1945.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

NINETEENTH ANNUAL REPORT

OF THE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH,

FOR THE

YEAR ENDED 30TH JUNE, 1945.

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COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

NINETEENTH ANNUAL REPORT (FOR YEAR ENDED 30TH JUNE, 1945).

NOTE.—*During the past year, a considerable part of the Council's activities was devoted to the solution of problems arising out of the war and to assistance and advice to various Government Departments and other institutions concerned with the war effort. This applied particularly to the Council's National Standards Laboratory and its Divisions of Aeronautics, Forest Products, Industrial Chemistry and Radiophysics. The expenditure on this class of work formed a substantial part of the total expenditure of the Council, but for security reasons reference to these activities is at times either confined to brief generalized statements or is omitted entirely.*

1. 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 an information service relating to scientific and technical matters.

2. *Work relating to the War and the Post-war Period.*—During the year under review, the Council's work in relation to the national war effort was continued, but, particularly towards the latter part of the year, greater consideration was given to problems concerning post-war reconstruction. For instance, much use has been made of the Council's Division of Soils for soil surveys of areas intended for closer settlement. The "secondary industry" Divisions which were established during the war, and which immediately devoted their attention to a wide range of problems confronting those responsible for the Australian production of the innumerable materials of war, can also readily relate their programmes to the variety of materials wanted for a fuller life under peace-time conditions. In some cases, too, the war-time researches have shown the way to the manufacture of new products that will play no little part in strengthening the Australian economy. Details of the various divisional activities are given in the sections that follow.

3. *New Divisions and Sections.*—It is now possible to make public the existence of the Council's Division of Radiophysics. This Division was formed at an early stage in the war, but, its activities being confined to a field of work, radar or radio-location, that was once highly secret, no mention of the Division has been made in previous annual reports. The Division, which has its central laboratory situated in the grounds of the University of Sydney, was able to be of great value to the Allied Nations' war effort in the South-West Pacific; a brief account of its formation and work is given in Section XVII.

During the year under review, the three sections forming the National Standards Laboratory were given the status of Divisions, namely the Division of Metrology, of Electrotechnology, and of Physics. The common services of the laboratory are administered through a "functional committee" representative of the three Divisions. The former large Division of Animal Health and Nutrition was divided into two Divisions known as the Division of Animal Health and Production and the Division of Biochemistry and General Nutrition. The latter Division is now responsible for the work of the Nutrition Laboratory in Adelaide. Another change has been that the former Biometrics Section is now known as the Section of Mathematical Statistics.

An important development during the year was the decision to carry out a comprehensive programme of research into building materials; work on concrete and other materials for large structures, bridges, dams, &c., on which large sums of public moneys are annually expended will form one important part of this programme. In the early years, much attention will also be given to housing problems in co-operation with the Commonwealth Experimental Building

Station of the Ministry of Post-war Reconstruction. Work in the field of flax processing is another responsibility which the Council accepted during the year, at the request of the Flax Production Committee of the Department of Supply and Shipping. Finally, the Council took over the former Scientific Liaison Bureau, as from 16th April, 1945. That body has now been amalgamated with the Council's Information Section.

4. *Wool and Textile Research.*—Following a report of the Textile Panel of the Ministry of Post-war Reconstruction, and in view of the outstanding importance of wool to Australia as a whole, the Government has recently taken action to initiate an extensive programme of research and publicity for the wool industry. The Council is to be entrusted with the scientific work involved, the necessary funds for which will be obtained under the *Wool Use Promotion Act* 1945. During the year, in consultation with various State Departments, universities, and other authorities, attention has been given to developing a programme of work on the wool production side. The full co-operation of the State Departments of Agriculture and other bodies has been freely offered for such research.

On the wool realization side, the Council arranged for three eminent wool textile authorities from abroad to visit Australia to advise as to the lines the textile investigations should follow. These authorities were Mr. B. H. Wilsdon, Director of the British Wool Industries Research Association, Dr. A. C. Goodings, Director, Textile Section, Ontario Research Foundation, Canada, and Professor J. B. Speakman, Professor of Textile Technology, University of Leeds, England. Their reports are now under consideration. It is also hoped to obtain in a similar way, the advice of Dr. F. T. Peirce, a physicist formerly attached to the British Cotton Industries Research Association.

5. *Amendment to Council's Act.*—Towards the end of the period under review, the Government decided to amend the Council's Act. Assent was finally given to the necessary legislation on 16th August, 1945. The amendment provides for the Executive Committee to be increased in number from three to five members.

6. *Finance.*—Section XXII. of this Report gives details of expenditure by the Council during the financial year 1944–45 of a sum totalling £921,275. Of this amount, £144,997 was contributed other than directly from Commonwealth Treasury. 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.*—The Division of Plant Industry has again been greatly helped by the co-operation of other institutions. Particularly is it desired to refer to State Departments of Agriculture, the Pharmacy Department of the University of Sydney, the Physiology Department of the University of Melbourne, the Departments of Physiology and Chemistry of the University of Queensland, and the Waite Agricultural Research Institute of the University of Adelaide.

One of the most important phases of pasture work is that which has to do with pasture production under irrigation, as, for example, in the areas between the Murrumbidgee and the Murray. The need for a station in that area will be met by the establishment of a laboratory and other ancillary buildings at Deniliquin, and it is planned that accommodation will be available in that laboratory for agrostologists of the New South Wales Department of Agriculture. The necessary land has been made available by the Deniliquin Hospital Board and the New South Wales Lands Department. The goodwill and co-operation of the pastoral industry were made evident in the free gift to the Council for Scientific and Industrial Research by Messrs. F. S. Falkiner & Sons Pty. Ltd. of nearly $2\frac{1}{2}$ square miles of land with access to the Deniliquin–Conargo-road. On this area the effects of irrigation on pasture and fodder crop production on the two main soil types of a large area of country can be investigated. Another illustration of the help received is the work of the New South Wales Water Conservation and Irrigation Commission in surveying and planning the irrigation set-up which is necessary for the work.

The need to do much more work in the pasture programme, because of its fundamental importance in wool production, to engage more in weeds control investigations, and to do more effective work in other parts of the Division's programme, brings home the urgent need to complete the present laboratory block at Canberra, and to provide still more laboratory accommodation.

During the past two and a half years the Division has co-operated actively with the War Agricultural Organization established in New South Wales to assist farmers to obtain increased production under war-time conditions. An officer of the Division is Chairman of the District Committee which has its head-quarters in Canberra, and a considerable part of his time has been devoted to District War Agricultural Committee business. The co-operation of the New South Wales Department of Agriculture is also involved in this work.

2. *Pasture Investigations.*—(i) *Agrostology.—A. Investigations in the Winter Rainfall Zone.—(a) Canberra, Australian Capital Territory.*—(1) *Pasture Management Studies.*—The grazing management experiment comparing rotational and continuous grazing of a sown pasture of *Phalaris tuberosa,* subterranean clover, and lucerne has been concluded and the full results will shortly be published. No increases in wool returns were secured from rotational, as compared with continuous, grazing. *Phalaris* and subterranean clover gave no differences in yield or chemical composition under the various treatments. Lucerne disappeared under continuous grazing, but was maintained as a good stand under rotational grazing. Its contribution to total yield was, however, relatively unimportant. Despite the lack of benefits from rotational grazing, there may be specific periods in the growth of both *Phalaris* and subterranean clover during which protection from grazing will be of value—i.e., by spelling at critical periods or "deferred grazing". Accordingly, two experiments have been started to determine at what stage in the growth of *Phalaris* and subterranean clover the seasonal yield is depressed by the continuance of grazing.

(2) *Soil Fertility Studies.*—(*a*) Pot experiments have been continued to determine the factors leading to the sub-normal development of lucerne and other pasture species on the soil of the Dickson Experiment Station. The initial pH of the Dickson loam is 5.5. The experiments have been concerned principally with the analysis of the factors leading to the response to lime under field and pot culture conditions. Increases in the yield of lucerne are secured when pH is raised by the use of either magnesium salts or calcium salts. No response is secured to calcium sulphate alone, but if calcium sulphate is added to pots in which pH has already been raised by magnesium salts, a further substantial increase in yield is obtained without further movement of pH. *Phalaris tuberosa* gave equal increases in yield following applications of equal quantities of calcium, either as the sulphate or hydroxide. No final conclusions can be drawn from the experiments. Responses appear to follow both a movement in pH, and an addition of calcium, but apparent anomalies remain to be explained. Work is continuing on this problem.

(*b*) A study is being made of the effect of various rates of superphosphate varying from $\frac{1}{4}$ cwt. to 2 cwt. per acre, applied annually and biennially to sown pasture. It is considered probable that the optimum rate of top-dressing of subterranean clover pastures in southern and central New South Wales may be appreciably lower than those of much of South Australia and Victoria. No precise comparison has yet been made of the relative value of, say, $\frac{1}{2}$ cwt. per annum and 1 cwt. every second year, despite the substantially lower cost of the second treatment, and this aspect is also covered in the experiment.

(*c*) Instances have been recorded of the failure of top-dressing of subterranean clover with superphosphate on areas cleared from dry sclerophyll forest on the Southern Tablelands. Small qualitative plots indicate a response to lime, wood ashes, and molybdenum, and suggest that these fertilizers may prove of value in establishing subterranean clover on these more difficult sites. Trials are in progress testing the value of these fertilizers and other trace elements.

(3) *Studies on Native Pastures.*—Consideration is being given to a considerable programme of work on native pastures, which carry the majority of the sheep of the Commonwealth. Meanwhile, work is in progress to determine the life history of *Danthonia semi-annularis* under pot culture conditions, and to explore means of field establishment of this native perennial grass. Work to enable fuller appreciation of the technique and scope of the introduction of pasture species into natural swards by surface seeding is planned, and studies on the competition between subterranean clover and the native perennial grasses of the Southern Tablelands have been initiated.

(4) *The Establishment of Pasture under Cover Crop.*—As a phase of a rotation with arable crops, it is a frequent practice to sow the pasture seed with the final crop of the rotation. It is recognized that this practice gives an inferior establishment of the pasture species to that secured

by sowing without cover crop. However, the use of cover crop will continue as a means of securing a cash return during the establishment year of the pasture. Accordingly, a comprehensive trial has been sown at the Dickson Station comparing various rates of cover crop and various means of sowing both the crop and the pasture species.

(5) *Rhizobium Studies.*—A pot experiment has been conducted to compare a strain of *Rhizobium* occurring on naturalized *Lespedeza* from Queensland with the common strain of this inoculation group used for cowpea inoculation. Preliminary results indicate a significantly greater dry weight of nodular tissue and nitrogen content in the tops of plants treated with the Queensland strain.

(6) *Festuca Mairei.*—A trial is in progress to compare the productivity and grazing value of a pasture of *Phalaris tuberosa*-subterranean clover and *Festuca Mairei*-subterranean clover, respectively. *F. Mairei* is a promising perennial grass from North Africa.

(*b*) *Western Australia.*—(1) *Species and Mixture Trials.*—Further data have been obtained regarding the behaviour of the two perennial grasses *Phalaris tuberosa* and veldt grass *Ehrharta calycina,* in comparison with the annual Wimmera rye-grass in the 15 to 25-in. rainfall belt. Three years' data are now available from a trial at Walebing (17½ inches rainfall). The yield for all species has fluctuated considerably throughout the three years, and in general the perennial grass species have failed to persist. In 1944, these plots consisted mainly of subterranean clover and weeds.

This experiment has also provided data on the effect of application of superphosphate to the grey-brown podsolic soils of the area. No important change in botanical composition has resulted, but total yield of herbage has been significantly increased. From this, and previous experiments, it can be stated that there is little doubt of the capacity of subterranean clover to respond to phosphate on this soil type and that an annual application of 1 cwt. per acre should suffice for maximum production.

An additional experiment was commenced at Gingin in 1944, on a different soil type, a deep red-brown podsolized sand. In this instance, *Ehrharta* established most successfully, followed by *Phalaris*, with Wimmera rye-grass last, the mean number of plants per unit area being 11.3, 6.5 and 3.9, respectively. Two rates of seeding were used, and in all species establishment was proportional to rate of seed sown. Late opening rains and consequent lack of germination of weeds during the pre-sowing fallow resulted in a high establishment figure for weed species. There was no significant difference between the density of seedlings of either subterranean clover or weeds in the various sown grasses. Subsequently, a harvest and botanical analysis indicated that the sown species had failed to contribute substantially to the total yield, the main contributions being made by the volunteer *Bromus gussonii* and miscellaneous species. It was evident that low soil fertility was responsible for a relatively low establishment rate and the subsequent failure of the sown species. The fertility status of this soil is receiving detailed attention in 1945.

The present uncertainty of securing a perennial grass which can be widely and reliably used in the 15 to 25-in. rainfall belt has led to the initiation of further studies on the annual Wimmera rye-grass. Although the species can be established successfully, its contribution to the pasture mixture declines rapidly and little contribution is made after a few years. It appears that three factors may be involved—lack of fertility, especially in the lighter soils; the development of surface conditions unfavorable to germination; and the incidence of hard grazing during flowering and seed setting in preventing the production of adequate seed. Trials are being laid down at York (17 inches), Wagin (17 inches), Broomhill (17 inches), and New Norcia (22½ inches) to investigate the effect of surface cultivation, and of nitrogen fertilizers in the productivity, persistence and re-establishment of Wimmera rye-grass under field conditions.

As subterranean clover does not grow satisfactorily on all soil types, a trial was commenced in 1944 with 25 varieties of annual medics to determine whether any of these might take the place of subterranean clover in some localities.

(2) *Control of Capeweed.*—Second-year data have been obtained from an *Ehrharta*-subterranean clover pasture sown on three different dates in 1943. To a large degree, differences in the initial establishment of the grass, due to time of sowing, have been maintained, and the late sown plots still show a much higher plant density. Although total yield of dry matter did not differ significantly between treatments, there was a highly important difference in botanical composition. The percentages of *Ehrharta* and capeweed were 86 and 6 respectively on the late-sown plots, while the average figures for the two earlier sowings were 38 and 32 per cent. respectively. It is clear that later sowing has resulted in a substantial reduction of capeweed in the second year. The logical development from these results, namely, spring sowing, is being studied.

(3) *Soil Fertility Studies.*—Responses by subterranean clover to fertilizers containing potash have been observed on the Karrakatta sands near Perth, but in the earlier experiment, inconsistent results were obtained. Two experiments have now provided information on the effect of pre-sowing, cultivation, rainfall and accompanying species. None of these factors appears to be responsible for the inconsistencies. The results of a pot experiment which indicated that subterranean clover responded to potash only if adequate phosphate was also applied, have been confirmed by a field experiment on newly cleared land. The addition of both potash and phosphate has given a sixteen-fold increase in yield. However, there is evidence that other elements may also be important, and these experiments have now been extended to cover various trace elements and several soil types. A point of interest is that sheep grazing on an *Ehrharta*-subterranean clover pasture at Crawley have appeared to suffer from cobalt deficiency, and an experiment has been planned in conjunction with the Western Australian Department of Agriculture to determine the effect of applied cobalt on the yield and cobalt content of subterranean clover.

The effect of legumes on soil fertility has also been studied. Soil samples taken from five paddocks of similar soil type, but on which lupins had been grown for varying periods of time, have shown that the total nitrogen content of the soil is related to the duration of lupin growth. The yield of wheat plants grown on these soil samples in pots has shown a similar relationship. It would appear from these results that lupins make a worth-while contribution to soil fertility.

A trial in conjunction with the State Department of Agriculture, to examine the effects of peas, lupins and subterranean clover on soil fertility and their value for wool production is now projected. These legumes, together with Wimmera rye-grass or oats, will form the pasture phase of a four-year rotation, in which wheat will be used as the index of soil fertility changes. The trial will be conducted at the Wongan Hills Experiment Farm.

(4) *Grazing Management Trial.*—An experiment designed to compare the effects of continuous and rotational grazing on the yield and composition of an *Ehrharta*-subterranean clover pasture was commenced at Crawley in 1944. In the first year of grazing, there was little difference between the two treatments.

(5) *Grazing Trials Related to Breeding Problems in Sheep.*—Work is planned in conjunction with the State Department of Agriculture on the relationship of the composition of the pasture to the incidence of reproductive diseases (infertility, dystokia, and prolapse of the uterus) experienced in Merino sheep in certain parts of the south-west of Western Australia. The disease appears to be correlated with a dominance of Dwalganup subterranean clover. An attempt is to be made to introduce Wimmera rye-grass and oats into a subterranean clover dominant pasture and to compare the incidence of the disease in Merino ewes in the better balanced pasture with that on untreated pasture. Experiments are being laid down on an area of 150–200 acres at each of three centres, and will continue for four years, grazing commencing in June, 1945.

B. Investigations in the Summer Rainfall Zone.—(*a*) *Gilruth Plains, Cunnamulla, Queensland.*—(1) *Grazing Management Experiment.*—The grazing management trial at Gilruth Plains, in which a Mitchell grass pasture is grazed with sheep at different rates (one sheep to $2\frac{1}{2}$ acres, 5 acres and $7\frac{1}{2}$ acres, respectively) and frequencies, has now been in progress for a period of four years. The results so far indicate that continuous grazing at the medium rate (one sheep to 5 acres) has been the best grazing treatment of those tested. At this rate, there has been no evidence of pasture deterioration, and sheep liveweights and wool production have been maintained almost as well as under light grazing (one sheep to $7\frac{1}{2}$ acres).

Comparing continuous and rotational grazing, no differences in sheep liveweights or wool production have been recorded, but the amount of forage available has tended to be more under continuous grazing and the difference between the treatments has been greater at the heavier rate of stocking. On the other hand, the proportion of Mitchell grass has increased under the system of rotational grazing involving winter grazing and summer spelling, as compared with the systems of continuous grazing, or summer grazing and winter spelling. Although the gross monetary return per unit of land was greater under heavy stocking for the first three years of the experiment, the cost of feeding a supplementary ration to the sheep under heavy stocking during the fourth year more than outweighed the aggregate monetary advantage. In addition, the pasture under heavy stocking has suffered, and its carrying capacity will probably be impaired for a number of years, the proportion of Mitchell grass being markedly reduced. The liveweights of sheep have been considerably lower under heavy stocking, particularly when pasture conditions were worst, but under light stocking have been only slightly greater than under medium stocking.

(2) *Other Investigations at Gilruth Plains.*—Following falls of rain in February, 1945, further soil moisture studies were made on the measurement of depth of water penetration, field capacity of the top 6 inches of soil, and the rate of loss of water from the surface of the wet soil.

Experiments on the establishment of Mitchell grass from seed have shown that burying seed ½ to 1 inch deep gave better germination than broadcasting, and the seedlings made quicker initial growth.

Initial chartings of the vegetation of permanent quadrats and transects have been made on a paddock set aside for the study of the regeneration of natural species, following their reduction by heavy grazings.

The study of the role of birds in the ecology of the Mitchell grass pasture has been continued.

An aerial survey of Gilruth Plains has been made by the Royal Australian Air Force and is being used as a basis for a detailed vegetation survey of the Station.

(*b*) *Lawes, Queensland.*—(1) *Paspalum Investigations.*—Introduced species of *Paspalum*, and particularly of *Paspalum scrobiculatum*, have continued to give promising results as perennial grasses for south-eastern Queensland. Their value lies mainly in their suitability to the climatic region, their capacity to retain a leafy and succulent habit, and their feed value in winter.

The method of establishing *Paspalum scrobiculatum* in rows has been further studied, and several experiments designed to investigate theoretical and practical aspects of this procedure are now in progress. At Lawes, the comparison of swards and rows of the grass, under grazing, has been combined with a comparison of yields from grass alone, with grass-lucerne mixtures, and grass top-dressed with nitrogenous fertilizers.

Preliminary data from a *Paspalum* species and variety trial suggest that one variety of *Paspalum scrobiculatum* is outstanding for sheep nutrition.

The sheep-carrying capacity of a mixture of *Paspalum scrobiculatum* and lucerne in rows 4 feet apart is being studied at Lawes on six half-acre plots. Sheep have been maintained in excellent condition, the stocking rate varying from four to two sheep per acre, according to seasonal conditions. A similar experiment on a slightly larger scale is being conducted on the Darling Downs at Anchorfield where the plots have maintained four sheep per acre in good condition over a period of twelve months.

A more complete experiment at Anchorfield has been designed to test various combinations of lucerne and *Paspalum scrobiculatum* in rows, and to compare these with rows of grass alone, lucerne alone, and lucerne in swards. Co-incident with this experiment, a series of plots of natural pasture will be subjected to both rotational and continuous grazing to observe differences, if any, between the methods of grazing and also to provide a standard of comparison with the sown pastures. These plots will also be available for worm control studies, in co-operation with the Division of Animal Health and Production, and for measurements of wool growth.

Difficulties have been experienced in establishing *Paspalum scrobiculatum* on some soil types on the Darling Downs, and it appears that this may be related to trace element deficiencies. Already, ephemeral zinc deficiency has been recorded, and this aspect is being followed up in pot trials.

(2) *Rhodes Grass Investigations.*—Preliminary experiments with Rhodes grass at Lawes have demonstrated certain outstanding qualities in the introduced Kenya Rhodes grass, C.P.I. 6585. A beef-cattle grazing experiment has been established to compare this strain with ordinary commercial Rhodes grass, and also to determine the value of Australian lucerne as a pasture legume when planted in conjunction with Rhodes grass swards.

(3) *Cattle Pasture Investigations.*—An officer has been transferred to Queensland to deal specifically with the problems of cattle pastures. Already a survey of parts of south-eastern Queensland has been completed. Major problems which will receive immediate attention include the prevention of re-establishment of *Eucalyptus* spp. on ring-barked country, and a study of the effects of burning on pasture maintenance and production.

(ii) *Investigations into Problems of Irrigated Pastures.*—A regional laboratory has been recently set up by the Council for Scientific and Industrial Research at Deniliquin, New South Wales, for investigation into the wide range of agricultural problems connected with the use of irrigation water on partially irrigated land. It seems likely that this laboratory and its accompanying field station will play an important part in developing methods whereby to stabilize the sheep industry of a whole province—the Riverina. Matters that will come under

study as soon as the basic equipment of the laboratories is completed, and the necessary trained scientists are available, may be briefly outlined under the four headings of soils, plants, animals and irrigation—

(*a*) *Soils Investigations.*—Detailed soil surveys to expand and supplement existing reconnaissance soil surveys on the Murray, Murrumbidgee and Darling rivers. Problems associated with soil structure, especially in relation to water penetration; drainage; and water usage on the major soil types.

(*b*) *Plant Investigations.*—Methods of land preparation for irrigated pastures; species and mixtures of species for improved pastures; forage crops; fertilizer requirements, including trace element studies; pasture management and the grazing of both irrigated and non-irrigated pastures severally and in conjunction; the relation of water use to pasture and fodder production.

(*c*) *Animal Investigations.*—The provision of an adequate and balanced food supply for the animal—especially sheep; the production and storage of drought fodders; the efficient use by the animal of pasture and fodder produced under irrigation.

(*d*) *Irrigation.*—The determination of the best irrigation methods for the major soil types; the maintenance of soil structure and fertility, and the efficient use of water by the different kinds of pasture and crop.

Climatically and physiographically, Deniliquin is the strategic centre of a large and important region of Australia. It also is within easy access to very important sheep and wool areas, and several of the most famous and successful Merino sheep studs of Australia are located in this region. To the north-west lie the semi-arid dryland pasture areas of New South Wales, to the south-west lies the important wool-growing area of the western district of Victoria. It is at the junction of the red and grey soil zones, and is at the centre of great irrigation areas.

These general considerations were very greatly strengthened by the free gift to the Council for Scientific and Industrial Research of some 1,550 acres of freehold land by Messrs. F. S. Falkiner & Sons Pty. Ltd. This land was part of Wanganella Estate with a frontage of half a mile to the Deniliquin–Conargo-road, some 12 miles from Deniliquin. This area of land will be used as an experiment station for field experiments on irrigated and dryland pastures and crops. Soil survey of the area shows that there is more than 900 acres of grey soils characteristic of the treeless plains of the Riverina, while certain characteristic soils of lighter texture, such as the Wakool sandy loam and Cobram fine sandy loam, are also represented in the area. The Blighty Channel of the New South Wales Water Conservation and Irrigation Commission is capable of being extended to command with water any portion of the land. The development of the area from a station paddock into a well equipped irrigation experiment farm will involve several years' work. The investigations could not be efficiently undertaken without the provision of adequate scientific laboratories. The Council is obtaining the permanent lease from the New South Wales Government of an excellent site of just over 7 acres of land with a frontage some 250 yards to Charlotte-street, Deniliquin. This land was under lease to the Deniliquin Hospital Board, and the Council is particularly indebted to that Board for its most considerate and helpful action in voluntarily relinquishing the lease several years ahead of its expiry date. Sufficient space is available for considerable small-scale experimentation with irrigation, the water supply for which will be pumped from the adjacent Edward River.

The immediate plans call for a laboratory of some 5,000 square feet floor space, together with an ancillary building, greenhouses, potting shed, and garage. The laboratory will provide facilities for the study of pastures and fodder crops; soils—particularly soil physics; soil survey; irrigation studies; and animal husbandry. Within three years the scientific staff is expected to include an officer-in-charge, three agrostologists to work on pastures and crops, one chemist, one soil physicist, one irrigation officer, and one man trained in sheep husbandry, while it is expected that from time to time members of the soil survey team of the Soils Division will make the station their head-quarters.

In addition to the scientific staff, there will be an experiment station manager with the necessary team of skilled labourers on the experiment station, and the necessary technical and clerical assistance at the laboratory at Deniliquin.

The policy will be to call upon the older established Divisions of Soils, Plant Industry, Animal Health and Production, and Biochemistry and General Nutrition, and from the existing Irrigation Research Stations at Merbein and Griffith, to undertake special studies and, when necessary, to locate officers at the Deniliquin laboratory for these studies. In this way the fullest resources of the primary industry divisions can be brought to bear on the problems under investigation.

The active co-operation and help of the New South Wales Water Conservation and Irrigation Commission has been of the greatest value in the initial stages, and this co-operation will continue. The organization of the regional laboratory will not be complete without close contact with the farmer and grazier. This contact and mutual interchange of information will, it is hoped, be achieved through the active participation of the New South Wales Department of Agriculture in the work of the laboratory, and provision has been made so that officers of the Department may be stationed at the laboratory. The initial developmental stages completed, it will also be practicable to obtain the collaboration of the farmers and graziers through an advisory committee of practical men of the region which the laboratory will serve.

(iii) *Pasture Plant Improvement.*—(*a*) *Canberra, Australian Capital Territory.*—Work on the value of a number of strains of subterranean clover, and of species of *Danthonia*, is proceeding.

(*b*) *Lawes, Queensland.*—The programme of lucerne breeding has been continued and a number of rust-resistant progenies have been planted for further studies. Additional selections have been made of material surviving under heavy grazing and flooding. A selected strain of *Phalaris tuberosa* has been planted for increase and for further testing of survival under grazing.

3. *Weeds Investigations.*—(i) *Galvanized Burr.*—The experiment in the St. George district in Queensland, designed to study the effects of controlled grazing on burr infestation, has been continued. Under the adverse seasonal conditions since the 1942–43 summer, the burr has decreased under all grazing treatments. This gives further confirmation to the viewpoint that seasonal conditions and not stocking exert the major influence in controlling the burr.

(ii) *Mintweed.*—A survey has been completed of the mintweed areas of Queensland and New South Wales, and the data secured are now being collated. Preliminary pot experiments concerned with the physiology of this weed have been commenced, and a field trial is projected on the Darling Downs to study the effect and control of mintweed in summer crops.

(iii) *Other Weeds.*—During the war period, as a result of loss of staff on war service, it was impossible to continue the full weeds programme. However, with the return of staff, a programme of investigations covering major weeds of pastures and cultivated lands will be resumed.

