherwise be wasted. At the request of the Commonwealth Food Controller experiments were carried out to determine methods for producing a satisfactory dehydrated product in a reasonable time. In the past, pears have been dried in halves, the process of sulphuring and dehydration took two to three days, and the product was inferior to sun dried. An attractive product of 10-12 per cent. moisture, golden in colour, translucent in appearance, and of good flavour has been obtained by blanching and sulphuring slices of $\frac{3}{8}$ inch thickness and drying for six hours at 165°-145° F. The slices were exposed to fumes of burning sulphur for one to two hours, but tests are now being made to determine whether this process could be replaced by the more expeditious method of dipping the slices for a few minutes in solution of sodium metabisulphite. Samples of dehydrated Packham and William pears are being stored at 65°, 86° and 98° F.

(*c*) *Apricots.*—Samples of apricots steam-blanched and sulphured have been dried to an attractive product of 12 per cent. moisture in 14 hours in a tunnel dehydrator at 135°-150° F. Greater amounts of sulphur dioxide were retained in the dried product by steam blanching and also by dipping the fruit in solutions of sodium citrate or sodium metabisulphite prior to sulphuring with fumes of burning sulphur. The effect of moisture and sulphur dioxide content on the storage behaviour of both dehydrated and sun-dried apricots in sealed lacquered cans is being determined at 65°, 86° and 98° F.

(*d*) *Peaches.*—Various peeling, dipping, blanching, and sulphuring treatments have been tried with freestone and clingstone peaches. Steam-blanching reduced the drying time considerably and gave a product of golden apricot colour which reverted to the natural peach colour on reconstitution. Peeled peaches dried faster than unpeeled and cutting the fruit into eighth segments reduced the drying time to 8 hours. Samples of various moisture and sulphur dioxide content have been prepared for storage in sealed lacquered cans at 65°, 86°, and 98° F. and parallel tests are also being conducted on sun-dried material.

7. 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 to collaboration with other Sections on various problems. Advisory work and small investigations on behalf of other government departments and food manufacturers have increased in volume considerably.

(ii) *Substitute Containers.*—Some further measurements, extending the work reported last year, have been carried out. Some baking powders packed in substitute containers for the civilian market have deteriorated seriously in storage as the result of excessive absorption of water vapour from the air. Studies of baking powders have therefore been begun in order to determine the resistance to water vapour transfer required in containers which can be regarded as satisfactory for each of the main types of baking powder made in Australia.

(iii) *Water Relations of Foodstuffs.*—Further measurements have been carried out, mainly for the purpose of interpreting or predicting the behaviour in storage of various proprietary products.

(iv) *Heat Penetration Studies.*—Many measurements of heat penetration into cans of food during retorting have been carried out. Among the products studied were cabbage, potato, silver beet, broccoli, ham and egg, and various meat packs. Measurements of temperature conditions and the rate of heating of material in various types of steam blancher have been carried out.

(v) *Electrical Moisture Meters.*—Studies on promising types of moisture meters for dehydrated products have been continued and the calibrations of some meters being used in egg drying plants have been checked.

(vi) *Spray Drying.*—Considerable modifications have been made in the laboratory spray drier to improve its performance. The drier has been used to prepare samples of various spray-dried products required for storage trials and other experiments.

(vii) *Vegetable Drying.*—A silicia gel unit designed to supply warm dehumidified air to a bin drier for the final stage of drying vegetables has been tested. The Section has co-operated with the Dehydration Section in various projects.

(viii) *Freezing of Fish.*—Some surveys of fish freezing facilities have been carried out on behalf of the Controller of Fisheries.

(ix) *Cooling of a Wet Body.*—Some further investigations of methods for the numerical integration of the equations arising out of this work have been carried out, but it has not been possible to resume experimental work.

IX. FISHERIES INVESTIGATIONS.

1. General.

In the report of the Division of Fisheries for 1942-43 it was stated that a comprehensive survey of the fishing industry had been carried out for the man-power authorities, with the object of suggesting means whereby maximum output could be obtained with the personnel and gear available. Shortly afterwards, the further step was taken of establishing a closer relationship between research and administrative bodies. The staff and resources of the Division were made available as required for service under the Department of War Organization of Industry, and several officers, including the Chief of the Division were seconded to the latter

department on a part-time basis; the Chief now acts as Commonwealth Controller of Fisheries in the department. The chief fisheries administrative officer in each State acts as Deputy Controller for his particular State. The new arrangement can be said to have worked efficiently and to have added to the effective prosecution, under existing circumstances, of the work of both the research and the administrative body.

Developmental activities fostered have been chiefly those of (i) the shark-oil industry, which is of considerable importance for medicinal (vitamin oil) production (ii) the seaweed industry, chiefly that producing agar-agar, a necessary commodity hitherto almost entirely imported from Japan, (iii) the trawling of fish in Tasmanian waters, and (iv) making tests on methods of catching pelagic fish.

A strong publicity policy has been developed in order to reach the trade and fishermen and secure their confidence and co-operation. The *Fisheries Newsletter*, which formerly was a "roneoed" quarterly issued by the Division of Fisheries principally to the trade, is now being printed as a two-monthly issue and sent to all fishermen.

It will be appreciated that there is considerable reciprocal advantage in the programme outlined above —reciprocal, that is, between research on the one hand and administration on the other. A considerable amount of information, which would not otherwise accrue, becomes available to research workers, direct contact is established with all branches of the industry, and the problems of the latter are seen in better perspective, and can be investigated more efficiently as as a result. On the other hand, the technical and biological information arising from research activities permits of a more accurate basis of administration and a realistic approach to proposals for development.

During the past year, officers of the Division were established in Queensland and Victoria in order to supervise investigations in these States. In general, the investigations have been centred on matters relating to production. More fundamental studies, which are of longer term significance, have merely been continued on a minimum maintenance basis.

2. Developmental Work in Tasmania.

The special programme of investigations which was begun in 1942 with the collaboration of the Tasmanian Fisheries Division, and which subsequently involved the co-operation also of private enterprise, was continued and considerably widened in its scope; both demersal (Danish-seine) and pelagic (purse-seine) fishing trials have been featured during the year. This was made possible by the placing in commission of the Tasmanian State experimental vessel *Liawenee* in mid-February, since this vessel, which was built largely at the Council's suggestion, was designed and equipped for both types of fishing; in addition, the privately-owned vessel *Mary* again participated in pelagic fishing trials.

Unfortunately, neither of these vessels was able to attain, in the 1944 pelagic fishing season, even the limited degree of success that was reached in the previous year. As far as the *Liawenee* was concerned, this was due to the unsuitability of the gear employed: It had been thought that a net of a slightly different type, a purse-lampara, might prove more suitable than the standard purse-seine previously employed, and this vessel was provided with one, but in practice it proved substantially inferior to the purse-seine, and work with it was not long continued. As regards the *Mary*, a considerable effort was made with a locally constructed purse-seine rather larger than those employed in the previous year, measuring approximately 180 by 15 fathoms; but several defects were eventually found in its construction and even when these were corrected fish continued to be lost on account of the mesh size employed, which was too large to retain any but the largest fish. It is believed by all associated with the tests that a purse-seine net of approximately the above dimensions (or a little larger), built of netting now known to be the correct mesh-size, would prove quite satisfactory; efforts will therefore be made to procure another net of this type for use next season.

The principal pelagic species sought was the so-called mackerel (*Trachurus novae-zelandiae*), found to be shoaling in its usual abundance during the season in south-east Tasmanian waters. Indeed, from observations made during this year, it now appears that the season extends from February, not March, to June; within this period mackerel shoals are liable to be encountered, on an average, on about two days in seven, and under good fishing conditions on about one day in five, which level of abundance would provide reasonable scope for a payable fishery.

Observations upon sprats (*Clupea bassensis*), the other principal pelagic fish of these waters, were scanty and inconclusive, as most of the effort this season was concentrated upon mackerel, which now appears potentially much more important.

However, with regard to the demersal fishing trials, a notable success was achieved, the existence of payable trawling grounds in south-eastern Tasmanian waters being demonstrated for the first time; the grounds had actually been partly prospected some years earlier, but the indications were then that they were not suitable for commercial fishing. Over the whole period of about twelve weeks (ranging from late February to mid-June, with some interruptions for pelagic fishing trials) for which the *Liawenee* was Danish-seining under commercial fishing conditions, her average catch of marketable fish was 18.4 cwt. per day's absence from port—a quite payable rate of catch. During the earlier part of this period the daily average was substantially higher. The principal species taken was king flathead (*Neoplatycephalus* sp.), which is the same as, or very closely related to, the tiger flathead of New South Wales trawl fishery. Naturally, it will be necessary to observe the rate of catch over the whole of the year before any final assessment of the potentialities of this class of fishing in these waters can be made. It is possible that the grounds will prove to be limited in extent.

Progress in these special Tasmanian investigations, for the period 1942-43, with some discussion of pelagic fishing generally, was reported in a paper published in the Council's Journal (vol. 16, p. 266, 1943).

3. Investigations in Western Australia.

A Western Australian branch of the Division was established in May, 1943. Little is known of Western Australian oceanic conditions. Existing information on ocean currents is ambiguous, many maps are misleading, and virtually nothing is known of hydrographical conditions. A survey of the fisheries and marine conditions on the west coast, on lines conducted in eastern Australia by the Division, was an obvious necessity since (*a*) the existent industry is a very small one, (*b*) the area is a large one and has an extensive shelf to the north-west, and (*c*) practically no real fishing, or ancillary, investigations have been carried out hitherto.

Obviously, owing to the war, only slender resources are at present available for this survey, which would hardly have been possible at this stage in any form whatever had it not been for the active co-operation extended by the State Fisheries Department, which is providing the use of its boats and personnel, as well as office accommodation. A laboratory has been made available by the Institute of Agriculture of the University of Western Australia, and a research room by

the Trustees of the Western Australian Museum. Valuable co-operation in the Division's work has been afforded by Miss A. M. Baird and Mr. G. Smith, of the Department of Botany.

Boat facilities have been a problem, particularly in connexion with marine work. The State Fisheries Department has provided boat facilities at Fremantle, the Swan River, Mandurah, and Geraldton, the 35-ft. launch *Kooruldhoo* being used on the monthly hydrographic surveys of the Swan River estuary. The Royal Australian Navy is permitting the use of a lugger at Geraldton for the survey of the waters to the Abrolhos and a patrol launch at Bunbury. The Harbour Master at Albany has made available the pilot boat for quarterly surveys. At other places fishermen and private owners have assisted with their craft, and a launch was specially hired for the shark survey at Esperance in January and February, 1944.

4. Biological Investigations.

(i) *Tuna.*—So far, out of the twelve species of tuna known to occur in Australian waters, the following have been recorded from Western Australia:—(1) Southern bluefin, *Thunnus maccoyii*—the common southern species, ranging from South Australia; (2) northern tuna, *Kishinoella tonggol*—the common northern tuna, extending south to about Fremantle; (3) yellowfin tuna, *Neothunnus macropterus*—so far recorded only sparingly along the west coast, but apparently commoner than in eastern Australia; (4) mackerfel tuna, *Euthynnus alletteratus*—on the north-west coast—status uncertain; (5) frigate mackerel, *Auxis thazard*; leaping bonito, *Cybiosarda elegans*; oriental bonito, *Sarda orientalis*—the last three species mentioned occur on the south-west coast, but are apparently not very common.

Only the first two can be regarded as of potential commercial importance, with perhaps the next two as possibilities in the northern regions. The oriental bonito has been recorded to the Australian fish fauna for the first time. There is no evidence that the striped tuna or the albacore occur in Western Australia.

(1) *Southern Bluefin Tuna.*—(*a*) *Western Australia.*—Knowledge of the life history of this fish, based on eastern States work, permitted the tracking down of the life cycle to the stage when the fish were nearly two years of age (1+ stage). No younger fish had been found. Investigations in Western Australia have added a further year to knowledge of the species, presumably to within a few months of spawning. In the winter months (June and July) large numbers of O+ fish averaging about 3 lb. occur in the Albany district feeding on the pilchard schools. In February, 1944, a specimen was caught at Bunbury weighing 1½ lb. and measuring 13¼ inches in length, the smallest known individual of the species. This fish must have been the progeny of the previous season's spawning. Large numbers were reported as being seen in the district. During the summer very few of the large sexually mature tuna were reported in Albany harbour.

(*b*) *Eastern Australia.*—Following on a very poor southern bluefin season in the spring of 1942, the season of 1943 opened in a very promising manner. On 11th September, several tuna were caught near Botany Bay (III-group), and further catches and sight observations were reported. The following month only II-group fish were being caught at Sydney, and they showed the phenomenon of retarded growth during the previous growing season (summer of 1942-43). These tuna continued to be reported in the Sydney areas until early November.

These observations are significant in relation to the subject of fluctuations in tuna and other pelagic fish in which the Division has been particularly concerned over the past several years. Its previous tuna work has shown there is a distinct correlation between tuna abundance and the extent to which they migrate north along the New South Wales coastline in spring. Only once since 1938 did the southern bluefin travel as far north as Sydney; this was in the spring of 1939, the best tuna-fishing season experienced in the period. Unfortunately, it was not possible to follow out the progress of the current season further down the coast, owing to lack of boats; nor was any attempt made to catch fish for the canneries.

A remarkable feature was the absence of reports of any catches of I-group tuna (averaging about 6 lb. at this period) either at Sydney or further south. However, the group was later reported in Victorian waters at the normal time.

(*c*) *South Australia.*—As in previous years a sampling of tuna populations in South Australia and an assessment of the conditions was made with the co-operation of local fishermen. Generally speaking, a good tuna season was apparent. All the usual age-groups were represented in the catches measured, together with a larger proportion than normal of large fish (between 60 and 92 lb.).

(2) *Northern Tuna.*—(*a*) *Western Australia.*—Biological observations have been made on specimens taken in Sharks Bay and off Geraldton. Many and continuous shoals were observed from the air in the winter months along the north-west coast, and some were photographed. Corroborative evidence of the regular presence of these shoals in the winter months was obtained from observers in ships.

The value of these observations lies in the fact that this species of tuna is characterized by the quietness of the shoals which permit easy netting (see *J. Coun. Sci. Ind. Res., vol.* 15, p. 94, 1942). Further, during the season of occurrence of these shoals, the sea conditions are reasonably calm for periods, enabling the use of purse seines—conditions which are not met with in south-east Australia. This seems to be the most promising portion of Australia for the use of large purse seines under open ocean conditions. From observations made the live bait position seems promising.

(*b*) *Eastern Australia.*—The autumn occurrences of northern tuna (see *J. Coun. Sci. Ind. Res.*, Vol. 15, p. 94, 1942) were again evident during 1944, and quantities were netted on the coast of New South Wales.

(ii) *Mackerel and Pilchards.*—During the early winter of 1943, extensive shoals of these species, notably the former (the true mackerel, *Scomber australasicus,* cf. the Tasmanian species mentioned above) were observed in the Geographe Bay area and on the south coast. There is reason to believe (cf. paragraph on sea-bird fluctuations) that there is less yearly fluctuation in marine conditions off south-west Australia than obtains in south-east Australia, but the capture of the fish in commercial quantities is rendered difficult by the weather and sea conditions and lack of shelter along the coast.

A beginning was made upon a special study of the pilchard (*Sardinops neopilchardus*) and anchovy (*Engraulis australis*) in Port Phillip Bay, with a view to evaluating fully the possibilities of this area (on the face of it one of the best) as a source of live bait for tuna fishing. However, for various reasons, it was impossible to carry this study much beyond the biological examination of market samples. It is hoped to be able to make a vessel available next season to make direct observations of shoals at sea and test various forms of fishing gear upon them.

The results of the tuna live-bait fishing experiments of the *Warreen* were published in the Council's Journal (Vol. 17, p. 59, 1944).

(iii) *Pelagic Fish.*—(*a*) *General.*—The results of the observations upon shoals of all principal pelagic species (tunas, pilchards, sprats, mackerel, salmon, &c.) made by the *Warreen* and other research vessels in the prinicpal areas of the south-east Australian seas, from 1938 to 1943 inclusive, were compiled with a view to obtaining information as to the optimum season for each species in each area, the general level of abundance within that season, and yearly fluctuations of that level; this was largely with a view to facilitating developmental work upon these types. Some of the more interesting conclusions, which can only be tentatively accepted until the data are submitted to more rigorous examination are given in paragraph (*b*) (*c*), and (*d*) below.

(*b*) *Striped Tuna* (*Katsuwonus pelamis*), in north-east Tasmanian waters, are, on the whole, the most frequent species observed, and seem to be fairly constant in abundance from year to year; however, the position for the same species in New South Wales waters is much less satisfactory.

(*c*) "*Mackerel*" (*Trachurus novae-zelandiae*), in south-east Tasmanian waters, are generally less abundant than the tuna mentioned above, though not particularly subject to fluctuations in abundance.

(*d*) *Pilchards* (*Sardinops neopilchardus*), in New South Wales waters, are usually fairly abundant (more so than mackerel) but appear to be subject to some fluctuations in abundance.

(iv) *Perth Herring.*—This is the only species of Western Australian fish which is being canned commercially at present. Prior to the war it had no market value whatever and was regarded as a nuisance by the fishermen. In view of the high degree of palatability of the canned product, equivalent to the imported tinned herrings and pilchards, it is felt that the industry will survive after the war despite overseas competition.

As it is an estuarine species, occurring in the estuaries south to, but not beyond, Wonnerup, the unrestricted exploitation would be hazardous and fears have already been voiced in the State Parliament regarding the status of the species. There is no evidence that depletion is a factor yet, but biological investigations have been set in train to ascertain its life history, &c. An active sampling programme which is designed to give information on growth rates and maturity has been carried out both in the field and in the cannery. Experimental fishing for smaller sizes than are sent to the cannery has been successful in obtaining sizes down to the O-group. Tagging investigations will be instituted as soon as the appliances are received to ascertain the degree of inter-estaurine migration which takes place, &c.

(v) *Shark Investigations.*—In the Western Australian region, longlining and other fishing tests were carried out at Bunbury, Augusta, Albany, Esperance and the Recherche Archipelago, Sharks Bay, the Murchison River, Geraldton, and Houtman's Abrolhos, and reports on results have been submitted at intervals. The existence of a payable fishery off Albany and Esperance was demonstrated.

Data concerning earlier shark fishing ventures in north-western Australia, at Carnarvon, and off Fremantle, are being collected, also current records of the fishery at Bunbury, where most of the sharks are taken. Sharks were also regularly inspected at the Perth markets. Useful information has already been obtained on the kinds and numbers of sharks caught, relative abundance of species, &c. As in Queensland in 1943, some of the commonest sharks in Western Australia were scientifically unnamed, so it was necessary to describe and figure a number of new or little-known species. The Queensland novelties were published by the Linnean Society of New South Wales, the Western Australian ones by the South Australian Museum, Adelaide, and by the Royal Zoological Society, Sydney.

Nine entirely new species of sharks have been discovered in Australia since the inception of these investigations in 1942, and many extensions of range and fresh biological facts have been disclosed concerning the kinds already known. The commonest commercial shark in Western Australia is the slender whaler (*Galeolamna eblis*), one of the new types. The school shark (*Notogaleus rhinophanes*) has now been proved to occur around the south and south-west coasts; this is the species most sought in Victoria for its vitamin-rich liver oil. Another shark, excellent as food, was quite unknown before this year; it is the whiskery shark (*Fur ventralis*), now a feature in the south as well as the Western Australian markets. Gummy sharks in Western Australia are much larger than those of the eastern States. Samples of liver oils of some of the 40 odd different kinds of sharks now known from Western Australia have been submitted for vitamin assay. Complete results are not yet available but some high potency values have been obtained from some of the school sharks.

In New South Wales, Miss E. Pope, by arrangement with the Director of the Australian Museum, continued the examination of sharks taken by the trawlers until pressure of other work and the temporary cessation of trawling terminated her voluntary operations.

Some additional information concerning the eggs, young, and growth of sharks was obtained in various States during the year, and the usual biometric and other observations continued. Some Western Australian sharks were tagged, but no recoveries have been reported.

(*vi*) *Black Bream* (*Roughleyia australis*).—This is an important species (yielding 5-7 per cent. of fish caught in the eastern States) in the catches of inshore fishermen, and work on material collected during the past four years was rounded off during the year by extensive field and market observations; a report has been prepared on the results of all these preliminary researches into the economic biology of the species. Growth rate has been found, on the evidence available, to be very slow as compared with that of other estaurine species of economic importance. In four years a size of only approximately 8 in. is reached, and sexual maturity is usually attained at this size. Growth rate is affected principally by seasonal fluctuations, being little influenced by sex or latitude. Actually, investigations indicate that a much improved yield would result if the bulk of the bream were allowed to reach the age of six years, when the size is about 10 in. If the legal minimum were placed at 10½ in. this end would be accomplished.

Further work, including tagging, is proceeding in order to obtain direct information on migrations, local races, and on spawning behaviour. The Victorian Fisheries and Game Department is co-operating in this work.

(vii) *Mullet Investigations.*—Market measuring at Brisbane has been continued in furtherance of the programme of stock analysis. A brief survey was made of the situation in Western Australia, and plans have been laid for detailed work in that State.

(viii) *Oyster Investigations.*—Routine observational work on reproduction, spat fall, and growth has been maintained. Oyster farming work on a semi-commercial scale has been developed. A concrete tank with reservoir and small subsidiary tanks has been constructed for experimental work in winter mortality, spat fall, growth, and "condition".

(ix) *King Flathead.*—The Tasmanian State experimental vessel *Liawenee* provides accommodation for an officer of the Council, and this has made possible

the initiation of a programme of intensive biological sampling of this fish, which is the principal species taken, in the field. The usual length, age, sex, maturity, feeding, and raciation studies are being made. This work has a potentially important conservational aspect with regard to the existing Australian trawl fisheries.

(x) *Barracouta (Thyrsites atum).*—From observations made upon the fishery and information supplied by persons associated with it, the suggestion has been put forward that the decline in the annual catch in Tasmania which set in about 1929 or thereabouts and has persisted until recently, was due to lessening of demand rather than (as was suggested in some quarters) a scarcity of fish. This problem is to receive further attention.

(xi) *Sea-Bird Fluctuations.*—During the season 1943-44 a census was conducted along Cronulla beach to gather quantitative data regarding the annual mortality of mutton-birds, so characteristic of New South Wales beaches between October and January each year. The mortality varies in extent from year to year, and there is evidence that a heavy mortality coincides with a poor season as far as pelagic fishes are concerned (see *C.S.I.R. Fisheries Newsletter,* Vol. 2, part 2, 1943). A group of voluntary helpers aided in the work, and figures of considerable interest were obtained. Generally, there was a low mortality as compared with the very high one of the previous season.

A similar annual mortality unknown in other parts of southern and western Australia, is evident on the eastern side of the Tasman Sea in New Zealand. This suggests a certain instability in marine conditions in the Tasman Sea area causing the considerable fluctuations which are known in the pelagic fish and bird fauna of this region. The survey is being continued.

(xii) *Aerial Surveys.*—The aerial survey of the pelagic fish resources of Western Australia, which began in December, 1942, was continued during August to November, 1943, and February to May, 1944. As a result of the war flights have been restricted to operational aircraft. Therefore, it has not been possible to plan the present aerial fishery surveys or to maintain regular observations over the whole area throughout the various seasons. Details of the operational flights cannot be given but many were unsuitable for fishery observations, especially in respect to such matters as altitude of the aircraft and the area covered by it.

Unfortunately, facilities were not available during the year 1943-44 to survey such a large portion of the Western Australian coastline as during the previous year. This was especially regrettable in respect to those areas where in May, 1943, very large occurrences of blue mackerel (*Scomber australasicus*), an excellent canning fish, were discovered. It is therefore not possible to say anything about the abundance of this species in 1944.

Tuna were again conspicuous in the areas in which they were observed in the first half of 1943, but the flights unfortunately could not be maintained over a sufficiently long period to determine the seasonal range of these important species. It seems, however, from information obtained from aerial and ground surveys, that the main tuna season in this particular area is likely to extend from autumn to spring, with the peak of occurrence in the winter months. If this is so, it is very fortunate indeed, since the climatic conditions in the particular area at that time are more suitable for fishing operations.

Of especial importance among the other pelagic fish observed are Spanish mackerel. There are probably several species of this genus in the area. These fish, which are of excellent edible quality, appear to be plentiful in the area but it is too early to define their seasonal range. However, they have been observed to occur at the same time as tuna and it is probable that they are also to be found during the summer months.