4. *Plant Introduction.*—(i) *Introduction and Exchange of Plants and Seeds.*—The introduction of seeds and plants from abroad for trial in Australia continued as actively as possible under war conditions, some 289 introductions having been made during the year, bringing the total to date to 8,514. As in the previous year, introductions brought in for trial by other sections of the Division, or by other Australian institutions, contributed largely to this total, prominent among these introductions being varieties of potato, lima bean, and other vegetables, and of flax, opium poppy and safflower. Among other plants of interest brought in during the year, mention may be made of "krym-saghyz" (*Taraxacum megalorrhyzon*), a Russian rubber plant related to the previously-tested "kok-saghyz"; guar (*Cyamopsis psoralioides*), which yields a mucilage of use in paper manufacture; varieties of sesame (*Sesamum* spp.), the oil of which is used in sprays and for other purposes; and yam beans (*Pachyrrhizus* spp.), the seeds of which have shown great promise in preliminary trials as an insecticide.

In exchange for these introductions, some 448 samples of seeds of Australian wild and cultivated plants were sent to institutions abroad. The issue of quarterly lists of introductions has proved to be a welcome innovation, and samples of seeds of introduced plants sent for trial to State Departments of Agriculture and other Australian institutions numbered 177.

(ii) *Forage and Pasture Plant Trials.*—Investigations under this heading have been conducted, principally at "Fitzroyvale", near Rockhampton, most of the work of this nature in southern Queensland having been passed over to the Agrostology Section. As in previous years, the work in central Queensland has had two main objectives—to obtain legumes which will improve the nutritive value of the natural pastures, and to study the possibilities of growing suitable protein-rich crops for use as supplementary feed.

Further work has served to emphasize the low value of the natural spear-grass pasture of central Queensland, the protein content ranging from under 2 per cent. with a single annual cut to 5–6 per cent. with seven cuts per annum, both these values being below the maintenance requirements of stock. Trials of different systems of management have failed to yield any worth-while improvements, and the productivity of the natural pastures falls rapidly with frequent defoliation.

Incorporation of the introduced legume Stylo (*Stylosanthes gracilis*) in the pasture results in doubling the yield, and the protein content of the legume is at least double that of the grass. It will be necessary to introduce and test further types of this species before its value can be fully ascertained, for the strain at present under test is readily damaged by frost. Other legumes which, while still at the stage of preliminary trial, show promise as pasture plants for central Queensland, include *Arachis diogoi* and *Stylosanthes viscosa*, both also from Brazil.

Of the species under trial as protein-rich supplementary forage crops, the most promising is the pigeon pea (*Cajanus cajan*), several varieties of which are being studied. In addition to producing high yields of protein-rich grain, a standing crop, some ten months old and 8 feet high, was very readily grazed by bullocks, the plants being completely stripped of leaves and pods.

At Lawes, in southern Queensland, recently introduced grasses which continue to show promise include two strains of *Urochloa* and two introductions of *Setaria spacelata*, while at Canberra drought-resistant legumes, especially species of *Astragalus* and *Trifolium*, are receiving further attention.

The work at Muresk (Western Australia) has been hampered by a very adverse season, which has served to underline the general unsuitability of perennial pasture plants for the region. Those which survive the dry summer make little growth and do not produce much seed. Of the annual species, strains of *Bromus marginatus* and *Lolium remotum* continue to show most promise, while none of the annual legumes tried compares favorably with subterranean clover.

(iii) *Vegetable Oil Plants.*—Vegetable oil plants under trial include varieties of soybean, linseed, rapeseed, sesame, and safflower. Work with soybeans has consisted of preliminary trials of many recently introduced varieties at several centres in order to assess their value under different climatic conditions. The most promising results have been obtained at Lawes, where several varieties have been selected for more extensive trials.

A varietal trial of linseed at Canberra suffered from severe drought, which made the results of observational value only. The varieties which gave the highest yields were, respectively, Lin de Tunisie, large-seeded Argentine, and Hindi, but these should be taken as an indication of their drought-resistance, rather than of their capacity to yield well under more favorable circumstances. In varietal trials at Muresk, several North American varieties have given the best yields, Indian varieties being notably low-yielding. Further work on this crop is in progress in southern Queensland, which is climatically very similar to the linseed-growing areas of Argentina.

In a further trial of rapeseed introductions at Fitzroyvale, the variety (C.P.I. 8538), which gave the highest yield last year, was again promising, with a seed yield of 3.8 cwt. per acre. One of the other introductions (*Eruca sativa*), which had given a low yield in the previous trial was prominent this year with a yield of 4.9 cwt. per acre. Further work is continuing at Redland Bay, near Brisbane, where arrangements have been made to conduct introduction trials on part of the Queensland Acclimatization Society's property.

Studies of sesame and safflower varieties are still in the preliminary stages, but both crops have made good growth in trials at Fitzroyvale.

(iv) *Guayule Rubber.*—Work on this plant has continued on a reduced scale, with the object of assessing its potentialities as a post-war crop, rather than as an emergency war crop. The plantations in Canberra have been maintained but growth was limited by the very dry season. Largely as a result of the dry conditions, growth was notably better on the heavier than on the lighter soils, but the plants have shown no response to fertilizers. The work at present in progress is designed to investigate the possibility of using different cultivation and harvesting methods, and to ascertain the areas of Australia most suitable for the cultivation of the plant. Trials indicated that guayule is not grazed by sheep, and experiments are being carried out to study the possibility of growing the plants in combination with a winter-growing pasture, thus eliminating the need for cultivation and obtaining some return from the land during the growth period. Trial plantings at a number of localities in northern New South Wales met with very severe weather conditions and were unsuccessful, but will be repeated this year. The trial plantings at Muresk (Western Australia) have made poor growth, but those on the lighter soils at Lawes are promising, and the species will be further investigated at the latter centre.

(v) *Miscellaneous Crops.*—Work at Muresk has included varietal trials of barley and oats. While none of the latter was superior to local varieties, some of the barleys were promising, and one variety in particular, Beecher (C.P.I. 8983), was outstanding.

Some of the introductions of the yam bean (*Pachyrrhizus* spp.), the ground-up seeds of which form a valuable insecticide, are making good growth at Fitzroyvale, while guar (*Cyamopsis psoralioides*), useful as a green-manure crop and as a source of mucilage for paper manufacture, is under trial at Lawes.

(vi) *Herbarium.*—As in previous years, the work of the Herbarium has consisted principally in the identification of pasture and other plants collected in the course of vegetation surveys and agrostological investigations. Included in these have been further large collections from "Gilruth Plains", and from New England, where pasture studies are in progress, and pasture plant collections from Trangie (New South Wales) and from the Northern Territory. Exchanges with other institutions have been continued, and some 11,155 specimens are now mounted and included in the general Herbarium.

5. *Wheat Investigations.—Take-all of Wheat.*—Since 1939, when the first significant results of different soil treatments on take-all of wheat were observed, we have added each year to our knowledge of the subject as the results of each succeeding experiment have become available. The organism that causes take-all may be assumed to be generally distributed in soils in which wheat may be grown, but the plants are able to resist the development of the disease provided they are well supplied with available plant food. Repeated cropping to wheat reduces or unbalances the amount of available plant food, the plants lose their resistance to the organism that has invaded their roots, and premature death takes place. Supplies of available plant food are built up by fallowing.

Two experiments are in progress at the present time ; one is to be continued for two more years, the other will be concluded in 1946. In both experiments, the effects of different means of conservation of plant food are being studied. Chemical examination of some of the plants produced this season demonstrates marked effects of different soil treatments on the availability of two of the elements as measured by the amounts in the ash. There is a suggestion of a relation between yield and the percentage of one of these elements in the plant ash, but more experimental work will be necessary to establish or disprove it.

6.-*Fruit Investigations.*—(i) *At Stanthorpe, Queensland.*—The general scope and purpose of the stock and scion investigations at Stanthorpe have previously been described (*vide* Eighteenth Annual Report, page 10). During the past year, routine cultural operations, growth measurements, and records of yield and behaviour of the different apple and pear stock-scion combinations under trial have been continued. The season was very dry, especially during early and late summer, and hot drying winds were experienced at blossoming time, as well as a damaging frost. These conditions seriously reduced fruit production, and trees in some trial plots bore no crop at all.

Preparations have been made to multiply the apple rootstocks, Merton Nos. 793 anf 789, in commercial quantities. These two rootstocks, which are immune to woolly aphis, and easily propagated, have given, when budded with Jonathan and Granny Smith scions, better performances in trials over a period of eight years than any of the other stocks tested. Several new apple rootstock types, also immune to woolly aphis, have been introduced from the East Malling Research Station, and these, together with other selected stocks, are being multiplied for testing under Stanthorpe conditions.

(ii) *Citrus Investigations at Griffith.*—Attention is drawn to an error in the Seventeenth Annual Report (1943) of this Council. Credit for the determination of the relative susceptibility of different citrus rootstocks to *Phytophthora citrophthora* was attributed in error to officers of the Council. Sample of the rootstock types being propagated by the Council were sent to the New South Wales Department of Agriculture, and were included with strains from many different sources in routine susceptibility tests. Thus, the incrimination of the pathogen and the grading of susceptibility of the different rootstocks referred to in the Report were the work of the New South Wales Department of Agriculture.

(iii) *In Tasmania.*—The investigations dealing with the physiological diseases of apples and pears in the orchard, and the disorders of these fruits following storage, have been maintained only on a very reduced scale. The officer responsible for these studies has been engaged on war emergency work in connexion with the examination of processed foodstuffs for the Services, and in the development of new processed products. This work is being carried out on behalf of the Department of Commerce and Agriculture.

The apple and pear problems have received attention to the extent of—(i) making the requisite chemical and other tests to prepare forecasts of the probable keeping quality of the season's fruit crop, (ii) carrying out storage experiments on fruit from two of the experiment plots used in the study of the relation between storage disorders and seasonal climate, and (iii) observing the experiment plots established in connexion with the work on cork in pears and dimple in Granny Smith and Cleopatra apples.

In addition to the routine examination of daily production samples of processed foods for quality, sterility, vitamin C content and packaging, investigations have been made in the development of new products, and technical assistance has been provided for manufacturers undertaking new processing methods. The most important of these new developments have concerned—(i) the production of a vitamin C enriched apple and black currant juice from black currant press residues ; (ii) the cooling of apple sauce ; (iii) the prevention of darkening and pink colour in apple sauce ; (iv) the prevention of can corrosion ; and (v) the reduction of vitamin C losses in processing.

At the request of the Tasmanian Department of Agriculture, a survey of the vitamin C content of pea and tomato varieties, both in the fresh state and after canning, was made.

7. *Drug Plant Investigations.*—These investigations have been continued in collaboration with the Department of Physiology, University of Melbourne, and the Department of Pharmacy, University of Sydney. In addition, co-ordination has been effected between the Council's work and current researches being made in this field by the Departments of Physiology and Chemistry of the University of Queensland.

(i) *Hyoscine and Atropine.*—An examination has been made of the leaf of *Duboisia myoporoides* and *Duboisia Leichhardtii* (native corkwood treses) from a large number of individual trees from natural stands in different localities. Trees yielding practically pure hyoscine and others yielding almost pure hyoscyamine were found in both species, as well as trees in which both alkaloids occurred in varying amounts. It has been concluded that the alkaloid content of aggregate samples from a number of trees in one locality depends upon the relative frequency of occurrence of these different types. In *D. Leichhardtii* and in *D. myoporoides* in the southern areas, hyoscyamine is the major alkaloid in the majority of trees, while in *D. myoporoides* in northern areas, hyoscine predominates. It has also been found that the nature and amount of alkaloid in the leaf of a single tree may vary markedly during the season. The causes of these seasonal fluctuations have not yet been definitely determined, and work which aims further to elucidate the problem is in progress. It has been found that the alkaloids, or a precursor, is synthesized in the roots. Studies of the alkaloids present in leaf, stem, and root at successive stages of seedling development are being made with a view to obtaining further information on the general problem of the chemical development of the alkaloids in the species.

A method of propagating both species successfully from cuttings has been developed and is being used to multiply selected tree types. It is interesting to note that when leafy and sparsely-leafed trees of *D. Leichhardtii* were so propagated, this difference in morphological habit was maintained in the resultant plants.

Additional plots of both species have been established at Nambour and Canberra for the growing of selected types and ascertaining the most effective and economic methods of cultivation, including time, method and frequency of harvest. Tentative conclusions only on several points are possible at this stage. Plantings of *D. myoporoides* at the rate of 134 trees per acre yielded 500 lb. of dried leaf when the trees were cut at the base twelve months after transplanting. *Duboisia Leichhardtii* grown at the rate of approximately 270 trees per acre yielded over 2,000 lb. dried leaf when cut fifteen months after transplanting. It would appear that the optimum rate of planting will be found to be greater than 134 trees per acre. Results also indicate that a system of pruning the trees at an early stage to assist the development of a good tree shape, and making the first leaf harvest within twelve months of transplanting (or when the trees are about 6 feet high), are desirable practices.

(ii) *The Opium Alkaloids.*—Further studies have been made on the changes which occur in the morphine content and dry weights of the opium poppy (*Papaver somniferum*) during maturation and on the distribution of morphine in the capsule and stalk. Further investigation of the effect of rain on the morphine content of maturing crops has led to the conclusion that the loss of morphine content occasioned by normal rains is not so great as was previously believed. The relative value of a number of varieties of opium poppy was further tested, and again considerable differences in the morphine and codeine contents, yield of dry matter, and in the time of maturation, were evident between varieties. Seed of the most promising varieties is being multiplied.

Preliminary breeding work, which aims to combine the most desirable characteristics of certain promising varieties, has been commenced, and results to date indicate a good probability of successful achievement. Other experiments in progress concern time of planting, and disease control. Commercial scale plantings have again been made under the supervision of the Council.

(iii) *Native Plants as Sources of Medicinal Drugs and Insecticidal Substances.*—The search for sources of supply of pharmacological and insecticidal substances in native plants was commenced this year in a systematic manner. Most available information on the alleged reputed, as well as established, medicinal and poisonous properties of indigenous plants and usage by aborigines, has been collated. On these bases, and on the basis of botanical affinity to plants known to contain pharmacological substances, lists of plants which appear most likely to yield substances of value and interest have been compiled. Survey of the occurrence of these plants and collection of samples, have been commenced in Queensland, and it is proposed to devote particular attention during the next year at least to the flora of north Queensland. Of some 200 species which have been subjected to preliminary field "spot tests", 38 appear definitely to contain alkaloids, 70 gave negative tests, and in the remainder, alkaloids were probably present in small amounts. More detailed laboratory examination of the species which gave the most positive tests in the field examinations is proceeding, and particular attention is at present being paid to the native species of *Strychnos*.

(iv) *Pyrethrum.*—The research programme concerned with *Pyrethrum cinerariifolium* and previously reported (*vide* Eighteenth Annual Report) has been curtailed because of changes in strategic requirements and in the potential demand for pyrethrum arising from recent advances in the production of synthetic insecticidal materials. The yields of the various strains under trial have been recorded at Canberra, and harvests made of the small plots established in each of a number of different locations, but pyrethrin assay results for last season's harvests are not yet completed. Seed of the five strains judged to be the most desirable on the basis of vegetative characters has been preserved. Other phases of the programme have been suspended.

(v) *Other Drugs.*—Plots of *Ephedra* spp. which yield ephedrine and of *Artemesia maritima* which produces santonin, as well as small plots of *Atropa belladonna, Hyoscyamus niger, Urginea maritima,* &c., have been maintained as sources of fresh seed supplies and propagating material. An examination of the ephedrine content of the *Ephedra* spp. throughout the season appeared to confirm the opinion that the highest alkaloid content occurs during autumn. Investigational work with these plants has now been concluded.

8. *Tobacco Investigations.*—At Canberra, observations were made on the incidence of the virus disease, yellow dwarf of tobacco, in plots containing over 3,000 plants. Tobacco has not been grown as a field crop in this area for about eight years; nevertheless 30 per cent. of the plants were infected. The occurrence and distribution were similar to that observed in earlier years in crops of tobacco in Victoria and other States. Many plants failed to grow to the normal size but did not show typical symptoms of the disease, and a study of the different types of dwarfing was commenced. The disease is of major importance in Victoria. Methods of control for the insect vector *Thamnotettix argentata,* as well as the leaf miner *Gnorimoschema operculella,* are being investigated.

A conference of Commonwealth and States tobacco technical officers was held at Canberra during June to discuss production problems and the future development of the industry.

9. *Vegetable Investigations.*—(i) *Potatoes.*—Genetical work aimed at combining a high degree of field resistance to viruses A, X, Y, and leaf roll into a number of hybrids is being continued. The successful synthesis of hybrids hypersensitive to virus Y from crosses involving the varieties Snowflake, Brown's River and Katahdin has been accomplished. Preliminary genetical work has indicated that this reaction to virus Y is inherited in a recessive fashion.

Fundamental growth studies on 60 potato varieties have been commenced. Basic quality studies on these varieties in co-operation with the Division of Food Preservation are in progress.

(ii) *Tomatoes.*—In co-operation with the Merbein and Griffith Research Stations, and the Division of Food Preservation, fundamental agronomic and processing data have been accumulated on the more promising types originally selected from a collection of all available varieties.

The genetics of disease resistance with respect to Fusarium wilt, early blight and leaf mould, are being studied with the aim of producing improved varieties resistant to these diseases.

(iii) *Peas and Beans.*—Systematic studies of all important agronomic characters of available varieties of these two crops are in progress. Hybridizations have been made with emphasis on disease resistance and quality. Co-operation of the Merbein and Griffith Research Stations, and the Division of Food Preservation and Transport, has made possible the investigation of agronomic and quality factors under irrigation conditions.

(iv) *Cabbage.*—Fundamental investigation of varietal variation in all important varieties has resulted in the isolation of improved uniform lines of these varieties. Dehydration studies by the Division of Food Preservation on the same material has elucidated quality factors involved.

(v) *Red Beet and Carrot.*—Inherent and environmental factors affecting quality in these two crops are still being investigated in co-operation with the Division of Food Preservation. In the course of this work large numbers of strains of a number of varieties have been grown over the last two seasons.

(vi) *Onions.*—Comparative agronomic studies on about two dozen varieties over two seasons have been completed. Last season, the Division of Food Preservation investigated the dehydration quality of this material. As a result of this work, a genetical programme aimed at improving the processing quality of the best existent onion varieties is in progress.

10. *Potato Virus Investigations.*—(i) *Effects of Virus X on Yield.*—A number of yield trials were arranged to test the effects of virus X on the yield of Up-to-Date potatoes. Some of these were performed in association with Departments of Agriculture in several States. Key trials were conducted at Canberra. In all experiments, certified Up-to-Date containing virus X was tested against the clonal families of virus X-free (FX) Up-to-Dates. In the Canberra trials also, the effect of time of harvesting on the reduction in yield due to infection was tested.

The Canberra results showed that very early harvesting prevented the development of yield differences between infected and FX Up-to-Dates. As the date of harvesting was delayed, yield differences developed. In crops that were nearly or quite ripe before they were dug, the stocks of Up-to-Date containing virus X yielded between 15 and 20 per cent. less than the average for the FX Up-to-Date clonal families. It was postulated that the formation of virus X in infected plants reduces the available reserves of protein stored in the leaves, without affecting the size of the haulm. While tubers are developing from currently formed metabolites, the infected plants are as efficient in tuber-formation as the healthy. When the plants begin to draw on reserve materials stored in the leaves to swell the tubers, the infected plants are at a disadvantage because of the diversion of reserve materials that has occurred for the formation of virus protein. The virus protein is not available for reconversion and use by the plant.

These results were borne out by field trials under widely different conditions. Where the crops ripened normally before harvesting, there were differences of 15 or 20 per cent. between the yields of FX and X-infected Up-to-Date. Where the tops of the plants were killed prematurely by frost or blight, differences were less or did not occur.

Some evidence was obtained of differences between clonal families of FX Up-to-Date in type, yield, and adaptability to various environmental conditions. These are being further studied.

(ii) *Varietal Resistance to Leaf Roll.*—This study was concluded, and the results assembled. In field trials no differences in population of the two aphid vectors of leaf roll, *Myzus persicae* and *Macrosiphum gei*, that indicated that they prefer to feed on any particular potato variety under trial were found. Thus, differences in varietal susceptibility to leaf roll were due to reactions of the plant tissues to inoculation, not to the numbers of aphid vectors visiting the plants. A range of susceptibility was found amongst the commonly grown Australian varieties. The variety most resistant under commercial conditions, Bismark, was both resistant to infection and intolerant of infection. Those plants that were infected were severly dwarfed, and produced so few tubers which could be used for planting as seed that tuber transmission was a relatively ineffectual mode of perpetuating the disease.

(iii) *Studies on Growth.*—These were continued from previous years. Leaf area and yield measurements were taken on a number of varieties of potato. These indicated a balance between main and axillary shoots and tubers, which largely determined the partition of metabolites, the rate of growth of each section of the plant, the efficiency of tuber formation, maturity, and total yield.

11. *Vegetable Fibres.*—(i) *Flax.*—Small replicated plots for the study of plant survival at three rates of sowing were established at Canberra, but the dry, cold winter prevented normal germination and brairding, even in plots lightly watered at frequent intervals. In all plots, there was a heavy plant mortality thought to be due, in part, to low temperatures. The early symptoms of this trouble appeared to be identical with a condition that is widespread in Victoria, particularly in dry seasons. Its distribution and occurrence indicate a deficiency in available plant food, a conclusion that was supported by results obtained in fertilizer and other plots at Canberra. Where lime was supplied at the rate of 10 tons per acre, the disease did not occur, and in other plots affected plants recovered following heavy watering throughout the dry winter.

Seed increase plots were maintained, a number of new varieties, including five from the Union of Soviet Socialist Republics, being sown for seed multiplication during the year.

(ii) *Browning of Flax.*—The condition that is known as browning of flax was first observed in Ireland during the first World War. Locally produced samples were brought to attention in 1941 in Victoria. During the following year, browning occurred in the experimental plots at Canberra, and in a few fields in the Deloraine district of Tasmania. In 1943, it was observed in some fields in the Western District of Victoria. Straw from one field from which another mill was supplied was also browned. This random distribution led to the suspicion that browning was associated with local soil conditions. In an experiment that was made in Canberra in 1944, it occurred in all pots that were waterlogged, but not in any others. Confirmation of these conclusions has been obtained in Tasmania where browning was found only in fields, or portions of fields, that were waterlogged just previous to browning. Provided that growth conditions before waterlogging are favorable for fibre production in the plants, browning may be regarded as an indication of extra quality. The quality of fibre from browned fields is usually one or more grades better than that from comparable straw from other fields that are free from browning. This may be accounted for, first by the good supply of soil water at the critical time for fibre production, and secondly to the suspension of growth and fibre development at the stage that is regarded as optimal for harvesting fibre flax.

(iii) *Accelerated Water Retting.*—The average time occupied at one of the mills in Victoria in water-retting batches of flax grown in the 1943 season was 123 hours. Only six of the 129 lots under review were retted in 70 to 80 hours. In small-scale experiments this year in Canberra, straw obtained from several growers in Victoria was fully retted in an average of 48 hours by " seeding " each tank with a portion of the liquors from the previous ret. The usual loose core test was employed in determining when retting was complete. The average grade of fibre obtained in these small-scale tests was the same as that obtained at the mills. Towards the end of April, 1945, full scale trials were made at a mill, the results being at first very satisfactory. Several rets were finished in 48 to 55 hours. Later on, some factor that was not obvious interfered, increasing the average time markedly. Experiments are now in progress in Canberra to determine the cause of the trouble, and to eliminate it.

(iv) *The Influence of Iron in Water Retting.*—Early in 1943, during the course of work in Canberra, it was found that if iron was left in contact with the retting liquors some would be dissolved ; the resulting fibre would be grey and of slightly better quality than that obtained by ordinary water retting. The average improvement in quality was half a grade, or £5 increase in value, per ton. Under ordinary commercial conditions at one of the mills in Victoria, the average improvement in quality over a period of more than six months was also half a grade. At the present time, more experiments are being made in Canberra with a view to obtaining additional data, and to discover the mode of action of iron. The first seven pairs of the new series of samples have been graded : once more the average improvement has been slightly more than half a grade. Iron is now being used in retting at all Australian mills where iron turnings are readily available.

(v) *The Relation of Straw Quality to Quality and Quantity of Line.*—In England, the quality of retted fibre was found to be related to the diameter of the straw. Here, we have attempted to determine the components of straw quality that influence the grade of fibre produced from given samples. It is practicable by examination of straw to tell with a very fair degree of accuracy the grade of fibre that may be expected from it. Length, diameter, colour, general feel or " handle ", rust, browning, strength, and general quality of the natural fibre are studied in relation to each other, and more important in relation to the conditions, as revealed by these factors, under which the sample was grown. It follows that differences between the grades of fibre and the percentages of line obtained from straw from different sources are fixed within narrow limits before the straw is retted. Modifications of retting technique may influence inherent quality by about one grade.

12. *Disease Investigations.*—(i) *Tomato Spotted Wilt.*—Work has been continued with the very mild strain of this virus. By tissue selection on the sensitive indicator host *Nicotiana atropurpureum*, this strain was finally isolated in pure form and used in a field plot set out in October, 1944, to test its possibilities for protective inoculation. Unfortunately, owing to the exceptionally severe drought conditions, field spotted wilt was virtually absent. However, artificial inoculation of a small section of the field plot indicated that protection was not afforded after the first few weeks. This observation was supported by evidence obtained in the greenhouse where it was found that the concentration of the mild virus in the juice of tomato plants decreased rapidly and virtually disappeared after some weeks. The yield potential of the plants is scarcely affected by the presence of the mild virus. Studies of this aspect of the problem are being continued.

(ii) *Fusarium Wilt of Tomato.*—Cultures of *Fusarium bulbigenum* var. *lycopersici* have been isolated from wilted tomato plants from various tomato-growing districts throughout Australia where Fusarium wilt has caused considerable damage.

Pathogenicity on the very susceptible variety of Bonny Best, and cultural characteristics of these isolations, are being compared and contrasted. Investigations on the relationship between attack by Fusarium and temperature and soil moisture conditions are being planned. Pathogenicity trials are being carried out on seedlings of the various varieties of the tomato to test for resistance and immunity to Fusarium wilt.

(iii) *Peas.*—Studies of the susceptibility of a large range of varieties to *Ascochyta pinodes* have been made using a sample large-scale inoculation technique. The work is in co-operation with the vegetable section, which has made preliminary crosses between the most resistant varieties and desirable commercial types. Studies of the *Ascochyta* and general fungal content of pea seed have been continued.

(iv) *Beans.*—Observations of a severe disease of the Fusarium type occurring in imported seed at Dickson Experiment Farm and at Griffith Irrigation Research Station have been made. Preliminary evidence indicates that a composite disease is present, the Fusaria alone being only mildly pathogenic.

13. *Publications.*—The following papers were published during the year :—

Angell, H. R. (1945).—Unavailability of plant food and take-all of wheat. *J. Coun. Sci. Ind. Res.* (Aust.) 18 : 37–46.

Angell, H. R. (1945).—Browning of flax and excess soil moisture. Ibid. 18 : 150–152.

Bald, J. G. (1944).—Progress of work with potato stocks free from virus X (FX potatoes). Ibid. 17 : 258–262.

Bald, J. G. (1944).—Development of differences in yield between FX and virus X infected Up-to-Date potatoes. Ibid. 17 : 263–273.

Hills, K. Loftus (1944).—Dormancy and hardseededness in *Trifolium subterraneum.* (2) The progress of after-harvest ripening. Ibid. 17 : 186–190. (3) The effect upon dormancy of germination at three different constant temperatures. Ibid. 17 : 191–196. (4) Variation between varieties. Ibid. 17 : 242–250. (5) The effect of the condition of the seed coat upon embryo dormancy. Ibid. 17 : 251–254. (6) The application of the results to the problem of re-establishment in the field and to seed testing and marketing. Ibid. 17 : 255–257.