Large shoals of small herring-like fish have also been observed from the air and from the ground in the tuna area referred to, under conditions which should make their capture fairly easy. The importance of these small fishes as a potential source of live-bait for tuna fishing on a commercial scale cannot be over-estimated, especially since it has been established that the tuna feed freely on them. Specimens of these small fish and of other potentially important pelagic species have been obtained for biological examination and identification.

The flights have also disclosed large areas which should provide rich reef fishing. An opportunity was taken to undertake limited investigations by boat of portion of a certain reef area. The result, together with such information as is available from the sparse civil population and from Service personnel in the area, suggests that rich fishing both for pelagic and demersal species is likely to be met with on a commercial scale.

In some areas covered by the flights, turtles were seen to be very numerous. These include the edible green turtle and also the hawksbill from which the "tortoise-shell" of commerce is obtained. At present these are not being exploited commercially. Flights undertaken over certain parts of the coastline from broadly April to October are also useful for obtaining information on the migrations of whales.

During the flights much evidence, photographic and otherwise, has been obtained about the species and distribution of seabirds, which often provide valuable evidence of the presence of certain species of fish. A search for seaweeds suitable for the manufacture of agar is being made in Western Australia by the Council in conjunction with the State Department of Fisheries. Although it is too early yet to say to what extent the method can be employed, it has proved valuable for locating large deposits of seaweed, especially those washed ashore. Searchers in a boat, when directed to one occurrence, found that portion of it comprises the species of seaweed known to be suitable for agar production. It is possible that the aerial examination of a large bed of such seaweed might disclose the colour and other features necessary for the identification of similar seaweed occurrences elsewhere.

Interest in the aerial observations of pelagic fish in Australia, which began in 1936, has been intensified by reports on the adoption of this method on a commercial scale in other countries. It is known that Japan initiated similar work probably in 1938. According to a film depicting industrial activities in the Union of Soviet Socialist Republics, which was recently shown in Australia, the method is also now being used by Russian fishermen, probably in Northern Pacific waters. Details are also available of recent developments in the United States of America. United States Navy "blimps" are being employed extensively for the spotting of pelagic fish along the west coast of America. Already, marked success has been achieved in the finding of pilchards or sardines off the coast of California, and during the last season the capture of over 14,000 tons of these fish was attributed by the fishermen to the reports received from the "blimps". It is authoritatively reported also that United States Navy personnel are being trained in the technique of spotting fish shoals from the air.

Aerial observations in Western Australia have already disclosed areas of much promise. They will be continued during at least portion of the coming year and might be extended to other localities if facilities are available. It is hoped that after the war, equipment will be available in which to train others in fish-spotting in Australia. The fisheries

resources of some thousands of miles of our coastal waters still await exploration by air or by sea. Recent flights in Catalina flying-boats suggest that aircraft of this or related types would be suitable for long-range surveys and especially for the training of fishery observers. "Blimps" would be very useful indeed for fishery observations because of their relatively low speed.

(xiii) *Poisonous Fishes.*—There have been many inquiries for Bulletin 159 describing poisonous and harmful fishes, and a revised and enlarged report on this subject is being kept up to date in case a second edition is called for. The case of a man being stung by the spines of a butterfish (*Selenotoca multifasciata*) in north-western Australia has been recorded. The fish was not hitherto suspected of being harmful.

(xiv) *List of Western Australian Fishes.*—There is no modern work on, or even list of, the species of this State, which has a fauna of about 650 known species. However, additions are frequently coming to hand and even the commercially utilized fishes are very little known. A preliminary list has been compiled and some new species have been described. The actual fishes referred to by the Western Australian fishermen by various common names have been identified and have been listed towards the proposed catalogue of vernacular names of Australian fishes.

(xv) *General Inquiries and Identifications.*—Fishes from every Australian State, from New Zealand and New Guinea have been submitted for identification, and the information concerning them has been provided to the institutions and individuals inquiring. Many Western Australian fishes have been determined for the first time, and some species from the little-known north-western areas have been identified from specimens and photographs secured during aerial surveys. Drawings of other fishes have been prepared. Collections of fishes, made before the war, at Bali, and Buin, Solomon Islands, were identified for the Australian Museum.

5. Oceanographic Work.

(i) *Hydrology.*—In order to maintain the routine observations on fluctuations in seasonal and annual oceanic conditions, physiochemical data were regularly collected at several fixed points off the coast of New South Wales, at two points in St. Vincent's Gulf, and at a series of points off the Western Australian coast. It is anticipated that similar work will be commenced in Tasmania and Queensland.

Similar work is being carried out in representative estuaries. It is of interest to note that data so far obtained strongly suggest that fluviatile muds have the property of absorbing phosphate. A considerable amount of hydrological work is being carried out in connexion with the Division's oyster culture experiments.

Interesting results are accruing from drift-bottle experiments instituted to afford information on currents in Western Australian waters. Of approximately 800 bottles liberated, about one in every six was recovered within a year. Results so far indicate that the usual cartographic representations of current drift round south-western Australia are misleading. There is a southward flow in winter along the west coast, the flow continuing round Cape Leeuwin and eastwards along the south coast. In summer this is reversed. All the drifts are consistent in the respective seasons, with the exception of certain anomalous results in the Abrolhos Island group.

(ii) *Plankton.*—The study of the floating organisms (much of it the food of fishes) was continued in association with the hydrological programme. It is becoming apparent that a marked seasonal cycle, such as exists in higher latitudes, is not a feature under Australian conditions.

6. Statistical and Economic Investigations.

A complication and analysis of economic data on existing Australian fisheries has been completed, and consideration is being given to the method of publication.

An analysis of the original records of trawlers is proceeding, the primary work being done by means of powers equipment by the Government Statistician. The objects are to provide more exact data for comparison with current and post-war catches, and reliable data for use in the biological study of the fish species caught. The statistician is also making tabulations from original account sales books referring to Queensland and South Australian fishery operations.

An account on the economics of the fishery for Spanish mackerel (*Scomberomorus commerson, S. queenslandicus,* &c.) has been prepared. An analysis of previous whaling activities in Australian waters has been made, and a summary prepared on the biology of whales. This work has been carried out in order to evaluate proposals for the establishment of a national whaling industry in Australia.

The statistics of the fish catch for Tasmania for 1942-43 were compiled and analysed, and a scheme was drawn up for facilitating future compilation and analysis on behalf of the Tasmanian Fisheries Division.

7. Technological Investigations.

(i) *Agar-agar Production from Seaweeds.*—Studies on processing methods have resulted in producing an agar of lower viscosity by raising the pH of the agar liquor after boiling. Seaweed growing on muddy bottoms can be effectively treated by this method, although preliminary washing is necessary to remove as much of the colloidal impurities as possible. Viscosity studies of various agars have been made, and it has been found that agar made from *Hypnea* (probably *musciformis*) has a low setting point and a viscosity comparable with Japanese agar, while that from *Gracilaria confervoides* can be lowered by pH control to a satisfactory degree. Agars from *Eucheuma spinosum* and *Gracilaria lichenoides* have high viscosities. As would be expected from theoretical considerations, filtration of agar sols under pressure is less satisfactory than filtration by suction. This is one of the difficulties that arose on application of laboratory tests to commercial production, as most industrial filters are of the pressure type.

In the field, the Division has co-operated closely with the harvesters in controlling the beds of seaweed and in an advisory capacity. As a result, between 200 and 250 tons of *Glacilaria* were collected in 1943, despite several setbacks. This quantity is sufficient to produce 60-80 tons of agar. The monthly survey of the main areas which was carried out by the Division gave a very useful check on the state of the beds and formed a basis for control of harvesting. Quarterly surveys of the coast between Brisbane and Eden yielded some interesting information on the development and conditions of growth of *Gracilaria confervoides.* These surveys are being continued. Experimental plots have been set out in an endeavour to catch the seaweed spores on various substrates, as direct transplanting methods have so far been unsuccessful.

Preliminary surveys on the Western Australian coast of *Eucheuma spinosum,* which is used in that State for agar manufacture on a small scale, have shown promise, but the difficulties of deep-sea and reef survey work in war-time are great. The work is continuing, however, and beach deposits of commercial importance have been discovered on Pelsart Island.

Three firms are now engaged in producing agar for meat-canning and medical purposes, and *Gracilaria confervoides* is being used directly by certain vinegar and leather manufacturers. *G. confervoides* is also being used as an effective substitute for Irish moss. No bacteriological agar is being produced at the moment, although reports from Australia and Britain on trial batches have been quite favorable.

(ii) *Identification of Seaweeds.*—The necessary taxonomic studies have been continued, these being concentrated on the red seaweeds, among which the agar-producing weeds occur.

(iii) *Shark Spoilage.*—Studies on the production of ammonia from spoiling shark flesh have been continued. It has been found that bacterial contamination of shark muscle is mainly a surface phenomenon, and that the production of ammonia also occurs on the surface, being strongly inhibited by lowering the oxygen tension. The bacteria isolated from shark muscle frequently produce ammonia from protein as well as urea, and it has yet to be decided which is the more important source in shark spoilage. The work so far indicates that careful handling and refrigerated transport will do much to overcome the ammonia problem. The fact that the phenomenon is restricted to surfaces suggests the possibility of using brine dips to reduce bacterial infection. There is still a possibility that some of the ammonia may be produced by enzymes in the shark muscle, and this problem is being investigated.

(iv) *Vitamin-oil Production.*—Assays on vitamin A content on oils from various species of shark were continued during the year.

8. Autumn School.

The second annual school in Oceanography was held in May. In addition to the giving of a course on general oceanographic subjects, experimental work in physiology and biochemistry was carried out. Over 30 students attended; Queensland and Adelaide Universities, as well as Sydney University, were represented.

X. NATIONAL STANDARDS LABORATORY.

1. General.

Activities of the Laboratory have so expanded that existing accommodation is quite inadequate. Approval has been given to the completion of the building, and the Department of the Interior has the design work in hand. The work of the Laboratory has continued to have a purely defence aspect, and investigations have been undertaken on behalf of the services, government departments and industrial organizations.

2. Metrology.

(i) *General.*—As in previous years, the Laboratory has been actively engaged in the examination of gauges, measuring equipment, and machine tools. Production of certain measuring equipment has been supervized; testing machines and accessory equipment have been examined and calibrated; volumetric glassware and weights have been certified; balances have been reconditioned; and work done in barometry and hydrometry. The Laboratory has been represented at meetings of the Scientific Instrument and Optical Panel of the Ordnance Production Directorate, the Optical Panel Advisory to the Secondary Industries Commission of the Ministry of Post-war Reconstruction, and the Standards Association of Australia.

(ii) *Examination of Gauges and Measuring Equipment.*—During the year, over 30,000 gauges were examined. These included large batches of screw gauges and adjustable screw gauges. Advice has been given to manufacturers and, when necessary, their equipment has been set up and tested in their works. Prototypes of instruments have been examined and advice given in improvements of design and manufacture.

Staff has been trained for industrial and departmental establishments. Lectures have been given at the University of Sydney and the Sydney Technical College. Educational visits to the Laboratory have been continued, and have included members of inspection services, educational bodies, and tool-room staffs of industrial organizations.

(iii) *Manufacture of Measuring Equipment.*—During the year, production of measuring equipment such as bench micrometers, small optical projectors, pitch measuring machines, and slip gauges was continued on behalf of the Ministry of Munitions. Experiments in the manufacture of special slip gauges out of Australian steels have proved successful. Difficulties of production of very thin slips were overcome, and these scarce sets are now available. Specialized laboratory equipment and apparatus difficult to obtain from abroad has been designed and manufactured at the Laboratory for other Divisions of the Council.

(iv) *Calibration of Testing Machines.*—The routine examination of test houses, their staffs and their methods, has been continued on behalf of the various inspection authorities. Special tests, visual tests, and calibrations have been carried out, and advice was given for investigations carried out on mechanical engineering problems such as testing of pivot hardness, rubber hardness, the use of high-speed photography in the analysis of rapid mechanical movements, calibration of accelerometers, and Bourdon tube designs.

(v) *Volumetric Glassware.*—Further assistance has been given to manufacturers of volumetric glassware in the calibration and design of production testing equipment and the improvement of the quality of products. Volumetric glassware has been calibrated, certified, and special investigations have been carried out on matters arising from the design and use of calibration equipment.

(vi) *Mass.*—Demands on this portion of the Section have increased considerably during the year, and service now includes reconditioning and adjustment of balances. Deliveries of standards of mass and balances from abroad are still outstanding, and additional steps have been taken in an endeavour to improve the accuracy of standardization. Demands for standardization of both metric and imperial weights are rapidly increasing.

(vii) *Barometry.*—The inspection services are showing increased demands for examination of pressure testing apparatus, and equipment is being designed to meet these demands.

(viii) *Hydrometry.*—Investigations on hydrometers have been stimulated by demands of the services and the development of local production.

(ix) *Time.*—Initial equipment for the establishment of a time testing section has been installed, and is functioning satisfactorily. Further apparatus is in course of planning or construction. A method has been developed for separating periodic errors of clock and chronograph.

3. Electrotechnology.

(i) *General.*—During the last twelve months, the main effort of the Electrotechnology Section has again been concentrated on the continuation of the confidential investigations undertaken on behalf of the fighting services. Early in the year, the urgent necessity for the improvement of electrical and radio equipment for use in tropical areas demanded much attention, and since, as mentioned in the last annual report, the responsibility for the co-ordination of this work was delegated to the Electrotechnology Section, action was

taken to provide appropriate research and testing facilities. Tropic-proofing investigations are now well in hand.

In addition, there has been a steady flow of electrical testing work, and a considerable number of miscellaneous investigations have been undertaken. At the same time, the testing facilities of the Section have been slightly extended.

(ii) *Confidential Investigations.* — Two major defence projects in hand for the Army and Navy, together with several minor investigations of a confidential nature, continue to occupy most of the time of the Section.

(iii) *Standardization and Testing.*—(*a*) *Standardization.*—Routine calibrations have been carried out on a number of the Laboratory's direct current and audio frequency instruments. A start has been made on the preparation of drawings for various items of equipment for D.C. and A.C. testing. It is hoped to arrange a programme of design and construction so that testing facilities should be substantially complete in time for the occupation of the proposed building extension.

With regard to the Laboratory standard of inductance, advice has been received from England that, owing to the war, the National Physical Laboratory is not at present in a position to undertake the testing programme. Arrangements have accordingly been made for the equipment to be retained in England until the tests can be carried out, and, on completion of these tests, it will be forwarded to the United States National Bureau of Standards for international comparison before shipment to Australia. In the meantime, a subdivided condenser, which the National Bureau of Standards offered to make available on loan, has been received, and has already been used to check three fixed mica condensers which have hitherto been used as standards. Very good agreement was obtained. It is intended also to send to the Bureau of Standards two of these condensers for calibration there.

A Sullivan tuning fork and multivibrator set on loan to this Laboratory has been returned to Munitions Supply Laboratories, at their request.

(*b*) *Testing.*—The Section has issued 71 formal reports during the year. The items tested comprised mainly D.C. indicating instruments, potentiometers, and resistances, but a number of tests at power frequencies and audio frequency have also been carried out, mainly on indicating instruments and capacitors. In addition, in connexion with the tropic-proofing programme, reports have been issued on the results of investigations of the climatic suitability of radio connecting wires, lacquers and electrical insulating varnishes, and capacitors of both local and overseas manufacture.

At the request of the Superintendent, Munitions Supply Laboratories, tests have been carried out on the cable testing equipment in a large industrial undertaking, with a view to its approval as a Test House, and a formal report has been issued.

A request has been received from the Director of Radio and Signal Supplies, Ministry of Munitions, asking the Laboratory to undertake the calibration of signal generators. Arrangements have been made for suitable equipment to be obtained from abroad, and, in the meantime, the Postmaster-General's Department is prepared to carry on temporarily with this work, as far as available equipment will permit.

Assistance has been given to another Division of the Council in connexion with the measurement of very small interelectrode capacitance of valves. Following a request from an electrical firm for calibration and adjustment of a large permanent magnet, a technique has been developed for the accurate measurement of large magnetic flux.

(iv) *Tropic-proofing Investigations.*—As a result of the decisions made at the conference convened by the Scientific Liaison Bureau in Melbourne on 14th May, 1943, to discuss the deterioration of service equipment in the tropics, this Section accepted responsibility for the co-ordination of work relating to the tropic-proofing of electrical and radio equipment. Evidence of serious deterioration was soon provided by large consignments of electrical and radio equipment and materials returned from New Guinea, and by the findings of a Scientific Mission which visited tropical areas to report on conditions existing there.

To enable suitable testing and research facilities to be established as soon as possible, temporary accommodation was found for a tropic-proofing experimental group, first in the Physics Department of the University of Sydney, and, more recently, in a chemical laboratory in the grounds of St. Andrew's College, University of Sydney. Laboratory equipment, including ovens, mould chambers, a humidity chamber, and a small quantity of electrical testing equipment, has been installed and is operating satisfactorily. Orders for additional electrical testing equipment have been placed overseas.

Considerable progress has been made, but activities hitherto have been restricted by lack of staff and accommodation. The position now is considerably better, and an increasing volume of useful results is being provided for the services. The investigations have been carried out in close co-operation with the fighting services, the Ministry of Munitions, the Standards Association of Australia, the Scientific Liaison Bureau, Munitions Supply Laboratories, the Postmaster-General's Research Laboratories, other Divisions of the Council, and a number of private industries.

The recent appointment of a physicist has made possible the expansion of work on the study of the absorption and diffusion of moisture in materials. The standardization of procedures and equipment for climatic testing is of the greatest importance, and considerable time has been devoted to this project. As a result, it is now possible to prepare tentative recommendations for humidity chambers for qualification and production testing.

To expedite the solution of the immediate problems associated with the use of electrical and radio equipment of present design and construction under tropical conditions, most of the resources established have been devoted to *ad hoc* investigations. These investigations have been undertaken, as far as possible, in accordance with the statement of priorities submitted by the services. Work is proceeding as follows:—(*a*) in the Electrotechnology Section on fixed capacitors, dry batteries, impregnation and sealing of insulating materials and radio frequency coils, dry metallic rectifiers for instruments, connecting wires, electrical indicating instruments, fungicides and electrical insulating varnishes; (*b*) at Munitions Supply Laboratories on the preparation of a specification for electrical insulating varnishes; (*c*) at the Postmaster-General's Research Laboratories on the sealing of transmitter insets for telephones; (*d*) at the Radiophysics Laboratory on the development of vibration testing equipment; (*e*) the Mycological Panel, Sydney (Scientific Liaison Bureau) on the testing of the resistance of electrical materials to mould attack; (*f*) the major radio and electrical industries have been giving very valuable help in a measure determined by their facilities.

Considerable progress has been made on several of these projects, and a number of technical reports have been prepared and circulated. Advice has also been given to service organizations and the Standards Association of Australia in the preparation of specifications for the testing and manufacture of service equipment. Lectures on the tropic-proofing of radio equipment have been given on three occasions.

(v) *Miscellaneous Investigations.*—The Section was represented at a conference convened recently in Melbourne by the Standards Association of Australia to discuss a proposed specification for electrical indicating instruments for the services. Assistance has been given to an electrical firm in tracing the cause of non-linearity in the deflection-current characteristic of electrical indicating instruments manufactured by this company. The construction of an experimental model of a 200-cycle frequency meter for the Department of the Navy has been completed, and the meter has been handed over to the Navy for test. Assistance has been given to a firm concerned in aircraft production, in connexion with the demagnetization of armour plate.

At the request of the Metrology Section of this Laboratory, assistance is being given in the setting up of electrical equipment associated with a high-speed camera. A request has been received for assistance in developing a suitable method for the measurement of the thickness of cast-iron pots which are accessible from the outside only. Preliminary tests are being made, using a D.C. resistance method of measurement. Advice was given to a Sydney firm regarding the checking of frequency stability of electricity mains for certain tests undertaken by this firm. An investigation has been undertaken of the performance of locally produced generator sets for the Royal Australian Air Force. Tests are still in progress.

(vi) *Other Activities.*—A course of four lectures dealing with the electrical transmission of numerical data was delivered to fourth year mechanical and electrical engineering students at Sydney University. A lecture demonstration on the theory of A.C. bridges was given to third year and fourth year students in the Physics Department.

4. Physics.

(i) *General.*—The work of the Physics Section during this year has continued to consist almost entirely of a series of investigations for the services or in connexion with the production of munitions. Many of these have arisen as a result of the Laboratory's association with the Scientific Instruments and Optical Panel of the Ministry of Munitions. At the present most of these investigations are in the special fields of optics, photometry, and heat. Provision has been made in the projected extension of the building for work in acoustics. Plans are also being made to extend the work of the Section to include X-ray diffraction and electron diffraction. It is not expected, however, that these plans will come to fruition for some considerable time.

The Section has been called upon to design and construct numerous instruments for the services and for other divisions of the Council and for Government Departments. The excellent facilities provided by the Laboratory's drawing office and workshops have made this possible. The optical shop in which precision optical components can be constructed has proved, as was anticipated, essential to the Laboratory. The officer in charge of the Section was made a member of the Royal Australian Air Force Flying Personnel Research Committee, and was also nominated as a member of the Advisory Committee on Housing Standards of the Ministry of Post-war Reconstruction to advise on physical problems arising in the work of the Committee.

Some of the more important projects are given below.

(ii) *Heat.*—(*a*) *International Temperature Scale.*—A series of investigations is in progress concerned with the maintenance of the International Temperature Scale. The methods of measuring temperature to this scale are prescribed by the allocation of definite temperatures to a number of fixed points. The methods of interpolation in the range 0° C. to 1063° C. are being investigated. This work has involved the construction of platinum resistance thermometers and an investigation of the effect of the physical constants of the platinum. The completion of this work will make the Laboratory independent of substandard laboratories abroad in the standardization of liquid-in glass thermometers. Somewhat similar work is being carried out on the thermoelectric characteristics of thermocouple wires and their dependence on the physical properties of the metals of which the wires are composed.

Following the setting up of equipment to realize the 1063° C. point on the International Temperature Scale, the Laboratory is now able to maintain the International Temperature Scale without dependence on laboratories abroad. To improve the accuracy of measurements above this temperature, a detailed investigation is being made on the operation of disappearing filament optical pyrometers.

(*b*) *Resistance Clinical Thermometry.*—An investigation, now completed, involved the design of a satisfactory thermometer suitable for anal use, in which temperatures can be read at a distance from the patient. The instrument is of the resistance type in a wheatstone bridge circuit with a meter to indicate the lack of balance of the bridge.

(*c*) *Thermocouple Psychrometers.*—In order to assist in a research project being carried out by another Division of the Council for one of the Services, an instrument involving the use of a series of thermocouples has been developed in the measurement of humidity in the atmosphere from an aircraft. The project has brought to light several interesting features in connexion with the use of thermocouples for psychrometric purposes, particularly in relation to the variation in the response of such an instrument with air speed.

(*d*) *Heat Transfer in Aircraft Engine Radiators.*—Assistance is being given to the Department of Aeronautics, University of Sydney, and the Army Inventions Directorate, in the temperature measurements associated with tests on a new type of radiator. Special assistance was necessary owing to the precision required and the somewhat unusual nature of the measurements to be made.

(*e*) *Viscosity.*—Some investigations have been made on methods of measuring viscosities of emulsions.

(*f*) *Industrial Pyrometry.*—In conjunction with the three Service inspection departments and the Munitions Supply Laboratories, the Section has undertaken the calibration and inspection of pyrometric equipment employed in munitions manufacture in New South Wales. Reports issued have greatly improved industrial facilities for the heat treatment of materials and the maintenance of the accuracy of control equipment. Data collected in this work show promise of yielding information of importance in the design and functioning of industrial furnaces. Officers from the laboratories of firms and other organizations have spent short periods at the Laboratory to receive special training in pyrometry. The Laboratory has given much assistance to the development of local manufacture of pyrometric instruments. These include thermocouple indicators and controllers and radiation pyrometers.

(*g*) *Tests on Australian-made Wooden Aircraft.*—The Section has collaborated with the Division of Forest Products in an investigation of wooden aircraft structures under tropical and Central Australian conditions. This work consisted in measurement of the temperature and humidity in these structures in the field, and included several visits by members of the staff to Northern Queensland and Central Australia for the installation of special equipment.

(iii) *Light.*—(*a*) *Optical Instruments.*—A number of optical instruments have been designed and the components constructed for other Divisions, and the Laboratory has provided the scientific supervision of

the design and manufacture of a number of optical instruments for the Services. These instruments include a naval gun-sighting telescope, photo-elastic apparatus, autocollimating strain gauge, microscope for a toolroom grinder, projection lenses for a gauge projector, and Lummer Brodhun photometer heads. Certain special optical instruments are of interest on account of the application of physical principles in other fields of science. These are a photo-electric turbidimeter which has been designed for the Division of Food Preservation and Transport for measuring the concentration of bacterial suspensions; and a prototype photo-electric haemoglobinometer, at the request of the British Medical Association Haemoglobin Committee, with a view to its eventual use in hospitals. Filters for use with colorimeters used in the measurement of haemoglobin have also been developed.

(*b*) *Optical Glass.*—The testing of all Australian-made glass has been continued, including that for export. Tests of optical glass are necessary to ensure that the glass is optically homogeneous, free from defects such as striae and "seed". Some of these tests require laboratory work of high order of precision.

(*c*) *Photometry and Colorimetry and Radiation.*—Through the co-operation of the National Physical Laboratory, England, and the United States National Bureau of Standards, accurate photometric standards of candle-power and flux are now maintained by the Laboratory for the Commonwealth. Steps have been taken to arrange for the manufacture of substandard lamps and their supply to all photometric laboratories in Australia. The Laboratory has given advice on photometric problems in the standardization of fluorescent lamps.

During the year, the facilities of the Laboratory for photometric and colorimetric investigations have been applied to a large number of problems for the Services. Among these are the preparation of a specification for aircraft signal lights for the Department of Air, the production of limit glasses to control their manufacture, the development of two types of photo-electric tricolorimeter, the supervision of the testing of fluorescent lamps, design and construction of equipment for the measurement of colour and gloss of opaque materials, and for very low intensity measurements.

(*d*) *Glare.*—The cause of severe visual fatigue experienced among operatives installing aluminium foil for the heat insulation of ships was found and a simple solution provided.

(*e*) *Dark Adaptation.*—Further work in this field has been undertaken and the Laboratory-designed adaptometer is being used in the Services.

(*f*) *Visual Problems.*—Applications of the physics of vision and illumination have been made in numerous problems in the Services and in industry. (1) *Anti-aircraft spotters' goggles:*—Considerable assistance has been given to firms undertaking the production of these goggles, which were developed at the Laboratory for protecting the eyes of anti-aircraft spotters and enabling them to see aircraft in the neighbourhood of the sun. The methods involve the fusion of two glasses of differing optical densities. The demand for these goggles has now extended to other branches of the Services. (2) *Welders' eye protective glasses:*—Following on investigations at the Laboratory concerning the present position of the welding glasses, a draft specification has been drawn up by the Standards Association for welders' goggles, these including glasses for gas welding, electric welding, welding of aluminium, and for welders' assistants. The Laboratory's recommendations have been accepted in this work. Work has also been carried out on the additional protection against impact afforded by glasses toughened in Australia and normal overseas products.

(*g*) *Lighting of Aircraft Interiors and Aircraft Instruments.*—A report has been prepared by the Laboratory on the relative merits of various methods of illuminating aircraft instruments for use at night, and conclusions reached that the most satisfactory method would be an orange self-luminous paint for important markings. Paint of this type has recently been received at the Laboratory and tests on its efficiency are proceeding.

Assistance has been given on numerous occasions to manufacturers concerning the suitability of various instrument dials for use under red light. In addition tests have been carried out on paints for the interior of aircraft, with a view to providing satisfactory brightness in the day-time, and absence of reflection of light at night.

Photometers made at the Laboratory have been calibrated and issued to Commonwealth Aircraft Corporation Pty. Ltd. and Department of Air for use in the measurement of intensities of red light in aircraft cockpits.

(iv) *Jewel Bearings.*—Due to the very large demand by the Services for electrical indicating instruments, it has been necessary to develop various alternative "jewels" to replace the sapphire jewels normally used for the bearings of such instruments, and now in short supply. This Laboratory was, some two years ago, concerned with the development of a process for the heat moulding of such jewels from pyrex glass, and two firms in Sydney, one of which was operating before the war, are now producing these jewels in quantity. Tests are being carried out on glass jewels, both local and overseas, and on sapphire jewels to determine their relative resistance to shock and vibration, as locally-made glass jewels appear to be slightly inferior to imported glass jewels in this respect, both being markedly inferior to sapphire. Jewels of other types of glass than pyrex are being moulded in the Laboratory for test. An investigation is also being made of the suitability of various oils in reducing the damaging effects of shock and vibration on pivot-jewel combinations.

XI. AERONAUTICAL INVESTIGATIONS.

1. General.

For reasons of national security it is not possible to write a report which adequately covers the work of the Division. In what follows, no details are given of the work described and many projects are not mentioned at all.

It is just over five years since the Chief of the Division arrived in Australia for the purpose of establishing the Division. When viewed with the perspective which another ten or twenty years will bestow, this first five years will probably appear as the period in which the Division acquired the nucleus of its scientific, technical, and administrative staff, acquired or constructed its first items of equipment, trained its staff in the use of this equipment, and raised its output of scientific and developmental work to a considerable magnitude. It is fitting that the Chief of the Division and some others of his scientific officers should now be away in England and the United States of America renewing scientific contacts and making new ones in relation to the latest developments in aeronautics in preparation for still further progress. Following the return of the Chief it is likely that a comprehensive plan for the second five-year period can be laid out.

A notable event during the year was the announcement of the developmental work which has been going on in England for some years on the new form of propulsive unit, the jet engine. This invention is likely to cause very great and far-reaching changes in aeronautics all over the world and should make possible

great increases in speeds and rates of climbs and ultimately, after further work, in fuel economy and range of aircraft.

The Division was visited during the year by Sir Henry Tizard, former Chairman of the British Aeronautical Research Committee. This visit strengthened the liaison between the Division and the British research laboratories, an essential feature for the proper carrying out of aeronautical research work in Australia. The field of aeronautical research still appears to be boundless and is ever-extending. New developments requiring investigation are constantly appearing and it is for such purposes that staff are now overseas seeking acquaintance with the fundamental techniques involved.

The work of the Division falls naturally into two kinds: (1) Assistance to the Royal Australian Air Force, the Australian aircraft industry, and the United States Army Air Force on the immediate problems of manufacture and operation of aircraft. (2) Long-range research on fundamental matters on which future progress will depend. Because of the war, the greatest weight of the Division's work has been thrown on to the first type, the immediate problems, but the long-range research has not been neglected altogether, so that there will be a basis on which to work when this type of research assumes its rightful place after the finish of active hostilities. The Division's staff and facilities are overtaxed in the calls made upon them in the solution of aeronautical problems and in the development of new aircraft equipment. To ensure the most effective use being made of staff and facilities, a committee has been set up representative of the Royal Australian Air Force, the Department of Aircraft Production, and the Division for the purpose of deciding the order of priority for all work required other than that originating in the Division. The work is organized under the four following sections, each the responsibility of an officer-in-charge.

2. Structures and Materials Section.

The full-scale wing testing laboratory has completed the first year of its existence and fully justified its construction in the tests to destruction which it has carried out on various wings and tailplanes for the Royal Australian Air Force and industry. Such tests provide vital information to both designers and operators of aircraft on the strength of the wings when constructed and after certain periods of flying time. Tests of panels representative of parts of new aircraft types have been carried out for the industry, and similar tests have been made on engine mounts to assess their strength. A great volume of work has been done on strength testing of small components, parts and materials of aircraft such as springs, hydraulic hose, steels, textiles, flexible drives, light alloys, spot welds.

Work has continued on the collection of design data on Australian timbers and wooden components for aircraft, and the construction of moulded wood products has been carried further. This latter work has as its object the perfecting of technique in this new form of wood construction. Aircraft flooring designed for maximum strength and minimum weight has been developed, and design information is being collected as part of an Empire-wide scheme to provide designers with the maximum and minimum conditions relative to temperature and moisture content to which wooden aircraft are subject. The application of the latest mathematical methods of the analysis of structures is continuing, and the perfecting of the electric strain gauge as a means of determining loads and stresses in structures is being developed.

On the metallurgy side many investigations have been made into problems relating to corrosion of the airframe and engine parts both in store and in use. For the industry and Department of Civil Aviation, various tests have been made for the purpose of defining reasons for failure of aircraft parts. An investigation is in hand on the copper brazing of joints in steel, as this has promising application in aircraft work. The fabrication of metal parts by the sintering of powdered metals under heat and pressure is also the subject of research work, as such a method will allow parts of complicated shape to be produced without any machining. The salvage of worn engine cylinders by chrome plating gives promise of successful development, and the examination of the properties of Australian aircraft steels has been continued.

3. Aerodynamics Section.

The major work in this section has been in providing assistance to the aircraft industry on the aerodynamics design of new aircraft types and modifications of existing types. The wind tunnel has been engaged almost full-time on this work. In addition, work for the Royal Australian Air Force and United States Army Air Force has been done on the improvement of engine test cells, bombs, towed targets, and rocket projectiles. Work for the Navy on hydrodynamic problems of some of their equipment has also been done. Advice has been given on the flow of air in food dehydration plants.

Theoretical work on the design of fans running in ducts has been carried further and made applicable to the design of compressors for jet propulsion. Compressible fluid flow has been investigated mathematically, and turbulence and boundary layer phenomena analysed. As speeds of aircraft approach that of sound the subject of gasdynamics is coming greatly into prominence. This subject, the theory of which is being studied, deals with the flow of gases at speeds approaching that of sound and takes into account the compression wave which may occur at such speeds.

Work in co-operation with the Royal Australian Air Force on full-scale flight testing continues but has been reduced in quantity. This follows upon the decision made by the Royal Australian Air Force to expand their flight testing establishment into No. 1 Aircraft Performance Unit, after which they indicated that their need for assistance from the Council was reduced. Simultaneously, liaison with the Aeronautics Department of Sydney University has been increased by the establishment there of a small extra-mural team of research workers to investigate in the wind tunnel the stability and control of Australian-designed aircraft.

4. Engines and Fuels Section.

A big programme of engine testing has been carried out during the year on engines varying from 5 to 1,650 horse-power. Captured Japanese engines have been tested for the United States Army Air Force, and the fuel consumption of an Australian-built Twin Wasp has been determined so that maximum range of the Beaufort might be utilized on ocean reconnaissance. Tests have been made of several small stationary engines of 10 horse-power and under, used by the Army and Royal Australian Air Force for driving generators. In one case, by co-operation with the manufacturing firm, considerable improvements were embodied resulting in the engine being able to perform very much more effective service than in its original design.

Information on cooling of an engine intended for installation in a new Australian-designed aircraft was supplied after tests had been done. Carburettor settings have been checked for the Royal Australian Air Force. The problem of excluding dust from aero-engines has been carried further by the construction of equipment for testing air cleaners, and another long-range project is concerned with the development of a rotary valve engine. An exhaust flame damper has been developed

for a Royal Australian Air Force aeroplane, and Japanese and German engine parts and components have been examined and reported on. In addition, large numbers of small tests on oils, greases, spark plugs, hydraulic fluids, &c., have been carried out.

5. Instruments Section.

In addition to doing work at the request of government authorities, this Section designs and constructs special research instruments needed by the other sections. Such work in the past year has included an electro-magnetic balance for a new wind tunnel, a photo-electric shut-off, an electric manometer, a flow-meter, an electro-magnetic fatigue machine, several oscillographs, electric strain gauge equipment, and a hot wire instrument for measurement of turbulence.

The work for government authorities covers the type-testing of instruments such as air-speed indicators, tachometers, pitot heads, flexible drives, temperature gauges and insulating material. In addition, captured Japanese instruments have been analysed and reported on to the Royal Australian Air Force.

XII. INVESTIGATIONS IN INDUSTRIAL CHEMISTRY.

1. General.

Difficulties associated with shortages of man-power and materials continue, but are gradually being overcome. The Chemical Engineering Section is now well equipped to conduct pilot plant work on several processes developed in the Divisional laboratories. Extensions occupied late in 1943 provide laboratory accommodation for control work alongside these pilot plants. With additional workshop space available as the result of re-arrangements in the Division of Aeronautics, the artisan staff has been considerably increased and is now able to serve the scientific staff more effectively.

Advisory work for other government departments and the services continues to occupy a large part of the time of senior officers and, in many instances, has involved investigational work. Industry has been helped in many ways, though there has not yet been established the close liaison that should become a feature of the Division's activities in the post-war period.

The Division now having been in operation for four years, it seems appropriate to examine the considerations upon which its future programme will be based. Up to the present the selection of research projects has been dictated by war-time needs and by the availability of staff and equipment. However, at the instigation of the Executive Committee, the Division has prepared a statement showing in broad terms its proposals for work in the post-war period. These proposals have been approved in general by the Council, but it will be impossible to implement them for some time.

It seems that worth-while projects within the Division's terms of reference as set out in the Annual Report for 1939-40 are not likely to diminish in number or in importance. On the contrary, work must be undertaken in new fields which are not now covered by any other research organizations. More and more the Division will turn to two main types of project; the first of which comprises projects based upon problems common to groups of companies or to numbers of industries. For instance, corrosion problems are met with in most industries and lead to losses of millions of pounds annually: they affect the farmer just as much as the manufacturer. Problems connected with the transfer of gases, liquids, and solids, with filtration, evaporation, and distillation, are common to dozens of industries, and the Division should be able to offer advice and assistance and to use its specialized equipment in their solution. In this category projects will tend to become more fundamental, it being considered that, in general, industry should make provision for solving its domestic problems.

The second type comprises projects based upon raw materials with which Australia is well endowed, and which are not now used or are not being used to best advantage. Agricultural surpluses will also need attention. Such projects will, in general, aim at utilization of specific materials and may involve application of known facts or processes to materials which differ to a greater or less extent from materials already used overseas. Here, also, some fundamental work will be needed. To cite one instance, Australia's deposits of zircon are among the most extensive in the world and it will, therefore, be wise to develop new uses for this mineral and its derivatives. Thus it is desirable to conduct research work on the chemistry of zirconium compounds and on the properties of zirconium metal and its alloys. As the result of long-term work in these fields useful applications are bound to be developed.

As projects of the first type are developed, the closest co-operation will be sought with the technical staffs of the industries. When the Division commenced work on cement, its investigators were able immediately to establish contacts with the technical men of the industry through the existing technical committee of the Cement Manufacturers' Association. Recently, at our suggestion, another important industry, the fellmongering industry, has undertaken to set up technical committees with which our officers will be able to confer. It is hoped that this principle will be applied much more widely in the future.

Experience has shown that quite often representatives of industries based upon chemical processes do not fully appreciate the advantages which may accrue from research work. Unless the industry is well-established and organized, it will probably be best to commence investigations in a small way and to expand operations when the confidence and support of the industry have been won.

Experience shows that individual companies in any given industry face major problems peculiar to themselves besides those which are common to the whole industry, and that in many instances they have not facilities to solve them nor could they easily provide these facilities. Such companies usually realize that they cannot with justification expect these problems to be investigated in the Divisional laboratories at the expense of the country as a whole, and would willingly bear the cost of investigations conducted on their behalf. Whether it would be appropriate, and also practicable, for the Division to provide facilities for work of this class are matters now under consideration.

In the report of the Secondary Industries Testing and Research Committee (1937) it was recommended that testing centres should be organized throughout the Commonwealth. In the field of industrial chemistry it hardly appears that the Council need provide testing services, since the Munitions Supply Laboratories, Customs Laboratories, and State Department laboratories are better equipped for such work. It is considered that the Division should undertake work of this type only if its officers would gain needed experience thereby. Routine analyses for outside bodies are not considered a legitimate activity of the Division. In certain instances where the Division possesses costly equipment not elsewhere available, it should obviously make this available for testing, but it should do this only until such time as suitable equipment is available in one or other of the recognized testing laboratories. On the other hand, development of satisfactory procedures is a legitimate activity of the Division, and it is anticipated that the Standards Association of Australia will frequently call upon it for work of this type.

There will always be need for work on some *ad hoc* problems of special importance or peculiar difficulty. Actually, a limited amount of work of this type is of value to members of a research staff.

The description of the activities of the various sections which follows focuses attention on the work of the scientific and technical officers. The essential part played by the clerical and stores staffs and by the tradesmen and labourers is recorded with appreciation by these officers.

2. Dairy Products Section.

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. Minerals Utilization Section.

The work of this Section has been concerned, chiefly, with a continuation and extension of the investigations listed in the previous annual report. The minerals of Australian origin to which attention has been especially directed are: *chromite, monazite, rutile,* fluorite, bauxite, graphite, pyrolusite, phosphorite, beryl, and lithium ores. The object of the investigations, in each instance, has been to devise appropriate chemical methods for transforming the crude minerals into one or more products acceptable to established industries. At the same time the possibility of devising new industrial uses for certain Australian minerals has been continually kept in mind.

(i) *Chromite.*—Work on this mineral was originally designed to develop a new acid process for the production of chromic acid from chrome iron ore. Chromic acid, being a versatile intermediate, leads to the production of a variety of industrially useful chromium compounds, such as chrome-plating salts, tanning salts, and pigments. Laboratory work has continued on several phases of this project concurrently with the establishment and preliminary trials of a pilot plant, designed and operated by the Chemical Engineering Section. The factors influencing the yields of the several chemical products obtainable by this new process have been defined. The preliminary trials of the pilot plant have indicated no serious departures from the performance expected as a result of the laboratory work.

(ii) *Monazite.*—The early work on this mineral devolved on the preparation of rare earth chlorides in a state suitable for the electrolytic production of ferrocerium pyrophoric alloy. This work has been completed. The method of treatment of the mineral was so designed to admit of a wide variety of cerium and other rare earth derivatives being produced at will. A second investigation had for its object the preparation of cerium group fluorides for incorporation in the cores of searchlight carbons. This investigation has also reached a satisfactory conclusion. The production of mixed cerium group oxides in a form suitable for the polishing of optical glass has also been undertaken. Samples submitted to users have been pronounced satisfactory and further work to perfect this product is contemplated. A pilot plant for the production of cerium group products has been completed by the Chemical Engineering Section and initial tests with this plant have been made. The plant will be capable of producing sufficient cerium oxide polishing powder to cover present Australian requirements of this material, which is in urgent demand and was hitherto imported only with difficulty.

(iii) *Rutile.*—Work on laboratory and pilot plant production of titanium tetrachloride for smoke screens has been completed and the results obtained have led to the adoption of the process for large-scale manufacture of titanium tetrachloride from rutile in Australia. Supplies of titanium tetrachloride have been made available to the Physical Metallurgy Section for the production of titanium metal. Some preliminary work on other potentially useful derivatives of titanium tetrachloride has been carried out.

(iv) *Phosphorite.*—The production of phosphorus oxychloride by chlorination of rock phosphate was brought to a satisfactory conclusion. The material produced was largely used in the synthesis of an important organic drug which could not have otherwise been produced in Australia at the time.

(v) *Bauxite.*—The investigations concerning the suitability of Gippsland bauxite for processing by the Bayer method, for alumina manufacture, have been completed. The results obtained may be considered as a contribution to the data for Australian bauxites in general in the event of the establishment of an aluminium smelting industry.

(vi) *Fluorite.*—Work on the production of synthetic cryolite and certain other industrial fluorine derivatives has been continued. Although primarily undertaken in connexion with the projected Australian aluminium industry, this investigation has a bearing on ceramic enamelling, metallurgical welding, and the production of hydrofluoric acid from Australian fluorite both before and after beneficiation by flotation.

(vii) *Graphite.*—The beneficiation of Australian graphite by combined chemical and physical processes has reached a stage at which the performance of the product in electrical dry cell manufacture can be satisfactorily assessed. Results have been very encouraging.

(viii) *Pyrolusite.*—The investigation concerning chemical treatment of natural pyrolusite ores has been continued, but attention has been directed chiefly to manganese dioxide anode mud. As in the case of graphite, the main objective has been to prepare material acceptable to the electrical dry cell industry in Australia, and close co-operation has been maintained with manufacturers of dry cells. The fundamental aspects of this problem are of general applicability to the natural manganese dioxide ores.

(ix) *Beryl.*—The preparation of beryllium derivatives and beryllium metal by novel methods in this laboratory has demonstrated the limitations imposed on such processes as anhydrous chlorination of some silicate ores, even when the value of by-products is taken into consideration. With these reservations the work was brought to a satisfactory conclusion so far as the original project was concerned.

(x) *Lithium Ores.*—Little opportunity has occurred for extending the work on Australian lithium ores, but the industrial potentialities of some of these minerals have been brought to the notice of users of such materials.

In addition to the investigations outlined above, the section has dealt with a wide variety of inquiries concerning the industrial utilization of Australian minerals.

4. Cement Section.

The work of the Section is carried out with the co-operation and financial support of the Australian Cement Manufacturers' Association, and has been directed chiefly to the following:—

(i) *Expansive Reaction in Concrete.*—The investigations are mainly connected with the presence and functions of the alkali metals, potassium and sodium, in portland cement. This matter has recently become of practical importance owing to the suggestion that the failure of a number of important concrete structures has been due to expansive reaction between certain types of aggregate materials and cements rich in the alkali metals. In order to guard against failures of this type, a widespread investigation of Australian aggregates and cements is being conducted. Apart from certain silicified surface rocks of the arid regions, the

great majority of Australian aggregate materials appear to be sound in this respect. Rapid methods for the detection of expansive reactions in concrete are being investigated.

In attempts to elucidate the problem of expansive reaction the constitution of cement clinkers is being studied by chemical and petrographic methods; cements of carefully controlled composition are being made; the nature of reacting material in set concrete is also being studied. Some attention has been given to the development of suitable analytical and testing methods.

(ii) *Standard Sands for Cement Testing.*—At the request of the Standards Association of Australia, an investigation is being made of Australian sources of supply of standard sand for cement testing. This is due to war-time difficulties in obtaining large supplies of standard sand from abroad.

5. Biochemistry Section.

The chief investigations have been concerned with fellmongery, and industrial fermentations, but some work has also been carried out on water vapour permeability and on rot-proofing.

(i) *Fellmongering . Investigations.* — (*a*) *Composition of Sheepskin.*—It has been found that the moisture content and fat content of fresh sheepskin vary widely from skin to skin, and that the lecithin content falls to about half its initial value during sweating.

(*b*) *Preservation of Dry Sheepskins.*—The effectiveness of spraying with 0.2 per cent. sodium trichlorphenate to prevent mould growth on sheepskins was demonstrated in the laboratory. Its value has now been confirmed on an industrial scale. The trichlorphenate is incorporated in the sodium arsenite solution which is sprayed on dried sheepskins for protection against "weevil" damaging during long storage.

(*c*) *Soaking of Sheepskins.*—Soaking increases the moisture content of sheepskin and tightens the wool slightly, but it does not delay the loosening of wool during subsequent sweating. The loosening of wool during continuous immersion in water is slower than that occurring during incubation in air. Continuous soaking in low concentrations of acid or alkali retards bacterial loosening of the wool. High concentrations of alkali loosen the wool rapidly, but they also damage the pelt.

(*d*) *The effect of Temperature on Ease of Pulling.*—It has been shown that the pull required to detach wool fibres from fresh or partially-sweated sheepskin is diminished by raising the temperature of the skin.

(*e*) *Distribution of Bacteria along Wool Fibres.*—By counting the number of bacteria on samples cut from the ends and from the middle of wool staples, the relative rates of multiplication on these portions have been determined. Penetration of the bacteria along the wool root has been investigated by plating washings from fragments of fibre cut from near the base of the root.

(*f*) *Studies of Run Pelts.*—The development of a method of counting nematodes on sheepskin has enabled the rates of multiplication of nematodes and bacteria to be compared. This should help in assessing the relative importance of these two organisms in the production of pelt damage.

(*g*) *Ammonia in Relation to Wool Loosening.*—Aerobic conditions are more favorable to the liberation of ammonia than anaerobic conditions of sweating. Attempts are being made to determine whether ammonia, amines, and related compounds play any part in the wool loosening process.

(*h*) *Proteolytic Enzymes.*—The conditions of growth leading to maximum yields of proteolytic enzymes by a mould are being investigated. If the cost of producing the enzymes on a large scale is not excessive, the enzyme may be adopted for the recovery of wool from skin pieces, head pieces, and shanks, with a consequent saving of labour and improvement in the quality of the wool.