Hutton, E. M., and Bald, J. G. (1945).—The relationship between necrosis and resistance to virus Y in the potato. Ibid. 18 : 48–52.

Moore, C. W. E., and Sharp, L. (1945).—Note on the establishment of *Phalaris tuberosa* in 1944 at Canberra, Australian Capital Territory. Ibid. 18 : 47.

Norris, D. O. (1944).—The evaluation of DDT as a fungicide. Ibid. 17 : 289–290.

Shaw, N. H., Barrie, Nancy, and Kipps, E. H. (1944).—The effect of lime, phosphate, and molybdenum on the growth of lucerne in Duntroon loam. Ibid. 17 : 233–241.

Thomas, L. A. (1944).—Stock and Scion Investigations. (III.) The root systems of some own rooted trees. Ibid. 17 : 167–178. (IV.) Apple measles. Ibid. 17 : 221–224.

Willoughby, W. M. (1944).—Irrigation and the wool industry. *Aust. Inst. Agric. Sci.* 10 : 102–107.

Willoughby, W. M. (1944).—Factors affecting the efficient production of supplementary pasturage and fodder under partial irrigation. Ibid. 10 : 157–165.

III. ENTOMOLOGICAL INVESTIGATIONS.

1. *General.*—The outstanding feature of the past season's work has been the attention devoted to the study of the possible uses of the new insecticides D.D.T. and 666. These insecticides are so outstandingly effective that they promise to revolutionize the control of many pests, although for the control of some pests they are not as good as well known insecticides that have long been in use. Most attention was directed to finding the best ways of applying the new insecticides for the control of the more important Australian insect pests, and much remains to be done in this direction, for the methods of application must vary considerably according to the pest attacked. A large scale programme of investigation on the use of D.D.T. for the control of agricultural and horticultural pests was carried out in co-operation with all the State Departments of Agriculture. Particularly promising results were obtained with the use of D.D.T. for the control of cattle tick, buffalo fly, and certain household pests, while the methods for the control of insects of medical importance, notably mosquitoes and house flies, have reached a high stage of development.

Investigation of the pests of stored wheat has been practically concluded ; effective methods for the control of infestations in main types of temporary storages having been developed.

An unusually large number of natural enemies of insect pests and weeds was introduced from other countries, and this work continues to show great promise. The biological method of controlling pests is, of course, even better than the best possible control by chemical means, so that efforts to use it against as many Australian pests as possible must continue to be an important section of the work of the Division of Economic Entomology.

2. *Insect Pests of Stored Wheat.*—(i) *General.*—The investigation of the problem of insect infestation in stored wheat has been one of the Division's major projects during the war, but the development of effective methods of combating the pests and the considerable reduction in Australian wheat stocks have made further intensive work unnecessary. The Division has been responsible for advising the Australian Wheat Board as to the best methods of reducing damage by pests, and has been fortunate in the facilities and financial support given by the Board, and in the co-operation extended by the State Departments of Agriculture, the Waite Agricultural Research Institute, and other organizations. As the investigations will terminate shortly, this is a suitable occasion for outlining both the Division's main contributions towards the solution of the problem, and the degree of success obtained in safeguarding the huge wheat

stocks held in Australia during this war. The problem was complicated by the different storage methods used in different parts of Australia—for each required its own methods of insect control —and it is convenient to consider the problems and their solutions in relation to the forms of storage.

(ii) *Bag Stacks.*—A policy of preventing the development of insect and mouse infestations was adopted, the wheat being stacked within mouse-proof fences on clean sites or sites sterilized by spraying. Temporary storage at the receival sidings was followed by long-term storage at the main depots where incoming wheat was carefully inspected to prevent the entry of infested material. Research on the effectiveness of mineral and tar oils, used straight or as emulsions and with or without the addition of other toxic materials, led to the production of sprays and dips suitable for sterilizing storage sites, dunnage, bags, &c. The preventive policy was very successful and wheat was stored at some depots for three years without suffering appreciable damage from pests. However, transport difficulties led to wheat remaining for long periods at the sidings, where eventually the damage produced by weevil and mice caused concern, and made the evolution of a method of fumigating complete stacks *in situ* a necessity. This previously unsolved problem was resolved by the discovery that several heavy fumigants (carbon bisulphide, ethylene dichloride, or methyl bromide) would readily penetrate from the top to the bottom of a wheat stack, and that a lethal concentration of the fumigant could be maintained in the stack without rendering its upper surface airtight or employing unusually high dosages. The method devised, which consists of erecting temporary gas-tight walls around the stacks for the period of fumigation, is very cheap and has been used effectively on the largest stacks in depots and sidings. Over 2,000,000 bushels of wheat have been fumigated by this method, and it is considered that this technique combined with a sound preventive policy makes it possible to store bagged wheat for a considerable period without appreciable loss from pests. Field trials have shown that the treatment of bagged wheat with magnesite dust would give a high degree of protection against *Calandra oryzae* (the principal pest), but such dust treatment is not considered economic—especially as the existing control methods guarantee immunity from serious damage.

(iii) *Silos and Terminal Elevators.*—Silos at the receival sidings were originally intended for temporary storage only, the wheat being transferred for long-term storage to terminal elevators and to bulk depots, but during the war, this movement of wheat was greatly restricted. Consequently, these silos remained full for long periods and insect infestation became a problem. Silo fumigation with methyl bromide was not successful, but " Cyanogas G " gave good results and was fairly extensively used for the fumigation of wheat prior to shipment. The main methods of control employed in silos and terminal elevators, however, were—(1) the periodical " turning " of wheat to reduce the temperature and break up damp pockets, and (2) the early diversion of wheat becoming infested to the internal market for gristing and consumption. As these forms of storage existed mainly in New South Wales and Victoria, where there is a large internal wheat market, no considerable weevil problem was anticipated in those storages. However, the movement of grain was impeded by transport difficulties, and in New South Wales a considerable weevil problem was experienced.

(iv) *Bulk Depots.*—These storages were developed in Western Australia, and consist of huge sheds, each containing a single mound of wheat, the capacity of a shed being sometimes as much as 10,000,000 bushels. The bulk depots were used for long-term storage, temporary storage at the receival sidings being effected in " temporary bulkheads " and " bins ", smaller structures in which also the wheat was stored in mounds. Bulk depots were later constructed in Victoria. This form of storage was very inexpensive, but provided a serious pest problem, and special attention was given to this matter. It was shown that the distribution of suitable mineral dusts over the surface of a bulk depot mound would greatly reduce the rate at which infestations appeared, and that infested areas could be adequately fumigated *in situ* by the direct application of carbon bisulphide or ethylene dichloride. This dust-cum-fumigation method was used at all the depots in Victoria with very good results ; the heavy infestations experienced in Western Australia were avoided, and the wheat was loaded out in excellent condition after long-term storage. On a more restricted scale, mineral dusts and surface-fumigation were employed in Western Australia ; additionally, export wheat was sometimes fumigated with " Cyanogas " at a fumigation silo which had been specially constructed for this purpose at Fremantle. In general, insect infestation in such wheat mounds can be controlled if the wheat is initially of low moisture-content, the structure of the shed is such that appreciable moisture-content increase is prevented, and the surface of the mound is accessible for the application of mineral dusts and fumigants.

Serious insect damage in bulk depots, temporary bulkheads, and bins is restricted to a shallow zone at the periphery of the wheat mound. Investigation has shown that the restriction of insects to this zone develops gradually during the history of the infestation, and is

caused by the heat generated by the insects, the loss of moisture resulting from the rise in temperature, and the consequent development of a combination of temperatures and moisture-contents within the mound which is lethal to the insects. The temperature of the interior lethal zone is maintained by insect activity in the peripheral zone, where higher wheat moisture-contents permit insect development at temperatures which are as high as, or higher than, those occurring in the lethal zone.

(v) *Results of Campaign.*—A considerable measure of success has attended the campaign against wheat weevil carried out by the Australian Wheat Board and based on the Council for Scientific and Industrial Research advice and research. Though serious weevil outbreaks have occurred and given concern (expecially in Western Australia), nothing comparable with the severity of last war's plague has been experienced. The main requirements for long-term storage of wheat (whether bagged or in bulk) are sound storage structures, the selection of suitable localities for depots, good transport facilities for the movement of wheat to and from the storage depots, the prevention of the entry of weevily material into the depots, and reliable methods for sterilizing storage sites and buildings and for controlling the infestations in the stored wheat. Most of the damage caused during this war was the result of defects in these matters, but experience and research provided solutions for many of the numerous problems which come under these headings. The inadequacy of transport facilities was probably, on the whole, the greatest menace to the safety of the tremendous quantities of wheat handled and stored, for this problem was not within the control of those concerned with the prevention of damage by pests.

3. *Insect Control of Noxious Weeds.*—(i) *St. John's Wort* (*Hypericum perforatum*).—Further large distributions of the three species of *Hypericum* insects now established in Australia were made during the latter end of 1944. Colonies previously established in the various States have, for the most part, made very satisfactory progress. Since their establishment in Australia, the work of distributing the three species of *Hypericum* insects has been materially assisted through the co-operation of the appropriate State Departments.

Inspections of certain of the St. John's wort areas in New South Wales and Victoria, where insect enemies of the weed have now been established, were made towards the end of 1944. Although it was not possible to visit all the areas where the insects had been released or established, the inspections made showed that the good progress which had taken place in earlier years was being maintained and increased.

At Mannus, near Tumbarumba, where a colony of 10,000 adults of *Chrysomela hyperici* was liberated in December, 1943, the insects were found to have survived. A further 60,000 adults were liberated at a nearby site early in December, 1944. In the Ovens Valley, German Creek, and Harrietville areas, in the neighbourhood of Bright, Victoria, *C. hyperici* is now widespread and is exercising a worthwhile degree of control over a considerable area. During the past two seasons, numerous liberations of this insect have been made at various points in the Ovens Valley and adjacent districts by individual land holders who have collected the insects for release on their own properties.

New districts in which *C. hyperici* was released during 1944 include Beechworth, where 20,000 adults were liberated on 23rd November, 1944, and Howqua River, near Mansfield, where 20,000 were liberated on 25th November, 1944. A further 40,000 adults were sent to South Australia for liberation near Belair in the National Park, where a liberation of 20,000 had been made the previous year. Some 10,000 adults were also liberated in the Yankalilla district of South Australia through the Waite Agricultural Research Institute.

The original colony of *Chrysomela gemellata* which is now established at Baker's Gully, near Bright, following its liberation in 1939, has made rapid progress during the last two years, and is now exercising a considerable degree of control over the weed in limited areas. Development over the past year permitted large distributions to be made. Some 42,000 adults were liberated at Warrenbayne, near Benalla, on 25th November, 1944. A further 50,000 were sent to the Waite Agricultural Research Institute, and these were later liberated in St. John's wort areas at Clare. Owing to the spread of this species from its original liberation site at Bright, it has probably come in contact with *C. hyperici*, so that mixed colonies of both species may now be found over a fairly wide area. Progress during the last two years has been particularly satisfactory.

A report from Piambong, New South Wales, indicated that the colony of *Agrilus hyperici* in that area was making satisfactory progress. No examinations were made of the colony at Mudgee. In Victoria, the main colony at Baker's Gully, Bright, has made good progress over the last two to three years, and the first collection of material for redistribution was made during the latter end of 1944. The material collected was forwarded to California.

Towards the end of 1944, five shipments of the three species of *Hypericum* insects now established in Australia were sent to California. The greater proportion of this material reached its destination in a very satisfactory condition. In all, 2,020 *Agrilus hyperici*, 318 *Chrysomela gemellata*, and 8,600 *C. hyperici* were included in the five consignments. Recent reports from California indicate that the work of attempting the colonization of *C. hyperici* is proceeding satisfactorily.

In New Zealand, where 30,000 adults of *Chrysomela hyperici* were liberated in the Awatere Valley in December, 1943, from material forwarded by this Division, the insect is reported to be making very rapid progress towards establishment, and already a good colony has developed.

(ii) *Lantana* (*Lantana camara*).—Following the establishment of the Lantana bug early in 1939, the work of distributing the insect throughout Queensland, and observing the development of new colonies, has been mainly undertaken by officers of the Queensland Department of Agriculture and Stock. The general position with regard to the progress of the introduced Lantana bug, *Teleonemia scrupulosa*, appears to be much the same as that mentioned in the previous Report. It was then indicated that colonies in the Gympie and Toowoomba districts appeared to be making rather better progress than formerly. This is particularly interesting, as in earlier years it was only in the more northern areas of liberation that the bug appeared capable of establishing itself or exercising any appreciable control over its host.

4. *Sheep Blowfly.*—Tests were carried out to determine whether or not D.D.T. would be a promising ingredient for blowfly dressing. Fully grown *Lucilia cuprina* larvae were unaffected by crawling in D.D.T. crystals or in inert dusts containing D.D.T. They were also unaffected by immersion for ten minutes in kerosene solutions of D.D.T. or in aqueous suspensions of D.D.T. produced by adding solutions of D.D.T. in acetone to water. These observations indicate that D.D.T. has no contact larvicidal effect. Surfaces treated with D.D.T. will kill adult sheep blowflies which rest on them.

The detailed examination of an experiment carried out several years ago to determine the natural population density of *L. cuprina* has been completed. The method was to release in the field a known number (about 40,000) of laboratory-reared flies which had been recognizably stained with alcoholic solutions of aniline dyes ; to record thereafter the ratio of the numbers of unstained to stained flies caught in traps ; and to calculate from this ratio and the number of stained flies released, the population of wild flies within the trapped area. The experiments were carried out in grazing country near Canberra ; 102 traps were set out in a systematic pattern within a circular area of 50 square miles surrounding the point of release of stained flies. Trapping was begun on the morning following the day on which the flies were released, and continued for two or three days.

The population densities recorded varied from 0.3 to 5.7 adult flies per acre. The population was relatively high in spring and autumn and lower in summer. During the spring increase, a very rapid rise in the natural population was demonstrated. The maximum distance from the point of release at which flies were taken was 4.7 miles. This distance was covered in less than 30 hours by a few flies. The rate of dispersal of stained flies varied from experiment to experiment, the differences showing some correlation with meteorological factors.

In a detailed statistical analysis of the experimental data, it was established that part of the variation between individual trap catches was due to local differences in the natural population within the trapped areas. The distribution of the stained flies was found to agree fairly well with a theoretical curve of distribution based on the assumption that the flies moved outwards at random. The coefficient of variation of the estimated population density, taking into account all measurable factors, was approximately 20 per cent.

5. *Medical Entomology.*—The Division of Economic Entomology has continued to act in the capacity of research centre for medical entomology for the armed forces, and has carried out many investigations with the aim of improving control measures for mosquitoes and flies, the two most important groups of insect vectors of disease in Australia and the neighbouring islands. Work has also been carried out against other insects of medical importance and some household pests.

(i) *Mosquitoes.*—The mosquito control problems fall into four categories—(*a*) Further work on repellents for application to exposed skin surfaces andclo thing ;· (*b*) insecticidal sprays for killing adult mosquitoes ; (*c*) improved methods of distributing insecticides ; (*d*) improved oils for treating the breeding grounds of mosquitoes.

Although details of much of this work cannot be described for security reasons, it is now possible to reveal that this Division played a major part in the tests with mosquito repellents which resulted in the Australian army being the first to use dimethyl phthalate in the field.

Many other substances, far superior to oil of citronella, were discovered, and some promising leads concerning the correlation of chemical structure and repellent activity are being investigated. It has been shown that good mosquito repellents are effective also against many other biting insects, such as sandflies, but may be ineffective against non-biting flies, such as the bush fly, *Musca vetustissima*, which at times causes great annoyance in the open.

Further work in the field of insecticidal sprays has confirmed the effectiveness of a spray containing D.D.T. plus a rapid knockdown agent such as pyrethrins. A spray of this type is also effective against flies and many other household pests.

The importance of applying insecticides in particles of a particular size range is now recognized, and experiments dealing with this aspect of insecticide application were carried out. Overseas reports on the effectiveness of D.D.T. in oil for use against mosquito larvae have been confirmed and it is clear that this method of killing larvae has many advantages over methods used in the past. Since the oil functions lagely as a carrier for the D.D.T., and since a continuous film on the surface of the water is not required, there is a very great saving in the amount of oil required.

(ii) *House Flies.*—Studies on essential oils from Australian plants, their constituents, and structurally related compounds as synergists for pyrethrins in fly sprays have been continued..

Some improvements have been incorporated in the Peet Grady method of testing fly sprays and several disadvantages of this method have been demonstrated.

The introduction of D.D.T. into fly sprays represents a marked advance in the control of house flies. With an adequate D.D.T. concentration in the spray, no fly hit by a droplet of spray mist will survive. A spray of this type can be marketed as cheaply as pre-war sprays, even the most efficient of which allowed a certain proportion of flies to recover after they had been knocked down and apparently killed. It has been shown that a very short period of contact (a few seconds) with a surface treated with D.D.T. at the rate of 50 mg./sq. ft. is snfficient to cause death to house flies.

(iii) *Fleas.*—Exposures of adult cat-fleas (*Ctenocephalides felis*) for 30 minutes, 5 mnutes and 1 minute, to filter paper or calico impregnated with D.D.T. at the rate of 50 mg./sq. ft. or greater, resulted in 100 per cent. mortality of fleas in 24 hours. Reduction of exposure time or weight of D.D.T. per square foot decreased the 24-hour mortality.

Fleas were also exposed in aerated jars for 30-minute periods to calico impregnated with Lethane 384, Thanite, paradichlorbenzene, and naphthalene. Exposures were made at hourly intervals after impregnation. Paralysis was most rapid in fleas exposed to Lethane-treated calico, and complete mortality occurred in all exposures up to $3\frac{1}{2}$ hours after impregnation. Thanite, paradichlorbenzene, and naphthalene were not effective under these conditions of testing.

Hatching of cat-flea eggs was not impaired by the presence of D.D.T. in the sand rearing-medium, but newly hatched larvae were rapidly paralysed and killed in 24 hours by concentrations of D.D.T. in the medium as low as 0.01 per cent. by weight. The same concentration was found to be lethal to fully grown larvae.

(iv) *Bed Bugs* (*Cimex lectularius*).—Treatment of quarters infested with bed bugs with a 4 per cent. solution of D.D.T. in kerosene has resulted in the disappearance of live bugs. This confirms promising reports from abroad where D.D.T. has been successfully used for the eradication of bugs.

(v) *Toxicity of D.D.T.*—A review has been made of all reports received from Britain and the United States of America dealing with the toxicity of D.D.T. to man and laboratory mammals. Although D.D.T. has been used very extensively in the dry state, either as a 10 per cent. dust, or to impregnate clothing for the control of body-infesting insects, no instances of damage have occurred. In solutions or emulsions, D.D.T. can be absorbed through the skin in toxic quantities. Little danger is expected from the occasional inhalation of, or contamination of food by, fly sprays containing D.D.T. Long periods of contact with strong solutions of D.D.T. in oils or organic solvents should be avoided.

6. *Household Pests.*—In addition to those mentioned in the previous section, the following pests of importance in houses and stores have been studied :—

(i) *Cockroaches.*—Tests with D.D.T. sprays and dusts have been carried out against the German cockroach (*Blatella germanica*). A spray containing 0.5 per cent. D.D.T. plus 0.03 per cent. pyrethrins caused little mortality when applied liberally to a natural infestation. A high mortality in this same infestation was obtained by means of a dust consisting of 10 per cent. D.D.T. impregnated on pyrophyllite.

(ii) *Silverfish.*—It was demonstrated that silverfish (*Ctenolepisma urbana*) were killed by contact with surfaces treated with D.D.T.

In these particular tests, contact for one hour with 50 mg. D.D.T. per square foot produced 50 per cent. mortality. Exposure for longer periods caused higher mortalities, as also did shorter exposures to higher concentrations (200 mg. D.D.T./sq. ft.). At 80° F. and 60 per cent. R.H., death often took place very slowly, moribund intervals sometimes surviving for six or seven days.

(iii) *Bacon Fly.*—A limited amount of work has been conducted on the infestation of bacon and hams by the bacon fly, *Piophila casei*. This insect is notoriously difficult to kill by insecticides or adverse conditions and the possibilities of the use of D.D.T. are being investigated. Adequate wrapping of uninfested meat appears to be the most promising method of preventing losses.

(iv) *Ants.*—The use of 5 per cent. D.D.T. dust gave complete control of the black house ant (*Technomyrmex albipes*) in houses in Canberra, and of the brown house ant (*Pheidole megacephala*) in offices at Home Hill, North Queensland.

In a series of tests, colonies of the meat ant (*Iridomyrmex detectus*) were controlled by blowing 5 per cent. and 1 per cent. D.D.T. dust down the entrance holes of the nests. This treatment, however, did not prevent successful repopulation of some nests by ants from neighbouring colonies.

7. *Cattle Tick.*—(i) *Biology.*—It has been shown that when large numbers of larval ticks are placed on an animal, only a small proportion of them actually become attached. Of these, about 95 per cent. attach themselves immediately after reaching the animal, and the remainder do so within about three days. The parasitic life of cattle ticks was intensively studied during the past season, and the length of the various parasitic stages was determined. This study gave the necessary data for the formulation of an improved system of dipping.

(ii) *Arsenical Dips.*—It was found that the stages of ticks most susceptible to arsenical dips are the young larva, the young nymph, and the young adult. Detailed study of the life cycle showed that, by dipping three times at three-day intervals, and repeating this after a further fifteen days, every tick on an animal, irrespective of the time it attached itself, would be exposed in a vulnerable stage to the dip before it could reach maturity. This "strategic dipping" proved effective in field trials. For example, from two animals dipped in this way, less than 300 ticks survived from the 2,000,000 ticks of a resistant strain with which they were infested, while normally infested animals were completely freed of ticks.

Additional evidence has been obtained that the difficulty in controlling cattle tick in many areas is due to the presence of arsenic-resistant strains of ticks in those areas. A strain of ticks originally obtained from near Rockhampton has been maintained at the Yeerongpilly laboratory, and has been shown to be much more resistant to arsenical dips than the local strain of ticks. For example, an animal was infested with the resistant strain, and another with the local strain, and they were sprayed with standard arsenic dip when the ticks were three days old. A large number of the resistant ticks reached maturity, whereas the local ticks were cleared from the whole body. In another experiment, several animals were infested with ticks of the resistant strain and each received one treatment with standard arsenic on the third, fourth, fifth, seventh, tenth, eleventh, fourteenth and seventeenth day after infestation. In all cases ticks reached maturity thus signifying that all stages in the life cycle of this strain of ticks offer considerable resistance to standard arsenical dipping fluids.

In laboratory experiments, arsenical dip of standard strength was buffered to pH's of 2, 4, 6, 8, 10 and 12, and mature ticks of the resistant strain were dipped for a period of one minute. Almost 100 per cent. mortality was obtained at both extremes, whereas there was no mortality in the solutions having a pH of 8. As the average pH of dipping fluids used under practical conditions was found to be 8.4, this result indicates that greatly improved control might be obtained by altering the pH of dips. Naturally, there are complicating factors to be overcome before this can be done.

Under laboratory conditions, dipping fluid contaminated with faecal matter became completely oxidized in about a month, but oxidation was prevented by covering the surface with a layer of oil or a floating solid. Contaminated dip quickly oxidized in vats under field conditions, but in a test, oxidation was prevented for three months by floating a raft on the dipping fluid in a previously used vat.

(iii) *D.D.T. Sprays.*—Experiments with D.D.T. were continued during the year, and it was found that all parasitic stages could be killed with one application of an emulsion containing 2 per cent. of D.D.T. This concentration also prevented successful reinfestation for a period of about twelve days. Lower concentrations decrease the protective period, and increase the

chances of survival. Field observations suggest that spraying with a 2 per cent. emulsion once every 30 days would completely eradicate the tick, whereas control could be obtained with treatments at longer intervals, or by the use of weaker emulsions.

Tests are in progress to determine whether D.D.T. used at strengths necessary for tick control is likely to prove harmful to cattle.

8. *Buffalo Fly* (*Lyperosia exigua*).—(i) *General.*—Research on the control of this pest has been continued at Malanda, on the Atherton Tableland. Up to the present, the investigations have been directed toward the control of the fly on dairy cattle, as it is felt that most hope can be held out for this aspect of the investigations. The control of the fly on beef cattle, should this eventually prove possible, will probably be a matter of the modification of measures designed for application to dairy herds.

(ii) *Traps.*—Following the successful test with the American horn fly trap in the summer of 1943–44, an illustrated leaflet was prepared and published in collaboration with the Queensland Department of Agriculture and Stock. The circulation of this leaflet enabled farmers to instal traps, and very satisfactory control of the fly on milking herds has been achieved by their use.

By dusting the narrow, weighted strips of canvas in a trap with coloured powders, and observing the positions of the marks on the cattle after they had passed through the trap, it was found that these strips did not fulfil their purpose of swinging under the belly and around the legs of the animals. The use of such strips thus appears unnecessary.

The gauze trapping boxes of the standard trap are rather complicated in construction, and hence a source of difficulty for amateur builders. It was thought that if simple screens of glass, or other transparent material treated with D.D.T. were substituted for the gauze boxes, equally effective control might be secured. Accordingly, a test trap was built of glass, the wooden framework being of the same dimensions as that of the standard trap. A peaked roof of glass was substituted for the flat, opaque ceiling of the ordinary trap. The inside surfaces of the glass of the sides and roof were sprayed with enough kerosene solution of D.D.T. to leave a deposit of about 20 grams on the whole surface. A set of canvas curtains exactly the same as that in the standard trap was fitted. The flies are not permanently retained by the trap, but are merely brought into contact with the D.D.T. on the glass when attempting to follow the beast past the curtains. A brief period of crawling on a D.D.T.-treated surface is sufficient to kill flies, and although many of the flies escape from the trap, almost all of these die soon in the vicinity of the trap. When a herd was trained to use this trap, it proved at least as effective in reducing the numbers of flies as the standard trap. Within a week or so of the commencement of trapping, the infestation on the herd was reduced from an average number of 200–300 flies per cow, with 5,000–10,000 on the bull, to a mean of less than a dozen flies per cow, and less than 100 on the bull, an infestation of no consequence to the animals.

The D.D.T. on the glass appeared to remain completely effective for about two months, after which there were indications that it was necessary to spray the surface again. At this rate of loss of the D.D.T., it would only be necessary to treat the glass twice in a fly-season of usual duration (December to April). Great economy in the use of D.D.T. would be effected by employing it in such traps, instead of spraying it on to the cattle themselves, and a simpler and cheaper trap could be substituted for the rather costly and complicated type at present advocated. Glass is not the most satisfactory material to employ, and, in fact, it was only used because under war-time conditions it was impossible to obtain a substitute in the form of gauze-reinforced cellophane.

(iii) *Sprays.*—Further experiments have been carried out with D.D.T. sprays which were found during the previous season to be so promising for the control of the buffalo fly. All work confirms the previous finding that on living cattle the insecticide persists for a very much shorter time than on dead surfaces. Pieces of greenhide from freshly slaughtered cattle were nailed to boards, and, after spraying with emulsions and solutions of D.D.T., exposed to the weather. It was found that after five months on continuous exposure, sufficient D.D.T. remained on the hides to kill buffalo flies caged on them. On living cattle, however, similar concentrations of D.D.T. have almost completely disappeared after a fortnight. The reasons for the failure of D.D.T. to persist on the hide of living beasts have not yet been discovered. Licking and rubbing of the cattle against posts and other objects doubtless remove some of the D.D.T., but it is unlikely that these factors are entirely responsible for the loss.

More experiments have been performed on the spraying of cattle with solutions and emulsions of D.D.T. An emulsion of D.D.T. in solvent naphtha, with a proprietary wetting agent, proved highly satisfactory. The advantage of solvent naphtha is its high solubility for D.D.T., which permits the employment of emulsions of much higher concentration than when kerosene is used as the solvent.

Continuing experiments of last season, efforts were made to find the minimum area of a beast that need be sprayed to ensure the control of the flies. Each beast in a herd was sprayed on an area 12 inches by 18 inches on either side of the shoulders. Adequate control of the flies resulted.