(ii) *Rot-proofing of Manufactured Goods.*—It has been learned that following instructions based on recommendations from this laboratory, the Ministry of Munitions has greatly reduced the rate of deterioration of bags used for the transport and storage of gun-cotton. The fungicidal efficiency of the solution previously recommended for the prevention of mould growth on boots during storage, and now being used extensively, has been confirmed.

(iii) *Water Vapour Permeability Investigations.*—(*a*) *Substitute Container Investigations.*—A lap-wound Australian-made substitute container has been rendered highly resistant to the transmission of water vapour by flushing with paraffin wax. These containers are being tested on an industrial scale for the packaging of skim milk powder. If successful they may be substituted for tinplate containers previously employed.

(*b*) *Moisture Barriers for Ordnance Stores.*—Samples of laminated wrapping materials, waxes, and wax mixtures submitted by the Department of the Army have been tested for water vapour and liquid water permeability. The high performance of some of these materials has led to their recommendation as wrapping materials for certain ordnance stores which are being sent to fighting forces in tropical areas.

(iv) *Industrial Fermentations.*—(*a*) *Production of Lactic Acid by Fermentation.*—Further work on lactic acid production from whey comprises a study of the effect of pH value, nutrients, oxygen content, and agitation, on the rate of fermentation.

(*b*) *Production of Butylene Glycol by Fermentation.*—Investigations have been undertaken of the production of butylene glycol from wheat using *Aerobacillus polymyxa*. It has been shown that several of the 90 strains of this bacterium isolated from samples of Australian soil produce higher yields of glycol than imported cultures. Studies are being made of the effect on yield of using mixed strains of *A. polymyxa* and mixtures of *A. polymyxa* with *Aerobacter aerogenes*, and of variables such as the period of autoclaving before inoculation, and additional nutrients in the mash. Conditions affecting bacterial variation are also receiving attention. The glycol is being supplied to the Organic Section for dehydration to butadiene.

(*c*) *Production of Vitamin D by a Mould.*—When exposed to sunlight, the residue obtained after leaching the proteolytic enzyme from a mould culture develops anti-rachitic activity for rats and, to some extent, for chickens. It is estimated that the dry material contains some 16,000 International Units of vitamin D_2 per 100 g. The unextracted residue can be fed to stock or poultry or the vitamin can be recovered by extraction with oil or lipoid solvent.

6. Physical Metallurgy Section.

The work of this section comprised four major projects. In addition to these a number of smaller investigations were carried out at the request of other sections or to assist various government departments and the munitions industry.

(i) *Production of Titanium Powder.*—A method involving the reduction of titanium tetrachloride by means of magnesium was developed and used to produce several pounds of titanium powder. The metal so produced is 98 per cent. pure, but under favourable circumstances a purity exceeding 99 per cent. can be obtained. The 98 per cent. grade has been shown to be entirely satisfactory for gettering electron tubes,

and at least one of the Australian valve manufacturing companies is adopting this method for the supply of their requirements of titanium powder.

(ii) *Siliconizing of Steels.*—This process, which consists essentially in treating steel in the presence of dry chlorine and silicon carbide or ferro-silicon at 900° C., results in the formation of an "acid-proof" silicon-rich skin. The experimental conditions, together with the effects of the contents of carbon and nickel in the steel on the formation of the skin, and the effects of the siliconizing on the dimensions and weight of steels have been investigated. Sufficient is now known of the process to justify trials being conducted by an interested company.

(iii) *Corrosion of Metals in Ethylene Glycol and Glycol-Water Engine-Cooling Mixtures.*—The determination of dissolved oxygen in ethylene glycol and glycol-water mixtures was undertaken as part of a research programme designed to study the vital part played by oxygen in the corrosion process. Although the analytical investigation is still in its early stages, it is evident that the results will be of value both in working out the exact mechanism of the action of oxygen and in developing an inhibitor of corrosion for use in liquid-cooled engines in important military aircraft.

(iv) *Corrosion of Aluminium Alloy Sheet.*—In response to a request by the Department of Aircraft Production, the corrosive deterioration of large tonnages of aluminium alloy sheet of both Australian and American manufacture has been investigated. It was found that the corrosion, which occurred during transport and storage, was primarily due to the access of moisture to the packing cases.

An extensive metallographic study of corroded uncoated sheet demonstrated that much of it would have to be rejected on the ground of having suffered widespread corrosion which had led to deep pitting. In some of the Alclad sheet examined, the aluminium surface layer had not been penetrated, and the sheet was found to be acceptable on American standards. However, a decision on the use of superficially corroded Alclad sheet was deferred pending the development of a reliable test for detecting deep pitting in Alclad materials. A test method was worked out and is undergoing trials to determine whether it is acceptable for general application.

(v) *Protective Coating for Water-Cooled Section of New Wind Tunnel.*—With a view to selecting the best rust-preventive coating for the water-cooled section of a new variable-pressure wind tunnel, intermittent spray corrosion tests were applied to special paints and metal sprayed coatings. The tests led to the recommendation of a multi-layer coating consisting of two layers of sprayed zinc, followed by one layer of a proprietary silicate-base paint.

(vi) *Miscellaneous.*—Information was supplied in reply to numerous inquiries on problems which required no experimental work for their solution. In addition, many minor investigations were undertaken with a view to assisting other government departments as well as private companies with important munitions contracts. The field covered in this service included subjects such as the comparison of zinc foil with aluminium foil for covering and sealing milk bottles, the selection of a special solder for tear-off covers on Army food packs, the specification of impurity limits for low melting point solders, and the testing of proprietary salt mixtures to evaluate their relative merits as heating media for the heat treatment of light alloys. The cracking of tomato pulp cans, the failure of high-speed wood cutters, and the flaking of enamel on welded steel impellers are typical of several cases of service failure, which were submitted for investigation.

The pitting of stainless steel photographic equipment, the corrosion of small arms, the corrosion of the intercylinder baffles of Hercules engines during shipment, and the rusting of soldered petrol tanks are typical examples of the minor corrosion problems which have been solved in short-term investigations.

7. Physical Chemistry Section.

The work of this Section has been directed chiefly to the study of the following:—

(i) *Flotation of Sulphide Minerals.*—Methods have been investigated for reducing the differences in flotation behaviour of oxidized (weathered) and freshly ground ores of sphalerite, galena, chalcopyrite, and pyrites. These differences cause most of the difficulties encountered in flotation practice with ores in which oxidation has occurred. The details of these procedures involving reduction of the oxidation effect by sulphide pre-treatment of the ore or rapid oxidation of all the ore to a uniform state, have been worked out in the laboratory. The results are being applied to synthetic mixtures of sulphides and will then be applied to Australian ores. The behaviour of both freshly ground and oxidized mineral was studied and the soluble products of oxidation were also determined by micro-analytical methods. The flotation behaviour of a number of other sulphide minerals has been investigated by laboratory tests with potassium ethyl xanthate as collector.

(ii) *Flotation of Tin Ore (Cassiterite).*—A provisional patent covering the reagents and conditions for the flotation of cassiterite from its ores has been taken out. Much work has been done with Tasmanian ores and it is hoped to extend the tests to pilot-plant scale.

(iii) *Flotation of King Island Scheelite.*—Flotation tests with scheelite and andradite (a major gangue constituent of King Island scheelite ore) have been conducted in the laboratory in an attempt to find conditions under which these minerals may be separated. Various collectors have been studied, including oleic acid and laurylamine. Conditions of separation in the mine water of King Island, which has a high content of calcium, magnesium, and sodium, have been found, but none of these is regarded as entirely satisfactory for commercial application.

(iv) *Flotation of Beach Sands.*—The flotation behaviour of the constituents of beach sands from New South Wales and Queensland, viz., rutile, ilmenite, monazite, zircon, and cassiterite, are being investigated with a view to their separation.

(v) *Flotation of Fluorite.*—The flotation of fluorite and of the gangue constituents of fluorite ore, mainly quartz and calcite, has been investigated with a wide range of reagents, in an attempt to float the gangue away from the fluorite instead of the more usual practice of floating the fluorite. Reagents other than oleic acid which will float the fluorite from the gangue have also been discovered and tested with encouraging results.

(vi) *Flotation of Graphite.*—By the addition of very small amounts of dilute acid followed by flotation with pine oil, it has been possible to raise the grade of South Australian graphite ores to 80-90 per cent. graphite with recoveries of graphite of 80-90 per cent. Calcite cements gangue to the graphite and the dilute acid attacking the calcite frees the gangue.

(vii) *Flotation of Other Non-sulphide Minerals by Paraffin Chain Salts.*—Investigations of the flotation of minerals such as quartz, calcite, pyrolusite, and topaz have continued with a wide variety of paraffin-chain salts as collectors.

(viii) *Removal of Carbon Deposits from Aeroplane Engine Parts.*—Physical and chemical methods for decarbonizing engine parts—particularly pistons—have

been investigated, and a successful chemical cleaner has been developed which cleans pistons very rapidly. The method is being used in a small plant which is now in operation in Queensland. A method for cleaning valves has also been developed.

(ix) *Molecular Weights of Resins.*—To study the structure of lightly condensed resins prepared by the Organic Section for use in aircraft manufacture, determinations of the molecular weights were required. Methods depending on the lowering of freezing point were unsatisfactory, so an isopiestic method was developed.

(x) *Physico-chemical Properties of Drugs.*—In collaboration with Dr. A. Albert, Sydney, and the Bacteriology School, University of Melbourne, the Section is studying the relationship between the chemotherapeutic value of a series of compounds and certain of their physico-chemical properties.

(xi) *Spectrographic Analyses.*—A wide variety of metals, minerals, and solutions have been examined qualitatively, and in many cases quantitatively, for this and other sections of the Division. Quantitative methods used were the arc, Lundegardt (flame), and Spekker photometric methods.

8. Foundry Sands Section.

The work of this Section has been directed chiefly to surveys of the moulding sands in several of the States, the testing of clays, and the solution of miscellaneous problems submitted by the trade.

(i) *Moulding Sands of Australia.*—Surveys of the moulding sands of several States of Australia have been carried out in collaboration with the respective Mines Departments. The principal pits were visited in each case, and samples were taken and are now undergoing laboratory tests.

(ii) *Testing of Clays.*—Since apparent variations had been recorded in different samples of Wyoming bentonite, tests were undertaken to make certain that these differences were not due to the method of testing. Results show that there was little or no variation in synthetic sands milled from the same sample, and that tests were well within the limits set out in the standard specifications of the American Foundrymen's Association. Further tests showed that the strength of specimens increased rapidly on standing even for 5 to 10 minutes, and it is therefore necessary to break samples immediately the permeability tests are completed.

Tests confirmed that different consignments of Wyoming bentonite showed considerable variation—differences of up to 25 per cent. being obtained. However, lack of complaints regarding Wyoming bentonite indicates that this variation is not sufficient to cause trouble in mouldings. Similar differences in the local material should not be detrimental.

Tests have been carried out on a number of samples of Australian clays to determine their suitability as substitutes for Wyoming bentonite, or as binders for synthetic sands. Some of these have yielded promising results, and it is proposed to carry out complete tests on a number of the better Australian substitutes.

Efforts have been made by the Department of Munitions to reduce the quantities of Wyoming bentonite imported, and foundries in New South Wales are now using a mixture of 50 per cent. Wyoming bentonite and 50 per cent. of New South Wales clays. The Section has been acting in an advisory capacity to the Controller of Materials Supply on technical matters arising in connexion with the use of bentonite and bentonite substitutes in foundries.

(iii) *Miscellaneous.*—An advisory service to foundries has been maintained, and a large number of tests have been carried out in connexion with the solution of problems of individual foundries. In addition, several foundries have been assisted in setting up testing apparatus.

9. Organic Section.

The activities of this Section have been directed chiefly to the preparation on a pilot plant scale of derivatives of ethylene, to the production of furfural, synthetic waxes, and other organic materials, to the study of synthetic resins for the manufacture of compregnated woods and other purposes, and to the investigation of a large number of minor problems directly connected with the war.

(i) *Preparation of Ethylene Chlorohydrin.*—The production of this chemical was undertaken to implement the decision of the Medical Equipment Control Committee to produce in Australia certain drugs for which ethylene chlorhydrin is required as an intermediate. A continuous process has been developed and employed in a large-scale glass apparatus, provided with temperature control, of approximately one-quarter of the capacity of the final commercial plant. The data obtained from it have been considered sufficient to allow the final plant to be constructed.

The same apparatus is being used for the study of the preparation of 2:2′-dichlorodiethylether, a chemical of value as an insecticide and for the production of certain thioplast types of synthetic rubber.

(ii) *Preparation of Ethylene Oxide.*—Numerous silver catalysts are under test to determine their efficiency for catalysing the oxidation of ethylene to ethylene oxide.

(iii) *Furfural and Its Derivatives.*—Pilot plant investigations in collaboration with the Chemical Engineering Section are being conducted on the production of furfural from agricultural waste material. Furfural is in very short supply and a number of companies have shown an interest in those investigations. Laboratory work of a fundamental nature is also being conducted into furfural production.

(iv) *The Analysis of Gaseous Hydrocarbon Mixtures.*—This investigation of the accurate analysis of cracked tar gases is being sponsored by the National Gas Association. The apparatus has now been built and calibrated, the technique mastered, and the first analysis of one of the cracked tar gases was recently completed.

(v) *Isolation of Mannitol.*—Mannitol, which is of increasing commercial importance, is present to the extent of 10 per cent. in the exudate obtained from the tree *Myoporum platycarpum*. During ten months, the exudate from one particular tree contained 9.6 lb. of mannitol. At present the exudate can be obtained only from trees which it is thought have by chance become infected with an organism. The mannitol is isolated from this source quite easily on the laboratory scale. A number of difficulties associated with its large-scale production have yet to be overcome. Likewise it has yet to be determined whether mannitol can be economically produced in this way.

(vi) *Synthetic Waxes.*—The possibility of converting the higher fatty acids which appear as by-products of glycerol manufacture to ketonic waxes has been investigated with successful results. Two processes are available—a batch process on which laboratory work has been completed and for which a pilot plant is being designed, and a continuous process which is still being investigated. The corrosion of metals by ketone wax —fatty acid mixtures is also being studied. Samples of these waxes have been submitted to manufacturers likely to be interested in them, some of whom have indicated ways in which they could be used.

(vii) *Synthetic Resins for the Manufacture of "Compregnated" Woods.*—The Section is collaborating with the Division of Forest Products by producing batches of resin suitable for the manufacture of compregnated woods. Some of this material has been used for the construction of propellers, which have been tested by the De Havilland Company. Advances in the technique of wood treatment made it desirable to retest the effect of the phenol-formaldehyde ratio in the resin and its degree of advancement. A series of resins was made for this purpose.

(viii) *Synthetic Resin Adhesives for Plywood.*—The Section is developing cast phenolic types of resin for use as a cool-setting adhesive. In order to test their efficiency it has been necessary to examine and standardize the condition of applying and curing the glue. When accurate tests have been defined, it will be possible to test the effects of various catalysts, and of ageing, to evaluate the possibilities of the resins as adhesives.

(ix) *Synthetic Resin Adhesives for Improved Wood.*—Two types which have been studied are the resol-aniline formaldehyde adhesives, and the cast phenolics of the type mentioned in the preceding section. Resins have been prepared and are undergoing ageing tests. It is evident that the greatest possibilities lie in the use of the cool-setting cast resins which have given a bond of such strength that failure occurs in the improved wood before failure at the glue line. One of the test blocks for De Havilland's has been glued with a cast resin and tests have now commenced.

(x) *Aniline-Formaldehyde Resins.*—A number of resins differing in the ratios of aniline to formaldehyde have been prepared for use as glues for improved wood and as moulding powders. The mechanical and physical properties of these resins have been determined, and improved processes for the preparation of the resins are now under examination.

(xi) *Testing of Resins and Plastics.*—In addition to moulding materials prepared in the sectional laboratories, moulding powders have been moulded and tested for outside organizations and, in particular, for the Inspection Directorates of the Army and Navy.

(xii) *Analysis of Thioplast Rubber.*—This work, which was undertaken for the Department of Supply and Shipping, has been commenced by determining the percentages of natural rubber or isoprene contained in commercial specimens of the thioplast rubbers. The amount is significant only in the case of thiokol R.D. which is probably not a true thioplast.

(xiii) *Production of Butadiene from 2:3-Butandiol.*—The experimental work so far has shown that little difficulty is to be expected in the pyrolysis of 2:3-butandiacetate to butadiene. The most difficult step lies in the filtration of the fermented liquor and the subsequent isolation from it of the butandiol. Most of the investigation has been concerned with this problem of isolation. A preliminary examination of direct conversion of butandiol to butadiene has been made, but with discouraging results so far.

(xiv) *Rat Poison.*—A rat poison, recently discovered in the United States of America, was prepared for test by the Department of Health and for field tests in New Guinea. This has included working out the details of the preparation, and these have been passed on to a manufacturer of chemicals.

(xv) *Precision Tubing.*—A method has been developed for the production of precision glass tubing by shrinking heated glass tubing by suction on to a chromium-plated mandrel.

(xvi) *Organic Chemicals.*—A number of organic chemicals have been prepared for other organizations or sections for use as flotation re-agents and for other purposes.

(xvii) *Miscellaneous.*—Among a wide variety of problems investigated, many of which were submitted by the services, were, the determination of the properties of a natural rubber occurring in Queensland; the analysis of a specimen of rubber of Japanese origin; the deterioration of the coating composition for braids of electric cables used in the aircraft industry; coatings for propeller blades; slushing compounds for jettison tanks; and the examination of a plastic thimble for X-ray work for the Commonwealth X-ray and Radium Laboratory.

10. Chemical Engineering Section.

The work of this Section has been directed to the pilot plant testing of processes developed in other sections, to the design and installation of small-scale chemical engineering equipment of general utility, the design and construction of equipment for other sections, and the maintenance of all services to the laboratories and the maintenance of the buildings of the Division.

(i) *The Production of Non-felting Woollen Goods by the Freney-Lipson Process.*—Most of the difficulties encountered in operating a semi-commercial pilot plant treating 60 dozen pairs of socks per eight-hour day have been overcome, and the plant is now producing treated socks which the trade is pleased to accept. These large-scale tests will make possible accurate costing of the process and will also reveal difficulties which may only occur during prolonged operation. When these large-scale tests are concluded the process will be demonstrated to interested members of the hosiery trade and other people.

(ii) *Pilot Plant Production of Ethylene from Ethyl Alcohol.*—Experimental work in collaboration with the Organic Section, was completed during the year. The plant is, however, still used to produce ethylene for other investigations.

(iii) *Pilot Plant Production of Chromic Anhydride.*—This investigation was undertaken to test on a pilot plant scale, a new acid process developed by the Minerals Utilization Section for the production of chromic acid from chrome-iron ore. Preliminary trials in the pilot plant have indicated that certain parts of the process are satisfactory; other parts will require extensive investigation before suitable equipment is evolved. In the course of this work, much has been learned about the construction of plants in which concentrated sulphuric acid is used.

(iv) *Pilot Plant Production of Furfural and Purification by Distillation.*—Initially the pilot plant production of furfural was undertaken in collaboration with the Organic Section to supply a small need for furfural for the manufacture of certain synthetic resins. Interest in furfural has since been stimulated in Australia, and the demand for it appears to be steadily growing. The investigation to the present time has been carried out using a digester capable of digesting 60 lb. of oat hulls per batch. Sufficient data have been accumulated to permit the design of a larger digester capable of handling 200 to 250 lb. of oat hulls per batch. An experimental continuous fractionating column capable of producing 10 lb. of furfural per hour has been operated successfully for some time.

(v) *Production of Ethylene Dichloride.*—During the year a small plant for the production of ethylene dichloride was erected and operated successfully for some time. A quantity of ethylene dichloride was supplied to Australian Fish Derivatives Ltd. for solvent extraction purposes.

(vi) *Production of Rare Earth Oxides from Monazite.*—A pilot plant capable of treating 100 lb. of monazite per batch has been constructed, and the initial

tests of the process developed by the Minerals Utilization Section have been made. The mixed cerium group oxides are required as polishing powders for optical glass.

(vii) *Design and Installation of Equipment of General Utility for Investigations into Chemical Engineering Problems.*—Apart from that required for pilot plants, a number of pieces of equipment have been installed for general use in the study of special problems. These include an all-purpose copper distillation unit suitable for the investigation of any distillation problem, a vacuum distillation unit completely lined with acid-resistant enamel, and evaporating pans and jacketed vats lined with acid-resistant enamel.

(viii) *Work for Other Sections.*—Apart from direct pilot plant work, the Section has undertaken the design and the supervision during construction of a great variety of equipment for other sections. Most of this is small, and is manufactured either in the Divisional workshops or by private engineering firms.

Among the major items of this type were an aircraft piston and valve cleaning plant, a rotary cement kiln, experimental rotary furnaces for mineral work, a ketone-wax pilot plant, and rotary and stationary mould fermenters.

11. Alunite Investigations.

Two officers of the Division are working in Perth as members of a team that is engaged on the development of methods for production of useful chemicals from the extensive alunite deposits of Western Australia. The investigations are being carried out under the direction of Professor N. S. Bayliss. Already a process for production of potash fertilizer from alunite has been worked out, and a commercial plant is now in production. Two acid processes for production of high-grade alumina from the alunite residues are being developed. A pilot plant for testing one of the processes on a semi-commercial scale is under construction, while laboratory investigations in connexion with the other process are well advanced.

XIII. LUBRICANTS AND BEARINGS.

1. General.

As in the past the work of the Section has fallen into two main parts. The first is a basic attack on problems associated with friction, lubrication, bearings, and wear, and the second is in the application to more immediate practical problems for the services and for industry. The pressure of work on *ad hoc* problems and the shortage of staff has prevented the more fundamental work from being carried very far. More assistance has been given to industry, but the greater part of the work has been for the Services, and this cannot be described here. Some expansion of the Section has been necessary and it is hoped that in future it will be possible to give more attention to problems associated with Australian industries. The University of Melbourne and the Departments of Chemistry, Physics, Engineering, Mathematics, and Metallurgy are continuing to give active collaboration, and Professor Hartung has made increased space and facilities available in the Department of Chemistry.

2. Lubrication.

Further apparatus and equipment have been constructed for the physical and chemical investigation of lubricants and lubricating oils. A number of investigations have been carried out, particularly on problems of boundary lubrication.

(i) *The Mechanism of Boundary Lubrication.*—According to earlier views the efficacy of a boundary lubricant depends on the degree to which its molecules are orientated on the rubbing surfaces. For example, non-polar molecules which do not orientate themselves on metal surfaces are poor boundary lubricants whilst polar molecules which are highly orientated are, as a rule, good boundary lubricants. Of special interest, in this connexion, are the lubricating properties of long chain fatty acids. These substances are very highly orientated. An extensive investigation has shown, however, that on inactive surfaces such as glass or platinum they are relatively ineffective as boundary lubricants. They lubricate whilst solid but break down at their melting points. Their behaviour is therefore very similar to that of long chain paraffins or thin films of lead or indium which lubricate at temperatures below their melting point.

On more reactive metal surfaces, however, fatty acids maintain their boundary lubricating properties to much higher temperatures. Experiments show that in these cases the breakdown temperature corresponds to the softening point of the metallic soap formed by chemical reaction between the fatty acids and the metal surface. It is evident, therefore, that fatty acids in themselves are poor boundary lubricants; they are effective only if they react with the metal surface to form metallic soaps possessing suitable mechanical properties and high softening points.

These observations have led to a general theory of boundary lubrication. According to this theory boundary lubrication of metals is effected by interposing between the rubbing surfaces a thin solid film, capable of reducing the amount of metallic contact and possessing a relatively low shear strength. Such properties are apparently possessed by thin films of soft metals (such as lead and indium), by waxes, and particularly by metallic soaps of adequate chain length. These soap films maintain their lubricating properties until at elevated temperatures they soften, lose their rigidity, and allow increased metallic seizure to occur, with a corresponding increase in metallic friction and wear. The higher the temperature at which this breakdown occurs the better the boundary lubricating properties of the lubricant. These results and conclusions are of interest both from the fundamental and from the practical point of view.