Experiments have been conducted in the use of D.D.T. sprays by farmers. The sprays were applied with ordinary atomizers to cows in the bails during the course of milking, just as pyrethrum and nicotine sulphate sprays are applied, the object being to envelop the flies in a mist. Besides killing all the flies thus brought into contact with the spray, preparations of D.D.T. applied in this fashion leave a deposit on the hide which remains effective against flies landing on the cow after the solvent has dried. This method of application does away with the need for making a special proceeding out of spraying, the farm routine being very little disturbed in the process. Also, the use of less D.D.T. is involved than when spraying the whole herd with a massive application in one operation.

Tests made with a proprietary toxicant (Thanite) indicate that it should constitute a very useful spray to control the buffalo fly until better preparations, such as D.D.T. have been thoroughly tested, and become available for use by farmers.

(iv) *Dispersal of Flies.*—Further work has been carried out on the marking of flies to enable their movement from herd to herd to be traced. The previously employed method of spraying flies with alcoholic solutions of dyes was discarded because the poor survival of flies thus marked and liberated on a beast in an insectary indicated that the dyes were probably injurious. Instead of staining, the flies were marked with fine metallic dusts. Insectary tests showed that sufficient dust adheres to the bodies of the flies for a period of at least six days to permit their microscopic separation from unmarked specimens. This method of marking enabled the demonstration of the migration of considerable numbers of flies from beef cattle to milking cows on an adjoining property, the flies being collected from the milkers for examination by means of a standard gauze trap. It is expected that this technique will prove a valuable method of investigating some aspects of the biology and control of the fly.

(v) *Biological Control.*—A consignment of the predaceous beetle *Platylister chinensis*, obtained from Fiji, was liberated in the Cairns district in a very suitable situation for its propagation. Both the adults and larvae of this beetle feed on the maggots of the buffalo fly and other dung-breeding flies, and it is hoped that the species will prove a useful control agent for the buffalo fly.

9. *Australian Plague Locust (Chortoicetes terminifera).*—Work has been continued along the major lines of investigation described in earlier reports, namely, a study of the general level of infestation in Eastern Australia; a study of population fluctuations in the Bogan-Macquarie Outbreak Area; experiments designed to render the outbreak centres less favorable for the production of swarms, by tree planting and the re-vegetating of "scalds"; field surveys of little-known outbreak areas; and taxonomic work. In addition, preliminary investigations have been carried out in certain new directions, notably on the possibility of using D.D.T. and other new insecticides against *Chortoicetes*.

The season 1944–45 was again free from serious infestation by *Chortoicetes*. A few swarms were reported from the Hunter River Valley and the Tamworth district in the spring, and from the Hughenden district (Queensland) in the later summer. In the Bogan-Macquarie Outbreak Area, where investigations have been continued from the Trangie Field Station, the general population level at the beginning of the season was the lowest yet recorded for the spring generation. It was higher in the second generation, although still well below swarming density in the outbreak area as a whole.

The experiments in which ecological control of swarm-formation is being attempted by tree planting received a set-back during the summer as a result of the severe and prolonged drought, and a breakdown in watering facilities. Heavy mortality of the trees resulted. With improved watering facilities and a more favorable run of seasons, it is hoped to bring the planting to the stage where less time will be taken up in maintenance, and some indication of the utility of the treatment will be obtainable.

Following the failure of the attempt to re-vegetate "scalds" (important as oviposition sites of *Chortoicetes*) by fencing and ploughing, an experiment has been started in which shrubby species of *Kochia* and *Atriplex* have been seeded on to fenced and ploughed scalds in a randomized arrangement to permit of comparison of the species with regard to their capacity to produce a satisfactory cover. No results are yet available.

A field survey has been made of certain minor and suspected outbreak areas not hitherto visited, as well as part of the region in South Australia that has been claimed as an outbreak area by workers in that State. The suspected outbreak areas along Cooper's Creek and north

of Eromanga were found to have the ecological characteristics one would expect of minor outbreak areas. The boundaries formerly proposed for the Wimmera Outbreak Area require some modification. The South Australian region is now classed as a suspected outbreak area.

An analysis has been commenced of the data obtained through the New South Wales and Queensland Locust Information Services relating to swarming by *Chortoicetes* during the seasons 1940 to 1945. When this is completed, a detailed review will be available of all outbreaks from 1937 to 1945.

For the interpretation of field data relating to population fluctuations under different weather conditions, it has been found necessary to obtain precise information on the rate of development and mortality of the eggs of *Chortoicetes* in different types of soil maintained at different water contents and temperatures. A series of laboratory experiments has been planned to provide this information, and preliminary work has been done on the technique of recognizing different stages in the egg's development by microscopical examination.

The appearance of D.D.T. as an insecticide of exceptional toxicity and persistency opens up the possibility of keeping the population of outbreak areas permanently below the density critical for swarming, by distributing D.D.T. from aircraft. This chemical, as well as another that appears even more promising against locusts, will be given extensive tests. Preliminary tests in the laboratory have shown that when locusts of various ages are confined on a substratum bearing a deposit of D.D.T. at the rate of 100 mg./sq. ft., all die within a day or two.

Preliminary investigations have been made of the habits of three species of wolf spiders in the Bogan-Macquarie Outbreak Area. These spiders are believed to be among the more important predators of *Chortoicetes*.

10. *Termites.*—The new insecticides, 666 (hexachlorcyclohexane) and D.D.T. (10 per cent. in kaolin), were tested for the control of mound colonies of *Eutermes exitiosus*. Four mounds were treated, two with 666 and two with D.D.T.; half an ounce of dust was applied to each mound in the normal way, and the mounds examined after a period of twelve weeks. In the two mounds treated with 10 per cent. D.D.T., no sign of any dead could be found, and in the mounds treated with 666 there were a few dead in the vicinity of the charge only. It appear unlikely that either material is likely to displace white arsenic for the control of mound colonies.

As a result of a failure to destroy a mound colony of *E. exitiosus* by blowing in a quarter of an ounce of paris green, an investigation was made of the comparative efficiencies of this material and white arsenic. Eight mounds were treated, four each with a quarter of an ounce of paris green, and four each with a quarter of an ounce of white arsenic. The mounds were examined after twelve weeks. All four colonies treated with white arsenic were completely destroyed, whilst of the four treated with paris green, one was completely destroyed, two had small surviving colonies, and one had a large surviving colony which included eggs and juveniles. On the basis of these results, it appears unwise to recommend paris green as being equally effective as white arsenic for the control of mound colonies.

Field tests forming part of the International Termite Exposure Test were continued. Information concerning the termite fauna of parts of the Solomons, Philippines and Borneo, was supplied to the Scientific Liaison Bureau, with the object of assisting the armed forces, and identifications were made of termites forwarded by that body from the New Guinea area. Assistance was also given to the Allied Works Council.

11. *Field Crop and Vegetable Pests.*—(i) *Potato Moth* (*Gnorimoschema operculella*).—In laboratory tests with insecticidal dusts used against the larvae of potato moth, derris, D.D.T., 666, yam bean (*Pachyrrhizus strigosus*), and synthetic cryolite were all effective; D.D.T. dust was also effective against adult potato moths. Similar tests were also made using D.D.T.-solvent naphtha emulsions at various concentrations against newly hatched potato moth larvae. All were effective, but curiously, the higher concentrations were less toxic than the lower.

In a field test at Home Hill, North Queensland, sprays containing D.D.T.-solvent naphtha emulsion, basic copper arsenate, and synthetic cryolite were applied, and D.D.T. gave the best protection to the tubers of the late crop. In another test with D.D.T.-solvent naphtha emulsion applied to a severe infestation on egg plants, complete control was produced in three days.

In field trials at Canberra, 666, phenothiazine, D.D.T., synthetic cryolite, derris and and astringent lead arsenate, were tested as dusts, and derris, synthetic cryolite, phenothiazine and D.D.T.-solvent naphtha emulsion as sprays. D.D.T. gave the best control in these trials, and the spray was better than the dust. At Crookwell, New South Wales, field trials were made with D.D.T. and synthetic cryolite. At harvest, the plots dusted with D.D.T. gave the greatest yield of sound tubers, this being one and a half times that of untreated control plants. At Batlow, New South Wales, another field experiment was made with D.D.T. dust on two crops which had previously been treated with derris and synthetic cryolite dusts, and a commercial dust reputed to contain D.D.T. At harvest, the plots treated with D.D.T. yielded the most sound tubers.

The study, introduction, and distribution of introduced parasites for use against the potato moth has constituted one of the major biological control investigations in progress during the past year. Recent evidence which has been obtained in the field suggests that certain of these introduced parasites may be making some progress towards establishment following their earlier liberation.

Seven consignments of *Microbracon gelechiae* were introduced during the 1944–45 season. Methods for large-scale laboratory breeding of this parasite were introduced, and during the season further distributions were made in potato-growing areas in several of the States, a total of 17,092 adult parasites being distributed. Of this number, 7,603 were released in Queensland, 7,773 in New South Wales, 1,264 in the Australian Capital Territory, and 450 in South Australia.

A further ten consignments of *Chelonus phthorimaeae* were introduced from California during the period under review, but due largely to delays in transit, the numbers obtained from these consignments were comparatively small. However, laboratory breeding of this parasite has been continued, and some further liberations made in suitable areas. In all, 2,420 adults of *Chelonus* were distributed. Of this number, 460 were released in New South Wales, 1,000 in the Australian Capital Territory, and the remaining 960 in South Australia. The most outstanding development in the work on *Chelonus phthorimaeae* was the recovery of a number of parasites by sweeping over potato crops at the Dickson Experiment Station, Australian Capital Territory. These parasites are considered to be the offspring of individuals liberated in this area during December, 1943.

Small trial consignments of several other parasites which attack potato moth were also made. Those included *Macrocentrus ancylivorus*, *Microdus gibbosus*, and *Omorgus phthorimaeae*, but in each instance the consignments were delayed and the numbers bred out were too small to enable laboratory colonies to be established.

The work of distributing parasites introduced for the control of the moth has been greatly facilitated by the ready co-operation received from Departments of Agriculture in those States where liberations of the parasites have been made.

(ii) *Cabbage Pests.*—At Home Hill, North Queensland, against centre grub (*Helulla undalis*), corn earworm (*Heliothis armigera*), common cluster grub (*Prodenia litura*), and cabbage cluster grub (*Crocidolomia binotalis*), dusts containing D.D.T., lead arsenate, calcium arsenate, and synthetic cryolite all gave satisfactory control. In a later crop of cabbages, D.D.T. dusts were better than all other treatments against the cabbage moth (*Plutella maculipennis*), and the green peach aphid (*Myzus persicae*). Magnesite plus nicotine was better than rotenone dusts against the green peach aphid. Dusts containing rotenone were ineffective against corn earworm and common cluster grub.

At Fyshwick, Australian Capital Territory, dusts containing D.D.T. and D.D.T.-solvent naphtha emulsions gave nearly complete control on a crop badly infested with cabbage moth. The emulsions were better than the dusts. Heavy applications of the dusts controlled the cabbage aphid (*Brevicoryne brassicae*) in the laboratory, but did not give control of this aphid in the field, and appeared to destroy its parasites and predators. Crude 666 emulsions, and a refined product from which all the alpha, and half the beta, isomers had been removed, gave excellent control of the cabbage moth and cabbage aphid when applied as sprays, and were better than a dust containing 666. Lead arsenate-nicotine combined dust was very much inferior to the D.D.T., and 666 treatments mentioned above, for the control of cabbage moth. Larvae of the cabbage butterfly (*Pieris rapae*) were controlled by all D.D.T. and 666 treatments used.

Apanteles glomeratus, the introduced parasite of the cabbage white butterfly, continues to maintain itself under field conditions in the Australian Capital Territory. A small consignment of this parasite was sent to the Waite Agricultural Research Institute during the year.

(iii) *Green Vegetable Bug* (*Nezara viridula*).—In laboratory experiments D.D.T. was dusted on to different portions of the body of adult bugs; those whose antennae had been treated succumbed first, followed by those whose tarsi had been treated. Supernatant water from an aqueous mixture of D.D.T. was also toxic to the bugs. In other laboratory tests various concentrations of dusts were effective against all stages of the insect.

At Canberra, small field tests were made with D.D.T. dust and D.D.T.-solvent naphtha emulsion against bugs infecting French beans and tomatoes. Both were effective and protected plants for one month.

Further attempts to introduce the tachinid parasites, *Trichopoda pennipes*, from Florida, during November and December, 1944, were unsuccessful, because of delays in the air transportation of consignments. No live material was obtained from any of the three consignments which were introduced, and, as a result, work for the season had to be discontinued.

(iv) *Other Vegetable Pests.*—Laboratory tests with D.D.T. dust on adult Rutherglen bugs (*Nysius vinitor*), and green peach aphid and potato aphid (*Macrosiphum gei*), gave complete kill of these insects. In the field at Canberra, D.D.T.-solvent naphtha emulsion was effective against bean aphid (*Dorsalis fabae*), and ineffective against red spider (*Tetranychus urticae*) in the glasshouse. In North Queensland, this emulsion effectively protected tomato plants infested with green jassid (*Empoasca fabae*), and increased the yield. Treated plants remained green long after the untreated plants had withered and died.

At Fyshwick, Australian Capital Territory, a single application of D.D.T. dust effectively controlled a heavy infestation of green peach aphid and potato aphid on a crop of lettuces. No further treatment of the crop was necessary.

12. *Orchard Pests.*—(i) *Oriental Peach Moth* (*Cydia molesta*).—Two applications of 0.1 per cent. D.D.T.-solvent naphtha emulsion at an interval of three weeks were made to a block of young peaches at Ardmona, Victoria. The sprays were applied late in the season with the object of protecting the fruit from attack by the Oriental peach moth. At harvest, 3.7 per cent. of the fruit from treated trees was infested, and 7.0 per cent. of the fruit on the untreated trees was attacked. Analysis of the treated fruit at harvest showed that there was a residue of 9 p.p.m. of D.D.T.

(ii) *Codling Moth* (*Cydia Pomonella*).—A field test was carried out on single tree plots in an experimental orchard at Canberra. The orchard contained different varieties of pear trees. The treatments were synthetic cryolite, lead arsenate, Black Leaf 155, and 0.1 per cent. D.D.T.-solvent naphtha emulsion. Five applications were made on the ordinary lead arsenate schedule. All fruit harvested from the trees treated with D.D.T. was clear. The other two treatments were inferior to lead arsenate which, in turn, was inferior to D.D.T. The fruit on the untreated control trees was all infested with codling moth, and a large part of the crop had fallen at harvest. Practically no fruit dropped off the trees treated with D.D.T.

(iii) *Light Brown Apple Moth* (*Tortrix postvittana*).—Further investigations on this native pest of vine fruits were carried out in the Mildura district during September, 1944. Investigations made at that time confirmed earlier observations that this pest was maintained in vineyard cover crops during the period when the vines were dormant. The early turning in of cover crops and the application of suitable sprays against the moth larvae, such as lead arsenate, were recommended as measures for bringing about a reduction in infestation of vine fruits throughout the affected areas.

(iv) *Citrus Red Scale* (*Aonidiella aurantii*).—Recent reports from South Australia, where liberations of *Comperiella bifasciata* have been made by the Waite Agricultural Research Institute during the past two years, indicate that the parasite has survived under field conditions. In New South Wales, where liberations have been made in the vicinity of Leeton in co-operation with the New South Wales Department of Agriculture, recent reports indicate that the parasite still survives. It is, however, too early as yet to determine whether *Comperiella* will succeed in establishing itself in any of the citrus areas in Australia in which it has been liberated, and, if so, whether it will exercise any worthwhile degree of control over its host.

(v) *Brown Olive Scale* (*Saissetia oleae*).—Laboratory colonies of *Metaphycus helvolus*, introduced against the brown olive scale, have been maintained, and some further small distributions of the parasite have been made in New South Wales where the Department of Agriculture is co-operating in its establishment. During the year, two additional consignments totalling 52 males and 71 females were forwarded to the Narara Viticultural Nursery. It is reported that a laboratory colony has been established from these and earlier consignments.

Reports from South Australia, where laboratory colonies have been maintained by the Waite Agricultural Research Institute, suggest that the parasite is showing some indications of maintaining itself in the field at certain points where liberations had previously been made.

(vi) *Other Orchard Pests.*—At Canberra, a single application of D.D.T.-solvent naphtha emulsion effectively controlled black peach aphid (*Anuraphis persicaeniger*) on badly infested peach trees, and pear slug (*Caliroa limacina*) on pear trees. D.D.T.-solvent naphtha emulsion proved ineffective when used against woolly aphis of apple (*Eriosoma lanigerum*).

13. *Insect Vectors of Plant Virus Diseases.*—(i) *Tobacco Yellow Dwarf.*—Investigations on the vector, *Thamnotettix argentata*, of the yellow dwarf virus disease of tobacco, were recommenced on a small plot at Canberra in 1944. This was the first tobacco grown at Canberra for a number of years, yet approximately 30 per cent. infection occurred, showing that host plants of yellow dwarf virus are present in the district. It is not known which plants act as reservoirs for the disease.

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

daily abundance of alate forms was recorded by means of a pair of mechanical nets. With the exception of a heavy infestation on lettuces under irrigation, the population remained very small throughout the district on account of drought conditions. No aphids were recorded in the mechanical nets after the end of October, when the population disappeared for five months. In April, 1945, a small autumn generation appeared on potatoes, and produced winged migratory individuals.

14. *D.D.T. Emulsions.*—It was known that in the United States of America, a number of D.D.T. emulsions had been used for the control of agricultural pests, but the solvents, and some of the emulsifiers, were not available in Australia. It was necessary, therefore, to evolve a suitable emulsion for use in experiments here during the 1944–45 season. Earlier work had already shown that a solvent naphtha emulsion at concentrations below 1 per cent. was non-injurious to potato plants. It was then found that a satisfactory solvent naphtha emulsion, with D.D.T. incorporated, could be made. This emulsion was found to be highly toxic to the larvae of the potato moth, *Gnorimoschema operculella.*

Phytotoxicity tests with the emulsion were then made on potato, beetroot, egg plant, and rhubarb ; seedlings of French beans, capsicum, tomato, lettuce, passion fruit, and cabbage, and these showed that it was not injurious to the plants. Cucumber seedlings, however, were seriously affected, and lucerne and pawpaw seedlings slightly affected.

Attempts to incorporate D.D.T. in white oil emulsions have not been satisfactory. The solubility of D.D.T. in these oils is low, and when the stock mayonnaise mixtures are diluted to the final spray strength, D.D.T. crystallizes out and adheres to the sides of the containing vessel. When tested on potted French bean seedlings in the glass-house, some of these emulsions inhibited growth. The leaves of treated plants did not expand to a size of more than half that of untreated plants ; the flowers were smaller, and the internodes greatly reduced. In these trials, the same white oil emulsions without D.D.T. did not produce any inhibition of growth. The degree of inhibition with different white oils varied considerably. The effect of D.D.T.-solvent naphtha emulsion was negligible.

Satisfactory emulsions have also been prepared using eucalyptus oils as the solvent for D.D.T. When tested on potted bean seedlings, some inhibition of growth occurred, but the effect was much less marked than that produced by the D.D.T.-white oil emulsions.

Because of the above results, the D.D.T.-solvent naphtha emulsion was chosen for use in our field crop experiments during 1944–45, and was used mainly at concentrations of 0.05 to 0.2 per cent. D.D.T.

15. *Systematic and General Entomology.*—During the year, numbers of insects and arachnids have been identified for various institutions and entomologists throughout Australia and New Zealand. Assistance has also been given in dealing with various systematic and taxonomic problems.

Further additions of insects, many of economic importance, have been made to the Divisional collection as a result of field work or exchanges with other institutions and individuals.

An outstanding acquisition during the past twelve months was the Goerling Collection of Western Australian Coleoptera. This fine collection, comprising over 4,000 specimens, was made by the late Mr. A. Goerling of Marloo Station in the Wurarga district, and presented by his son, Mr. H. M. Goerling of " Oakley Park ", Pinjarra.

16. *Publications.*—The following papers were published during the year :—

Fitzgerald, J. S. (1944).—The effectiveness of various mineral dusts for the control of grain pests. Coun. Sci. Ind. Res. (Aust.) Bull. 182.

Greaves, T. (1945).—Experiments on the control of cabbage pests in North Queensland. *J. Coun. Sci. Ind. Res. (Aust.)* 18 : 110–120.

Helson, G. A. H. (1944).—A preliminary field test of insecticides against potato moth *Gnorimoschema operculella* (Zell.). Ibid. 17 : 179–185.

Mackerras, I. M., and Mackerras, M. J. (1944).—Sheep blowfly investigations. The attractiveness of sheep for *Lucilia cuprina.* Coun. Sci. Ind. Res. (Aust.) Bull. 181.

Norris. K. R. (1944).—Experimental determination of the influence of the red-legged earth mite (*Halotydeus destructor*) on a subterranean clover pasture in Western Australia. Ibid. Bull. 183.

Powning, R. F. (1945).—The analysis of D.D.T. and pyrethrins in kerosene-based sprays. *J. Coun. Sci. Ind. Res. (Aust.)* 18 : 121–123.

Wilson, Frank (1945).—The restriction of insect infestation to the periphery of bulk wheat. Ibid. 18 : 1–5.

IV. ANIMAL HEALTH INVESTIGATIONS.

1. *General.*—At the beginning of the year, a new Division was created, and the work which had been centred in the Animal Nutrition Laboratory at Adelaide passed to the new Division of Biochemistry and General Nutrition.

The work of the Division of Animal Health and Production has been carried out during the year at two main centres, Melbourne and Sydney, as well as at field stations at Cunnamulla (Queensland), Badgery's Creek (New South Wales), and at Werribee (Victoria). Co-operative woth with State Departments of Agriculture has continued. The Biochemistry Section of the Division of Industrial Chemistry has 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.*—The experiment designed to determine the influence of nutritional stresses on the maintenance of immunity against pleuro-pneumonia was continued and is due for completion in the coming year. In an endeavour to fix the virulence and immunizing properties of the vaccine, preservation of the seeding cultures in the frozen state at −80° C. by means of solid carbon dioxide was introduced. During the year 336,720 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. During the year a preliminary investigation was carried out in conjunction with the Walter and Eliza Hall Institute, Royal Melbourne Hospital, on the diagnosis by complement fixation of human genito-urinary infections due to organisms of the pleuro-pneumonia group. There was considerable reciprocal cross-reaction between the human and bovine types.

(ii) *Enterotoxaemia of Sheep and other Diseases due to Clostridia.*—Study of the haemolysins of the *Cl. welchii* group was continued. Attempts to determine the mode of action of delta-haemolysin were not successful.

(iii) *Caseous Lymphadenitis of Sheep.*—The vaccination experiment in sheep referred to in the last Report was continued. In addition, an experiment, carried out on guinea pigs, was designed to compare the immunizing capacity of vaccines derived from the frozen and thawed cells of three strains of *C. ovis.* It was found that an old laboratory strain "W" gave significantly high protection. This strain is being used in the experiment with sheep.

(iv) *Tuberculosis of Cattle.*—Complement-fixation was carried out, using an antigen prepared from distilled water extracts of human and bovine lipid-extracted bacilli. Of 525 sera from cases of bovine tuberculosis confirmed at autopsy, 92 per cent. gave positive reactions; of 86 tuberculin reactors which showed no visible lesions at autopsy, 50 per cent. gave positive reactions. During the year 183 serum samples were tested for the Queensland Department of Agriculture and Stock.

(v) *Mastitis in Dairy Cattle.*—During the year the systematic epidemiological studies were continued on the experimental herds. Some of the cows in the second epidemiological experiment, previously referred to, have come into production. One small herd consists of heifers from a herd free from *Str. agalactiae.* As calves they were suckled by their dams, but as weaners they were run with cows carrying infections of *Str. agalactiae.* On coming into production they were removed to isolation. Six heifers have come into production and 851 quarter milk samples have been submitted to bacteriological examination.Streptococci have been isolated from 8 per cent. of the samples, but *Str. agalactiae* has not been recovered. Another group of calves from the same herd was reared on milk containing *Str. agalactiae.* The calves were later placed in isolation. Four of these animals have come into production and 488 quarter milk samples have been examined, and streptococci have been isolated from 8.5 per cent. of the samples but *Str. agalactiae* has not been recovered. A third group of calves were left to be suckled by their dams and as weaners were placed in isolation. Six of these have come into production and 1272 quarter milk samples have been examined. Streptococci have been isolated from 3.5 per cent. of the samples but *Str. agalactiae* has not been recovered. During the year some penicillin was made available for experimental purposes by the Commonwealth Serum Laboratories. A preliminary experiment was carried out to determine the possible value of penicillin for the eradication of infections of *Str. agalactiae* and of staphylococci from the quarter. A dose of 15,000 Oxford units was adopted, and if the infection failed to re-appear over a period of eight weeks after treatment of the quarter the infection was judged to be eradicated. Clinical infections due to *Str. agalactiae* gave the following results. Of 24 quarters, nine (37 per cent.) lost the infection after a single dose. Of 57 quarters, 41 (72 per cent.) lost the infection after two consecutive doses with an interval of about twelve hours. Most of the

quarters which failed to meet the criteria received further treatment and the infection was overcome in all but three of the 81 quarters. The dose rate was increased in the treatment of five quarters but the numbers are too small to show any significance. A few persistent sub-clinical infections have been treated but not sufficient to give results of value for discussion. Staphylococcal infections proved to be more resistant to treatment. Even sub-clinical staphylococcal infections (25) failed to respond to four consecutive doses except in one case. The penicillin reduces the bacterial count very radidly but the complete elimination of the infection is a high criterion to meet.

(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 original flock of 300 ewes which were placed under observation in 1940, only 59 remained at the beginning of the year. During the year 27 of these died and showed chronic damage in the liver. A second flock of 300 young ewes was placed in the experiment in November, 1943. These were divided into two groups, one to be given the opportunity to graze on the summer growing annual *Heliotropium europaeum*, and the other restricted from such grazing. During 1944 the one group grazed on heliotrope for 52 days. During 1945 the same group grazed on heliotrope for a period of 76 days. The drought during the year restricted normal grazing, and for much of the time the experimental animals had to subsist mainly on supplementary feed. During the year 61 of the ewes in the second flock died. Of these, 45 were in the "heliotrope group" and sixteen in the "non-heliotrope group". Haemolytic jaundice occurred in eighteen of these sheep and seventeen of them had grazed on heliotrope. In the majority of the sheep dying, the liver copper concentration was over 1,000 p.p.m. and reached 3,070 p.p.m. in one case. The pathological examination of the material has not been completed, but there is no doubt that the grazing on heliotrope favoured the occurrence of haemolytic jaundice. Further studies of the soil and of the pastures on the experiment farm were started during the year. At the laboratory studies were continued on copper assimilation and copper storage in the liver. An experiment was carried out to determine the effect of an increased intake by sheep of molybdenum on the storage of copper in the liver. It was shown that when the intake of molybdenum by sheep on a normal diet was increased by 10 mg. or 100 mg. per day, the copper concentration in the liver was significantly reduced. A reduction was also observed when a copper supplement was added to the diet.

(vii) *Haematuria Vesicalis of Cattle.*—A new attack of this problem has been started, based on the finding that the molecular ratio of ethereal sulphate to combined phenol is "highly-significantly" lower in the urine of cows in red-water districts than in unaffected districts. It is planned to make a more detailed study of the urinary phenols, and to this end precise analytical methods are being developed.

(viii) *Contagious Abortion of Cattle.*—During the year about 11,000 doses of "Strain 19" vaccine were prepared and supplied to the Victorian Department of Agriculture. Studies on the causes of unsatisfactory viability were continued. The problem appears to be complex; on the one hand it was found that the prescribed buffered saline does not prevent a lowering of pH to undesirable levels and that stronger buffer may be necessary; on the other hand, strong evidence suggests that in some cases zinc leached from the rubber stoppers may reduce viability; and it also seems that, with certain batches of potatoes, cells harvested after the prescribed two days' incubation are less viable than those harvested after one day, although, with other batches of potato, the reverse holds. Viability in various suspending fluids showed that sterile skim milk was greatly superior. It also was much superior to others in experiments on preservation by drying from the frozen state.

The experiment designed to test the resistance of vaccinated calves to natural infection is still under way. The experiment on the influence of dosage and route of inoculation upon antibody response of adults, was completed, using the agglutination reaction as an index of response; it showed that the intracutaneous and intracaudal (subcutaneous tissue at the tip of the tail) routes were much more efficient than the subcutaneous, dose for dose, and of the same order of efficiency as 5.0 ml. subcutaneously, and that 1 ml. intracaudally gave 2.2 times the response given by 5 ml. subcutaneously. The report is expected to appear in the *J. Comp. Path.* for October, 1945. A further experiment on calves four to eight months old also showed that 0.2 ml. intracutaneously or intracaudally was as efficient as 5.0 ml. subcutaneously.

(ix) *Bacterial Oxidation of Arsenical Cattle-dipping Fluids.*—During periods of disuse arsenical cattle-dipping fluids may become less efficient through oxidation of tervalent arsenic to the quinquevalent level. The phenomenon and a method of combating it with lactose was published during 1943 in the *J. Coun. Sci. Ind. Res.* (*Aust.*) 16 : 129. It has been presumed without proof that spontaneous oxidation, as in South Africa, is due to bacterial actions. During the year a bacterium closely resembling the South African bacterium (*B. arsenoxidans*),

was isolated from dipping fluid from Brisbane, Queensland. Its cultural characteristics and some of the factors governing its arsenic-oxidizing activity have been studied and will form the subject of a publication.

(x) *Toxicity of Wheat for Stock.*—In continuance of the line of inquiry referred to in the last Report, the decarboxylating bacterial flora was found fairly regularly in the stomach, not only of wheat-gorged horses but of horses fed on normal diets. Repeated, but unsuccessful efforts were made to isolate in purity bacteria capable of producing histamine in peptic digest of wheat or in histidine broth. *Cl. welchii* was never found in this material. With the mixed cultures, decarboxylation was most effective anaerobically and at low pH. Support was not obtained for a suggestion that 3 per cent. of ground limestone added to wheat might prevent the required fall in pH in the stomach, or that copper in practicable doses might depress the bacterial flora or inhibit histidine decarboxylase. The toxic sulphur-containing protein purothionin was examined as a possible cause of wheat toxicity, but repeated injections of small doses, amounting in all to 1 gram, corresponding to about 20 lb. of wheat, produced no obvious abnormality.

(xi) *Anaplasma centrale.*—The pure strain of *Anaplasma centrale* has been maintained as in the past. In addition a further trial was started to determine the longevity of the organism in blood which has been quickly frozen to and kept at $-80°$ C.

3. *The McMaster Animal Health Laboratory.*—(i) *Parasitological Investigations.*—(*a*) *Study of Anthelmintics against Haemonchus contortus.*—A further series of arsenites and arsenates was tested but none were strikingly effective. In general the arsenites were more effective than arsenates. Phthalates, washing blue, and Storarsol were ineffective. Hexachlorocyclohexane, "666", had only slight anthelmintic effects.

(*b*) *Study of Anthelmintics against Trichostrongylus spp.*—Small doses of phenothiazine given daily or every few days depressed egg production and checked development of larvae in faeces, but few worms were killed and egg counts soon returned to previous levels when doses were discontinued. Two heavily infested sheep, dosed daily with 1.0 gram and 0.5 gram phenothiazine, respectively, died in two to three weeks from trichostrongylosis. In a preliminary trial phenothiazine was as effective in sheep which were scouring as in those with normal faeces. Gentian violet in relatively large doses showed only moderate efficiency. Nicotine-bentonite was no more effective than nicotine sulphate. "666" was moderately effective in three out of six sheep and ineffective in the others.

(*c*) *Study of Anthelmintics against Oesophagostomum columbianum.*—Daily doses of 0.5 and 1.0 gram phenothiazine were given to two groups of four sheep for 18–32 days. The smaller dose was relatively ineffective, whereas the larger dose was highly effective in three out of four sheep. Thiophenylnaphthylamine, methylphenothiazine, and phenylnaphthylamine had slight effects only. Nicotine-bentonite and "666" were both ineffective in the doses used.

(*d*) *Epidemiology.*—The field trials in Queensland have been continued and new ones have been undertaken. Trials are now under way in Queensland at Clermont, Capella, Roma, Emerald, Gindie, Jericho, Barcaldine, Blackall, Chinchilla, Cambooya and Karara. In South Australia trials are in progress at Pillana (Eyre's Peninsula) and Clare, and another is to be set up at Kybybolite. In New South Wales trials were commenced at Mendooran and Bombala. This work is gradually providing a clearer picture of the seasonal conditions which favour worm infestations and of the relative importance of different worm parasites in the areas concerned. The more detailed epidemiology trial at "Saumarez", Armidale, has been continued. There and elsewhere, in the spring or early summer and often again in autumn, the worm population suddenly declines to very low levels without treatment. This phenomenon known as "self cure" has occurred at the same time on properties 20 miles apart. Investigation has shown that it is not due to worms dying from age.

A further study has confirmed previous observations that *Dictyocaulus filaria* infestation increases in the autumn, reaches its highest level in late winter and decreases markedly and suddenly, without treatment, in September–October.

(*e*) *Administration of Phenothiazine in Salt Lick.*—The field trial commenced last year was rendered inconclusive by drought conditions. It was found that sheep offered 1 : 15 phenothiazine/salt mixture consumed only 1.48 to 2.3 g./head/day, and those offered 1 : 30 mixture 0.93 to 2.8 g./head/day. The use of "straight" phenothiazine in place of the phenothiazine plus antioxidant and dispersing agents as used for drenching, made no difference to the sheep's intake. The daily intake of phenothiazine was usually much below 0.2 g./head whereas 0.5 g./head is not expected to be effective. In view of the importance of this matter two further trials have been undertaken.

(*f*) *Effect of Worm Parasites on Body Weight and Wool Growth.*—Relatively light, subclinical, infestations with *Trichostrongylus* spp. resulted in reduced food consumption, loss of body weight and considerable reduction in wool growth. Wool growth was gradually reduced to as little as 40 per cent. over a period of four months, compared with worm-free sheep on the same food intake. The sheep were then cured of trichostrongylosis and infested with *Haemonchus contortus*. The infestations were very light and adverse effects on appetite, body weight and wool production were correspondigly small. They were then cured of haemonchosis and subsequently infested with *O. columbianum*. The effect of this parasite upon appetite was very pronounced. Within three weeks food consumption fell from about 2.5 lb. per day to 1.5 lb. and after 30 weeks was still below 2.0 lb. per day. The effect on body weight and wool production will be correspondingly severe. These experiments emphasize the economic importance of inapparent worm infestations and serve to stress the importance of preventive measures.

(*g*) *Administration of Phenothiazine.*—Several new or modified devices for dosing sheep with phenothiazine and methods to prevent staining of the wool by phenothiazine were examined and tested during the year.

(*h*) *Substitutes for Nicotine Sulphate.*—Because of the serious shortage of nicotine sulphate, various substitutes were considered, particularly tetrachlorethylene. The Division of Industrial Chemistry prepared several emulsions of tetrachlorethylene and copper sulphate but, since glass or earthenware containers would be needed, packing and transport would be costly and difficult. Several firms have devised syringes which will deliver a mixed dose of the two drugs and these have proved satisfactory on test. A special report on the use of substitutes for nicotine sulphate was prepared.

(*j*) *Parasitological Studies at Armidale.*—A rotational grazing trial is under way at Abingdon with four sheep per acre, moved weekly through a series of four paddocks. In spite of this, infestations with *H. contortus* increased in spring and again in autumn. The trial is continuing. The value of three doses of phenothiazine during winter was tested again, but the large stomach worm increased in the spring and further drenching was necessary to control it. Nodule worm also increased in the following autumn. Continuing the series of trials to determine whether improved nutrition in winter will counter the effects of parasitism in weaners, one experimental group was fed *ad lib.* on straw (subsequently replaced by oaten chaff) and another group on 4 oz. lucerne chaff per day in addition to natural grazing. These methods were not successful and a further trial has commenced in which access to green oats will be allowed for various periods. Doses of 7 grams of phenothiazine were found as effective against *H. contortus* as 18 grams. Neither dose was highly efficient against the immature forms of this parasite in the sheep. Doses of 14 g. and 18 g. phenothiazine were only partially effective in controlling *Trichostrongylus* spp. under outbreak conditions among 10-month old weaners. Further studies have commenced on the climatic factors influencing longevity of eggs and larvae.

(ii) *External Parasites of Sheep and Control Methods.*—(*a*) *Arsenic in Dips.*—In an experiment with arsenic-sulphur dip the sheep dipped first retained as much soluble and insoluble arsenic as those dipped last, when suint would have increased the wetting power of the dip fluid ; addition of soap as a wetting agent did not affect the quantity of arsenic retained ; the base of the wool contained less soluble and insoluble arsenic than the tip ; the neck, midside, and belly tended to retain less arsenic than other parts of the fleece. The amounts of arsenic retained in the fleece after 48 days by two sheep dipped in sodium arsenite and by two dipped in arsenic-phenol solution were not significantly different. Samples from two sheep dipped in arsenic-sulphur gave somewhat variable results. This needs confirmation but it suggests that where arsenic is effective, as it is when properly applied for the destruction of the body louse of sheep, nothing is gained by using complex dips. A solution of 1 : 10,000 sodium arsenite has completely eradicated lice from individual sheep which were carefully dipped.

(*b*) *Rotenone in Dips.*—A group of 43 ked-infested sheep were dipped in a suspension of 8 oz. Timbo root (rotenone content 4.6 per cent.) per 100 gallons. All adult keds were killed but a few emerged from pupae later and survived. Ten weeks after dipping three of the 43 sheep each carried a few keds. Such a small residual infection is only found by careful search but is sufficient to build up a massive infestation during the year. A similar suspension of Timbo root was used on some louse-infested sheep but many lice survived.

(*c*) *D.D.T. in Dips.*—An emulsion prepared by I.C.I.A.N.Z. was tested on a few individual sheep. A 1 : 5,000 dilution of D.D.T. prepared by adding the emulsion to water, killed all adult keds in a few hours and over four weeks elapsed before it was possible to re-establish keds on the dipped sheep. Keds emerging from pupae which may survive such a dipping would be killed by residual toxicity. Adult lice were all killed at a 1 : 2,500 dilution of D.D.T. but some survived when a dilution of 1 : 5,000 was used. Opportunities are being sought to check these results on much larger numbers of sheep and under field conditions.

(*d*) *Studies on the Life History of Bovicola ovis.*—Difficulty is experienced in getting normal egg production from females under artificial conditions. *B. ovis* will live on material scraped from the sheep's skin, but the life cycle is speeded up by the addition of yeast. The eggs require a temperature of about 37° C., none hatch at 32° C. nor if kept at 27° C. for two days and subsequently at 37° C. Hatching occurs in nine to eleven days and the period from egg to egg ranged from 38 to 50 days. These lice are apparently much less susceptible to humidity than to temperature changes—50 per cent. or 70 per cent. relative humidity is satisfactory, 90 per cent. is unfavorable but not necessarily lethal. The heaviest concentration of lice on the sheep is found along the mid-line of the back and there is a decrease down the sides towards the belly. The largest numbers are usually found in the region of the withers.

(*e*) *Trombidiosis of Sheep in Queensland.*—Lesions of the legs of sheep on the black earths of the central highlands of Queensland were investigated in co-operation with the Queensland Department of Agriculture and Stock. The cause was found to be a new species of trombiculine mite (*Trombicula sarcina*, Womersley, 1944). Sheep recover spontaneously and except in special cases preventive measures would be uneconomic. This mite also causes acute irritation to human beings. Grey kangaroos (*Macropus major*) are natural hosts of the parasite.

(iii) *The Blowfly Strike Problem.*—(*a*) *The Modified Mules Operation.*—The use of this operation by woolgrowers is increasing. A high incidence of strikes in the operation wounds among a mob of lambs treated at marking time was investigated and was found to be associated with the relatively long wool on the breech which led to matting and infection of the wound. Experiments to determine the effect of the modified Mules operation on subsequent size of the " bare area " when applied to lambs and weaners, respectively, were started at Gilruth Plains.

(*b*) *Optimal Tail Length.*—A series of trials has been in progress during the last year, involving about 6,500 Merinos on three properties and about 800 Corriedales on one property. The modified Mules operation was applied to all the Merino sheep. On three occasions severe fly waves occurred, in one case before the Mules operation had been applied and in the other two instances when the sheep were carrying six and seven months wool on the crutch. The strikes recorded in the different groups in these three outbreaks were :—Short tails, 21, 42 and 31 per cent. ; medium tails, 5, 17 and 19 per cent. ; medium-long tails 3, 16 and 9 per cent. ; and long tails, 3, 7 and 12 per cent. Among the Corriedales, despite a dry season, 21 per cent. of the short tail group were struck compared with 3 per cent. of the medium-long group. In lambs docked when flies were very active the strike rates were :—Short, 21 per cent. ; medium, 7.5 per cent. ; and medium-long, 4.3 per cent. Thus the medium-long tail, with the tail stump one-quarter to a half an inch below the tip of the vulva, is the optimum. The long tails (docked at about 4 inches) give similar results as regards flystrike but are more difficult to crutch or shear and cause some increase in " dags ".

(*c*) *Operation to Reduce Tail Strike.*—The removal of a section of skin from the upper surface of the tails to retract the wool-growing skin from the sides and tip of the tail has been tested in four trials, but as yet the incidence of strike in the flocks concerned has been too low for any conclusions to be drawn.

(*d*) *Lamb-marking Dressings.*—Three trials have been carried out under conditions where flies were active at marking time. In the first trial B.T.B. blowfly dressing reduced strike from 18 per cent. to 3 per cent. In a second trial results were :—Controls, 39 per cent. ; a commercial tar oil dressing, 44 per cent. ; B.T.B., 25 per cent. ; B.T.B. and citronella soap emulsion, 11 per cent. ; and copper sulphate solution, 13 per cent. In the third trial two groups of lambs were used and a mixture of boric acid, citronella, and bentonite was tested. Results were :—First group—controls, 14 per cent. ; copper sulphate, 4.5 per cent. ; B.T.B., 9 per cent. ; and the boric acid, citronella, bentonite mixture, 0.7 per cent. Second group—Controls, 19 per cent. ; copper sulphate solution, 10 per cent. ; and the new mixture, 2 per cent. Further trials are pending.

(*e*) *Dehorning Merino Rams.*—Some sixteen ram lambs were dehorned with a modified calf dehorner, but in no case was the whole of the horn-growing tissue successfully removed, and some regrowth occurred. Further modification of the instrument may achieve better results. In a few lambs, where all the horn growing tissue was carefully removed surgically, no regrowth took place. Amongst adult rams, in the eighteen months following dehorning regrowth averaged 2.5 inches in three-year-old rams, 1.5 inches in four-year-old, 1.0 inch in five-year-old, and 0.5 inch in six-year-old rams. Better results were obtained by cutting at about 3.75 inches from the skull so that the central cavity was not opened. Owing to the dry season there has been no head strike in the dehorned rams nor the controls. There is no evidence that these rams, dehorned as adults, fight less than rams with their horns intact. The dehorned rams are easier to shear and handle generally.

(iv) *Biochemical Studies.*—(*a*) *Studies on Mineral Metabolism of Sheep.*—The experiments with sheep fed on the standard low calcium-high phosphorus diet with the addition of coarsely and finely ground limestones is now being terminated as the sheep reach maturity. Coarsely ground limestone is less effective than finely ground in off-setting the adverse effects of the diet upon dentition, appetite, growth, and wool production. The trials with diets comprised of wheaten chaff with oats, maize, or wheat have shown adverse effects comparable with those on the standard low calcium diet. With each of these diets the adverse effects were offset by the addition of ground limestone. Throughout these experiments the adverse effect upon appetite of a diet low in calcium and high in phosphorus has been very striking. Observations on six weaners over a period of six months suggest that poor utilization of calcium and phosphorus from meat and bone meal is probably due to the particles of bone in such meals being relatively coarse. The dental abnormalities seen in sheep on the low calcium-high phosphorus diets resemble those seen in fluorosis. The foodstuffs used in these experiments are, therefore, being analysed for fluorine content. The water supply was found to be very low in fluorine. Among some 90 water samples from 60 towns in New South Wales only one contained as much as one part per 1,000,000 of fluorine, the majority containing 0.2 p.p.m. fluorine or less.

(*b*) *Studies on Poisonous Plants.*—Force-feeding experiments on sheep with *Oxalis cernua* (soursob) and *Threlkeldia proceriflora* (soda-bush), both of which are rich in salts of oxalic acid, showed that they may cause an acute hypocalcaemia which can be cured by injection of calcium gluconate. In the case of soda-bush poisoning, a sheep thus cured of the acute symptoms developed lesions in the urinary tract. This will be the subject of further investigation.

(*c*) *Miscellaneous.*—Several samples of soil which are habitually licked by sheep were analysed. Many contained a large percentage of calcium carbonate, some were moderately rich in magnesium carbonate, and a few contained more sodium chloride than is usually found in soils. Clinical and other observations were made on an outbreak of pregnancy toxaemia in Tasmania, in collaboration with the Department of Agriculture. In an experiment on dairy cows, in co-operation with the McGarvie Smith Animal Husbandry Farm, it was found that the depressing effect of heavy feeding on wheat was offset by the addition of limestone. The effects of methods of collection and storage on the results of blood and serum analyses are being investigated. Samples of tomato seed and stock food made therefrom were analysed. Shortage of common stock foods led to a brief survey of horse feeding in commercial stables and revealed that diets commonly used are often highly uneconomic.

(v) *Endocrinological Studies.*—(*a*) *Oestrogens in Sheep's Urine.*—Assay by chemical methods proved unsatisfactory because of the low concentration of oestrogens in sheep urine, except in late pregnancy, and the presence of phenolic and other compounds which mask colour reactions. Biological assay of oestrogens in 24-hour urine samples, collected from sheep at intervals during dietary regimes and in late stages of pregnancy will be undertaken. The samples have already been extracted and concentrated.

(*b*) *Artificial Induction of Lactation.*—Preliminary work has been carried out to study the mode of action of synthetic oestrogens in stimulating lactation and the nature of the factors which modify their effects in individual animals. Injections of hexoestrol have induced lactation in eight ewes out of twelve. Response differed markedly and appears to be controlled by factors other than dose rate, body weight, or food intake. Two, which did not respond to administration of hexoestrol over a period of three weeks, were injected with 10 mg. of thyroxin and both yielded some milk four days later. The same dose of thyroxin given to two sheep not previously treated with hexoestrol had no apparent effect on their mammary glands. The effects of several probable breakdown products of synthetic oestrogens are being studied.

(*c*) *Pregnancy Toxaemia of Ewes.*—The possibility that excess of oestrogens produced in the late stages of twin pregnancy may explain the loss of appetite which often initiates pregnancy toxaemia is being investigated.

(vi) *Wool Biology.*—(*a*) *Progeny Testing.*—This work has continued with encouraging results. It has been found that a ram may be ranked similarly on individual characters when successive observations are made on the same progeny, e.g., at one year and two years of age, and when the same rams are retested with a different, random selection of ewes. Seven rams have now been compared under these conditions. Results suggest that when body weight, clean scoured fleece weight, and staple length are to be compared, groups of 30 progeny should give sufficiently accurate results for practical purposes. Some rams have ranked differently when judged on their ram progeny than when judged on their ewe progeny.

(*b*) *Specimens from Rambouillet and Black Top Merinos.*—Specimens of skin and fleece from five Rambouillet and seven Black Top Merino ewes were received from California. The follicle population and yields were much lower than in comparable material from Australian Merinos.

(*c*) *Studies on Methods of Sampling Merino Fleeces.*—Observations were made on samples from eight regions of the body of thirteen mature Merino sheep ranging from superfine to strong. The sheep were kept on a standard diet in single pens and each area was sampled at 100 and 150 days' fleece growth. Fibre diameter showed a consistent increase from shoulder to midside to thigh. In some cases the trend was insignificant but it was never reversed. The midside sample was also very close to the mean of the eight sites whereas the shoulder was below the mean and the thigh was above it. It is concluded that when broad differences in fibre diameter are to be measured the midside sample should be used. Samples from opposite sides were comparable. The weight of clean scoured wool and of wax and suint produced in this experiment are not yet available.

(*d*) *Comparison of Fleece Production by Fine-wool Merinos and Corriedales in Response to Fluctuating Planes of Nutrition.*—Three groups of eight 2-tooth ewes are being studied. They are kept in single pens and fed on a standard food mixture. Food consumption is controlled so that one group is on a declining level of nutrition, another on an increasing plane, and the third is uniform throughout. This is a continuation of the previous study on the ability of various strains of Merino to produce wool from a given food intake.

(*e*) *Comparative Histology of the Hair-follicle Group.*—The arrangement and structure of the glands and hair follicles in the skin of 27 mammalian species have now been examined for comparison with the sheep. The range has included the domesticated animals, marsupials, monotremes, and primates. The same general follicle-group plan occurs over most regions of the body in all these species but the concept of the " follicle group ", as defined for the sheep, cannot be applied to other species without qualification. This work, apart from its comparative value, supports the view that the follicle group is a promising unit for measuring genotypic differences in the skin of the various breeds of sheep.

(*f*) *New Instruments for Wool Metrology.*—A working model of a compressometer was made by the National Standards Laboratory and is expected to give fairly rapid approximations of the density of fibre population. Two measuring and recording instruments were devised, viz., a simple integrating wheel for estimating mean fibre thickness, and a more complicated instrument, not yet completed, to record the number of observations, sum the measurements, and group the data into predetermined class intervals so that the standard deviation can be readily calculated. A type of microprojector suitable for local manufacture is also being devised by the Standards Laboratory.

4. *The F. D. McMaster Field Station.*—(i) *General.*—The staff at the Station remained in a depleted condition. During the year the officer-in-charge made a short visit to the United States of America and New Zealand to conduct inquiries on research in animal breeding and in animal production in those countries. Seasonal conditions were unfavorable until January, 1945, after which good summer and autumn rains fell. Following the rains the growth of grass was prolific and crops were sown. The live-stock carried included 93 rams, 443 ewes, 191 lambs and 77 aged wethers. Of the ewes, 404 were mated in various experiments. The dairy cattle comprise three Jersey cows and two heifer calves. The Zebu cow gave birth to another half-bred Jersey bull calf.

(ii) *Zebu Hybridization.*—(*a*) *Beef Cattle.*—There are no further developments to report.

(*b*) *Dairy Cattle.*—A Zebu cross-bred dairy herd is being built up. Two cows now in milk are having their production tested in the University dairy herd, and all the Jersey females are being mated with the half-bred Zebu yearling bull as opportunity offers. It is hoped to be able to develop a cross-bred herd of sufficient size to investigate the inheritance of dairy temperament and to observe the effect on production of introducing Zebu " blood ". Evidence will be derived from dam-daughter comparisons, the dams being tested-Jersey females and the daughters being cross-breds.

(iii) *Fertility of Sheep.*—During the year special studies were completed on (*a*) time limits and selection of mating periods for ewes ; (*b*) accession to sexual maturity by Merino ewes on the Station ; (*c*) rates of reproduction, accession to sexual maturity, and effect of delayed accession on the growth of specific Merino and cross-bred sheep populations ; and (*d*) infantile mortality associated with delayed accession to sexual maturity. Observations reported in these studies may be summarized as follows :—(*a*) The first and second 17-day periods of mating are most important during the height of the breeding season. Six years of observation show 81 per cent. of ewes conceived to matings made in the first 17-day period and fifteen to those made in the second, giving a total of 96 per cent. for the first 34 days of the mating season. (*b*) A particular flock of 98 stud Merino ewes purchased as two-and four-tooths was mated for six consecutive years. The percentages of lambs born were 23, 56, and 82 at ages of approximately fifteen to 24 months, 28 months to 33 months, and 40 months to 45 months, respectively. Thereafter the ewes bore approximately 80 per cent. of lambs annually. Their

female progeny, although fewer in number, showed the same trend but on lower levels. (*c*) Comparisons were made of the foregoing results and those from (1) mating maiden Merino ewes in the Riverina District of New South Wales, (2) normal reproductive rates of Merino ewes, and (3) Border Leicester and first-cross (Merino x Border Leicester) maiden ewes on the Station. The comparisons showed that ewes of the particular flock observed at the Station were not unusual either in delayed accession or in ultimate levels of fertility; that cross-bred maiden ewes reached sexual maturity much earlier; that their fertility level was higher and that the population developed from 81 Border Leicester ewes by cross-breeding was 185 per cent. greater than that developed from the 98 original stud Merinos by mating them with Merino rams during the same six years. (*d*) Infantile mortality and that of ewes during lambing was shown to be associated with delayed accession to sexual maturity.

In addition, age as a factor modifying the occurrence of oestrus has been studied. It has been found that a group of Merino weaners examined daily from nine months of age onward, showed 48 per cent. as their maximal occurrence of oestrus for only one month prior to their reaching 21 months of age. In the following year the figure was 100 per cent. for two consecutive months and, during the subsequent year, 100 per cent. for five consecutive months. Adult Merino ewes during the same periods had maximal occurrences of 100 per cent. in the five consecutive months of the same annual seasons until 1943 when they were probably nine to ten years of age and when their occurrences of oestrus were considerably reduced.

(iv) *Inheritance of Skin Wrinkles in Sheep.*—Populations have been developed to the following sizes:—F_1 208; F_2 114; F_3 12; back cross 53. Of these 78 are lambs which must be held until adult age before they can be finally classified. However, observations to date justify a provisional hypothesis that "wrinkling" and "plain body" are paired characters the inheritance of which is Mendelian and polygenic. Plain body is dominant to wrinkling. For this year's mating all adult F_1 and F_2 females have been pooled and randomized into five sub-groups each of which has been mated with an individual Merino ram. Each of the rams has been phenotypically classified and selected to make a series having ascending scores for wrinkling. The scores of the five rams are 0, 10, 15, 21 and 25 respectively. Their progeny will all be back-crosses and the object of the mating is to determine to what extent wrinkling of the progeny from comparable mates will be influenced by different degrees of wrinkling in the sires.

(v) *Inbred Flocks of Australian Merinos.*—(*a*) Beginning with the ram M_3 and his mates, this flock consists of 7 rams, 16 ewes and 4 lambs. Four rams and seven ewes are not inbred but the average coefficient of inbreeding of the remainder is 24.4 per cent. in which the highest is 25.0 per cent. Detailed examination of this flock awaits provision of further facilities, but appraisal indicates that plainness of body, a peculiar lockiness of the fleece wool, a high degree of crimping, and considerable uniformity of fibre diameter are being established.

(*b*) The original Boonoke flock has been augmented by purchases of sheep of the same breeding from Dookie College. It is retained as two sub-groups which consist of 10 rams and 81 ewes, and 7 rams, 13 wethers, 74 ewes, and 21 lambs, respectively. Planned matings are gradually increasing consanguinity within the sub-groups.

(vi) *Faults and Specific Breeding Groups.*—(*a*) *Hollow Back.*—The group totals 29 parents and offspring mated to give an F_1, being hollow-backed rams x straight-backed ewes, and to give an inbred back-cross by the hollow-backed Merino ram x F_1 by the same ram. As yet there is nothing to report.

(*b*) *Parrot Mouth.*—The M_3 inbred flock is being used for these observations.

(*c*) *Hairiness* (synonym "fluffy tip").—Matings continue between a particularly "hairy" Merino ram and Merino ewes with and without "hair". There are no observations to report. All sheep on the Field Station have been examined for "hairiness".

(*d*) *Polledness.*—Matings continue in an endeavour to secure a full "depression" ram. The group now contains 58 parents and offspring.