(ii) *The Action of Extreme Pressure Lubricants.*—The above theory has been extended to a study of the action of extreme pressure lubricants. When the pressure between moving surfaces is high and high temperatures are developed, it is usual to convert the ordinary mineral oil into an extreme pressure lubricant by adding to it compounds containing sulphur, chlorine, or phosphorus, or other active ingredients. Experiments on organic compounds containing sulphur, chlorine, and other active groups have shown that these substances react with the metal surfaces to form protective films which greatly reduce the extent of metallic seizure and hence the friction and wear. The behaviour of these compounds is very specific and depends on the reactivity of the active groups. Certain sulphur, chlorine, and other compounds which have been investigated are able to retain their lubricating properties at very high temperatures. This work has led to the development, in collaboration with others, of extreme pressure lubricants which have performed very satisfactorily in full-scale workshop tests, and are now being widely used. The investigations are being continued.

(iii) *The Lubrication between the Piston Rings and Cylinder Wall of a Running Engine.*—The previous report described a preliminary investigation into the conditions of lubrication between the piston rings and cylinder wall of a running engine. The experimental method consists of an analysis, by a cathode ray technique, of the electrical conductance across the oil film between the moving piston rings and the cylinder wall while the engine is running. This work has been continued.

The results show that metallic contact between the cylinder wall and the piston ring can never be completely eliminated. Even using lubricating oils much heavier than are common in automobile practice intermittent breakdown of the lubricant film occurs. This effect is, in general, more marked in the regions of top and bottom dead centres and probably accounts for the increased wear in those portions of the cylinder. The results also show, as is to be expected, that increasing the engine speed or the viscosity reduces the amount of lubricant breakdown and metallic contact. The most marked effect, however, is that due to temperature. A marked increase in the amount of metallic contact accompanies any increase in the temperature of the oil film on the cylinder wall. This deterioration in lubrication is much greater than can be accounted for simply by the decrease in viscosity due to the temperature rise. It is consistent with earlier observations on the breakdown of lubricants at higher temperatures and is probably due to the desorption of the polar constituents of the oil from the surface.

These observations are of interest from the fundamental and practical point of view. The results also demonstrate the applicability of this method of analysis to problems of cylinder lubrication and abrasive wear, its chief value being its analytical nature and the rapidity with which the results may be obtained as compared with conventional wear tests.

(iv) *Lubricants for the Drawing of Non-ferrous and Ferrous Metals.*—Previous investigations have shown that, apart from their properties as coolants, drawing fluids function mainly as extreme pressure lubricants between the work and the die. High temperatures are readily developed at the surface of the drawn object and it is necessary therefore that the drawing fluid should also maintain its lubricating properties at elevated temperatures. Experiments show that ordinary soap emulsions break down at relatively low temperatures due to the boiling-off of the excess water which disrupts the lubricant film. For this reason these emulsions are suitable only for the simplest and least severe drawing operations of non-ferrous metals. If the soap is applied as a "dry" film, however, experiments show that it maintains its lubricating properties to very high temperatures. Such lubricant films are indeed suitable for a wide range of drawing operation of ferrous and non-ferrous metals, and are now being extensively employed in the drawing of brass cups and tubes.

In certain extreme drawing operations of ferrous metals, however, where the pressures are high and the frictional heat may be excessive, "dry" films of ordinary soap have not proved satisfactory. In conjunction with the oil companies, sulphurized and chlorinated soaps have been developed for use as "dry" films in severe drawing operations of this type. These compounds are now being used successfully in the drawing of steel cups and tubes.

(v) *Lubrication with Metal Films.*—Earlier investigations have shown that thin films of soft metals deposited on a hard substrate may, under appropriate conditions, be very effective as extreme pressure lubricants. The load is taken by the hard substrate, whilst the shearing occurs in the softer metal. As a result, coefficients of friction that are low in comparison with those obtained on lubricated metals may be obtained. Further, under suitable conditions, there is no appreciable contact through the film on to the hard substrate. Experiments have been carried out on the drawing of steel cups using thin films of electro-deposited lead as the lubricant. The results show that with lead films thicker than 0.0001 inches the steel cups draw satisfactorily without the use of any other lubricant or coolant. The surface finish on the drawn cups is also good. It is possible that this type of lubrication may prove of general utility in those drawing operations involving marked deformation of the work and where a good surface is required in the finished article.

(vi) *Examination of Lubricating Oils.*—Chemical analyses and physical tests have been carried out on lubricating oils submitted by the services and others. Experiments have also been carried out on the use of imported bases in lubricating oils with a view to reducing imports. A fluid has also been developed for drilling and slotting optical glass; this has now replaced an imported fluid.

3. Friction and Wear.

Previous reports have described investigations into the physical processes that occur during the wear of metals and other materials. This work has been continued. For this purpose further apparatus has been developed to measure the wear and friction between sliding surfaces under various experimental conditions.

(i) *The Theory of Action of White Metal Bearing Alloys.*—Previous reports have described investigations on a large class of bearing alloys which consist of a hard metal matrix in which are dispersed fine particles of a softer metal (e.g. copper-lead alloys). In these alloys the load is taken by the hard matrix and it was shown that the extrusion and smearing of a thin film of the softer constituent over the harder matrix determines the intrinsic frictional and wear reducing properties of the alloy. This mechanism, however, cannot explain the action of white metal bearing alloys which consist of a soft matrix in which are embedded a number of hard crystals.

The traditional theory is that the load is taken by the hard particles which can sink into the softer matrix and so lead to a more uniform distribution of load over the bearings. On this view the function of the hard particles is to resist wear. Investigations, however, show that in some types of white metal bearing alloys, the hard particles play no appreciable part in the frictional or wear properties of the alloy: the frictional properties may, indeed, be determined essentially by the properties of the matrix. In other types of white metal alloys the hard crystallites may play a larger part, but the experiments suggest that in general these hard particles do not contribute appreciably to the frictional or wear properties of the alloys. These results are of interest both theoretically and practically and may have applications in the development of bearing alloys.

(ii) *The Properties of Lead-base and Tin-base Alloys.*—Owing to the occupation of Malaya by the Japanese there has been a general attempt to conserve tin wherever possible. Large quantities of tin are used in white metal bearing alloys, and experiments were carried out to compare the frictional and wear properties of a typical tin-base alloy with those of a typical lead-base alloy which was proposed as a substitute. The experiments showed that the frictional properties of the lead-base alloy when clean and when lubricated, at room temperature and at elevated temperatures are generally slightly better than those of the corresponding tin-base alloy. Its wear is appreciably heavier, however, when lubrication breaks down completely. Its hardness is also less and its thermal conductivity lower. Apart, therefore, from the question of thermal and mechanical properties which may play a vital part in the practical behaviour of a bearing, the lead-base bearing alloy should, in practice, be at least as satisfactory as the tin-base alloy from the point of view of its frictional behaviour. The experiments indicate, however, that under severe conditions, the rate of wear of the lead-base alloy may be appreciably higher.

Latest information shows that lead-base alloys are being widely adopted in America to replace tin-base alloys and are proving completely satisfactory.

(iii) *The Surface Damage of Sliding Metals.*—A technique has been developed for satisfactorily examining the contours of metal surfaces. The technique consists of cutting a taper section at a very oblique angle to the surface under examination, so that a contour of the surface is obtained with its vertical component magnified about ten times. Comparison between these contours and those obtained with highly specialized instruments for measuring surface finish, shows that this method yields accurate results for surface irregularities as small as 10 millionths of an inch.

This technique has been applied to an investigation of the wear of rubbing metal surfaces, both when clean and when lubricated. The results show that with clean surfaces the metals are torn and highly distorted; there is marked metallic seizure and clear evidence of welding of the surfaces over minute local regions even though the surface temperatures during sliding have been far below the melting point of the metals. In the presence of a good boundary lubricant, however, the surface damage and the amount of seizure and welding are markedly reduced. These results shed considerable light on the mechanism of metallic wear and the boundary lubrication of metal surfaces.

(iv) *Frictional Properties of Aircraft Materials.*—Requests have been received from the American aircraft industry for data on the frictional properties of various alloys used in aircraft. Frictional measurements have been made on a number of materials, and the information has been forwarded to America.

(v) *Wear of Brake Materials.*—Bren gun carriers and Army transport vehicles used in Australian and New Guinea areas, often have to operate under sandy and wet conditions. Experiments in the laboratory have shown that the wear of brake band materials may be greatly increased by the presence of small quantities of water or dust. Investigations have been carried out on the wear properties of brake materials under various running conditions, and the results have enabled the Army to select locally produced brake materials for Army vehicles operating under wet and dusty conditions.

(vi) *Chromium Films for Reducing Wear.*—Earlier work has shown that the wear of metal surfaces may be considerably reduced by plating the surfaces with a thin film of chromium, provided the film exceeds a certain minimum thickness. Further experiments showed that the wear of the chromium film at 240° C. is no higher than that at room temperature. This work has been continued in collaboration with Munitions Supply Laboratories, and recent investigations show that outside a well defined range of plating conditions the chromium deposits have poor wear-resisting properties. Within this range, the wear-resisting properties of chromium are extremely good: its own wear is very small and the wear of the other rubbing surface is also greatly reduced. Further investigations are being carried out on the effect of lubricants on the frictional and wear properties of chromium films.

4. The Development and Manufacture of Aircraft and other Bearings.

The growth of the aircraft industry in Australia has led to an increased demand for locally produced aircraft bearings. The industry has been considerably assisted by the techniques for the manufacture of these and other types of bearings which have been developed by the Section. This work has expanded considerably and has been extended to a number of new bearings involving electrolytic deposition as well as stationary or rotary casting methods. The techniques so developed have been handed on to the services and to the manufacturers. Parallel with this work, the Section has carried out a more basic investigation into the properties of bearing alloys, and the influence of structure on these properties. A study has also been made of the factors responsible for the development of defects in manufacture or failure in service.

The bearing work of the Section is done in association with the Pilot Bearing Annexe of the Department of Aircraft Production, and general application of the work comes under the Bearing Control Committee.

(i) *Structure and Examination of Bearing Alloys.*—Casting conditions have a great effect on the frictional and mechanical properties of bearing alloys. During the last few years a study has been made of the structure of different classes of bearing alloys (particularly the copper-lead alloys) and the influence of composition, casting temperature, atmosphere, and rate of quenching on the porosity, segregation, cracking, and bond strength. By these means it is hoped to specify and standardize more precisely the conditions necessary for the manufacture of successful bearings.

In the course of this investigation it was found necessary to develop special metallographic methods for the examination of the structure of the alloys. This is also important in detecting flaws which may occur in the bonding or in the alloys themselves. A method of polishing and etching various types of lead-copper alloys has been satisfactorily developed and has proved of great value in determining the structure of these alloys, the nature of the bonding, and the causes of failure in bearings which have not proved satisfactory in service. At the request of the services and industry similar examinations have been carried out on other types of bearing alloys, particularly cadmium-nickel alloys used in Army vehicles.

(ii) *White Metal (Babbit) Bearings.*—White metal bearings are used in a very large variety of light duty engines, machinery, &c., and many large engineering workshops manufacture or reline worn bearings themselves. A number of inquiries have been received from time to time for advice in the manufacture of this type of bearing. Following on a specific request from Aeronautical Inspection Directorate for similar information, a report has been prepared and made generally available, describing the accepted sound procedures for manufacturing white metal bearings.

(iii) *Bearing Testing.*—Investigations are being carried out on the performance of bearings under various conditions of load, speed, types of lubricant, &c. The apparatus incorporates a specially designed bearing testing mechanism and equipment for measuring the electrical conductance across the oil film between the journal and the bearing. By means of these electrical measurements the breakdown of the lubricant film and subsequent seizure of journal and bearing may be followed. The conditions responsible for the breakdown and seizure may also be determined.

(iv) *Techniques for Casting Bronzes and Light Metal Alloys.*—The Section has been working in collaboration with the Department of Aircraft Production on the development of simple standard methods for producing satisfactory castings of bronzes and light metal alloys. As these techniques are developed the information is passed on to manufacturers.

5. Thermal Stresses in Metals.

(i) *Bearing Alloys.*—A continuation of the investigation into the surface temperature of sliding metals has confirmed the earlier observations that the local temperature rise may be very high and can lead to the softening and plastic flow of the surface. The heating is, however, confined to the summits of the surface irregularities and to a very thin layer at the surface.

In addition to this localized surface heating, aircraft or other bearings may be subject to a bulk heating and cooling as the engine is accelerated or decelerated. If the bearing alloy is bonded on to a steel shell the difference in the thermal expansion of the steel and the alloy will set up thermal stresses which may under certain conditions lead to plastic deformation and cracking of the bearing alloy. The effect is most pronounced near the bond.

Further investigations have shown that cyclic heating and cooling may produce very marked plastic deformation and subsequent failures of certain types of bearing alloys which are *unattached* to steel. For example, with tin-base bearing alloys, cyclic thermal treatment between 30° and 150° can produce severe deformation after only 20 cycles whereas after 200 cycles the metal is badly disrupted. On the other hand lead-base alloys do not show this type of thermal fatigue. The results indicate that the effect is due in part to the difference in the thermal expansion of the crystalline constituents of the alloy.

(ii) *Pure Metals.*—The investigation has been extended to a study of the behaviour of pure metals under similar conditions. Plastic deformation as shown by the development of slip lines has been detected in the non-cubic metals, tin, cadmium, and zinc, after a very small number of thermal cycles. Grain boundary migration is also observed. Even a single heating and cooling is sufficient to produce deformation lines for cadmium and zinc; on the other hand, no deformation has been detected in the cubic-metal lead even after a large number of cycles. Further experimental work has indicated that this phenomenon is due to the anistropy of thermal expansion, a property of non-cubic metal crystals. The experiments show that on heating and subsequently cooling a polycrystalline non-cubic metal, the crystal grains expand to varying degrees along the different axes and thus set up stresses at the grain boundaries, which may cause plastic deformation of the metal. X-ray photographs show that the lattice distortions produced by the deformation remain in the metal and accumulate as the number of cycles is increased. In some cases recovery occurs after a large number of cycles.

This observation, which is a new one, is of some fundamental interest and has a bearing on the theory of the strength of materials and of the physical properties of metals. The work is still in the early stages but the results suggest that it may have practical applications to the failure of certain metals and alloys in service and may explain some points of difference in the behaviour of lead-base and tin-base bearing metals.

6. The Study of Transient Phenomena.

Electrical and photographic methods have been developed for the experimental investigation of events that occur in a very short interval of time (of the order of millionths of a second). These methods are being applied to the study of transient phenomena associated with friction and impact. They are also being used to investigate explosive reactions and to measure the velocity of rapidly moving projectiles.

(i) *Visual Examination of Hot Spots.*—Earlier experiments have shown that when surfaces rub against each other, very high temperatures may be developed at the minute points of real contact. These results, which were based on thermoelectric measurements showed that even in the presence of the best lubricants and at relatively low loads and speeds, local temperatures of the order of several hundred degrees centigrade may be readily attained. This has been directly demonstrated using a glass disc as one of the rubbing surfaces. The incidence of hot spots may be readily observed through the glass disc at comparatively low loads and speeds, and the experiments show that the lower the thermal conductivity of the second rubbing surface the smaller the load (or speed) necessary to produce visual hot spots. However, if the rubbing surfaces have a melting point below about 550° C. hot spots cannot be observed even under conditions of extreme load and speed. These results show that visual hot spots correspond to temperature flashes of the order of 550° C. Further measurements show that these high temperature flashes may only last for an interval of the order of a few millionths of a second. This work has been extended to a study of the effect of friction on the detonation of explosives.

(ii) *Explosives Reactions.*—A general study is being made of the mechanism of the initiation and propagation of explosive reactions by friction and by impact, using electrical and photographic techniques.

7. Miscellaneous.

Assistance and advice have been given to the Department of Aircraft Production, to Government organizations, and to industry on a variety of problems. A number of minor investigations have been carried out on problems such as the corrosion of bearings, the comparison of new and reclaimed oils, and the removal of lubricant stains. Members of the Section are assisting or are acting on various committees such as the Bearing Control Committee, Committees of the Australian Council for Aeronautics, the Lubrication Sub-committee (Munitions Supply Laboratories), and the Standards Association. There has also been co-operation on a number of problems with Scientific Liaison Bureau, Directorate of Technical Practice, and Munitions Supply Laboratories.

XIV. OTHER INVESTIGATIONS.

1. Dairy Research.

(i) *General.*—The work of the Section has again been devoted chiefly to problems arising out of the war. Particular attention has been given to the keeping quality of dairy products under difficult conditions, and much of the knowledge gained will be of permanent value in improving these products. Close collaboration has been maintained with the Services, Government Departments, and numerous members of the dairy industry. The Section has frequently been consulted on questions relating to dairy products, and sometimes investigational work has had to be undertaken in order to provide the necessary information. Several investigations involving large-scale production of dairy products have been undertaken and this Section is grateful to manufacturers who generously co-operated in such work.

(ii) *Hardened Butter Substitutes.*—The production of what is known as "tropical butter spread", mentioned in last year's report, increased rapidly during the year. Large-scale production introduced manufacturing problems calling for research, and much time was devoted to them. The original product contained 20 per cent. of hydrogenated butterfat in order to raise the melting point of the pure butterfat to about 105° F. Other hardening agents which became available after manufacture commenced were investigated, and fully hydrogenated peanut oil is now being used; 3 per cent. of this gives the required increase in melting point, so that with 1 per cent. of salt and 2 per cent. of skim milk powder, the spread now contains 94 per cent. of pure butterfat. The physical properties of butterfat as influenced by its treatment have been studied and conditions defined which enable a spread to be made which is spreadable at ordinary temperatures but has satisfactory "standing up" properties at temperatures up to its melting point. The method of cooling is vital in

this respect. Experiments with the spread to stimulate the appearance of butter have so far not met with much success. However, water can readily be incorporated in the spread simply by stirring, the milk powder acting as an emulsifying agent. The spread "reconstituted" in this way is practically indistinguishable from butter. Experiments were made with the object of imparting a more definite but essentially "buttery" flavour to the spread. The use of 3 per cent. peanut oil instead of 20 per cent. hydrogenated butterfat effected a distinct improvement in this respect, and an increase in the proportion of salt and milk solids and the addition of a trace of citric acid were beneficial. Stronger and more definite flavours such as those imparted by more than about 1 part per million of diacetyl or traces of butyric acid were not generally favoured.

(iii) *Dry Butterfat.*—Production of dry butterfat during the year was limited to the requirements for the manufacture of "tropical butter spread" or for the salvaging of small quantities of badly deteriorated butter, and little research was done on production problems. Reports received of trial shipments of the butterfat in black iron drums, showed that there was no inherent reason why the drums should not be satisfactory, but when an appreciable head space existed because of leakage or inefficient filling, deterioration of the fat through oxidation was serious.

(iv) *Oxidation of Butterfat.*—When other causes of deterioration, such as bacterial, are eliminated in dairy products containing butterfat, oxidation of the fat which leads to objectionable tallowy flavours assumes great importance. It is the only form of deterioration to which such products as dry butterfat and "tropical butter spread" are susceptible and is of vital importance to the keeping quality of milk powder and butter in cold storage. Considerable work has been done on the problem with particular reference to oxidation in "tropical butter spread" and milk powder. The progress of oxidation and the appearance of "off flavours" in butter-fat appear to have some characteristics which often make inapplicable results obtained with other fats. It has been found that tests accelerated by using high temperatures sometimes give entirely misleading results when applied to the course of the reaction at low temperatures. A substance can act as a pro-oxidant at say 20° C. and as an anti-oxidant at 80° C. Some anti-oxidants which are claimed to be very effective with other animal fats, have been found to have little action with butter-fat and this fat is more susceptible to certain pro-oxidants than other fats. It has been found that quantities of oxygen considerably less than those quoted by some overseas workers are sufficient to produce objectionable tallowy flavours, and experiments are being made to determine the minimum amount which can lead to the fault. The improved test for peroxides in fat of Lips, Chapman, and McFarlane has been further developed and appears to be considerably more sensitive than any previously used. It is now possible to detect incipient oxidation before any change in flavour is apparent. Considerable attention has been paid to the pronounced pro-oxidant effect of the Australian dairy salt used in "tropical butter spread". It has been found that chemically pure salt and several overseas brands of salt do not have this action. The traces of copper and iron present in the salt can only account for a small portion of the effect. The pro-oxidant action can be eliminated by roasting the salt or by washing with certain solvents. Research is continuing with the object of isolating the substance responsible for the action. Salt is known to hasten the oxidation of the fat of butter in cold storage, and experiments have been commenced to determine if this is due to the same cause as the pro-oxidant effect in dry butterfat at room temperature and if it can be eliminated by the same means. After three months storage it would appear that the mechanism of the two oxidations is different, but longer storage is necessary before this can be definitely established.

(v) *Cheese.*—Although tinned process cheese normally keeps well, even under extreme conditions of temperature, several cases of severe deterioration have been investigated by the Section. Examples of gross bacterial deterioration, leading to blowing of the tin and putrid odours, were caused by the development of putrefactive and gas forming sporulating anaerobes. Organisms of the *C. sporogenes* and *C. welchii* types were found in large numbers in affected samples. In every instance where this type of deterioration had occurred, lactose to the order of about 2 per cent. was present in the cheese, presumably owing to the addition of skim milk powder during processing. The same organisms have been isolated from cheese, which did not contain lactose but in no instance had they developed and caused deterioration. The exact part played by lactose in its association with the defect is not clear, but a supposition that it could act both by supporting the development of the organisms and by necessitating lower processing temperatures with a resultant increase in initial infection; it is suggested by the occurrence of another serious defect in cheese containing skim milk powder. An objectionable brown colour developed in a few days when the cheese was subjected to temperatures as high as 120° F. similar to those under Service conditions.

Severe corrosion of the tinplate leading to serious loss has occurred in some instances with processed cheese and has been investigated.

(vi) *Keeping Quality of Milk Powder.*—(*a*) *Compressed Sugar and Full-cream Milk Powder.*—Further observations have confirmed the excellent keeping quality of blocks compressed from a mixture of 80 per cent. whole milk powder and 20 per cent. sugar. Samples kept in the laboratory in unsealed tins for over two years, although they have developed a slight staleness, are still palatable.

(*b*) *Commercial Milk Powders.*—As indicated in last year's report, a preliminary experiment indicated that gas-packed, spray-dried, whole milk powder kept better at elevated temperatures than skim milk powder normally packed in air. This result was rather unexpected, and a more comprehensive survey of the relative keeping qualities of several Victorian brands of roller and spray-dried, whole and skim milk powders packed in air and in nitrogen is now in progress. During the preliminary stages of this experiment, information was also obtained on the efficiency of the present gas-packing techniques in removing the head space oxygen from tins of whole milk powder.

It is obvious that the first requirements for effective gas packing is a gas-tight tin. The products from three firms that supplied gas-packed samples did not fulfil this requirement; of the 26 batches each of 30 tins received, most showed at least 50 per cent. leaking tins.

From storage tests lasting six months at 100° F. the following conclusions have been drawn. The useful life of skim milk powder is not extended by gas packing. Whole milk powders that were not gas packed, deteriorated much faster than skim milk powders, but gas-packed, spray-dried, whole milk powders (3 per cent. oxygen in the head space gas) generally kept better than the skim milk powders. Some samples of reconstituted spray-dried whole milk were no more than slightly stale after six months, whereas the skim milk powders reconstituted with water and fresh butter-fat were generally unusable as liquid milk. A further increase in quality of spray-dried, whole milk powders was noted in samples gas packed to 1 per cent. oxygen in the head-space gas instead of 3 per cent. The roller-dried, whole milk powders examined were generally of poor keeping quality. Even gas-packed samples deteriorated rapidly.

After six months' storage at 84° F. most of the samples were in fair condition and definite conclusions cannot yet be drawn, but in general the trends are similar to those noted for samples stored at 100° F. Samples stored at 60° F. are still in good condition.

(vii) *Lactic Acid from Whey.*—Attention to the fermentation of whey to produce lactic acid has continued. In general it has been found that only slight modification of existing procedures is necessary to ensure successful commercial fermentations, and assistance of this type has been given to one manufacturing firm. Under the most favorable laboratory conditions, the rate of fermentation in whey by lactobacilli has been found to be most erratic, varying at pH 5.0 from 24 to 72 hours. Best results have been achieved by the use of selected mixed strains of lactobacilli. Mixed cultures have not shown superiority under commercial conditions, however, for reasons which are obscure but possibly associated with alterations in the properties of whey stored, handled, and heat-treated in bulk quantities. In the commercial fermentations the problem of contamination has been found to be most important. It has not been found practicable to ferment at the optimum pH owing to the simultaneous development of lactate-consuming contaminants. The latter have been controlled by fermenting under more acid conditions, though in this way fermentation times are increased to about four days.