5. *National Field Station, "Gilruth Plains", Queensland.*—(i) *General.*—The season has remained comparatively dry throughout, with relief rain in July–August, 1944, and in February, 1945. There has not been a really good fall of rain since December, 1942. The rainfall for the last three years has been 15.85 inches, 6.81 inches and 10.54 inches.

The rain in July and August, 1944, was too early and insufficient to make much grass growth, and the rain in February was patchy, the response in many parts disappointing. The country and the stock would have been in a very much worse condition than they are had it not been for the fact that for the last twelve months the place has been very lightly stocked. Supplementary feeding of some of the sheep was commenced early in July but was discontinued after the rain in that month. Feeding of some sheep was again commenced early in February but continuance for a long period was again made unnecessary by the rain at the end of that

month. On the whole the sheep have maintained their condition well, and the wool at shearing was attractive, with very little unsoundness. Lambing commenced at the beginning of September and 49 per cent. of the lambs were marked at the end of October.

(ii) *Observations on the Control of Crutch Strike.*—In experiments depending on the activity of blowflies for results, the continued dry conditions have militated against them. In only one experiment were results of some value obtained. This was an experiment commenced at lamb marking in October, 1944, to investigate the relative merits of the modified Mules operation performed at lamb marking or performed at a more mature age, and also to test the efficacy of a surgical treatment of the tail in preventing tail strike. The Mules operation was again found to have value in protecting lambs from strike. The figures for tail strikes were rather small but seemed to indicate that the tail treatment had at least some effect. In all other blowfly experiments no further strike results can be reported.

(iii) *Observations on Sheep Classing.*—In the experiment the results obtained so far are rather inconclusive but indicate that classing at about eighteen months of age is more efficient than classing at six months to eight months. At the younger age, however, fairly good results were obtained. Study of the data suggests that classing on the basis of production would be considerably more efficient than subjective classing by hand and eye. The data are, however, not yet sufficiently complete to assess the results with certainty.

(iv) *Miscellaneous Investigations.*—An experiment, designed to compare the relative production of rams and wethers, was commenced at marking in 1944. This has not yet progressed far enough to yield results.

An experiment was also commenced at marking in 1944 to test further the possibility of dehorning rams as lambs. A measure of success has been obtained but the method requires further investigation.

In October, November and December, experiments in the feeding of wheat to sheep were carried out; the conclusions drawn are as follows. It is not possible to feed sheep satisfactorily with wheat by laying it in trails on the ground even when the ground is hard. Troughs of some description are necessary. With the sample of wheat used which was, if anything, below F.A.Q. there did not appear to be any liklihood of serious losses when sheep ate relatively large quantities even when they came on to the wheat without any previous training. Where they had uninterrupted access to it, birds, chiefly galahs, consumed as much as 15 lb. of wheat per day at each feeding place.

6. *Publications.*—The following papers were published during the year:—

Dick, A. T. (1944).—Aspiration biopsy of the liver in sheep. *Aust. Vet. J.* 20 : 298–303.

Franklin, M. C., and Macgregor, C. H. (1944).—Experimental investigation of the cause of death of Merino rams after long journeys by rail. Ibid. 20 : 328–331.

Franklin, M. C., and Reid, R. L. (1944).—Observations on the cyanogenetic properties of linseed "nuts". Part I. Feeding trials with sheep. Ibid. 20 : 332–337.

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V. BIOCHEMISTRY AND GENERAL NUTRITION.

1. *General.*—During the period under review, the nutritional research projects undertaken in connexion with the victualling of the Armed Services have for the most part been completed. A new and enlarged edition of the "Food Composition Tables" was published, and in addition to those used by the Department of the Army about 15,000 copies have been distributed to individuals who are concerned in various ways with the nutritional well-being of the Australian people. Some lines of investigation undertaken during war-time have been continued and will be extended. These concern mainly the composition and nutritive quality of Australian foods.

There has been no break in the sequence of the long-term research projects which are concerned with the nutrition of the Merino sheep. Apart from a lessened activity in some, which was the direct consequence of war, all have been actively pursued towards the solution of nutritional problems which influence the Australian wool-producing industry. Lack of funds, however, still seriously limits the speed with which discoveries made in the laboratory can be extended by field experience to recommendations which may be applied directly to station practice.

2. *Nutrition and Wool Production.*—Various aspects of the relationships between the nutrition of the Merino sheep and the quantity and quality of the wool it produces have been the subject of study in this laboratory for a considerable period, and some of the findings have been discussed in previous Reports. These researches have demonstrated unequivocally that a change in the nutritional level of the order of that which occurs during any year under natural grazing conditions in Australia will alter very materially the rate of wool production and markedly affect the mean fibre diameter of the fleece.

Extension of these observations to the study of samples collected at bi-monthly intervals from sheep grazing under widely different conditions in South Australia and in Queensland has proven that variations of this order are a general occurrence over most of the areas where sheep are depastured in Australia. Analyses of the variance of the diameters of the wool fibres have demonstrated that the change in mean diameter brought about by fluctuations of nutritional level is accompanied by no less material alterations in the characteristics of the fibre-diameter distribution curves. These findings bear directly on the selection of sheep which are most suitable for the efficient production of wool from each of the wide variety of nutritional environments to which sheep are subjected in Australia—which is, with little doubt, the most important problem of the wool-producing industry. The more intensive studies with sheep kept under carefully controlled conditions in the laboratory annexes and in pens have revealed the marked changes which the nutritional level can bring about. In the mature sheep the most obvious effect is in the quantity and quality of its wool production. When the young growing animal is confined to rations similar in effect to those available in many natural grazing areas, not only is its rate of growth and wool production retarded, but its ultimate size, shape, and wool-producing efficiency are all very different from those it would assume if more favorable nutritional conditions had allowed full expression of its hereditary propensities. The difficulties involved when an attempt is made to select animals in one environment for the efficient utilization of the fodder under entirely different feeding conditions have thus been clearly revealed. As soon as the necessary materials and personnel become available, it is proposed to test the relative efficiency of a number of well-established strains of Merino sheep when they are subjected to a variety of different environments. The results of this investigation should provide a rational basis for breeding policy.

3. *Drought Feeding and Metabolic Studies.*—The primary importance of a relatively cheap source of protein for use as a supplementary feed has been stressed in previous Reports, and mention has been made of the possibility of utilizing simple nitrogenous compounds, such as urea, as protein substitutes for this purpose. The investigation of this aspect is being extended to a more intensive study of the nutritional requirements of the symbiotic micro-organisms which inhabit the rumen and which are functional in the synthesis of useful protein from simple compounds. Meanwhile, observations of the over-all effectiveness of urea supplements when added with other materials to the rations of sheep confined in pens and fed on protein-deficient rations are being continued. There is now little doubt that under certain conditions the efficiency of the conversion of urea to protein is high, but as yet these conditions are not well enough understood to enable a recommendation to be made for the general employment of such supplements. The ultimate usefulness of simple nitrogenous compounds of this sort to the wool-producing industry will depend on a more complete knowledge of the other materials which necessarily must be fed along with them in order to ensure that they may be dealt with efficiently by the micro-organisms concerned. The programme has thus been enlarged to embrace microbiological studies of this synthesis.

The investigations concerned with cellulose digestion, and with the physiological and biochemical studies of the intermediary metabolism of the products which arise from the bacterial degradation of cellulose, are being continued.

During the past year it became possible to take up the work on the digestion of carbohydrates by the sheep. Chemical methods for the quantitative determination of the first four of the aliphatic fatty acids have been perfected, and, by the use of this tool, knowledge of the fermentative processes which occur in the rumen has been considerably extended. Study of the digestion products arising from *in vitro* fermentations and from samples withdrawn through fistulae from the rumen of the sheep has provided a basis of knowledge for the interpretation of the processes involved. The work is proceeding.

(i) *Energy Metabolism.*—For the past year the work on energy metabolism has been devoted mainly to a study of the dissipation of energy by sheep during prolonged intervals of starvation supervening on periods of feeding at different levels. Observations are being made of the capacity of the simpler fatty acids to provide the energy requirements of the fasting sheep. These investigations comprise a part of the more comprehensive programme concerned with the utilization of cellulose and other complex carbohydrates by the ruminant.

A study is being made of the relationship between the level of feeding and the energy dissipated by sheep fed on the rations employed in the previously reported experiments, which were carried out to determine the effect of the level of nutrition on the growth, development, and wool-producing capacity of Merino sheep. The results allow a reasonably precise estimate to be made of the energy content of the tissues laid down during periods of maximum and of seriously retarded growth, and thus extend the usefulness of the data collected over the four years during which these experimental observations were made.

(ii) *Vitamin A in Drought Feeding.*—The progress of the studies devoted to the solution of problems associated with the supply of vitamin A to flocks during prolonged periods of dry feeding has been outlined in previous Reports. Observation on the behaviour of sheep which were confined to vitamin A deficient rations has indicated that it would be reasonable to expect the symptoms of vitamin A deficiency to become apparent in sheep after they have grazed continuously for six months on dry pasture. The conditions known to prevail in certain areas of western Queensland and of New South Wales are such as may be expected to provide the circumstances necessary for the onset of these untoward effects. Experimental investigations of the effects which supervene when supplements containing vitamin A are fed to sheep grazing on such areas may be undertaken when facilities become available. It is likely that the effects of the lack of sufficient vitamin A will reflect principally on the ability of sheep to reproduce. The delivery of dead or of weak offspring is a regular feature of vitamin A deficiency. Experiments with sheep in pens are at present in progress to determine the actual amount of vitamin A necessary to enable them to reproduce normally.

(iii) *Plant Proteins.*—Work on the amino acid constitution of the protoplasmic proteins of plants, which are the raw materials from which the sheep produces wool fleece, has been continued. The arginine, histidine and lysine contents of the large-scale preparations of proteins from the leaves of *Phalaris tuberosa*, *Hordeum murinum*, *Medicago sativa* and *Medicago denticulata*, mentioned in the previous Report, have been estimated in replicate assays. The possibility of errors in the histidine estimations has been recognized and check estimations are being made with modified procedures. The main findings are similar to those previously reported from this laboratory for protein preparations which were not properly representative of the whole of the proteins in plant leaves.

In recent years the occurrence of hydroxy-lysine among the hydrolytic products of proteins has been claimed. Endeavour to detect the presence of this amino acid in leaf proteins has so far indicated that it occurs only in very small quantities, if at all.

Methods involving partition chromatography have been developed successfully in Great Britain for the separation and qualitative identification of the amino acids in very small quantities of protein hydrolysates. The possibility of utilizing such procedures for the purpose of checking the constituents of fractions obtained in the analytical work with plant proteins is being investigated.

The protein of the seeds of *Trifolium subterraneum* has been analysed. In common with the seed proteins of other legumes this was characterized by a very small methionine content. The cystine content was found to be extremely small. The tryptophane contents of the whole proteins in the seeds of several legumes have been determined and found to be low.

Work on the effects of infection with mosaic virus upon the proteins in the leaves of tobacco plants, which was begun some years ago in collaboration with the Waite Institute, has been completed. Analytical evidence suggested that the changes in the composition of the " whole " proteins are small. Physical characteristics which determine the solubility of the proteins in certain solvents were, however, observed to be profoundly altered.

(iv) *Physiological and Tissue Metabolism Studies.*—The study of oxygen transfer in tissues of normal animals and in those of animals which have been rendered deficient of certain minor elements has been continued. Methods for the assay of tissues for cytochrome *c* oxidase have been perfected and applied to the determination of the concentration of this enzyme in various organs of normal and of copper-deficient sheep drawn from experiments discussed elsewhere in this Report. Spectrophotometric estimations of the cytochrome *c* content of these tissues have also been made as an integral part of a comprehensive investigation of the physiological mechanisms which become so clearly affected in the copper-deficient animal. A study of the effect of chronic cyanide poisoning on the oxygen-transfer mechanism has been undertaken in connexion with this investigation.

As a part of the programme of work concerned with the intermediary energy metabolism of the sheep, methods have been evolved for the continuous intravenous injection of nutrient solutions into sheep confined in the chamber of the indirect calorimeter.

In a study of the carbohydrate metabolism of the sheep, which has long been recognized as being very different from that of other animals, symptoms of diabetes mellitus have been induced by intravenous injection of alloxan. These symptoms were observed to respond favorably to insulin. A histological investigation of the pancreatic lesions is being made.

4. *Fluorine and Chronic Fluorosis.*—Some years ago in this laboratory a comprehensive study was made of the effects of chronic fluorosis experimentally induced in sheep by adding known quantities of fluorides to their diet. Apart from untoward effects on the general health and productivity, well-defined lesions of the teeth such as mottling of the enamel and selective abrasion of the molars were observed. Characteristic lesions of this type have since been observed to be prevalent in flocks confined to certain artesian waters in Australia. Analyses carried out by the Queensland Department of Agriculture and Stock have shown that bore waters which serve the affected areas contain fluorine in concentrations ranging from two to twenty parts per million. These concentrations are probably increased materially by evaporation from the bore drains in which the water is reticulated. Experimental investigations have been undertaken to determine the minimum quantity of fluorine that will produce untoward effects in young sheep when they consume it in their drinking water. The findings from this study will determine the procedures which may be recommended to combat the disabilities of chronic fluorosis suffered by the flocks in these areas.

5. *Minor Element Deficiencies.*—(i) *General.*—The development of the researches concerned with minor element deficiencies has been discussed in the reports submitted during the period intervening since the discovery was made in this laboratory that a minute quantity of cobalt in the diet is essential for the normal health of ruminants. The elucidation of the aetiology of coast disease as a dual deficiency of cobalt and copper focussed attention on the importance of the role which minor elements assume in agriculture, and quickly led to the recognition that not only the welfare of grazing sheep and cattle, but also the productivity of cereal crops and the development and persistence of desirable pasture species on relatively huge areas in Australia are seriously impaired either by the absolute shortage or by the low availability of copper, zinc, molybdenum, &c., within the soils. Intensive study on very deficient areas has provided the information necessary for the recognition of areas where deficiencies of this nature are less frank. These latter have proven to be very extensive, and here the response to treatment is economically of far greater consequence than that of the more restricted and more obviously affected areas where the deficiencies were first discovered.

During the past five years investigations in the field have of necessity been confined to areas relatively close to the central laboratory. With increased facilities it will be possible to extend these studies to other States of the Commonwealth.

In the period under review the research has been directed more vigorously towards the investigation of the physiological mechanisms which are impaired when animals and plants suffer from deficiencies of these essential elements. An investigation of the constitution of the wool keratin from copper-deficient sheep is being carried out.

(ii) *Cobalt Deficiency.*—Observations of experimental flocks depastured on the cobalt-deficient calcareous dunes at Robe have proved that the equivalent of 0.1 mg. of cobalt per day, administered in three doses each week, is sufficient to provide for the total requirements of growing Merino sheep. Critical analyses of the available fodder from the paddocks on which the flocks were confined, indicated that the quantity of cobalt ingested each day in the fodder would be approximately 0.04 mg. of cobalt. The cobalt requirement of the sheep thus lies between 0.04 and 0.14 mg. per day. Experiments carried out over the past four years show conclusively that cobalt must be supplied at frequent intervals. Massive doses administered at intervals of over a month did not prevent the onset of the acute symptoms of cobalt deficiency. During the year the analytical procedures for the determination of the minute amount of cobalt

were further improved and simplified, and with the more handy technique the seasonal variation of the cobalt concentration has been determined in a number of pasture plants growing on the deficient tracts, and the response to cobalt dressings has been observed. In the areas under review dressings of 5 lb. cobalt sulphate per acre have little effect on the concentration of cobalt in the fodder plants.

A series of studies has been undertaken to extend knowledge of the physiological mechanisms which require cobalt if they are to function normally. It has been proved unequivocally that intravenous injection of cobalt neither prevents nor corrects the untoward effects of cobalt deficiency in the sheep; cobalt must be ingested at frequent intervals. This, and the fact that ruminants are seemingly the only animals affected, provides a working hypothesis which may lead to the understanding of the role which cobalt plays in nutritional physiology. From experiments carried out by the Division no conclusive evidence has been obtained that frequent massive doses of whole liver containing less than the therapeutic dose of cobalt are effective in preventing cobalt deficiency. The changes in the blood during extreme cobalt deficiency are being studied further.

(iii) *Copper Deficiency.*—During the year the experiment designed to determine the relative behaviour of Merino and Border Leicester sheep when subjected to various degrees of copper deficiency and of copper excess was completed. Most of the animals were brought from the field station for intensive study in the laboratory.

In order to provide further information of the break-down of the wool-producing mechanism in copper-deficient sheep, an experiment has been started with a very even flock of ewe weaners drawn from a strain of Merinos which has the hereditary propensity to produce stylishly crimped wool. This flock has been divided into eight groups which are being treated with the equivalent of 0, 1, 2.5, 5, 7.5, 10, 15 and 20 mg. Cu per day, respectively, while depastured on the deficient terrain at the Robe Field Station. The results, after less than one year's observation, indicate that the very marked improvement in the quality of the wool reaches a maximum in the groups receiving between 7.5 and 10 mg. Cu per day. The fleeces from these animals will be used for further study of the nature of this lesion. The animals later will be mated and the effect that the various levels of copper intake exert on the ability to produce normal lambs will be observed.

The experimental trials with sheep on copper-dressed pastures at Robe have been continued. As in the two previous years sheep which received copper supplements in addition to that obtained from the copper-dressed pastures have again produced slightly more wool than those which received their copper only through the grazing. The latter groups in several instances have had subnormal blood copper levels and the fleeces of some of them now show the signs of copper deficiency. Ewes which were lambed on these pastures are producing their second successive lambs.

The ability of copper dressings to provide the full complement of copper necessary for normal wool production by grazing sheep is being investigated on a larger scale on the different types of country where the field stations at Keith and at Borrika are situated. On the former site, steely wool was produced only by the group receiving no copper and depastured on the areas which had not been dressed with copper. At Borrika no steely wool was observed in any of the experimental animals during 1944, although in some seasons this symptom of copper deficiency is very prevalent. At the Elliston Field Station observations have rendered it clear that the main limiting factor of this area is cobalt deficiency; copper deficiency, however, is incipient at this site. At the Tintinara Field Station similar effects have been observed, the main deficiency being cobalt. At Glenroy Field Station there is unequivocal experimental evidence that cobalt deficiency can limit very seriously the well-being of sheep depastured on this type of heavy black soil.

The detailed mapping of the deficient areas is now nearing completion.

During the year a trial has been undertaken on the State Experimental Farm at Kybybolite, South Australia, where, in co-operation with the South Australian Department of Agriculture, an experiment has been started to determine the limitations imposed by minor element deficiency and by parasitism on sheep grazing on the improved pastures of this area.

(iv) *The Wool from Copper-deficient Sheep.*—A brief summary of the findings from the investigations concerned with the effects of copper deficiency on wool production has been discussed previously. A report of the results of the physical examination of the fleeces from the copper-deficient and the copper-treated experimental sheep has been received from the Wool Industries Research Association, Torridon. The most striking findings which concern the manufacturing performance of copper-deficient wools are those from the scouring, carding, combing and spinning tests. The treatment of the sheep with copper produced marked differences in the properties of their fleeces, mainly in the tensile strength of the fibres and in the

crimp. The nature of the wool grease was apparently altered also ; the copper-deficient fleeces acted abnormally during scouring. The low tensile strength of the wool from the unsupplemented animals was probably the main reason for the extensive breaking of the fibres during scouring. Although there was no significant difference in fibre length between the fleeces from the copper-deficient animals and those from the copper-treated animals, after carding the former were so short as to be fit only for French combing. The tears observed in combing reflected this breakage during carding.

Insofar as could be determined with the relatively small amount of wool that was available for these tests, the fleeces from animals treated with 5 mg. copper per day behaved normally. The fleeces from the 50 mg. per day group appeared to process a little better than those from the 5 mg. copper per day group.

A detailed study of the amino acid distribution in the normal and copper-deficient wool is being made and the physical behaviour of the fibres is being tested. Histochemical observations of the follicles of experimental copper-deficient sheep have already clearly indicated the origin of the copper-deficient lesion in the wool structure.

6. *Agrostology and Plant Nutrition.*—The markedly beneficial effect of small quantities of copper sulphate on the yield of cereal varieties and on the persistence and yield of pasture legumes and grasses grown on the Robe calcareous sand has been demonstrated. The effectiveness of single dressings of copper sulphate has been shown to persist over a number of years. There was some evidence, from observations made in the field, that copper sulphate applied to the soil twelve months before seeding with cereals or pasture species was considerably more effective than similar quantities of copper sulphate applied at seeding ; this was particularly so in regard to the yield of oats.

Data had been obtained previously to show that copper applied to oats at seeding was of greater value than an equal dressing applied later in the season to plants which had become established. From data obtained in 1944 it was evident that copper applied four months or eleven months before seeding was of very much greater value than an equal quantity of copper applied at seeding. Addition of copper sulphate (14 lb. per acre) at seeding increased the grain yield of oats from 1 bushel to 14 bushels per acre, while over 50 bushels were obtained where the copper dressing had been applied as a topdressing four months or eleven months before seeding. This response of oats to copper sulphate applied before seeding was similar in many respects to the response in development and yield which was obtained following a heavy dressing of nitrogenous fertilizer. The yield and seed production of barrel medic sown under a cover crop of oats was also considerably enhanced when the copper dressing was applied some months prior to sowing.

Investigations into the mineral nutrition of plants grown on the sandy mallee and heath soils of the Ninety-mile Desert in South Australia were commenced in 1944. Cereals and pasture species grown on the Laffer sand without the addition of phosphate remained extremely dwarfed and developed marked symptoms of phosphorus deficiency. Addition of phosphate permitted vigorous growth, and maximum yields were obtained when superphosphate was applied at the rate of 2 cwt. per acre: A deficiency of two trace elements was revealed and responses to their application depended upon the species of plant concerned. The yield of oats was considerably increased by a dressing of zinc sulphate, lucerne showed a response to copper sulphate, and the yield and particularly the seed production of subterranean clover was improved by the addition of zinc sulphate and copper sulphate together. It is evident that the trace elements zinc and copper will play an important part in the development of the vast area of mallee and heath sands in the Ninety-mile Desert in South Australia and Victoria.

7. *Accessory Food Factors and Food Composition.*—The investigation of the vitamin C content of dehydrated lucerne leaves by bioassays with guinea pigs has been completed. The vitamin C measured in this way appeared to be slightly less than that determined by any of the several chemical procedures, all of which involve the reduction of 2 : 6-dichlorphenolindophenol.

Work on the chemical determination of riboflavin and of thiamine has been carried out as a preliminary to an investigation of the vitamin B_1 and vitamin B_2 content of some Australian foods.

8. *Publications.*—During the year the following papers were published :—

Best, R. J., and Lugg, J. W. H. (1944).—Partial composition of tobacco mosiac virus protein : the amide, tyrosine, tryptophane, cystine (plus cysteine), and methionine contents. *Aust. J. Exp. Biol. Med. Sci.* 22 : 247–250.

Lugg, J. W. H., and Clowes, G. J. (1945).—Partial amino-acid composition of the proteins of some legume seeds : the tyrosine, tryptophane, cystine (plus cysteine) and methionine contents. Ibid. 23 : 75–79.

Lugg, J. W. H., and Weller, R. A. (1944).—Large-scale extraction of protein samples reasonably representative of the whole proteins in the leaves of some plants: the amide, tyrosine, tryptophan, cystine (plus cysteine) and methionine contents of the preparations. *Biochem. J.* 38 : 408–411.

Lugg, J. W. H., and Weller, R. A. (1944).—On the sulphur present in the seeds of certain legumes, with special reference to the cystine plus cysteine and methionine contents of the proteins. *Aust. J. Exp. Biol. Med. Sci.* 22 : 149–155.

VI. SOILS INVESTIGATIONS.

1. *General.*—The Division of Soils has continued with a wide programme of investigations and surveys in the Commonwealth. Following reorganization of the Division last year into the four sections of Soil Surveys, Chemistry, Physics, and Bacteriology, there has been a steady growth of staff and in the quantity of work undertaken. The principal obstacle to rapid progress is still the lack of experienced staff; but this is being rectified by the training of new personnel. The setting up of a regional base at Perth with a permanent officer in charge for soils investigations in Western Australia has marked a step forward in decentralization which it is proposed to carry further.

The Division has its head-quarters at the Waite Agricultural Research Institute of the University of Adelaide, and the staffs of both institutions are closely associated in agricultural research. Co-operation with the State Departments of Agriculture, Lands, Irrigation and Forestry and the State Reconstruction and Land Settlement authorities has continued smoothly. In the Commonwealth sphere the Division has provided certain technical advisory service to the Rural Reconstruction Commission and the Department of Post-war Reconstruction.

It has become evident in recent years that the field work has turned more and more to the relation of soils and land-use. The soil survey is of little importance unless the classification and mapping of soils can be put to direct use, while the proper definition of soil problems affecting production is a basic step in achieving agricultural progress. The three main objectives of the Division are—(1) To make systematic investigations of Australian soils for the use of the farming community and the advisory and administrative services in the various States. (2) To make soil surveys of virgin areas for future settlement and such settled areas as present problems in development. (3) To conduct fundamental research in the pedology, chemistry, physics and bacteriology of Australian soils. Both Government departments and private agricultural interests are becoming increasingly concerned with the investigation of problems in land-use and fertility and the assistance rendered by the basic soil studies.

2. *Soil Survey Section.*—The field study of soils has been under constant review to improve the technique of surveys and establish a better scientific foundation for land utilization studies. Surveys have been conducted either on a close detailed pattern or on a wide scale where the nature of the country or the potential uses did not justify more precise work. In several cases wide reconnaissance journeys were made to sum up the relative values of areas for developmental purposes. Almost all the work has turned on the requirements of post-war land settlement primarily for servicemen, the exceptions being a proposed irrigation development in already settled country and some soil erosion studies. The field work has been carried out in all the States to a varying degree.

(i) *Western Australia.*—An officer has been appointed with head-quarters in Perth to be responsible for soils investigation of the Division in the Western Australian region.

The surveying of areas proposed for post-war development in the Blackwood River district was continued from October to May as climatic conditions prevent field work in the winter and early spring. It was necessary to set up a camp for the survey which was in virgin country distant from settlements. The work was carried through by an arrangement with the Departments of Lands and Agriculture, with which a close liaison was maintained. The former provided a land surveyor for establishing accurate base lines for the soil survey to work from and for the management of the camp. Considerable experience was gained in the methods and requirements for soil surveying in a dense type of scrub-heath country.

In all, 76,000 acres were covered in moderate detail and an additional 53,000 acres in wider traverses, thus completing the survey of the Blackwood River district sufficiently closely for assessing its value for settlement, the requirements and general lines for subdivision, and the probable problems facing development. The maps and report are being compiled.

An additional area of 4,300 acres was surveyed in detail in the Nillup settlement as typical of a much larger area partly settled in the adjoining district to Blackwood River.

(ii) *Tasmania.*—The main field activities have been in the north-west portion of the State on the swamp areas being examined for settlement on behalf of the Tasmanian Post-war Land Development Committee. The season proved particularly bad and slow progress was made

under hard conditions. A beginning had been made in the previous summer in a reconnaissance of 5,000 acres of the virgin Montagu Swamp which proved distinctly promising. It was hoped this year to cover a large area, but at no stage was the swamp quite dry, and restricted progress only was achieved. The Department of Lands has had land survey work in hand for a long time, and it has been estimated that Montagu swamp covers at least 50,000 acres plus additional areas on the nearby Welcome and Dismal Swamps. The soil survey of these will be a major task for attack next summer. It is believed also that a considerable section in the adjacent Duck River valley will be useful for development, and aerial photographs have been secured of it. The soil survey of the already developed Mowbray Swamp in the district was begun and will provide a good guide to the quality of the virgin land.

Liaison has been maintained with the Departments of Lands and Agriculture. The experimental field work on plots laid down on the Waterhouse Estate surveyed last year have been followed closely. The final summing up of this belt of country indicates its unsuitability for post-war development until a number of serious problems have been solved.

(iii) *South Australia.*—Considerable attention has been given to potential irrigation areas at the request of the South Australian Government which is concerned with selection and development of post-war settlement schemes. Most of the proposed new irrigation schemes have been small. A general inspection has been made of a number of local units suggested as possible schemes but none proved sufficiently attractive for State enterprise. Detailed surveys have been made of 7,000 acres at Lyrup, 2,000 acres at Loxton, a reconnaissance of 2,000 acres at McIntosh and of 1,500 acres at Chaffey. Reports and recommendations on soils and the potential use of these areas have been made to the appropriate authority. A great body of experience is now available on the types and potential usefulness of soils occurring along the Murray Valley. An additional survey covered the old Pekina settlement to define suitable portions for irrigation with the limited water supply available.

For three years the Department of Lands has maintained an experimental block on Kangaroo Island to study methods of pasture establishment and management. Sufficient progress seemed to have been made to warrant the soil survey of a large area for subdivision. To date 65,000 acres have been mapped. The maps and field report are partly completed.

A small unit of 1,500 acres in the Hundred of Kongorong in the south-east which had been offered to the Land Board for purchase was examined at its request, and proved unsuitable for subdivision. Inspection was made of nine large estates proposed for resumption and subdivision for post-war settlement. These estates are all in country of assured rainfall and mostly good soils, and it was not deemed necessary to survey them in detail at present. This will be done if it is decided to subdivide for allotment to soldier settlers.

A number of small unit surveys have been made for Government departments or for private interests, and recommendations made as to soil types and uses of the land.

(iv) *Victoria.*—The soil erosion survey begun last year in the Dookie-Benalla district was continued as far as soil conditions permitted. The extreme dryness of the soils during the past twelve months in that area has prevented proper investigations being made. Two parishes—Dookie and Currawa—have been completed as to soil and erosion mapping and considerable progress made with wider surveys of adjacent areas not subject to erosion. Tests have been made of the rate of infiltration of water into soils of various types under variable conditions of slope and ground cover to devise a means of estimating the erodibility of soils. Attention is being paid particularly to the tunnelling type of erosion. The work is being done by arrangement with the Soil Conservation Board of Victoria and should provide a very useful basis for extension and experimental work in control.

A reconnaissance journey was made through four districts in company with officers of the Departments of Agriculture and Lands to inspect broadly areas of Crown land proposed for possible settlement schemes. A report has been made to the State authority and the Rural Reconstruction Commission on the suitability of the areas, two of which were rejected, one recommended, and one accepted in part, subject to detailed surveys. There did not appear to be more than one large area of Crown land in Victoria of suitable type for post-war land settlement.

(v) *New South Wales.*—As in previous years, the field surveys have been concentrated on the irrigation areas and at least one party has been at work throughout the year. All surveys are made at the request of the New South Wales Water Conservation and Irrigation Commission. The Provisional Deniboota Irrigation District was the subject of a reconnaissance survey three years ago which indicated a large proportion of the soils was inferior and not suitable for irrigation. As this was a serious obstacle to the scheme, detailed information was sought, leading to the present survey. To date 160,000 acres have been mapped, but due to

extremely dry conditions the survey of the remaining 150,000 acres has been postponed temporarily. The maps so far prepared indicate substantial agreement with the findings of the previous reconnaissance survey, but it will not be possible to make a sound assessment of the scheme until the full area has been examined.

A proposed irrigation area of 3,100 acres at Coomealla which would form an extension of the present horticultural settlement was surveyed to determine the quality of the soils for irrigation and potential uses for specific crops. The land is essentially similar to the existing Coomealla settlement and would be mostly suited to vine growing. The map and report are being prepared.

Brief reconnaissance visits were paid to the Abermusden district and Denimein district for the purpose of determining their general quality and the requirements of future soil surveys. The former is to be surveyed during 1945.

In connexion with toxaemic jaundice research by the Division of Animal Health and Production, an examination was made of the soils on the Barooga experimental field station. It is proposed to follow up the research in the coming year in a number of localities where the disease occurs to investigate fully the soil factor as contributing to its incidence.

(vi) *Queensland.*—An extensive traverse in company with officers of the Departments of Lands and Agriculture has been made in the Dalby, Taroom, and Theodore districts in which very large aggregate areas have been selected by the State authorities for post-war land settlement to dairying and mixed farming. The visit was made by arrangement with the Queensland departments and to assist the Commonwealth Department of Post-war Reconstruction in investigations of settlement schemes.

At the request of the Cane-growers Council and Bureau of Sugar Experiment Stations, an inspection was made of problems in river and general soil erosion arising in the cane-growing districts of Queensland. The reports on both these investigations are being prepared at the present time.

(vii) *North Australia.*—The Army farms in the Northern Territory were inspected and advice given on the irrigation and drainage characteristics of the soils. A Divisional report presented comments and descriptions of soils in northern Australia and their place in zonal soil classification.

(viii) *Aerial Photographs.*—The policy of seeking aerial photographs for survey work has been vigorously followed. The value of these is now commonly recognized, and it can be said that in virgin country, not already land surveyed, they are essential and in all cases contribute very greatly to accuracy and speed of field work. Four areas were flown for the Division during the year and prints obtained of four others previously photographed, for soil survey work. The plan to photograph all of occupied Australia on a scheme prepared by the Army Survey Unit for land survey purposes will assist very greatly with future reconnaissance work, although for detailed soil surveys the scale needs to be larger and only vertical photography used.

(ix) *Cartography.*—During the year seven large maps of surveyed areas were prepared for publication and thirteen other plans, mostly accompanying Divisional reports, have been drawn.

3. *Soil Chemistry Section.*—The Soil Chemistry Section is jointly organized with the Chemistry Department of the Waite Institute under single direction. The work is divided between research projects and the routine testing of soil samples.

The most important research has been devoted to the study of methods for the examination of soils. The equipment necessary for the Lundegardh flame spectrum technique has been built and the application of this method to the determination of exchangeable cations in soils examined. The standard method cannot be used without modification with the large model spectrograph available, and this has necessitated a detailed statistical examination of the results obtained to determine the sources of error and the most suitable technique to eliminate or reduce them. The adoption of this method for the determination of exchangeable cations in soils will assist considerably in the routine examination of soil samples from the various surveys. Other spectrochemical work during the year has included the estimation of molybdenum in subterranean clover from a field experiment of the Council's Division of Plant Industry, a preliminary survey of the trace elements in samples of Dwalganup subterranean clover from Western Australia and New South Wales for the Council's Division of Animal Health and Production, and the examination of a variety of samples for trace elements generally.

A steady flow of soil samples for analysis has come from the surveys in Western Australia, South Australia, Victoria, Tasmania, and New South Wales. The routine testing has been organized to permit a continuous series of analyses of these samples, and in the past year over

500 have been completed in regard to mechanical analysis, pH, and salt content. A proportion of this total has been examined in greater detail. The policy of sampling more intensively adopted by the Division in surveys brought in over 900 samples last year for laboratory examination.

4. *Soil Physics and Mechanics.*—The study of soil structure and water relations of soils has been the main activity of the Section. Work begun last year on soil structure in wheat soils at the Waite Institute has been continued. Additional results have confirmed the loss of structural stability following cultivation of the soils resulting in an increasingly poor physical condition of the surface soil. A method has been developed which will enlarge the application of structure measurements when used in the comparison of field plots for work of this type. This method will overcome to a large extent the effects of texture variation on structure assessment.

Structure measurements have also been commenced on soils at Griffith (New South Wales), in conjunction with a project of the Irrigation Research Station on the rehabilitation of orchard soils in the Murrumbidgee Irrigation Areas. Other physical work is being carried out in collaboration with that station in an experiment on vegetable tillage.

Investigations have been made into the water relations and structure of soils of the area being surveyed by the Western Australian Government near the Ord River in the Kimberley district. Infiltration experiments were carried out with officers of the Western Australian Department of Agriculture on the three major soil types, and these have been presented in a Divisional report. The physical character of the Ord River soils is being further examined in the laboratory.

Co-operative work in an experiment on spray irrigation was begun with the South Australian Department of Agriculture and the Engineering and Water Supply Department. A test area was surveyed closely and measurements made of the infiltration rates of the soils. Apparatus is being developed for assessing the suitability of soils for spray irrigation in areas proposed for new settlement on the Murray River.

Studies of the engineering properties of soils have been continued in three main directions. The investigation of soil cement and the water-proofing action of resin in soils has continued on a restricted scale, as the officer concerned with this research was on loan to the United States Army for the greater part of the year. A Divisional report has been prepared for the South Australian Government Geologist dealing with the physical properties and permeability of samples of a mica schist from a proposed dam site and the suitability of this rock for use as a rolled fill material for construction purposes. Investigations have just begun into soil conditions under building foundations. This work is being carried out in conjunction with the Experimental Building Station of the Department of Post-war Reconstruction and the State housing authorities in Sydney and Melbourne.

The definition of soil textures on the basis of limiting mechanical composition was put forward in 1934. In the light of subsequent experience and a large volume of data, the previous schedule may be amended and a study of the available material is under way. The highway authorities have decided to adopt the existing or amended standards for texture which may be fixed by the Division.

5. *Bacteriology Section.*—The investigation of the nitrogen-fixing organisms of leguminous plants has been the main line of research. Experimental work on the effect of the trace element molybdenum on the nutrition of grasses and legumes in pastures has been concluded, although several avenues of investigation remain to be explored. There is strong evidence that the influence of molybdenum is closely associated with the nitrogen nutrition of the nodulated legume plant, increasing the percentage and total amount of nitrogen in it by raising the nitrogen-fixing efficiency of the bacterial tissue. Molybdenum applied at the rate of 1 oz. ammonium molybdate per acre to normally nodulated plants produces an equivalent effect to the addition of an adequate dressing of ammonium sulphate.

Existing stock cultures of *Rhizobium* for legume inoculation have been maintained with periodic tests for their nitrogen-fixing ability. New strains have also been added to the collection. Cultures for legume seed inoculation continue to be in demand and their use is now widespread in the agricultural areas of South Australia.

A preliminary investigation into the possibility of biological toxicity in soils has commenced and promising lines of research are opening up.

Bacteriological examination of canned foodstuffs from South Australian factories continued until early in 1945 when it was taken over by the staff of Commonwealth Food Control. Serious cases of spoilage continue to receive attention in the Division's laboratory with the isolation and identification of the organisms concerned.

6. *Publications.*—The following papers were published during the year :—

(i) *Division of Soils.*—

Crocker, R. L. (1944).—Soil and vegetation relationships in the lower South-East of South Australia. A study in ecology. *Trans. Roy. Soc. S. Aust.* 68 : 144–172.

Downes, R. G. (1944).—The use of the hydrometer for the mechanical analysis of soils. *J. Coun. Sci. Ind. Res. (Aust.)* 17 : 197–206.

Hosking, J. S. (1944).—The use of the Sharples supercentrifuge in the fractionation of colloidal material. Ibid. 17 : 23–29.

Oertel, A. C. (1944).—The quantitative spectrochemical analysis of agricultural samples. Ibid. 17 : 225–232.

Oertel, A. C., and Prescott, J. A. (1944).—A spectrochemical examination of some ironstone gravels from Australian soils. *Trans. Roy. Soc. S. Aust.* 68 : 173–176.

Prescott, J. A. (1944).—Soil surveys as a basis for the selection of new areas. *J. Agric. S. Aust.* 48 : 191–195.

Prescott, J. A. (1944).—A soil map of Australia. Coun. Sci. Ind. Res. (Aust.), Bull. 177.

Taylor, J. K. (1944).—Surveys for potential land-use. *J. Aust. Inst. Agric. Sci.* 10 : 20–25.

(ii) *Mineral Deficiencies Investigations.*—

Anderson, A. J. (1944).—Double-compartment pot cultures for studies in plant nutrition. *J. Coun. Sci. Ind. Res. (Aust.)* 17 : 144–150.

Anderson, A. J. (1944).—An automatic irrigator actuated by a soil-moisture tensiometer. Ibid. 17 : 151–156.

VII. IRRIGATION SETTLEMENT INVESTIGATIONS.

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

1. *General.*—The staff reductions due to the war have been partially corrected by the appointment, as Assistant Research Officers, of two recent graduates. These two officers are now undergoing further training, one at the Divisions of Economic Entomology and of Plant Industry, for biological work ; and the other at the Division of Soils for studies in soil physics.

The outstanding event in dried fruit production has been the devastating effect of drought conditions on the vines. The reactions of the vine to recurring damage have been observed and recorded throughout the year, and the probable effect on the next crop examined. No previous record of severe damage to irrigated horticultural plants, attributable to drought conditions, has come under notice.

The treatments in the fertilizer field trials have been continued, with a view to measuring residual effects, and the study of trace elements commenced, in the form of applying solutions to the cut surfaces of pruned vines.

Fruit processing is still largely affected by cessation or shortage of supplies caused by the war, and it has been possible to use satisfactory alternatives, including substitute substances and reduced concentrations. Investigations include further studies of drying rates as a measure of the effectiveness of substances used in the dips, and fundamental studies in reference to the functions of oil in the dipping process.

The initial stage of investigation of the problems of vegetable production has been completed. The chief interest at present is in variety trials of tomatoes, beans and carrots, including some introduced varieties.

2. *Viticulture.*—The horticultural areas of the irrigated settlements on the Murray River have hitherto been considered immune from the effects of drought. This last and greatest of all droughts extended throughout two seasons, 1943–44 and 1944–45. Soil and irrigation conditions for growth were maintained at a satisfactory level, but the extraneous factor of hot dust-laden winds was sufficient to cause wide-spread damage to horticultural plants. A gale of 60 miles per hour, carrying dust sufficient to obscure vision to distances of a few feet, occurred on 16th October, 1944, and the impact was such that the growing terminals of the vine shoots, and new growth on citrus, were destroyed. Damage to growing shoots recurred during mid-November owing to strong dusty winds and temperatures ranging over 100° F. Drought conditions in middle and lower Murray areas were so severe that there was no development on annual plants of any kind. Wind erosion from surrounding country was sufficient to maintain an atmosphere of dust for long periods, in addition to the periodic dust-storms affecting south-eastern Australia. The effect of these conditions on the vines was observed and recorded.

The September storms destroyed the terminal of the advanced shoot, which later continued growth as a lateral. Leaves were also affected. By end of November, all primary leaves on the middle and basal portion of the annual shoots were totally or partially destroyed, and the emergence of small non-persistent laterals was noted at the majority of the nodes. On the stronger shoots, destruction of the terminals of the primary shoots resulted in a group of persistent laterals in the vicinity of the eighth to eleventh nodes. The nutritional upset occasioned by the loss of leaves and the replacement by immature leaves on laterals was reflected as a poor setting of fruit, wilting of bunch terminals, and continuous dropping of berries after setting in early November until early December. The growth of the remaining berries was also affected, and growth curves of the berries disclosed a reduction in size to two-thirds of the normal throughout the season; the reduced size persisted until harvest. The loss in dried fruit was estimated as 40 per cent. of the potential yield disclosed by bud-counts in September, representing a value of nearly £2,000,000.

The destruction of the terminals of primary shoots and of leaves, and the development of laterals, resulted in growth abnormalities which presented a pruning problem not hitherto experienced. The percentage of fruit buds at the nodes on the annual fruiting wood was determined by examination of the buds in May, 1945. The examination disclosed a high percentage of fruit buds, and sound development of the inflorescence primordia on the mid-portion of the fruiting cane (fourth to seventh bud inclusive); and a reduction in fruitfulness from the seventh bud outwards. In normal canes the percentage of fruit buds increases progressively out to about the fourteenth bud. These results have been communicated to vine growers, and pruning modifications adopted to meet the case.

Long-dated manurial trials have been continued but yields were not measured last season.

Preliminary swabbing trials were commenced last winter with both sultanas and lexias in which all pruning cuts were swabbed at pruning time with a strong solution of a salt containing one of the "minor" elements—boron, iron, manganese, molybdenum, or zinc. No increases in yield were obtained with any of these treatments during the first season.

Investigations were commenced on the causes of the chlorosis of currant vines and certain fruit trees in various parts of the settlement. In all the cases of chlorotic currant vines examined to date the trouble has been identified as the so-called "lime-induced iron chlorosis". This is associated with soils of high pH, often highly calcareous, and can occur with or without the presence of high salt concentrations. It is caused by the unavailability of iron within the plant. This type of iron deficiency has been shown to be fairly prevalent in the Mildura district and has been identified in currants, peaches, nectarines, apricots, almonds, apples, pears, and all types of citrus. Sultanas are much less susceptible to this trouble than currants. Investigation on methods of treatment, &c., are proceeding.

3. *Fruit Processing.*—The shortage of edible oils remains acute and, as adequate supplies of cottonseed oil were still not available last season for the manufacture of the usual cottonseed oil emulsion used in dipping sultanas and other vine fruits, it was necessary to use peanut oil which was in better supply. Trials carried out in previous years had shown that this oil could be used with equally satisfactory results.

Potassium carbonate has been in very short supply owing to the somewhat unexpected cessation of shipments from America, and it became necessary to reduce the concentration used in the cold dip to the minimum strength compatible with safety and in some cases to use a mixture of caustic soda and potassium carbonate as a substitute, in order to conserve the limited supplies available and dry the sultana crop. Advice to the industry in this regard was based on trials carried out over a number of years.

Further dipping trials were carried out last season, and in view of the potash position particular attention was paid once again to the relative merits of potassium carbonate, potassium hydroxide, sodium carbonate, and sodium hydroxide when used in the cold dip for sultanas, and to determining the minimum potash strength which can be used with safety. In addition to large scale trials carried out on standard drying racks, drying rate curves were obtained under approximately commercial conditions by drying the fruit on wire trays which were made to fit on a standard rack, and which could be removed and weighed at convenient intervals. The results showed that under the conditions prevailing and using standard quantities of peanut oil emulsion and potassium linoleate as wetting agent, dips containing 5, $2\frac{1}{2}$, $1\frac{1}{2}$ or 1 per cent. potassium carbonate, or 1 per cent. potassium hydroxide, gave the same drying rates, while that obtained with 0.5 per cent. potassium carbonate was significantly slower. Sodium carbonate gave unsatisfactory results, a dip containing 5 per cent. sodium carbonate being less effective than one containing 0.5 per cent. potassium carbonate.

Investigations were continued on the use of various paraffin oil-sulphonated oil and peanut oil-sulphonated oil emulsions in dipping sultanas. Investigations on the wetting and spreading properties of various oil emulsions used in dipping have also been continued, and further fundamental work has been carried out on the function of the oil in the dipping process.

A limited amount of work has been carried out on the losses involved in the seeding of lexias. The manufacture of dipping emulsion for the 1945 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. Maturity and quality tests were continued on navel oranges from selected sites, to determine the effects of bud selection and root stocks on the fruit.

4. *Entomological Pests.*—Control measures for dried fruit pests are still in successful use, and there have been no alterations. The light brown apple moth (*Tortrix postvittana*) has been further investigated, in co-operation with the Division of Economic Entomology. In early spring over-wintering larvae were readily found on the leguminous cover crops grown among the horticultural plants, and on lucerne. Some of the winter larvae were parasitized by a Tachinid fly (*Voriella uniseta*) the larvae of which destroy the pupa of Tortrix. As the season advanced, severe wind and dust storms developed, destroying portions of the vines and possibly the moth and larvae population as well. By mid-October it was difficult to find light brown apple moth in any form. It was not possible to estimate the proportions in which the parasitic fly and the severity of the season contributed to the elimination of the pest, but it is considered that the severe season was the major factor. Additional control measures comprised the early destruction of cover-crops harbouring the pest and spraying foliage of vines with lead arsenate. The fact that there was no development on control areas indicated that the additional control measures were not required in this particular season.

5. *Vegetable and Vegetable Seed Production.*—Investigations in connexion with the growth and seeding habit of root crops, comprising carrots, parsnips, red beet, and onions, sown at monthly intervals throughout the year have been completed, and the results published in the Council's *Journal.*

The vegetable programme has since been extended and work now in progress is being carried out in conjunction with the Division of Plant Industry and with the close co-operation of the Council for Scientific and Industrial Research Vegetable Problems Committee. Investigations include variety trials, under irrigation conditions, of tomatoes, beans, and potatoes; and an environmental and genetical trial of carrots and red beet sown during winter and summer months.

Useful information has already been obtained for tomatoes and beans. The Pearson 29–17 variety of tomato has been outstanding for both yield and quality. As a result, arrangements were made through the Seeds Committee and district officers of the State Department of Agriculture for selected growers to produce seed on a commercial basis. Canning trials were also carried out in co-operation with the Mildura Co-operative Fruit Co. Results of the bean trial have been made available to the district officers of the Department of Agriculture who have passed on any information of interest to growers. By this means, varieties of beans new to the district are being grown commercially with satisfactory results to the growers concerned.

The potato trial proved most interesting. Of the sixteen varieties tested, all showed extensive second growth except three, namely, Katahdin, Sebago and Factor 265. Virus-free Factor clones yielded more heavily than the ordinary infected Factor. Katahdin appears a suitable variety when grown under irrigation conditions because of its high percentage of first grade tubers, its lack of secondary growth, its relative freedom from Fusarium wilt, and its dehydration and cooking qualities.

Considerable information has been collected in the environmental and genetical investigations carried out on carrots and red beet, and it is at present being examined.

6. *Irrigation and Land Use.*—The Station has co-operated in the planning of post-war land settlement, by inspection and preliminary selection of lands possibly required for settlement under irrigation, and the fitting of the soil and irrigation environment in relation to the proposed crops. Contacts include the Commonwealth Rural Reconstruction Committee, Parliamentary Committee on Land Settlement for South Australia, Sub-Committee for Land Settlement of the Victorian Cabinet, Murray Valley Development League, State Rivers and Water Supply Commission of Victoria, Water Conservation and Irrigation Commission of New South Wales, and the Mildura Development Committee. Final selection in all cases is postponed pending soil survey.

The increased production during the war, and the increase in pasture and fodder production necessitated by drought, have resulted in expansion of irrigation to additional areas. The Station has assisted in the selection of sites suitable in soil types and general environment to the required product, and has gained considerable experience, with useful records, of diversified land-use under irrigation.

Adjustments in usage and periodicity of irrigation water due to fuel shortage and the demand for economy in water distribution have been made. The Station has co-operated closely with the State Departments and producers' organizations concerned in securing the necessary economies with a minimum effect on production.

In the Wakool area, soil preservation investigations have commenced, by determining the status of injurious salts prior to irrigation, with a view to measuring salt translocation subsequent to irrigation.

7. *Drug Plants.*—Work is now limited to the production of the opium poppy and the pyrethrum plant on military establishments, with the addition of a small area of pyrethrum under direct control of the Station. The extent to which these industries can be maintained in Australia after the war is doubtful. The Station maintains a general guidance of production in the middle and lower Murray areas.

8. *Finance.*—The grant of £1,000 from the Australian Dried Fruits Control Board has not been fully expended, owing to staff reductions, and the special grant of £1,000 from the Mildura Packers' Association has been utilized for special work in fruit processing. Minor subsidies, from the State Rivers and Water Supply Commission (Victoria) and the Water Conservation and Irrigation Commission (New South Wales) have been maintained.

9. *Publications.*—The following paper was published during the year :—

Jiles, J. E. (1945).—Investigations into production of vegetables and vegetable seeds in the Red Cliffs district. *J. Coun. Sci. Ind. Res.* (Aust.) 18 : 124–132.

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

1. *General.*—The Irrigation Research Station at Griffith was established in 1924. It has 140 acres of irrigable land, 30 acres of which are planted, and it is provided with good laboratory facilities.

2. *Field Experiments with Fruit Trees.*—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 treatments ; and various minor studies.

Besides these experimental fields on the Station's property, at present there are experimental plots on eight settler's farms. Much information concerning the appropriate methods of irrigation for different soil types and slopes has been obtained from these experiments. Results, so far, seem to indicate that under certain conditions, provided sufficient nitrogen is applied, the health and yield of trees can be maintained quite well where subterranean clover is grown and all cultivation is eliminated. Growth of lucerne between trees frequently leads to serious problems.

3. *Irrigation Investigations.*—Experiments are being continued to determine the best methods of irrigation of both orchard and vegetable crops. Care and economy in the use of water is necessary in order to obviate the formation of high watertables which frequently lead to salting of the soil, and in the case of citrus, decline in health associated with waterlogging.

The general problem of establishing suitable methods of orchard irrigation is being studied, with variations in the frequency and heaviness of application. In addition, experiments include restricted area watering and wilting treatments of trees. Careful recording of the effects of these treatments on tree health, on yields, and on watertable fluctuations has enabled considerable progress to be made towards defining methods and frequencies in terms of the " evaporation interval "—a physical measure based on the evaporation power of the air, which varies with the season but is easily recorded.

Further investigations have also been carried out into the hydraulic principles of irrigation. These include a study of the technique of making soakage determinations and the effect of furrow shape and slope on the rate of soakage into the soil. The changes in the rate of soakage of water into the soil after the virgin soil has been cultivated for several years have been studied.

Investigations concerned in the irrigation of vegetables have shown the importance of uniformity in slope and soil type throughout the length of the furrow run. Methods of ensuring this have been evolved. To understand better the soil moisture requirements and placements of fertilizers in vegetable culture, a study of the extent and distribution of the root systems of vegetables on heavy and light soils has been made. The root systems were well distributed to 3 feet, half the roots being in the top foot of the soil.

The principles underlying soakage or the movement of water in soils under the conditions of hilling, as practised in vegetable irrigation, are being investigated. Modifications of furrow shape, hill size and treatment of soil, affect soakage efficiencies.

4. *Drainage Investigations.*—Waterlogging and salting in all degrees of intensity are widespread on the Murrumbidgee Irrigation Areas. This condition represents the heritage of past irrigation practices, augmented by recurrent wet winters. The optimum depths and spacings of tile drains have been determined for the main soil types of the Murrumbidgee Irrigation Areas. Trials with mole drains on different soil types are being carried out. Methods of reclaiming salted horticultural land by the use of tile drains and also by the use of lucerne are under investigation. The movement of salt in the soil is studied by repeated sampling.

5. *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 twenty to 30 years old the areas have passed through the first cycle of their 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. The changes in the soil structure that occur after several years tillage are being studied and compared with the changes that occur in the soil after years of pasture and lucerne. Investigations are also being carried out 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.

6. *Vegetable Investigations.*—Field experiments with carrots, tomatoes, and cabbages have been carried out during the year, and involved tillage investigations (including depth of ploughing and sub-soiling), fertilizer requirements, time of seeding trials, &c. Great headway has been made in elucidating the nutrient requirements of vegetables on the Murrumbidgee Irrigation Areas. It has been found that the leafy type of vegetables such as cabbages and silver beet respond to applications of nitrogen on unfallowed land but not on fallowed land. Tomatoes require a liberal dressing of phosphoric acid at planting-out, and increases have been obtained using fortnightly side-dressings of phosphoric acid after fruit set. The nitrogen requirements of tomatoes seem to depend on the previous history of the soil. Carrots have failed to show responses to either nitrogen or phosphoric acid, applied both at seeding or during growth. With carrots, the most important factor influencing growth appears to be the time of seeding. Mid-summer sowings greatly outyield those at any other time of the year.

7. *Land-use Studies.*—Following on 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, Water Conservation and Irrigation Commission, Co-operative Societies, and 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. *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 scheme is working in the first place on a three-year programme 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.

9. *Publications.*—The following papers have been published during the year :—

"A Fertilizer Policy for Fruit Trees and Vines on the Murrumbidgee Irrigation Areas, New South Wales." Compiled by officers of the Council for Scientific and Industrial Research Irrigation Research Station, and Department of Agriculture, New South Wales. Pamphlet.

"Advice on Horticultural Land-Use in the Murrumbidgee Irrigation Areas." Compiled by members of I.R.E.C. Pamphlet.