2. Radio Research Board.

During the year, the work of this Board has been mainly centred in laboratory space made available in the Electrical Engineering School of the University of Sydney. Following a conference of the fighting services and others that was held in Sydney in September, 1942, there has been a considerable increase in the volume and scope of the programme of the Board's work. The results of this work are proving of considerable practical value to the Services, but for security reasons no details can be given. The University of Queensland is now affording helpful co-operation in the running of a field station established in Brisbane. The Mt. Stromlo Observatory, the Watheroo Observatory, and the Melbourne Observatory have also continued to give valuable assistance.

3. Mineragraphic Investigations.

Twenty-four investigations have been carried out into the mineral association of rocks, ores, and mill products submitted by mining companies and institutions, and the majority have been contributive to the search and production of metals required for war purposes. Each investigation was complete in itself and was directed to some problem often concerned with the treatment of the economic mineral in an ore, concentrate, or tailing. Seven investigations were concerned with ores that were subjected to experimental treatment in the ore dressing laboratories, while six dealt with material under investigation by the Mineral Resources Survey at Canberra. One of the latter included a petrological examination of a series of rocks and ores from the Everton molybdenite mine in Victoria. Here the ore consists of molybdenite disseminated through the granitic rock around the margin of a central, barren core of porphyrite, similar in composition but slightly different in texture to the surrounding porphyritic granodiorite.

Five investigations were related to tin deposits in Tasmania. Ore from the Cleveland mine, near Waratah, contains fine-grained cassiterite disseminated through quartz and mica intergrown with pyrrhotite and a little stannite. At times there is an intimate association of cassiterite and stannite similar to that previously observed in the North Valley lode at Mt. Bischoff, indicating that stannite may be formed by the solution and replacement of the earlier-formed cassiterite.

A small, but interesting, occurrence of cobaltite has been recorded in the Broken Hill lode. Cobaltite has been formed by the conversion of an earlier cobalt-rich arsenide, safflorite-lollingite, of which traces may be found, and the replacement is similar to the development of arsenopyrite from the iron arsenide, lollingite, which has been described previously. A petrological examination of bore cores from the site of a proposed weir on the South Para River in South Australia revealed the relatively weak character of the foundation rocks. The petroliferous glauconite sandstone at Lakes Entrance, Victoria, was examined in relation to its porosity.

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

4. Ore-dressing Investigations.

Co-operative investigations have continued in the laboratories at the Kalgoorlie School of Mines, the South Australian School of Mines and Industries, and the Metallurgy School of the University of Melbourne.

At Adelaide, work on local phosphate deposits has continued. South Australian rock phosphate is too high in iron and alumina for superphosphate manufacture, but if finely ground and applied directly to the soil has some value as a fertilizer. Other investigations have included the production by flotation of high-grade fluorite concentrate, and the examination of a deposit of talc for the Department of Mines. Further assistance was given in the production of graphite and of other minerals required for the war effort.

At Kalgoorlie, further work was done on the production of a pyrite concentrate suitable, in lieu of elemental sulphur, for production of sulphuric acid. A recently-installed pyrite flotation treatment plant was inspected, and assistance given in a number of special problems associated therewith. Other investigations included the treatment of sand dump material to determine the recoverable quantity of tungsten mineral, the separation of cassiterite and tantalite from concentrates containing the two minerals, cyanidation of battery tailings, and tests to find the operating conditions for producing a marketable concentrate from a molybdenite ore.

At Melbourne, bismuth, copper, antimony, molybdenum, tungsten and other ores were examined to determine whether the respective minerals were recoverable and to determine the appropriate methods of treatment; particular attention has been given to tungsten minerals. Preliminary laboratory work on a low-grade antimony dump ore has enabled it to be successfully treated and antimony concentrates recovered; the method of recovery under the conditions determined by the laboratory tests is by flotation after grinding. Published methods for the analysis of tungsten having been found unsatisfactory, a study of the principal methods of analysis was undertaken and a satisfactory method and technique eventually established; a report is being prepared for publication. A minor investigation was carried out on the reduction of the sand content of a shell grit for use in both the manufacture of glass and in poultry farming.

5. Biometrics.

(i) *General.*—Early in the period under review members of the sectional head-quarters staff were transferred, owing to limited accommodation, from the Council's head office to new quarters generously made available by the University of Melbourne in the School of Commerce. Throughout the past year the Section has continued to be actively engaged in co-operation with officers of the Council's divisions and in meeting

requests for assistance from sources outside the Council. These sources include various branches of the services, Commonwealth and State Government departments, research organizations, and private individuals. To meet the increased demands further additions were made to the staff and calculating equipment. Early in 1944 one officer, who had been seconded to the Department of Home Security and the Directorate of Man-power, returned to the staff to continue research in the Division of Animal Health and Nutrition.

(ii) *Division of Plant Industry.*—For the Agrostology Section, records were maintained for two long-term grazing trials. Assistance was given in the design of grazing trials on subterranean clover species and mixtures of lucerne and rhodes grass, and in mapping the density of a natural pasture. For the Plant Introduction and Genetics Sections, numerous designs and analyses of fertilizer, spacing, frequency of cutting, yield and survival trials of introduced and selected species were made. The species included grasses, legumes, drug and rubber-bearing plants. Much work was done on vegetable production trials usually concerned with variety comparisons, but also including fertilizer and soil pre-treatment studies. A germination trial of carrots and several trials with fungicides on garden peas were also subjected to analysis.

Several studies on the take-all disease of wheat were analysed. Other work for the Division included examination of growth data for apples of different stock and scion, root distribution of citrus trees, a fertilizer and irrigation trial with vines, fertilizer trials with pine species, and a study on time of harvest of flax in relation to yield quality and stem section.

(iii) *Division of Economic Entomology.*—The principal work for this Division centred on spray and dusting trials against vegetable pests which include potato moth, cabbage moth and butterfly, aphids and green vegetable bug. Among other work there were tests to improve the precision of Peet-Grady chamber data, a test on preferred surface for egg laying by potato moth, the standardization of a moisture meter for wheat, and the examination of data on the colour preference of flies.

(iv) *Division of Forest Products.*—Throughout the period under review the Section has continued with the planning of investigations and the analysis of experimental data for the several sections of this Division. For the Timber Mechanics Section, analyses have been made of experiments on the effect of thickness, moisture content, glues, and other test conditions on properties of plywood; on the effect of method of cutting specimen on Izod results; and other miscellaneous experiments. For the Chemistry Section a number of experiments relating to the manufacture and testing of paper pulp have been analysed; these include Lampen mill studies, studies of the main paper tests, and various chemical studies of wood and paper.

For the Flax Processing Section the work done included retting experiments from agricultural trials, dew retting and storage studies, and experiments on factors affecting retting results. For the Timber Physics Section the design and analysis of experiments on the effect of high temperatures on strength properties of timber were completed, and for Improved Wood, Veneering and Gluing Sections, the design and analysis of factorial experiments and balanced incomplete block experiments to determine the effect of resins, catalysts, and methods of making and gluing specimens, on strength properties.

Routine computations included the calculation of specification tests on aircraft timbers (22,000), moisture content calculations (48,000), miscellaneous test results (21,000), and the calculation of means, standard errors, &c., for mechanical properties of five species of timber, and for shrinkage of eight species of timber.

(v) *Division of Animal Health and Nutrition.*—The Section has continued with the extensive study of data derived from the parasitological field trials at Armidale (New South Wales). Throughout the past year the work consisted principally of the reduction of primary climatological data in order to correlate them with the variations in worm burden. Other work in parasitology included the analysis of data from numerous field trials designed to determine the efficacy of various anthelmintics, and the analysis of data from epidemiological trials on twelve stations in Queensland. For the Wool Biology Section work is still proceeding on the analysis of data from the feeding trial conducted at Adelaide, and preliminary calculations have been made on data collected for the purpose of estimating the accuracy of sampling for various attributes of the skin and fleece. The remaining major contributions to the year's work consisted of the analysis of a number of field trials at "Gilruth Plains" and at Helenslee, further analysis of epidemiological work on mastitis, and a continuation of the work on progeny testing data from "Gilruth Plains" and Noondoo.

6. Standards Association of Australia.*

The demand for specifications for defence requirements has been sufficiently maintained to preclude the possibility of any substantial resumption of the normal activities of the association. Some projects which had been postponed for some years have, however, demanded attention without further delay, and the consideration of these has been resumed. In addition, preliminary steps have been taken for the preparation of a comprehensive range of standards intended to assist post-war reconstruction measures, particularly in relation to housing.

The number of standard specifications now issued exceeds 700, of which over 230 are special war-time specifications. A new series of publications, known as Interim Specifications, has been issued. These are not approved standards, but are issued without endorsement upon the request of a government department or other responsible authority, when required to meet an immediate need. In appropriate cases the association proceeds to review these and amend them, as necessary, with a view to their publication as standards. One useful achievement which the adoption of this practice has helped to bring about is the co-ordination of the various service specifications for similar products.

Evidence of widespread extension of the knowledge and use of standards has been provided by a phenomenal growth in the demands made upon the association's library for information concerning specifications and related matters, and by the extent of the business transacted by the publications department of the association, which handles over 250,000 copies of specifications per annum.

XV. INFORMATION SECTION.

1. General.

Throughout the year the demands for the services of the Information Section by the Council's own staff, Government departments and industrial and commercial organizations has continued unabated. The Section has continued to make its contribution to the war effort in the preparation of summaries and bibliographies on various aspects of technical production, the utilization of Australian materials in place of those in short supply, and on industrial matters generally. During the latter part of the year attention has also been directed to the supplying of information on problems concerned with post-war reconstruction.

* 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.

2. Information for Council.

A considerable part of the work of the Section has again been associated with the compilation of data and literature surveys for the Executive Committee and the various Divisions of the Council. In connexion with the question of the establishment of a Federal Geological Survey a summary of the steps taken since the beginning of the century to implement various proposals put forward from time to time was prepared. A similar summary was also prepared concerning parallel steps taken to co-ordinate the work, on a federal basis, of the activities of the various States associated with artesian and sub-artesian waters. Arising out of the Council's recommendations to discontinue the use of sodium chloride licks for stock, a survey of the literature was made and from the data available it was shown that sufficient salt was available in the grasses and waters utilized by stock to more than supply their needs.

Assistance has again been given to the Division of Industrial Chemistry in connexion with projects already planned or in exploratory work leading up to future projects. A survey was made of the available data relating to the occurrence and chemical composition of natural gases reported at different times in the past from various parts of the Commonwealth; this work was undertaken as a preliminary to the Division's project to explore the natural gas resources of Australia, using improved methods of low temperature fractional distillation analysis. Another bibliographical survey covered the isolation of amyl alcohols from the fusel oil residues of the alcoholic fermentation industries and the preparation of amylene therefrom and also of p-tertiary-amyl-phenol.

In connexion with plastic investigations, a survey of methods for the production of vinyl acetate from acetylene was prepared. A further literature survey of the preparation and chemistry of the polysulphides of sodium and calcium was made to assist in research projects concerned with the manufacture of synthetic rubber of the thiokol type. For reference purposes in relation to the work on plastics, a compilation of trade names was prepared, covering Australian plastics, plastic moulded products, moulding powders, synthetic resins, &c., giving for each the manufacturer's name and the type of product. In anticipation of the Divisions' investigations of Australian lithium ores, a survey was made of the various methods employed overseas for their processing and the relative merits of the methods discussed; a summary was also prepared on the methods employed for the recovery of rubidium and caesium.

Assistance for other Divisions included the compilation of information relating to infra-red dehydration, heat deterioration of textile fibres, the atomic hydrogen arc, fluorescent analysis, diffraction gratings, canning and dehydration of fruit and vegetables, and the tropic-proofing of electrical equipment.

3. Information for Government Departments, Manufacturers, Etc.

The various services, government departments, manufacturers and private individuals have continued to make good use of the Section. In consequence, in addition to its activities more specifically related to literature surveys, the Section has played an important part in putting inquirers into touch with authorities or laboratories concerned with the relevant subjects, both within and without the Council's ranks.

Assistance has been given to various Government Departments on matters concerning post-war planning as well as for present war-time projects. In these connexions, literature surveys were made on the various phases of cork-growing and manufacturing industries, and the economics of magnesium production, recovery of starch from potato dehydrator waste water, and the manufacture of rubber from wheat. A number of requests for information were received from the Services; the most notable of those for which reports were prepared included the cultivation of soya-bean and the manufacture of soya-bean meal, the preparation of moisture-proof packages for protection of equipment, and the biology and control of marine borers.

From time to time requests were received from salvage authorities regarding the disposal of old or damaged supplies and the utilization of waste materials. In one instance a comprehensive report was prepared on the possible methods for utilizing old army boots and hats. Further summaries and bibliographies have been prepared on the utilization of scrap leather, of tomato residues, of grape seeds and lemon pips for oil, and citrus waste for fodder, and the processing of steel scrap for powder.

A selection of other matters which have been dealt with include:—*Preparation of chemicals:* Sodium hypochlorite, methanol, cellulose acetate, ethyl cellulose, salicylanilide, methyl chlorsilane, p-nitrophenol, hexamine, resorcinol, lactic acid, citric acid, cream-of-tartar, ammonium sulphate, and by-products in salt manufacture. *Manufacturing:* Shellac, cocoa, potato starch, yeast extracts, silica gel, steel chain, steam turbines, small diesel engines, fishing boats. *Metallurgical problems:* Zinc, cadmium, and indium plating, hardening of lead, soldering aluminium, smelting of antimony ores, uses of cerium compounds, austempering of stainless steel, corrosion of metals by acids, metal spraying, high temperature salt baths, powder metallurgy, rubber dies for sheet-metal working, rubber to metal cement, heat insulation. *Food problems:* Vitamins in cocoanuts, margarine from dripping, food yeast, calorific value of foodstuffs, specific heats of meats, egg substitutes, dehydration of fish and meats, botulism in foodstuffs, sulphuring of fruit. *Agricultural problems:* Effects of vitamins and colchicine on plant growth, cultivation of olives, cinchona, soya-beans, and tung trees, vegetable-growing, slaughter-tapping of Hevea, eucalyptus and tea-tree oils, texture of dried peas, hydroponics, branding of cattle. *Miscellaneous:* Substitutes for shellac, general and formaldehyde tanning of sheepskins and furs, mercurial carrotting of hats, purification of sea and salt waters for drinking and irrigation purposes, rat and rabbit poisons, marking inks, bleaching of beeswax, dehydrating agents, grouting of concrete dams, reasons for deterioration of concrete.

4. Publications, Abstracts, Committees.

A major function of the Section is the editing, publication and distribution of the Council journal, bulletins, annual report and numerous other reports, and the preparation and issue to the press of statements concerning the work of the Council. With the growth of the Council the work entailed has steadily increased, and during the year an extra appointment was made to ensure continued efficient distribution.

Within the Section there is constituted an abstracting panel for the preparation of the "Australian Chemical Abstracts", which are confined to reports and articles published in Australia and to Australian patents and which are published by the Australian Chemical Institute.

Officers of the Section have continued to act on various special committees; an officer also acts as the Council's liaison officer with the Munitions Supply Laboratories, the Department of War Organization of Industry, and the Scientific Liaison Bureau.

5. Library.

An event of outstanding importance to Australian libraries and scientific workers has been the completion of arrangements during the year for the preparation of a revised edition of the "Catalogue of Scientific and Technical Periodicals in Australian Libraries". The Council has been fortunate in obtaining the

services of Mr. E. R. Pitt, editor of the first edition and formerly Chief Librarian of the Melbourne Public Library, for the purpose. An editorial committee on which the Sydney and Melbourne Public Libraries, the Melbourne University Library and the Council are represented has been formed to assist Mr. Pitt in his work. It is not anticipated that the new edition will be available for printing and distribution in under two years.

In the meantime, a complete list of periodicals and serials filed in all the Council's various libraries has been prepared and copies will be available to each of the Council's divisions and sections. This list will assist interdivisional borrowing and will render unnecessary continued application to Head Office Library for information concerning the locale of particular volumes taken by the Council. The list, a feature of which is the Russian section which includes information both in translation and transliteration of all Russian serials in the Council's libraries, will also be exceedingly useful in the preparation of Council for Scientific and Industrial Research entries for the revised edition of the catalogue.

Technical libraries are being established by other public and semi-public bodies and private firms in ever-increasing numbers, and advice in regard to their efficient organization continues to constitute an important part of the work of the library staff. Unfortunately, facilities in Australia for the adequate training of librarians still falls far short of the demand, and it is impossible for these newly established libraries to take their proper place in the community until they can be staffed by adequately trained and experienced librarians.

There is a steadv increase in the demands made on Head Office Library for references from other libraries throughout the Commonwealth. These requests are met either by sending the volumes on loan or by sending typed or film copies of the articles required. On the other hand, the demands of the Council for holdings in outside libraries have shown an even greater increase, and the readiness with which these demands are met and the facilities for obtaining these references which are placed at the Council's disposal by all the libraries with which contact has been made are greatly appreciated.

6. Overseas Liaison and Photographic Copying.

The established use of the microfilm camera in the Council's scientific research liaison offices in London and Washington has resulted in a large volume of unprinted reports, many of which are of a secret or confidential nature, being transferred to Australia regularly and expeditiously. On receipt, this material is distributed to the appropriate organization by the Information Section.

Scientific workers in university and government laboratories continue to use the Section to obtain photographic copies of scientific articles or reports otherwise inaccessible to them. In this connexion many libraries and organizations continue to give most helpful co-operation by lending the Council their special literature for photographing. This contribution, combined with the general library exchanges referred to above, is a powerful factor in the welding of the scattered scientific information available throughout Australia into a national whole.

XVI.—FINANCIAL MATTERS, STAFF, AND PUBLICATIONS.

1. Finance.

The statement of expenditure from 1st July, 1943, to 30th June, 1944, is as follows:—

	£	£	£
1. Salaries and contingencies			62,386*
2. Remuneration of Chairman and Members of Council			2,578†
3. Investigations—			
(i) Animal Health and Nutrition Problems		72,366	
Less contributions from—			
Commonwealth Bank	5,500		
Department of Agriculture and Stock, Brisbane	1,000		
George Aitken Pastoral Research Trust	2,000		
University of Sydney	250		
Australian Cattle Research Association	1,500		
Australian Wool Board	8,975		
Australian Meat Board	68		
Revenue Funds—			
Parkville	61		
Vaccine	942		
Pleuro Pneumonia	212		
Mastitis	2,767		
Toxaemic Jaundice—Barooga	1,207		
F. D. McMaster Field Station	300		
Parasitology	42		
"Gilruth Plains" National Field Station	4,942		
Nutrition Laboratory	299		
Oestrus Experiment	11		
		30,076	
			42,290
(ii) Plant Problems—Division of Plant Industry		49,233	
Less contributions from—			
Australian Wool Board	1,500		
Department of Supply and Shipping	3,521		
Department of Commerce	1,290		
Plant Industry Revenue Fund	180		
		6,491	
			42,742
(iii) Entomological Problems—Division of Economic Entomology		21,474	
Less contributions from—			
Australian Wheat Board	1,940		
Central Wool Committee	109		
Entomology Revenue Fund	18		
		2,067	
			19,407

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

† Provided from Consolidated Revenue Fund.

	£	£	£
(iv) Horticultural Problems of the Irrigation Settlements—			
(*a*) Citricultural—Research Station, Griffith	16,768		
Less contributions	7,845		
		8,923	
New South Wales Water Conservation and Irrigation Commission	2,218		
New South Wales Department of Agriculture	320		
Yenda Producers Co-operative Society Limited	43		
Leeton Fruit Growers' Co-operative Society Limited	43		
Griffith Producers' Co-operative Company Limited	128		
Rural Bank of New South Wales	427		
Leeton Co-operative Canneries Limited	256		
Griffith Revenue Fund	4,410		
(*b*) Viticultural—Research Station, Merbein	7,018		
Less contributions	4,086		
		2,932	
			11,855
Dried Fruits Control Board	700		
Irrymple Packing Proprietary Limited	234		
Mildura Co-operative Fruit Company	234		
Red Cliffs Co-operative Fruit Company	234		
Aurora Packing Proprietary Limited	234		
Department of Supply and Shipping	282		
Merbein Research Station Revenue Fund	2,168		
(v) Soil Problems	10,966		
Less contributions from—			
Commonwealth Bank	3,000		
			7,966
(vi) Food Preservation and Transport Problems		33,515	
Less contributions from—			
Commonwealth Bank	3,750		
New South Wales Department of Agriculture	800		
Queensland Meat Industry Board	850		
Australian Meat Board	375		
Metropolitan Meat Industry Commission	500		
Egg Producers' Council	456		
Apple and Pear Marketing Board	10		
Department of Commerce	2,880		
Food Preservation Revenue Fund	103		
		9,724	
			23,791
(vii) Forest Products Problems		54,501	
Less contributions from—			
Commonwealth Bank	3,250		
Australian Paper Manufacturers Limited	500		
Associated Pulp and Paper Mills Limited	500		
Australian Newsprint Mills Limited	500		
Tar Distillers' Research Committee	338		
Department of Supply and Shipping	956		
Miscellaneous contributions	84		
		6,128	
			48,373
(viii) Mining and Metallurgy		6,137	
Less contributions from—			
Australasian Institute of Mining and Metallurgy	368		
Department of Supply and Shipping	850		
		1,218	
			4,919
(ix) Radio Research		11,898	
Less contributions from—			
Postmaster-General's Department	4,423		
Departments of Army, Navy and Air	6,000		
		10,423	
			1,475
(x) Information Service including Library		6,717	
Less contributions from Foreign Journal Service		858	
			5,859
(xi) Industrial Chemistry		80,360	
Less contributions from—			
Ministry of Munitions	474		
Australian Cement Manufacturers Association	1,500		
Department of Supply and Shipping	13		
		1,987	
			78,373
(xii) Fisheries Investigations		15,823	
Less contributions from New South Wales Government		197	
			15,626
(xiii) Aeronautical Research		83,727	
Less contributions from—			
Department of Air		34	
			83,693
(xiv) National Standards Laboratory		106,950	
Less contributions		24,845	
			82,105
(xv) Miscellaneous—			
(*a*) Dairy Research		3,831	
(*b*) Biometrics Section		5,877	
(*c*) Lubricants and Bearings	20,115		
Less contributions from University of Melbourne	700		
		19,415	
(*d*) Various		4,400	
			33,523
Total of Item 3—Investigations			501,997

2. Contributions and Donations.

The following statement shows the receipts and disbursements during the year 1943-44 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled "The Specific Purposes Trust Account":—

	Receipts 1943–44 and balances brought forward from 1942–43.	Expenditure 1943–44.
	£	£
Commonwealth Bank (Animal Health and Nutrition, Horticultural, Food Preservation and Transport, and Forest Products Investigation)	15,591	15,500
Australian Wool Board (Animal Health and Nutrition Investigations—Sheep Research)	14,374	11,218*
Australian Cattle Research Association (Mastitis Investigations)	1,500	1,500
George Aitken Pastoral Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,500	2,000
Queensland Government Cattle Research (Animal Health and Nutrition Investigations)	1,000	1,000
University of Sydney (Animal Health and Nutrition Investigations)	250	250
Australian Meat Board (Toxaemic Jaundice Investigations, Barooga, New South Wales)	68	68
C.P.P. Fairbairn (Animal Health and Nutrition Investigations—Foot-rot Control)	30	..
Victorian Central Citrus Association—Citrus Problems (Plant Industry Investigations)	100	..
Tobacco Trust Fund—Prime Minister's Department and Department of Commerce — Tobacco Problems (Plant Industry Investigations)	13,303	1,290
Department of Supply and Shipping—Medicinal Plants (Plant Industry Investigations)	4,040	3,674†
Commonwealth Bank—Bee Research (Entomological Investigations)	92	..
Australian Wheat Board—Wheat Infestation (Entomological Investigations)	1,948	1,948‡
Central Wool Committee—Wool Infestation (Entomological Investigations)	152	124§
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	2,500	2,000
Murrumbidgee Irrigation Area Executive Committee—Project Farm, Griffith Research Station	100	..
Department of Agriculture, New South Wales (Soils and Irrigation Extension Service, Griffith)	750	320
New South Wales Water Conservation and Irrigation Commission (Soils and Irrigation Extension Service, Griffith)	510	218
Griffith Producers' Co-op. Coy. Ltd. (Soils and Irrigation Extension Service, Griffith)	300	128
Rural Bank of New South Wales (Soils and Irrigation Extension Service, Griffith)	1,000	427
Yenda Producers' Co-op. Society Ltd. (Soils and Irrigation Extension Service, Griffith)	100	43
Leeton Fruit Growers' Co-op. Society Ltd. (Soils and Irrigation Extension Service, Griffith)	100	43
Leeton Co-op. Canneries Ltd. (Soils and Irrigation Extension Service, Griffith)	300	256
Mildura Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	240	234
Irymple Packing Company (Dried Vine Fruits Investigations, Merbein)	240	234
Red Cliffs Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	240	234
Carried forward	61,328	42,709

	Receipts 1943–44 and balances brought forward from 1942–43.	Expenditure 1943–44.
	£	£
Brought forward	61,328	42,709
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	240	234
Dried Fruits Control Board (Dried Fruits Investigations)	1,000	700
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	108	..
Department of Supply and Shipping (Production of Pyrethrum)	285	285‖
Department of Commerce and Agriculture (Dehydration of Fruit)	63	63¶
Australian Meat Board (Meat Investigations)	375	375
Metropolitan Meat Industry Commissioner of New South Wales (Meat Investigations)	500	500
Queensland Meat Industry Board (Meat Investigations)	850	850
Apple and Pear Marketing Board—Apple Juice Certification (Food Preservation Investigations)	10	10
New South Wales Department of Agriculture (Food Investigations)	800	800
A. Lawrence & Co. (Division of Food Preservation and Transport)	30	..
W. Angliss Ltd. (Division of Food Preservation and Transport)	100	..
L. Berger & Sons (Division of Food Preservation and Transport)	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	..
Horitz Fruit Drinks (Division of Food Preservation and Transport—Fruit Juice Investigations)	5	..
Egg Producers' Council (Division of Food Preservation and Transport—Egg Investigations)	624	456
Egg Producers' Council (Watery Whites in Eggs)	2	..
Department of Commerce and Agriculture (Division of Food Preservation and Transport—Dehydration Investigations)	3,691	2,880
Australian Paper Manufacturers Limited (Paper Pulp Investigations)	500	500
Associated Pulp and Paper Mills Limited (Paper Pulp Investigations)	500	500
Australian Newsprint Mills Pty. Ltd. (Paper Pulp Investigations)	500	500
Veneer and Woodworkers' Supply Coy. (Division of Forest Products)	1,000	..
Bureau of Forestry, Canberra, and Forest Services of Queensland, Victoria, New South Wales and Western Australia—Wood Structure (Forest Products Investigations)	25	..
Tar Distillers' Research Committee (Creosote Investigations)—Division of Forest Products	338	338
Sundry Contributors (Forest Products Investigations)	2,608	84
Australasian Dairy Council (Wood Taint in Butter Investigations)	11	..
Department of Supply and Shipping—Flax Processing (Forest Products Investigations)	985	985**
Brisbane Timber Merchants' Association (Division of Forest Products—Veneer and Gluing Work)	8	..
Department of Supply and Shipping (Ore-dressing)	850	850
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	368	368
Postmaster-General's Department (Radio Research)	4,672	4,423
Departments of Army, Navy and Air (Radio Research)	6,000	6,000
Carried forward	88,436	64,410

* Includes £743 on account of 1942–43 expenditure. † Includes £153 on account of 1942–43 expenditure. ‡ Includes £8 on account of 1942–43 expenditure. § Includes £15 on account of 1942–43 expenditure. ‖ Includes £3 on account of 1942–43 expenditure. ¶ Includes £63 on account of 1942–43 expenditure. ** Includes £29 on account of 1942–43 expenditure.

	Receipts 1943–44 and balances brought forward from 1942–43.	Expenditure 1943–44.
	£	£
Brought forward	88,436 ..	64,410
Sundry Contributions (Foreign Journal Service)	1,058 ..	858
New South Wales Government (Fisheries Investigations)	252 ..	252*
Department of Air (Aeronautics) ..	34 ..	34
National Gas Association (Gas Investigations—Industrial Chemistry) ..	58 ..	..
Department of Supply and Shipping (Tinplate Substitute Container Investigations—Industrial Chemistry)	111 ..	111†
Australian Cement Manufacturers (Cement Investigations—Industrial Chemistry)	1,500 ..	1,500
Department of Commerce (Apple and Pear Investigations)	272 ..	..
Ministry of Munitions	27,631 ..	26,151‡
Department of Navy	10,602 ..	4,123§
Army Inventions Directorate ..	65 ..	65
Sundry Contributors (Council for Scientific and Industrial Research—Publications)	23 ..	..
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 ..	..
Kelsall & Kemp (Tas.) Ltd. (Division of Industrial Chemistry)	50 ..	..
Alfred Lawrence & Co. Ltd. (Division of Industrial Chemistry)	105 ..	..
University of Melbourne (Friction Research)	700 ..	700
Department of Interior (A.R.P. Expenditure)	32 ..	22‖
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Nutrition Investigations) ..	148 ..	..
Revenue Fund—Contagious Pleuropneumonia Investigations (Animal Health and Nutrition Investigations)	269 ..	212
Revenue Fund—Helenslee Field Station (Animal Health and Nutrition Investigations)	357 ..	..
Revenue Fund—Oestrus Experiment (Animal Health and Nutrition Investigations)	296 ..	11
Revenue Fund—Sale of Contagious Pleuro-pneumonia Vaccine (Animal Health and Nutrition Investigations)	2,436 ..	942
Revenue Fund—Sale of Strain 19 Vaccine (Animal Health and Nutrition Investigations)	93 ..	..
Revenue Fund—Anaplasmosis Investigations (Animal Health and Nutrition)	36 ..	..
Revenue Fund—Parkville Laboratory (Animal Health and Nutrition Investigations)	683 ..	61
Revenue Fund—Werribee Farm Mastitis Investigations (Animal Health and Nutrition Investigations) ..	2,767 ..	2,767
Revenue Fund—Drought Feeding Investigations, Werribee—(Animal Health and Nutrition)	63 ..	..
Revenue Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations) ..	6,244 ..	4,942
Reserve Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations) ..	1,132 ..	..
Revenue Fund—Bacteriological Investigations (Animal Health and Nutrition Investigations) ..	72 ..	..
Revenue Fund—Parasitological Investigations (Animal Health and Nutrition Investigations) ..	556 ..	42
Revenue Fund—Infertility, F. D. McMaster Field Station (Animal Health and Nutrition Investigations)	1,401 ..	300
Carried forward	148,027 ..	107,503

	Receipts 1943–44 and balances brought forward from 1942–43.	Expenditure 1943–44.
	£	£
Brought forward	148,027 ..	107,503
Revenue Fund—Nutrition Laboratory (Animal Health and Nutrition Investigations)	792 ..	299
Revenue Fund—Toxaemic Jaundice Investigations, Barooga, New South Wales (Animal Health and Nutrition Investigations)	1,376 ..	1,207
Revenue Fund—Plant Industry Investigations	1,074 ..	180
Revenue Fund—Entomological Investigations	606 ..	18
Revenue Fund—Griffith Research Station (Citricultural Investigations) ..	7,585 ..	4,410
Revenue Fund—Merbein Research Station (Viticultural Investigations)	7,961 ..	2,168
Revenue Fund—Citrus Preservation Investigations	102 ..	..
Revenue Fund—Division of Food Preservation and Transport ..	257 ..	103
Revenue Fund—Egg Investigations, Egg Producers' Council (Division of Food Preservation and Transport)	132 ..	..
Revenue Fund—Mining and Metallurgy	14 ..	..
Revenue Fund—Ore-dressing Investigations	752 ..	..
Revenue Fund—Fisheries Investigations	17 ..	..
Revenue Fund—Oyster Investigations	134 ..	..
Revenue Fund—Division of Aeronautics	62 ..	..
Revenue Fund—National Standards Laboratory	214 ..	..
Revenue Fund—Dairy Investigations	5 ..	..
Revenue Fund—Industrial Chemistry	38 ..	..
	169,148 ..	115,888

3. Staff.

The following is a list of the staff of the Council as in July, 1944. 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.
Deputy Chief Executive Officer—A. E. V. Richardson, C.M.G., M.A., D.Sc.
Consultant—G. Lightfoot, M.A.
Secretary—G. A. Cook, M.C., M.Sc., B.M.E.
Assistant Secretary—F. G. Nicholls, M.Sc.
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. (seconded).
J. S. Hosking, M.Sc., Ph.D. (Acting Officer-in-Charge).
N. C. Hancox, M.Sc. (seconded from Division of Industrial Chemistry).
J. R. Barned, B.Sc., A.M.T.C.
A. L. Gunn.
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.
R. McVilly, A.F.I.A., A.A.I.S.
C. Munro (on service leave—R.A.N.V.R.).
F. Butler.
J. Farey (on service leave—A.I.F.).
F. J. Whitty (on service leave—A.I.F.).
R. Bennett (on service leave—A.I.F.).
J. Bourne (on service leave—A.I.F.).
C. Garrow, A.F.I.A. (on service leave—R.A.N.V.R.).
C. Cole (on service leave—R.A.N.V.R.).
K. Gamble (on service leave—R.A.A.F.).
B. Gaynor (on service leave—A.I.F.).

* Includes £55 on account of 1942–43 expenditure. † Includes £98 on account of 1942–43 expenditure. ‡ Includes £897 on account of 1942–43 expenditure. § Includes credit of £20 on account of 1942–43 expenditure. ‖ Includes £22 on account of 1942–43 expenditure.

H. Lee (on service leave—R.A.A.F.).
J. M. Short (on service leave—A.I.F.).
K. J. Fogarty (on service leave—R.A.N.V.R.).
I. McMurdie.

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.).
Miss E. Dunne.
J. Coombe.

Records—
P. Domee-Carre.
P. Knuckey.
B. Gooley (on service leave—R.A.A.F.).
M. Combe (on service leave—R.A.A.F.).
M. Reynolds (on service leave—A.M.F.).
Miss W. Livingston.
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.
Senior Clerical Officer, Sydney—R. F. Williams.
Architect—W. R. Ferguson, B.E.

2. Secretaries of State Committees.

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

Victoria—
G. A. Cook, M.C., M.Sc., B.M.E., 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, M.Sc.(Agric.), Institute of Agriculture, University of Western Australia, Nedlands.

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)—Miss A. Nicholson (acting).
Senior Clerical Officer (half-time)—D. Banyard (acting).
Clerk, Records—K. J. Prowse (on service leave—A.I.F.).
Clerk, Records—T. A. Lewis (on service leave—R.A.A.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. (on service leave—R.A.A.F.).
Assistant Research Officer—D. O. Norris, M.Sc. (Agric.).
Assistant Research Officer—Miss M. Mills, B.Sc.

Plant Improvement—
Principal Research Officer—J. R. A. McMillan, D.Sc.Agr., M.S. (seconded).
Assistant Research Officer—F. W. Hely, B.Sc.Agr.

Plant Introduction—
Research Officer—W. Hartley, B.A., Dip.Ed.

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

Vegetable Fibre Investigations—
Research Officer—A. V. Hill, M.Agr.Sc.
Research Officer—J. Calvert, D.Sc. (on service leave—R.A.A.F.).

Agrostology—
Principal Research Officer—J. G. Davies, B.Sc., Ph.D.
Research Officer—C. S. Christian, M.Sc.
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. (on service leave—R.A.A.F.).
Assistant Research Officer—N. Shaw, B.Agr.Sc. (seconded).
Assistant Research Officer—T. Wilkinson, B.Sc. (on service leave—A.I.F.).
Assistant Research Officer—W. M. Willoughby, B.Sc.Agr.
Assistant Research Officer—E. H. Kipps, B.Sc.
Assistant Research Officer—S. G. Gray, B.Sc.Agr.
Technical Officer—Miss N. Barrie, B.Sc.Agr.

Tobacco Investigations—
Research Officer—A. V. Hill, M.Agr.Sc.
Assistant Research Officer—K. F. Plomley, B.Sc.Agr. (on service leave—R.A.N.V.R.).

Drug Plant Investigations—
Senior Research Officer—C. Barnard, D.Sc.
Research Officer—K. L. Hills, B.Agr. Sc.
Technical Officer—L. J. Webb.

Rubber Plant Investigations—
Principal Research Officer—J. G. Davies, B.Sc., Ph.D. (T. Kok-saghyz).
Research Officer (guayule)—W. Hartley, B.A., Dip.Ed.
Technical Officer (T. Kok-saghyz)—C. W. E. Moore, B.Agr.Sc.
Special Officer (Cryptostegia)—R. S. Dwyer.

Vegetable Investigations—
Research Officer—E. M. Hutton, B.Ag.Sc., M.Sc.

At Dickson Experiment Station, Canberra—
Manager—L. Sharp, Dip.Agr.

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 (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.

At Muresk, Western Australia—
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)—Miss A. Nicholson (acting).
Senior Clerical Officer (half-time)—D. Banyard (acting).
Clerk, Records—K. J. Prowse (on service leave—A.I.F.).
Clerk, Records—T. A. Lewis (on service leave—R.A.A.F.).

Wheat Pest and Termite Investigations—
Senior Research Officer—F. N. Ratcliffe, B.A. (on service leave—A.I.F.).
Research Officer—F. J. Gay, B.Sc., D.I.C.

Medical and Veterinary Entomology—
Principal Research Officer—I. M. Mackerras, B.Sc., M.B., Ch.M. (on service leave—A.I.F.).
Research Officer—Mrs. M. J. Mackerras, M.Sc., M.B. (on extended leave).
Research Officer—D. F. Waterhouse, M.Sc.
Assistant Research Officer—D. Gilmour, M.Sc. (on service leave—R.A.A.F.).

Biological Control Investigations—
Research Officer—T. G. Campbell.

Toxicology Investigations—
Assistant Research Officer—R. W. Kerr, B.Sc.
Assistant Research Officer—R. F. Powning, A.S.T.C.

Vegetable Pests Investigations—
Research Officer—G. A. H. Helson, M.Sc.
Technical Officer—T. Greaves.

Locust Investigations—
Research Officer—K. H. L. Key, M.Sc., Ph.D., D.I.C.

At Trangie, New South Wales—
Assistant Research Officer (locust investigations)—L. R. Clark, M.Sc.
Technical Officer (locust investigations)—D. L. Hall, Dip.Agr. (on service leave—R.A.A.F.).
Technical Officer (locust investigations)—L. J. Chinnick, Dip. Agr.

At Melbourne, Victoria—
Research Officer (wheat investigations)—F. Wilson.
Technical Officer (wheat investigations)—A. T. Mills.

At School of Veterinary Science, Brisbane—
Senior Research Officer (cattle tick investigations)—L. F. Hitchcock, M.Sc.
Assistant Research Officer (cattle tick investigations)—W. J. Roulston, B.Sc.
Technical Officer (cattle tick investigations)—W. R. Horne.

At Malanda, Queensland—
Research Officer (buffalo-fly investigations)—K. R. Norris, M.Sc.
Technical Officer (buffalo-fly investigations)—R. A. J. Meyers, Q.D.A.H., Q.D.D.

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, O.B.E., D.Sc., D.V.Sc.
Senior Research Officer (pathology, bacteriology, dairy cattle)—D. Murnane, B.V.Sc. (on service leave).
Senior Research Officer (serological investigations)—A. D. Campbell, L.V.Sc.
Research Officer (immuno-chemistry)—A. T. Dann, M.Sc.
Research Officer (bacteriology, dairy cattle)—E. Munch-Petersen, M.Sc., Ph.B.
Research Officer (bacteriology—biochemistry)—A. T. Dick, M.Sc.
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*).
Assistant Research Officer—Miss C. E. Eales, B.Sc.
Assistant Research Officer—Miss M. J. Monsbourgh, B.Sc.
Technical Officer—H. G. Turner, B.Agr.Sc.
Technical Officer—E. Wold.
Technical Officer—A. E. Wright.
Technical Officer—J. J. Spencer (on service leave—A.I.F.).
Librarian—Miss F. V. Murray, M.Sc. (part-time).
Clerk—J. Foley (on service 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 service 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.).
Research Officer (field investigations, ectoparasites)—N. P. H. Graham, B.V.Sc.
Research Officer (chemistry of wool)—M. R. Freney, B.Sc. (seconded).
Research Officer (wool biology)—H. B. Carter, B.V.Sc.
Research Officer (parasitology, field studies)—I. W. Montgomery, B.V.Sc. (on service leave).
Assistant Research Officer (blowfly strike, field studies).—I. L. Johnstone, B.V.Sc.
Assistant Research Officer (biochemistry)—C. R. Austin, B.V.Sc.
Assistant Research Officer (parasitology, field studies)—J. F. Barrett, B.V.Sc.
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.
Secretary—J. Ward Walters.
Senior Research Officer (metabolism)—E. W. Lines, B.Sc. (on service leave).
Senior Research Officer (biochemistry) (as from 1st July, 1941)—J. W. H. Lugg, Ph.D., D.Sc., F.R.I.C.
Research Officer (ruminant physiology)—R. H. Watson, D.Agr.Sc. (seconded).
Research Officer (agrostology)—D. S. Riceman, B.Ag.Sc.
Research Officer (mineral deficiency, field investigations)—H. J. Lee, B.Sc.
Assistant Research Officer (metabolism)—F. V. Gray, B.Sc.
Assistant Research Officer (metabolism)—T. A. F. Quinlan-Watson, B.Sc.
Assistant Research Officer—I. G. Jarrett, B.Sc.
Assistant Research Officer—A. F. Pilgrim, B.Sc. (on service leave—R.A.N.V.R.).
Technical Officer—J. O. Wilson.
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.

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—Miss I. J. Stewart, B.Agr.Sc.
Farm Manager—C. D. Nation.

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. (seconded).
Assistant Research Officer (biochemistry—A. B. Beck, M.Sc.

7. Mineral Deficiency of Pastures Investigation.

At Waite Agricultural Research Institute—
Assistant Research Officer (chemist)—R. E. Shapter.
Assistant Research Officer—A. J. Anderson, B.Sc. (Agric.).

8. Division of Soils.

At Waite Agricultural Research Institute—
Administration—
Chief—J. A. Prescott, D.Sc. (part-time).
Deputy Chief—J. K. Taylor, B.A., M.Sc., B.Sc.Agr.
Soil Survey Section—
Senior Research Officer—C. G. Stephens, M.Sc.
Assistant Research Officer—J. G. Baldwin, B.Agr.Sc., B.Sc. (on service leave—A.I.F.).
Assistant Research Officer—R. Brewer, B.Sc.
Assistant Research Officer—B. E. Butler, B.Sc. (Agric.) (on service leave—R.A.A.F.).
Assistant Research Officer—R. L. Crocker, M.Sc. (seconded).
Assistant Research Officer—E. J. Johnston, B.Sc.Agr. (on service leave—R.A.A.F.).
Assistant Research Officer—T. Langford Smith, B.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer—K. H. Northcote, B.Ag.Sc.
Assistant Research Officer—J. H. Shepherd, B.Sc.
Assistant Research Officer—R. Smith, B.Sc. (Agric.).
Assistant Research Officer—R. C. Sprigg, B.Sc.
Assistant Research Officer—G. A. Stewart, B.Ag.Sc.
Technical Officer (cartography)—P. D. Hooper.
Soil Physics Section—
Senior Research Officer—T. J. Marshall, M.Ag.Sc., Ph.D.
Assistant Research Officer—G. D. Aitchison, B.E. (seconded).
Assistant Research Officer—G. B. Clarke, B.Sc.
Soil Chemistry Section—
Senior Research Officer—C. S. Piper, D.Sc. (part-time).
Assistant Research Officer (spectrography)—A. C. Oertel, M.Sc.
Assistant Research Officer—Miss M. P. Thomas.
Technical Assistant—H. R. Skewes (seconded).
Soil Microbiology—
Assistant Research Officer—T. H. Strong, M.Agr.Sc. (on service leave—R.A.A.F.).
At Hobart—
Research Officer (soil surveys)—G. D. Hubble, B.Ag.Sc.
At Melbourne—
Assistant Research Officer (soil surveys)—R. G. Downes, M.Agr.Sc.

9. Irrigation Settlement Problems.

At Irrigation Research Station, Griffith—
Officer-in-Charge—E. S. West, B.Sc., M.S.
Chemist—A. Howard, M.Sc. (seconded).
Research Officer—R. R. Pennefather, B.Agr.Sc.
Research Officer—D. V. Walters, M.Agr.Sc.
Assistant Research Officer—O. Perkman, B.Sc.Agr.
Assistant Research Officer—V. J. Wagner, B.Agr.Sc.
Assistant Research Officer—E. L. Greacen, B.Sc.Agr.
Assistant Research Officer—K. Spencer, B.Sc.Agr.
Assistant Research Officer—J. T. Fitzpatrick, B.Agr.Sc.
Assistant Research Officer—L. F. Myers, B.Agr.Sc.
Orchard Superintendent—B. H. Martin, H.D.A.
Technical Officer—T. J. Masters.

At Commonwealth Research Station, Merbein—
Officer-in-Charge—A. V. Lyon, M.Agr.Sc.
Senior Research Officer (chemist)—E. C. Orton, B.Sc.
Assistant Research Officer—A. L. Tisdall, M.Agr.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer—W. J. Webster, B.Sc.
Technical Officer—J. E. Giles.
Research Officer—R. C. Polkinghorne (part-time).

10. Division of Forest Products.

At South Melbourne—
Administration—
Chief—S. A. Clarke, B.E.
Principal Research Officer—C. S. Elliott, B.Sc.
Librarian and Records Clerk—Miss M. I. Hulme.
Draughtsman—B. Whitington, B.Sc., B.E.
Draughtsman—L. Szente, Dip.Eng. (Budapest).

Chemistry Section—
Principal Research Officer-in-Charge—W. E. Cohen, D.Sc.
Research Officer (chemist)—Miss T. M. Reynolds, M.Sc., D.Phil. (seconded).
Research Officer (chemist)—D. E. Bland, M.Sc. (seconded).
Assistant Research Officer—A. J. Watson.
Assistant Research Officer—Miss B. M. Brims, B.Sc.
Assistant Research Officer—J. Sterling, B.Sc.
Technical Officer—A. G. Charles.
Technical Officer—Miss J. Meade.
Wood Structure Section—
Principal Research Officer-in-Charge—H. E. Dadswell, D.Sc.
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.
Technical Officer—Miss F. V. Griffin.
Seasoning Section—
Assistant Research Officer-in-Charge—G. W. Wright, B.E.
Assistant Research Officer—A. C. Pond, B.E. (Hons.) (on service leave—R.A.A.F.).
Assistant Research Officer—J. W. Gottstein, B.Sc.
Technical Officer—J. T. Currie.
Technical Officer—H. D. Roberts.
Timber Physics Section—
Senior Research Officer-in-Charge—W. L. Greenhill, M.E., Dip.Sc.
Assistant Research Officer—P. H. Sulzberger, B.Sc.
Technical Officer—W. F. Johnston.
Timber Mechanics Section—
Senior Research Officer-in-Charge—I. Langlands, B.E.E., M.Mech.E.
Research Officer—R. S. T. Kingston, B.Sc., B.E.
Assistant Research Officer—N. H. Kloot, B.Sc.
Technical Officer—J. J. Mack.
Technical Officer—G. Barrow.
Preservation Section—
Principal Research Officer-in-Charge—C. S. Elliott, B.Sc. (acting).
Assistant Research Officer—H. B. Wilson, B.Sc.
Assistant Research Officer—N. Tamblyn, M.Sc. (Agric.).
Veneering and Gluing Section—
Research Officer-in-Charge—S. F. Rust, B.Sc., M.S.
Research Officer—C. E. Dixon, M.Sc.
Assistant Research Officer—G. W. Tack, B.Agr.Sc.
Assistant Research Officer—J. F. McCrea, M.Agr.Sc.
Assistant Research Officer—M. D. Fry, B.Sc.
Technical Officer—R. Deeble.
Timber Utilization Section—
Senior Research Officer-in-Charge—R. F. Turnbull, B.E. (Hons.) (seconded).
Research Officer—A. J. Thomas, Dip.For. (seconded).
Assistant Research Officer-in-Charge (acting)—A. Gordon, B.Sc.
Technical Officer—A. Rosel.
Flax Processing—
Senior Research Officer-in-Charge—W. L. Greenhill, M.E., Dip.Sc.
Assistant Research Officer—A. M. Munro, M.A. (Oxon.).
Assistant Research Officer—Miss J. F. Couchman, B.Sc.
Assistant Research Officer—Miss W. M. P. Cook, B.Sc.
Technical Officer—M. Tisdall.
Technical Officer—G. Christensen (on leave).
Photography—
Technical Officer—E. S. Smith.
Technical Officer—Miss A. M. Lightfoot.
Maintenance Section—
Technical Officer—S. G. McNeil.

11. Division of Food Preservation and Transport.

At State Abattoir, Sydney—
Chief—J. R. Vickery, M.Sc., Ph.D.
Librarian—Miss B. Johnston, B.Sc. (part-time).
Physics Section—
Officer-in-Charge—E. W. Hicks, B.A., B.Sc.
Assistant Research Officer—M. C. Taylor, M.Sc.
Fruit Storage Section—
Officer-in-Charge—S. A. Trout, M.Sc., Ph.D.
Canning and Fruit Products Section—
Officer-in-Charge—L. J. Lynch, B.Agr.Sc.
Senior Research Officer—W. A. Empey, B.V.Sc.
Research Officer—F. E. Huelin, B.Sc., Ph.D.
Assistant Research Officer—J. F. Kefford, M.Sc.
Assistant Research Officer—R. S. Mitchell, M.Sc.Agr.
Assistant Research Officer—H. A. McKenzie, B.Sc.
Technical Officer—Mrs. I. M. Stephens, B.Agr.Sc.
Dried Foods Section—
Research Officer—Miss T. M. Reynolds, M.Sc., D.Phil., (seconded from Division of Forest Products).
Research Officer—A. Howard, M.Sc. (seconded from Irrigation Research Station, Griffith).
Assistant Research Officer—H. S. McKee, B.A., D.Phil.
Assistant Research Officer—S. M. Sykes, B.Sc.Agr.
Assistant Research Officer—A. R. Prater, B.Sc.Agr.
Assistant Research Officer—D. McG. McBean, B.Sc.
Assistant Research Officer—J. Shipton, B.Sc.Agr.
Microbiology Section—
Officer-in-Charge—W. J. Scott, B.Agr.Sc.
Senior Bacteriologist—D. F. Stewart, B.V.Sc., Dip.Bact. (seconded from N.S.W. Department of Agriculture).
Assistant Research Officer—A. M. Olsen, B.Sc.
Technical Officer—P. R. Maguire.
Technical Officer—D. F. Ohye.
At Division of Animal Health and Nutrition, Melbourne—
Assistant Research Officer (bacteriologist)—J. M. Gillespie, M.Sc.
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.
At Australia House, London—
Senior Research Officer—N. E. Holmes, B.E.E., M.Mech.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.
Assistant Research Officer (biologist)—G. L. Kesteven, B.Sc.
Assistant Research Officer (biologist)—J. A. Tubb, M.Sc.
Assistant Research Officer (chemist and hydrographer)—D. J. Rochford, B.Sc.
Assistant Research Officer (biochemist)—C. G. Setter, B.Sc., A.M.T.C. (seconded).
Assistant Research Officer (biologist)—Mrs. L. M. Willings, B.A.
Assistant Research Officer (biologist)—Mrs. V. Jones, M.Sc.
Technical Officer—A. Proctor (laboratory).
Technical Officer—K. Sheard.
Technical Officer—R. Allan.
At Perth—
Research Officer (biologist)—D. L. Serventy, B.Sc., Ph.D.
Assistant Research Officer (biologist)—G. P. Whitley (seconded from Royal Australian Museum).
At Melbourne—
Senior Research Officer—S. Fowler.
Assistant Research Officer—M. Blackburn, M.Sc.
At Hobart—
Assistant Research Officer (biologist)—W. S. Fairbridge, M.Sc.
At Brisbane—
Assistant Research Officer (biologist)—I. S. R. Munro, M.Sc.

13. Australian National Standards Laboratory.

Administration—
Officer-in-Charge—N. A. Esserman, B.Sc.
Senior Clerical Officer—R. F. Williams.
Clerk—S. J. Cosser (on service leave—A.I.F.).
Clerk—W. J. Gillespie (seconded from Division of Fisheries).
Drawing Office—
Designing Draughtsman—C. Williamson.
Draughtsman—R. H. Furniss.
Draughtsman—A. G. Chinnery.
Library—
Librarian—Miss M. Barnard, B.A.
Assistant Librarian—Miss B. Mortlock, B.A.
Assistant Librarian—Miss M. McKechnie.
Workshop—
Foreman-Supervisor—J. Hanna.
Sub-Foreman—F. E. Trotter.
Instrument Maker—F. Boland.
Instrument Maker—A. H. Masters.
Tool Maker—D. A. Greenwood.
Fitter and Turner—D. J. Harper.
Electrical Fitter—C. F. Collins.
Maintenance Electrician—N. Wunderlich.
Plumber-Tinsmith—W. D. Palmer.
Patternmaker-Carpenter—A. Taylor.
Chargehand—W. Hyett.
Chargehand—L. T. Mills.
Chargehand—J. W. Porter.
Metrology Section—
Officer-in-Charge—N. A. Esserman, B.Sc.
Research Officer—P. M. Gilet, B.Sc., B.E.
Research Officer—C. G. Greenham, M.Sc.
Assistant Research Officer—E. E. Adderley, B.Sc.
Assistant Research Officer—Miss A. Alexander, B.Sc.
Assistant Research Officer—J. V. Bainton, B.E.
Assistant Research Officer—G. A. Bell, B.Sc.

Assistant Research Officer—C. F. Bruce, M.Sc. (N.Z.).
Assistant Research Officer—W. A. F. Cunninghame, B.E.
Assistant Research Officer—H. H. Davis, B.Sc., B.E., Ph.D. (Cantab.).
Assistant Research Officer—Miss I. Dewhurst, B.Sc., B.Ed.
Assistant Research Officer—Miss M. Dive, B.Sc.
Assistant Research Officer—M. F. Lamrock, B.Sc., B.E.
Assistant Research Officer—Miss M. Pearce, M.Sc.
Assistant Research Officer—Miss P. Weine, B.Sc.
Assistant Research Officer—Miss P. Yelland.
Assistant Research Officer—Miss E. York, B.Sc.
Assistant Research Officer—Mrs. H. H. Davis, B.Sc.
Assistant Research Officer—A. V. Dicker, B.E.
Assistant Research Officer—Miss C. M. Guilfoyle, B.Sc.
Assistant Research Officer—J. A. Macinante, B.E., A.S.T.C.
Assistant Research Officer—Miss C. M. Middleton, B.Sc.
Testing Engineer, Grade II.—R. A. Holloway, B.Sc., B.E. (on loan from N.S.W. Railways).

Electrotechnology Section—
Officer-in-Charge—D. M. Myers, B.Sc., D.Sc.Eng.
Research Officer—W. K. Clothier, B.Sc., M.E.
Research Officer—L. G. Dobbie, M.E.
Assistant Research Officer—G. J. A. Cassidy, B.E.E.
Assistant Research Officer—P. A. Champion, B.E.
Assistant Research Officer—D. J. Cole, B.E.E.
Assistant Research Officer—Miss M. Douglas, B.Sc.
Assistant Research Officer—F. A. Edwards, B.E.
Assistant Research Officer—B. V. Hamon, B.Sc., B.E.
Assistant Research Officer—A. H. Hean, B.E.
Assistant Research Officer—H. W. Stokes, B.Ec.
Assistant Research Officer—A. M. Thompson, B.Sc.
Assistant Research Officer—Miss N. Watts, B.A.
Assistant Research Officer—J. S. Dryden, B.Sc.
Assistant Research Officer—P. T. Wilson, B.E.
Assistant, Clerical—Miss G. Levy, B.A.

Physics Section—
Officer-in-Charge—G. H. Briggs, D.Sc., Ph.D.
Research Officer—A. F. A. Harper, M.Sc.
Assistant Research Officer—H. Corker, B.Sc.
Assistant Research Officer—N. A. Faull, B.Sc.
Assistant Research Officer—R. Giovanelli, M.Sc.
Assistant Research Officer—W. R. G. Kemp, B.Sc.
Assistant Research Officer—R. T. Leslie, B.A., B.Sc.
Assistant Research Officer—E. H. Mercer, B.Sc.
Assistant Research Officer—J. W. Pearce, B.Sc.
Assistant Research Officer—H. F. Pollard, B.Sc.
Assistant Research Officer—W. A. Caw, B.Sc.
Assistant Research Officer—G. R. Morris, B.Sc.
Assistant Research Officer—W. I. B. Smith, B.Sc.
Assistant Research Officer—W. H. Steele, B.Sc.
Technician—J. E. Thompson.
Assistant, Clerical—Miss E. Andrews, B.A.

14. Division of Aeronautics.

Administrative—
Chief—L. P. Coombes, D.F.C., B.Sc. (Eng.).
Acting Chief—H. A. Wills, B.E.
Secretary—B. McA. Foster, B.C.E., D.I.C.
Clerk—Mrs. E. M. Coxon.

Structures and Materials Section—
Principal Research Officer—H. A. Wills, B.E.
Research Officer—F. S. Shaw, B.E.
Research Officer—J. R. Green, D.Phil., B.E.
Assistant Research Officer—W. W. Johnstone, B.E.
Assistant Research Officer—R. C. T. Smith, M.A., B.Sc.
Assistant Research Officer—Miss E. H. Mann, B.A.
Assistant Research Officer—F. W. Hooton, B.Sc., B.E.
Technical Officer—J. P. O. Silberstein.
Technical Officer—F. A. Dale.
Technical Officer—A. N. Pickering.
Technical Officer—Miss D. A. Lemaire, B.Mech.E.

Metallurgy Sub-Section—
Officer-in-Charge (on loan from North American Cyanamid Co. for duration of war, part time)—G. B. O'Malley, B.Met.E.
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.
Assistant Research Officer—C. J. Osborn, B.Met.E.
Technical Officer—F. G. Lewis, B.Sc.

Aerodynamics Section—
Senior Research Officer—G. N. Patterson, B.Sc., M.A., Ph.D.
Research Officer—T. F. C. Lawrence, B.Sc., B.E. (at Sydney University).
Assistant Research Officer—G. K. Batchelor, M.Sc.
Assistant Research Officer—R. W. Cumming, B.E.
Assistant Research Officer—J. B. Willis, M.Sc.
Assistant Research Officer—J. F. M. Scholes, B.Eng.Sc., B.E. (Aero.).
Assistant Research Officer—F. G. Blight, B.Sc., B.E. (Aero.).
Assistant Research Officer—Miss B. L. Gent, M.A.
Assistant Research Officer—A. F. Pillow, B.A.
Assistant Research Officer—R. H. Adair, B.E.
Technical Officer—F. Redlich, Dipl. Ing.
Technical Officer—G. J. Dailey.
Technical Officer—L. T. Watson.
Technical Officer—P. C. a'B. Chomley.
Technical Officer—G. F. Gerrand.
Technical Officer—V. J. Smith (at Sydney University).

Engines and Fuels Section—
Senior Research Officer—M. W. Woods, D.Phil., B.Sc., B.E.
Research Officer—T. S. Keeble, B.E., B.Sc.
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.
Assistant Research Officer—R. A. Wright, B.Sc.(E).
Assistant Research Officer—R. V. Pavia, B.Mech.E.

Instruments Section—
Research Officer—A. A. Townsend, M.Sc.
Assistant Research Officer—W. S. Cugley, B.Sc.

Drawing Office and Workshops—
Supervisor—D. W. Eaton.

Photography—
Technical Officer—Miss E. F. Lightfoot.

Library—
Librarian—Miss H. P. Meggs (part-time).

15. Division of Industrial Chemistry.

Administrative and General—
Chief—I. W. Wark, Ph.D., D.Sc.
Divisional Secretary—L. Lewis, B.Met.E.
Assistant Secretary—A. E. Scott, M.Sc. (on leave from University of Adelaide).
Clerk—A. Patterson, A.F.I.A.
Clerk—Miss E. M. Wright.

Biochemistry Section—
Research Officer—F. G. Lennox, D.Sc.
Assistant Research Officer—W. J. Ellis, A.S.T.C. (seconded).
Assistant Research Officer—W. G. Crewther, M.Sc.
Assistant Research Officer—Miss M. E. Maxwell, M.Sc.
Assistant Research Officer—Miss A. M. McArthur, M.Sc.
Technical Assistant—R. A. Fookes.

Minerals Utilization Section—
Principal Research Officer—R. G. Thomas, B.Sc.
Research Officer—A. Walkley, B.A., B.Sc., Ph.D.
Research Officer—A. W. Wylie, M.Sc., Ph.D.
Assistant Research Officer—P. Dixon, M.Sc. (seconded from Commonwealth Research Station, Merbein).
Assistant Research Officer—G. B. Gresford, B.Sc., A.M.T.C. (seconded).
Assistant Research Officer—F. K. McTaggart, M.Sc.
Assistant Research Officer—T. R. Scott, M.Sc., B.Ed.
Assistant Research Officer—F. R. Hartley, M.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer—R. C. Croft, B.Sc.
Assistant Research Officer—A. D. Wadsley, M.Sc.
Assistant Research Officer—I. C. Kraitzer.
Assistant Research Officer—E. S. Pilkington, A.S.T.C.
Technical Officer—K. L. Elliot.
Technical Officer—V. A. C. Bertrand.

Dairy Products Section—
Research Officer—G. Loftus Hills, B.Agr.Sc. (seconded).
Assistant Research Officer—J. Conochie, B.Sc.(Agric.) (seconded).
Technical Officer—W. G. T. Laffan, H.D.D. (seconded).

Organic Section—
Senior Research Officer—H. H. Hatt, B.Sc., Ph.D.
Research Officer—J. S. Fitzgerald, M.Sc., Ph.D.
Assistant Research Officer—N. C. Hancox, M.Sc. (seconded).
Assistant Research Officer—K. E. Murray, B.Sc.
Assistant Research Officer—R. G. Curtis, M.Sc.
Assistant Research Officer—R. J. L. Martin, M.Sc.
Assistant Research Officer—A. G. Dobson, M.Sc.
Assistant Research Officer—D. J. Clark, M.Sc.
Assistant Research Officer—L. K. Dalton, D.S.T.C.
Technical Officer—K. H. Otway.
Technical Officer—W. E. Hillis, A.G.Inst.Tech.

Physical Chemistry Section—
Research Officer—K. L. Sutherland, M.Sc.
Assistant Research Officer—J. Rogers, M.Sc.
Assistant Research Officer—Miss E. C. Plante, B.Sc.
Assistant Research Officer—R. J. Goldacre, B.Sc.(Hons.), (seconded from Department of Agriculture, N.S.W.).
Technical Officer—H. F. A. Hergt, A.M.T.C.
Technical Officer—J. A. Corbett.

Foundry Sands Investigations—
Assistant Research Officer—H. A. Stephens, B.Sc.
Technical Officer—G. V. Cullen.
Technical Officer—J. E. Marshall, F.M.T.C.

Cement Section—
Research Officer—A. R. Alderman, Ph.D., D.Sc.
Assistant Research Officer—A. J. Gaskin, M.Sc.
Assistant Research Officer—H. E. Vivian, B.Sc.Agr.
Technical Officer—H. T. Philippe.

Physical Metallurgy Section—
Officer-in-Charge (on loan from North American Cyanamid Co.)—G. B. O'Malley, B.Met.E. (part-time).
Research Officer—H. W. Worner, M.Sc.
Assistant Research Officer—J. G. Munro.
Junior Research Officer—D. A. Cunningham.
Technical Officer—K. R. Hanna.
Technical Officer—Miss R. I. Shoebridge, B.Sc.

Chemical Engineering Section—
Principal Research Officer—E. J. Drake (seconded).
Research Officer—D. R. Zeidler, M.Sc.
Assistant Research Officer—E. H. Waters, M.Sc.(Hons.) (seconded).
Assistant Research Officer—I. Brown, B.Sc.(Hons.).
Assistant Research Officer—R. W. Urie, B.Sc.
Assistant Research Officer—J. F. Pearse, B.Sc.(Hons.).
Assistant Research Officer—B. W. Wilson, M.Sc.
Technical Officer—J. Coutts, A.M.T.C.
Technical Officer—J. L. Clay, A.M.T.C.
Senior Draughtsman—C. Simpson.
Draughtsman—H. H. Evans.
Draughtsman—L. R. Bull.
Tracer—Miss M. M. Meehan.

Chemical Physics Section—
Senior Research Officer—A. L. G. Rees, M.Sc., Ph.D.

At University of Melbourne—
Assistant Research Officer—M. E. Smith, B.Sc. (Hons.), Ph.D.

At University of Western Australia—
Alunite Investigations—
Assistant Research Officer—G. H. Payne, M.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer—W. E. Ewers, M.Sc.
Assistant Research Officer—F. C. Johnson, B.Sc.

Library—
Librarian—Miss H. P. Meggs (part-time).

16. Section of Biometrics.

At Sectional Head-quarters, Melbourne—
Senior Research Officer—E. A. Cornish, M.Sc., B.Agr.Sc.
Technical Officer—Miss V. M. Botham, B.Sc.

At Divisions of Plant Industry and Economic Entomology, Canberra—
Assistant Research Officer—G. A. McIntyre, B.Sc., Dip.Ed.

At Division of Forest Products, Melbourne—
Assistant Research Officer—E. J. Williams, B.Com.

At Division of Animal Health and Nutrition, Sydney—
Assistant Research Officer—Miss H. A. Newton Turner, B.Arch.
Technical Officer—Miss M. Hornby, B.A.

17. Radio Research.

At University of Sydney—
Research Officer—F. W. Wood, B.Sc.
Assistant Research Officer—L. S. Prior, B.Sc.
Assistant Research Officer—C. B. Kirkpatrick, B.Sc.
Assistant Research Officer—D. G. Stewart, M.Sc.
Assistant Research Officer—L. Heisler, B.Sc.
Assistant Research Officer—Mrs. M. Harrison, B.Sc.

18. Ore-dressing Investigations.

At University of Melbourne—
Officer-in-Charge—H. H. Dunkin, B.Met.E. (part-time).
Research Officer—J. G. Hart.
Technical Officer—F. D. Drews.

At School of Mines, Adelaide, South Australia—
Officer-in-Charge—Professor H. W. Gartrell, M.A., B.Sc. (part-time).
Assistant Research Officer—D. R. Blaskett, B.E.

At School of Mines, Kalgoorlie, Western Australia—
Officer-in-Charge—B. H. Moore, M.E., D.Sc., F.S.A.S.M. (part-time).

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.
Assistant Research Officer (Chemistry)—J. N. Gregory, M.Sc.
Assistant Research Officer (Chemistry)—E. B. Greenhill, M.Sc.
Assistant Research Officer (Chemistry)—M. F. R. Mulcahy, M.Sc., A.G.Inst.Tech.
Assistant Research Officer (Chemistry)—R. G. Vines, M.Sc.
Assistant Research Officer (Chemistry)—M. A. Stone, D.A.C.
Assistant Research Officer (Engineering)—A. E. Ferguson, B.E.E.
Assistant Research Officer (Engineering)—T. V. Krok, B.E.
Assistant Research Officer (Engineering)—G. K. Tudor, B.E.
Assistant Research Officer (Engineering)—R. R. Muncey, B.E.E.
Assistant Research Officer (Metallurgy)—A. J. W. Moore, B.Sc.
Assistant Research Officer (Metallurgy)—R. W. K. Honeycombe, M.Sc.
Technical Officer—D. J. Swaine (on extended leave).
Technical Officer—J. F. Peart (on extended leave).

20. Other Investigations.

Dairy Products Investigations—
Officer-in-Charge—W. J. Wiley, D.Sc.
Research Officer—E. G. Pont, M.Sc.Agr.
Research Officer—G. Loftus Hills, B.Agr.Sc. (seconded from Division of Industrial Chemistry).
Research Officer—C. C. Thiel, B.Sc.(Agric.), Ph.D.
Assistant Research Officer—J. Conochie, B.Sc.(Agric.) (seconded from Division of Industrial Chemistry).
Assistant Research Officer—D. Morell, B.Sc.
Technical Officer—W. G. T. Laffan, H.D.D. (seconded from Division of Industrial Chemistry).

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

4. Publications of the Council.

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

(i) Bulletins.

No. 164.—Studies in the Biology of the Skin and Fleece of Sheep. 1. The Development and General Histology of the Follicle Group in the Skin of the Merino. 2. The Use of the Tanned Sheep-skin in the Study of Follicle Population Density. 3. Notes on the Arrangement, Nomenclature and Variation of Skin Folds and Wrinkles in the Merino, by H. B. Carter, B.V.Sc.

No. 165.—Potato Virus X.: Mixtures of Strains and the Leaf Area and Yield of Infected Potatoes, by J. G. Bald, M.Agr.Sc., Ph.D.

No. 166.—Fertility in Sheep—An Experimental Study of Periodicity of Oestrus and Non-breeding Seasons in Australia, by R. B. Kelley, D.V.Sc., and H. E. B. Shaw, B.V.Sc.

No. 167.—The Detonation of Nitroglycerine by Impact, by F. P. Bowden, Sc.D., F. Eirich, Ph.D., A. E. Ferguson, B.E.E., and A. Yoffe, M.Sc. (not for distribution).

No. 168.—A Survey, Census and Statistical Study of the Horticultural Plantings on the Murrumbidgee Irrigation Areas, New South Wales, by A. Howard, M.Sc., A.A.C.I., and G. A. McIntyre, B.Sc.

No. 169.—The Entomological Control of St. John's Wort (*Hypericum perforatum* L.). With particular Reference to the Insect Enemies of the Weed in Southern France, by Frank Wilson.

No. 170.—Pea Mosaic on *Lupinus varius* L. and Other Species in Western Australia, by D. O. Norris, B.Sc. (Agric.).

No. 171.—Experiments with Insecticides against the Red-legged Earth Mite (*Halotydeus destructor* (Tucker)), by K. R. Norris, M.Sc.

No. 172.—Zebu-cross Cattle in Northern Australia—An Ecological Experiment, by R. B. Kelley, D.V.Sc.

No. 173.—The Detonation of High Explosives by Impact, by F. P. Bowden, Sc.D. (Cantab.), F. Eirich, Ph.D., M. F. R. Mulcahy, M.Sc., R. G. Vines, B.Sc., A. Yoffe, M.Sc. (not for distribution).

No. 174.—Recent Advances in the Prevention and Treatment of Blowfly Strike in Sheep. Supplement to Report No. 2, by the Joint Blowfly Committee (Appointed by the Council for Scientific and Industrial Research, and the New South Wales Department of Agriculture, and the Queensland Department of Agriculture and Stock).

No. 175.—The Recovery of Inter-block Information in Quasi-Factorial Designs with Incomplete Data. 2. Lattice Squares, by E. A. Cornish, M.Sc., B.Agr.Sc.

No. 176.—The Analysis of Cubic Lattice Designs in Varietal Trials, by I. F. Phipps, B.Agr.Sc., M.Sc., Ph.D. (Waite Agricultural Research Institute), A. T. Pugsley, B.Agr.Sc. (Waite Agricultural Research Institute), S. R. Hockley (Waite Agricultural Research Institute), and E. A. Cornish, M.Sc., B.Agr.Sc. (Section of Biometrics).

(ii) Industrial Chemistry Circulars.

No. 4.—Separation of Ergot from Rye Corn, by Enid C. Plante, B.Sc., and K. L. Sutherland, M.Sc.

(iii) QUARTERLY JOURNAL.

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Vol. 17, No. 2, May, 1944.

(iv) ANNUAL REPORT FOR THE YEAR ENDING 30TH JUNE, 1943.

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.

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} Executive Committee.

G. A. COOK, Secretary.
26th September, 1944.

APPENDIX.

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

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H. J. Braund, Water Conservation and Irrigation Commission, New South Wales.
E. R. Iredale, Rural Bank of New South Wales.
C. T. Lasscock, Rural Bank of New South Wales.
H. G. B. Williams, Rural Bank of New South Wales.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith.
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S. A. Trout, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.

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(*Established in connexion with the co-operative investigations of the Council and the Victorian Department of Agriculture on the cool storage of non-tropical fruits.*)

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F. M. Read, M.Agr.Sc., Department of Agriculture, Victoria.
J. R. Vickery, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.

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