"Facts for Irrigation Farmers—Proceedings of Extension Schools for Farmers." Compiled by officers of the Council for Scientific and Industrial Research Irrigation Research Station and Extension Groups. Pamphlet (1944).

Eagle, E. M. (1945).—Extension groups conference. S.I.E.S. Newsletter, No. 5 (June).

Greacen, E. L. (1945).—Low pressure pipelines. Ibid., No. 5 (June).

Myers, L. F. (1945).—Achievements of extension groups. Ibid., No. 4 (March).

Myers, L. F. (1945).—Extension groups and S.I.E.S. Ibid., No. 4 (March).

Pennefather, R. R. (1944).—Solving the problems of the Murrumbidgee Irrigation Areas. Ibid., No. 1 (July).

Pennefather, R. R. (1944).—An action programme to fight salt. Ibid., No. 2 (October).

Pennefather, R. R. (1945).—Controlled irrigation—Its meaning and methods. Ibid., No. 3 (January).

Pennefather, R. R. (1945).—Importance of large flows—Farmers can determine the required flow by trial waterings. Ibid., No. 3 (January).

Pennefather, R. R. (1945).—Irrigation methods must suit soil types. Ibid., No. 3 (January).

Pennefather, R. R. (1945).—Specifications for irrigation facilities. Ibid., No. 5 (June).

Wagner, V. J. (1944).—Reclamation of salted land. Ibid., No. 2 (October).

Walters, D. V. (1944).—What is salt damage? Ibid., No. 2 (October).

Walters, D. V. (1945).—Calculations for controlled irrigation—Formulae to simplify waterings. Ibid., No. 3 (January).

Walters, D. V. (1945).—Daylight-only watering. Ibid., No. 4 (March).

Walters, D. V. (1945).—Salt reclamation investigations. Ibid., No. 5 (June).

West, E. S. (1945).—Expectation of wet winters. Ibid., No. 4 (March).

West, E. S. (1945).—"I.R.S., Griffith, 21 Years Progress".

VIII. FOREST PRODUCTS INVESTIGATIONS.

1. *General.*—A large proportion of the work carried out by the Division during the year has been associated directly with the war effort. Information was collated for the Services on the identification, properties, and uses of the timbers of New Guinea, the Philippines, and the Malayan, Dutch East Indies region. This was supplied by means of special sets of cards which have had a wide distribution. Reports which have come to hand indicate that this method of distributing information has been most successful, so much so that work is now in hand extending the principle to Australian timbers. Projects related to the manufacture and utilization of wooden aircraft in Australia have been prosecuted vigorously, and the Division has been called upon to give considerable assistance to the Royal Australian Air Force and the aircraft industry. One of the many problems in this field has been in connexion with the gluing of aircraft wings. Other experiments have included the investigation of temperature and moisture conditions in wooden aircraft both on the ground and during flight. The routine specification testing of Australian timbers used in aircraft construction has been continued.

The co-operation with the Australian pulp and paper industry has been maintained, and the Sixth Pulp and Paper Co-operative Research Conference was held in April, 1945. This proved a most successful conference in that there was considerable discussion on the progress of the fundamental work being carried out by the Division, and numerous ideas for further work were brought forward. In the standards field, advice has been given to the newly constituted "Committee on Dimensions of Timbers in Buildings" set up by the Standards Association with a view to rationalizing sizes of timber used in house construction. In association with the Queensland Forest Service and the Queensland Timber Stabilization Board, a preliminary examination of the mill design and the sawmilling practice common to the cypress pine mills of southern Queensland has been initiated. There tends to be a lack of flow in timber mill design, and the investigation has been undertaken to determine difficulties and to place the industry on a sounder economic and productive basis. In the building materials field, there are many problems which come within the scope of this Division. Work on some which have been referred by the officer-in-charge of Building Materials Research has commenced. The Division maintained a liaison officer in Sydney during the year and, in addition, various officers visited

all States of the Commonwealth. The Section of Flax Processing Investigations, which was initiated at the Division of Forest Products in 1937, as the Fibre Section, expanded considerably after the outbreak of war, and it has now been decided to establish a separate Flax Laboratory for these investigations.

It has become increasingly apparent that there are numerous forest products problems relating to the post-war period that need urgent investigation. For this reason and because of limited staff it was necessary to review and modify the scope of certain of the investigations that had been undertaken during the war period. Particular attention has been paid to the preparation of a series of lectures for a reconstruction training course being developed for Service personnel proposing to enter the building trade. The need for a more concentrated examination of timber utilization in Australia is clearly evident when it is realized that, at the present time, only approximately 10 per cent. of the timber of the forests is effectively utilized, disregarding uses for low grade purposes such as fuel. Utilization can be assisted by timber preservation, in which field an outstanding problem is connected with the satisfactory treatment of the sapwood of various species for the prevention of decay and insect attack.

The Division has recently suffered severe losses in senior staff. Mr. I. Langlands, for many years officer-in-charge of the Timber Mechanics Section, has been appointed officer-in-charge of Building Materials Research; Mr. W. L. Greenhill, officer-in-charge of the Timber Physics Section and the Flax Processing Investigations, has been appointed officer-in-charge of the Flax Research Laboratory as from 2nd July, 1945; Mr. S. F. Rust, officer-in-charge of the veneer and gluing section, is shortly to take up a position in private industry. These losses have necessitated staff re-organization and five of the Sections of the Division will have new officers-in-charge.

2. *Wood Structure.*—(i) *Timbers of the South-West Pacific Area.*—The investigation of the timbers of this region has formed the major project of the Section. Demands for information were received from all the Services and were satisfied by the distribution of specially designed card-sorting sets covering the important timbers of the various regions in which the Services were interested. In these sets each card is devoted to a particular timber, and on it is set out information regarding the properties and uses of the timber and identification methods. In addition, a photograph of the appearance of the cross section of the timber at three magnifications and a photographic reproduction of the leaves, fruits, and flowers are included wherever possible. In the preparation of the botanical details, valuable assistance has been rendered by the National Herbarium, Melbourne, and the Government Botanist, Brisbane.

Special card-sorting sets have been prepared for (*a*) New Guinea timbers, (*b*) Philippine timbers, and (*c*) the timbers of Malaya, British North Borneo, and the Dutch East Indies. The number of important species included in the New Guinea set has been increased to 129, while 107 species have been covered in the Philippine set and 122 species covered in the set covering Malaya, British North Borneo, and the Dutch East Indies. In all cases the timbers had to be examined macroscopically and the data recorded; in addition, the literature was searched for information on structural features, strength properties, durability, and uses. The pertinent information for each species was transferred to the card for that species by notching at the appropriate perforations.

Explanatory notes were prepared and included in each set for the use of untrained personnel. Although the cards were printed, a tremendous amount of labour was involved in notching them accurately and in the examination of the woods represented. To date, over 300 sets covering the Philippine timbers, 80 sets covering the Malayan and Dutch East Indies timbers, and 72 sets covering the New Guinea timbers have been distributed to the Services.

The officer-in-charge of the Section visited New Guinea in the early part of the year at the request of the Army, to give a series of lectures in wood technology and wood identification, and to train selected personnel in the use of the card-sorting key. This trip presented an excellent opportunity of investigating the timbers of the areas visited. Some 1,100 specimens of New Guinea timbers have been obtained, each backed by botanical material which has been sent to the Government Botanist, Brisbane, for determination. The examination and identification of the wood specimens is proceeding and, to date, 875 have been sectioned and examined microscopically.

(ii) *Wood Anatomical Investigations.*—Arising from the examination of numerous New Guinea timber species, it was found that more information was needed on the anatomy of the various members of the family Meliaceae occurring in the South-West Pacific Area. Therefore, all the specimens of this family collected in New Guinea and all available specimens from other islands of the South-West Pacific Area were re-examined and attempts made, on the basis of

wood anatomy, to place these specimens into a number of groups. Certain structural features were selected as a basis of comparison and some eight more or less definite groups recorded. Just how each of these groups is related to general botanical classification will have to be determined after the botanical side of the work has been completed by the Government Botanist, Brisbane.

(iii) *Timbers of the Northern Territory.*—In the continuation of the investigation of the timbers from this region, some 44 specimens collected by the Army, together with herbarium material, were examined. From the results of this examination and from the examination of Northern Territory timbers previously collected, a card-sorting key for the identification of 39 timbers of this region has been completed and a number of sets supplied to the Army.

(iv) *Identifications.*—Timber identifications completed during the year numbered 1096. Most of these identifications were received from the Services and comprised timbers from the New Guinea region.

The preparation of card sorting identification keys has been extended to cover the various sleeper timbers used in Australia (48 different timbers) and the various timbers likely to have been used for piles in the New Guinea region. Sets of the latter were supplied to the Australian Army. The key developed for sleeper timbers is based, as are the others, on macroscopic features alone and has been found of quite general use in the identification of the more common Eucalypt timbers employed for various purposes in Australia.

Numerous other identifications carried out by the Section have included glue lines, wood flour, fibres, wood wool, and paper.

(v) *Reaction Wood.*—Further investigations have been carried out on the reaction wood (tension wood) in *Eucalyptus regnans* and other hardwoods. Individual fibres from tension wood areas have been isolated and their structure and behaviour during swelling compared with normal wood fibres from the same tree. In co-operation with the Commonwealth Forestry Bureau the amount and type of reaction wood present in bent stems of *Drimys* and *Gnetum* have been examined. It was of interest to find that the eccentricity in the case of *Drimys* was similar to that observed in coniferous woods, while, on the other hand, the eccentricity in the case of *Gnetum* was similar to that observed in hardwoods. During the visit of the officer-in-charge to New Guinea, it was observed that tension wood was particularly prevalent in certain species of the tropical rain forests. In some cases it was so pronounced that considerable difficulty was encountered in sawing the logs. Species giving the most trouble were identified and methods for their identification demonstrated. It was suggested that these species should not be selected for felling, or, if felled, should not be brought into the mill.

(vi) *Growth Studies.*—In co-operation with the Commonwealth Forestry Bureau, experiments are being carried out to determine the exact portion of the growth ring of *Eucalyptus gigantea* that is laid down each month during the growing season. Similar studies are proposed with other species including *E. regnans.*

(vii) *Fibre Studies* (in co-operation with the Section of Wood Chemistry).—Fibre investigations have been continued, particular attention being paid to the fibres isolated from the brittle heart of *E. regnans.* These fibres behave similarly to normal fibres from the same tree except on treatment with acid, e.g., boiling with 3 per cent. sulphuric acid for two hours. As a result of the acid treatment the brittle heart fibres fall into a number of pieces, breaks occurring at the cell wall failures which have been observed in brittle heart. It is most interesting that these broken fibres are only developed by acid treatment, and it has been assumed, as a result, that the acid might remove something from the outside of the fibre, but this has not been proved so far. Holocellulose fibres with no lignin present, when given a drastic treatment with alkali to remove the hemicelluloses estimated as xylan, did not break; on the other hand, fibres from brittle heart prepared by means of a raw kraft cook and containing a considerable amount of lignin gave broken fibres on acid treatment.

An examination has been made of the structure of fibres obtained from both normal wood and brittle heart of *E. regnans* and having (*a*) a high percentage of lignin, (*b*) a high percentage of xylan and no lignin, and (*c*) no lignin and no xylan. In these examinations there was distinct evidence of some material attached to the outside of the fibres isolated by the kraft process and containing a high percentage of lignin. This material was probably some of the original middle lamella and consisted mainly of lignin. Fibres with a higher percentage of xylan but no lignin, e.g., holocellulose fibres, did not reveal the presence of any of this material. The holocellulose and kraft fibres, on swelling with sulphuric acid, behaved similarly, although the presence of the lignin in the kraft fibres did restrict the swelling to some extent. The fibres from which both lignin and xylan had been removed by alkaline treatment swelled in a

different manner. It would appear, therefore, that the caustic extraction has had a weakening influence on the outer layer of the fibre, although it cannot be said that all of this layer has been removed because there is still distinct evidence of its presence.

(viii) *Photography.*—In connexion with the work of photographing numerous botanical specimens and botanical illustrations a portable copying stand has been devised. This has proved most effective.

Experiments with high speed photography in the investigation of the toughness of timber have shown that sharp photographs can be obtained at any predetermined stage of deflection of the specimen being tested. These photographs not only illustrate the type of failure developed in the specimen but also form a valuable means of measuring the nature and extent of the deflection of the specimen before failure commences.

The large volume of routine photographic work has been maintained during the year, and some 83,000 enlargements and 58,000 prints have been handled. Most of the prints were photographs of cross-sections of timbers of the South-West Pacific Area and were utilized in the preparation of the numerous card sets referred to above.

3. *Wood Chemistry.*—(i) *General.*—During the past eight years, the Wood Chemistry Section has, as far as circumstances permitted, engaged in research into several fundamental problems of vital interest to the Australian pulp and paper industry. For this purpose, the industry has subsidized the Section with an amount representing approximately 30 per cent. of the latter's annual expenditure. Problems which have been under investigation include the chemistry of eucalypt lignin and of eucalypt polysaccharides; methods of wood and pulp analysis; methods of pulp evaluation and of paper testing, and, in collaboration with the Section of Wood Structure, the structure of the eucalypt fibre. These studies have been continued during the past year and the results reported and discussed at the Sixth Annual Pulp and Paper Co-operative Research Conference held at Burnie, Tasmania, in April, 1945.

(ii) *Wood and Pulp Analysis.*—(*a*) Earlier studies have shown that limiting of particle size in a wood sample, while being very desirable for some analytical determinations, does not always result in a sample which could be taken as being representative of the original wood substance except with some timbers low in extractives. Recent investigations, using the wood of *Eucalyptus calophylla*, showed that two trees of the one species varied widely in extractives and the sampling of each tree would have to be considered separately. To avoid this, current work aims at the use of certain particle sizes for those types of determinations which require such a limitation. A correction factor is provided to take cognizance of errors which are incurred in thus selecting the sample.

(*b*) The lignin determination has been subjected to a critical examination which has revealed that the acid-wood and acid-pulp ratios must be rigidly defined and observed if reproducible results are to be ensured. Routine lignin determinations, such as might be carried out daily in a pulp mill, have been considerably simplified by investigations which have shown that the time of hydrolysis with hot acid may be shortened by one-half without affecting the ultimate result. Evidence has been produced to show that it is most important to maintain at its prescribed strength the cold sulphuric acid employed during the initial stages of the determination of lignin in pulp. Otherwise, very serious errors may be incurred. Current work aims at investigating this aspect as it applies to the determination of lignin in wood.

(iii) *Lignin.*—Investigations of methods for extracting "native" lignin from eucalypt woods have been continued. Previously, dry methanol at elevated temperatures and pressures had been used for periods as long as 72 hours. Under these conditions, the extracted lignin was light in colour, but could not be regarded as "native", because it had undergone a certain amount of chemical change in the form of methylation. Recent work has been devoted to the use of extractions of very short duration, in order to obtain some lignin as near to its "native" condition as is possible, even if this means sacrificing yields. Supplies of this material are being accumulated for a detailed study of its constitution and reactions.

Exhaustive studies have disclosed that under the most drastic conditions, only one-half of the lignin in eucalypt wood may be extracted by means of methanol. Addition of hydrogen chloride to the methanol, as a catalyst or hydrolytic agent, facilitates the extraction of one-half of that which is insoluble in pure methanol. The remainder, representing one-quarter of the original lignin, resists all attempts, short of complete hydrolysis of the carbohydrate fraction, to extract it. The location and mode of occurrence in the wood of these three fractions is being investigated, in collaboration with the Section of Wood Structure, by using thin wood sections in place of sawdust, and by following the removal of lignin with the microscope.

(iv) *Carbohydrate Fraction.*—Earlier work resulted in the perfection of methods for the isolation and approximate fractionation of the carbohydrate fraction of eucalypt wood. For the past three or four years, this study has been neglected because of lack of staff. With its

resumption during the current year, a method described by Ekenstam (*Svensk Papperstidn*, 45 : 81, 1942), for fractionating pulps and wood carbohydrates generally, according to their molecular chain length, has been examined. The method uses phosphoric acid of various strengths to dissolve the different carbohydrate fractions. It shows promise of being a useful tool, not only in the examination of high-alpha and dissolving pulps, but also in revealing the mode of occurrence of the hemicellulose groups in the cell wall. Of the total carbohydrate fraction isolated from *E. regnans*, approximately 74 per cent. of it has been shown to consist of cellulose chains, each of which contains considerably more than 1,000 building units. The method is at present being used to examine the various fractions into which the total carbohydrate fraction may be split by means of prescribed extractions with alkaline solutions.

(v) *Pulp and Paper from E. calophylla* (*Marri*).—This work was undertaken at the request of the Departments of Forestry and of Industrial Development, Western Australia. It involved a study of samples taken throughout the length and breadth of two trees. One of these trees had been selected as being comparatively free from gum vein defects, whereas the other, as is usual with this species, contained large numbers of gum veins. There was no difficulty in pulping the gum-free wood to secure a high yield of pulp (55 per cent.) at a low chemical cost. From the " gummy " wood the pulp yields were much lower (45 per cent.), the chemical costs excessive, and the pulp difficult to bleach. From either tree the pulp was of the same quality, namely, inferior to the usual eucalypt pulps in bursting and tensile strength but superior in tearing resistance. A full report has been furnished to the above-mentioned authorities.

(vi) *Pulp Evaluation.*—(*a*) *Stock Division.*—Equipment and procedures for the accurate sampling of fibrous material, such as paper pulp, while suspended in water, are necessary adjuncts to pulp evaluation, whether the latter involves physical or chemical testing or both. Equipment which has been developed by the Section is being continually and critically studied with the object of increasing its scope and enhancing its performance. This equipment is now in use throughout the Australian paper industry and has proved to be an important time-saver in certain mill-control tests.

(*b*) *Influence of Salts on Paper Properties.*—Earlier work has demonstrated that kations may exert a tremendous influence on the freeness or drainage properties of a pulp, this influence being greatest with trivalent kations. More recent studies have revealed that kations present in the feed water of the laboratory sheet machine do not significantly affect the properties of sheets formed in their presence, most probably because the time factor is too short for any change to take place. On the other hand, kations which are present while the pulp is being processed to develop its strength characteristics display a marked influence on the latter. Once again, the valency of the kation determines its reactivity in this respect, even when the effects due to hydrogen-ion concentration have been neutralized. Pulps naturally carry with them salts which are present in the process water employed in their manufacture, and here again the kations will exert an appreciable influence on the properties of the paper which is formed from these pulps.

Current work is concerned with the swamping of the effects due to salts in the feed water and salts carried by a pulp from the mill process water. In the paper mill, this is partially achieved by the normal sizing technique, but, in the laboratory, the problem is not so easily dealt with. Thus it has been shown that the addition of aluminium sulphate (1 gram per litre) to all water used in the laboratory processing of a pulp will " swamp " the effects due to two waters which differ widely in their salt content, and thus reduce them to a common level so far as the pulp is concerned. This quantity, however, is grossly excessive, representing at certain stages, more than 100 per cent. of the weight of pulp concerned. Furthermore, it sets up corrosive conditions, which are detrimental not only to the laboratory pulp evaluation equipment, but also to the operator's hands.

(*c*) *Preparation of Pulp for Processing.*—A standardized procedure for the preparation of pulp for processing in the Lampen mill, known as the " Unbeaten Test ", has been laid down by the Pulp Evaluation Committee of the Papermakers' Association of Great Britain and Ireland. Similar procedures, such as those for the Clark Kollergang precision beater and for pulps which have never dried and which therefore require far less work to be done on them, have been investigated.

(vii) *Tropic Packaging.*—In connexion with the drafting of Australian standard specifications for tropic-packaging materials, and with their subsequent manufacture in Australia to meet these specifications, moisture vapour permeability determinations have been made on a large number of materials, which have included moisture barrier films, adhesive tapes, dip-sealing compounds, and various cylindrical containers fabricated from some of these.

Apart from the routine testing required by the above, the testing cabinet and several features of the test have been subjected to a critical study. The variance of tests with respect to position of sample in the cabinet has been determined. The efficiency of the beeswax-rosin seal employed in the test has been investigated, and a comparison of single-faced and double-faced cells has revealed that the latter may safely be used for accelerated tests.

Moisture vapour permeability determinations on various plywoods fabricated from several different woods and with various glue lines, have revealed that plywoods, such as resin-bonded plywood, which are frequently recommended for use in the construction of kilns, reconditioning chambers, tropic rooms and the like, are entirely useless as barriers against the diffusion of moisture vapour. The tests have, therefore, resolved themselves into showing the efficiency of various glue lines to withstand the severe conditions when plywood is subjected to a saturated atmosphere on one face and to a dry atmosphere on the other face. The water resistance of various ammunition containers has also been determined.

4. *Timber Physics.*—(i) *Physical Properties of Australian Timbers.*—The work of collecting detailed information on the more important physical properties of Australian timbers is carried on from year to year using whatever suitable material comes to the laboratory. From time to time it is necessary to collect and analyse such results and revise lists of values. This has been done during the last twelve months, the previous occasion being 1939–40. Furthermore, a survey has been made of the species for which insufficient or no information is yet available so that these can be included in future programmes of work.

(ii) *The Effect of High and Low Temperatures on the Strength of Wood, Plywood, and Glued Joints.*—This project appears to have created great interest both in Australia and overseas. The preliminary tests which were made only at a moisture content of 15 per cent. have now been extended to a wide range of moisture contents, and the later results confirm and extend those published. When expressed as a percentage of the crushing strength at 20° C., the weakening effect of temperature per degree centigrade for all species examined varies from about 0.3 per cent. at 0 per cent. moisture content to approximately 1 per cent. near 20 per cent. moisture content, thereafter decreasing to about 0.7 per cent. at fibre saturation point. It is thus possible to predict with considerable confidence the effect of temperature on the maximum crushing strength of any species at any moisture content. In static bending, the modulus of rupture and modulus of elasticity decreased with increasing temperature at all moisture contents from 8 per cent. to 20 per cent. In toughness no serious weakening was experienced; in fact the general effect was for a marked increase at high temperatures and high moisture content. The same type of result was, in general, obtained with plywood in compression tests. In tension tests, however, the effect of temperature varied considerably with moisture content and over different temperature intervals. Considerable reduction in strength occurred at temperatures above 50° C. at high moisture content; this was particularly serious when the direction of the grain of the outer plies was at 45 degrees. The danger of ignoring temperature corrections in structural design, particularly of aircraft, is thus well demonstrated.

(iii) *Battery Separators from Australian Timbers.*—Laboratory tests have been continued on the storage of batteries constructed with treated and moist separators. With a properly sealed battery, little, if any, deterioration has taken place after two and a half years' storage.

(iv) *Temperature and Moisture Content Conditions in Wooden Aircraft.*—The investigations previously completed on Anson aircraft have now been extended to the Mosquito. This work, undertaken in the first place at the request of the British Air Ministry, has included both ground and flight tests and has provided a wealth of information on the conditions of temperature and moisture content to which aircraft may be exposed in service.

At the request of the Royal Australian Air Force a series of tests was initiated during the latter part of the year to compare the infra-red reflectance of various aircraft finishes, the object being to reduce the temperatures attained by aircraft exposed to solar radiation. Preliminary data indicate that substantial benefits can be obtained by the use of special infra-red reflecting ingredients, at the same time retaining the desired colour scheme.

(v) *High Frequency Electrical Heating.*—Various modifications found necessary in the equipment have been carried out and minor tests have been made including the possible application of high frequency fields for pre-heating plastics, setting twist in rayon yarn, and various timber fabrication problems.

(vi) *The Crazing of Plywood.*—This investigation has been commenced at the request of the officer-in-charge of Building Materials Research, and aims at improving the bahaviour of plywood exposed to external weather conditions. Preliminary work has been carried out on methods of evaluating the crazing and on the use of a weatherometer for standardizing test conditions.

(vii) *Miscellaneous.*—The following miscellaneous investigations are recorded:—(*a*) Numerous tests on the dimensional stability of papers and plastics used for range charts (Army). (*b*) The possibility of using electrical moisture meters for testing leather.

5. *Timber Mechanics.*—(i) *Flooring Tests.*—A working plan has been prepared and material obtained for the testing of sample floor sections made from the various Australian timbers commonly used for this purpose. This will provide more precise information regarding their relative serviceability. It is proposed to investigate tallowwood, jarrah, Sydney blue gum, mountain ash, cypress pine, and radiata pine in ordinary tongue and grooved flooring in the widths most commonly used. In jarrah and mountain ash, end-matched, tongued and grooved flooring will also be tested. In addition, plywood flooring of hoop pine and silky oak will be investigated. In this case the desirable spacing of the nogging will be studied.

(ii) *Box and Crate Design.*—Close liaison continues to be maintained with the Services, the Department of Munitions, and the Operational Safety Committee. Considerable attention has been given to the design of nail-less explosives boxes of various types. Damage encountered in transit has been observed and, where necessary, the design of explosive and other boxes has beem modified and improved.

During the past year experiments have been carried out to determine the most suitable cushioning material for carboys for acid transport. In the past, kieselguhr has been the standard cushioning material, but it has certain disadvantages. By the use of lighter substitutes, the weight of box plus cushioning material can be halved, a saving of 25 lb. Mineral wool and flax tow have been recommended, although in one State the railways raised an objection to flax tow. As a result, inflammability tests have been carried out; they showed that flax tow is considerably less inflammable than other common packing materials such as straw and wood-wool.

Tests have also been carried out for the Army on the taping of trench mortar bomb containers to determine the effect of various factors on the holding power of the tape under service conditions.

(iii) *Tests on Northern Australian and New Guinea Timbers.*—The mechanical properties of four New Guinea timbers and of a large number of samples supplied by the A.W.C. from the Northern Territory have been determined.

Tests have also been carried out on coco-nut logs, both in the round over a span of 20 feet and in the form of small clear specimens both green and seasoned. The mechanical properties are very variable from log to log and within the log. Crushing strength and hardness increased in one log from the centre to the outside in the ratio of about 60 : 1, whereas moisture content varied in an inverse manner from 740 per cent. to 50 per cent.

(iv) *Timber Structures.*—Preliminary tests have been carried out on split ring and shear plate joints under long time loading. A Whittemore strain gauge attached to a calibrated bolt was used initially to estimate the load, but large errors due to temperature fluctuations were troublesome. Calibrated compression springs which take up the creep are now being used to load the connector joints. Other tests have shown that split ring joints with 8-in. end margin, fitted with stitch bolts, are liable to fail in less than three months when subjected to twice the design load. Tests on split ring joints in mountain ash at design load show approximately $\frac{1}{4}$-inch slip after about seven months, and at half design load, a slip of 0.14 inches after about eight months. With yellow stringybark the slip was much less. Shear plate tests with yellow stringybark also indicate a smaller slip than with split rings. Large scale tests on yellow stringybark and mountain ash are now about to commence.

A few preliminary tests were carried out on nailed joints in both green and kiln dried timbers. Reasonably good agreement with the results published in the *Handbook of Structural Timber*, Supplement No. 1, was obtained. Since they form a very simple and speedy method of attachment in light structures and are likely to be of particular interest not only now but after the war, an extensive series of tests has been planned to determine the strength of nail joints. Factors such as type of timber, moisture content, direction of grain, ratio of thickness of plank to nail diameter, slenderness ratio of the nails, and spacing of the nails will be studied.

(v) *Fundamental Creep Investigations.*—A large scale project to determine the effect of creep in timber in tension and compression has been planned. The tests will be carried out under controlled conditions of temperature and humidity. The equipment including strain measuring apparatus is complicated and requires very considerable work in its manufacture, and for this reason progress has been slow. Prototypes are now, however, complete, the problems involved have largely been solved, and manufacture of equipment, for the first two of the ten replications, is under way. Experiments begun before the war to determine the effect of creep in green wooden beams are now being continued.

Preliminary tests have been carried out to study the effect of long-time loading on small timber columns having a ratio of effective length to least dimension of 30–50 and initial eccentricity of loading. Green yellow stringybark columns 1 inch by $\frac{3}{4}$ inch in cross section with a ratio of effective length to least dimension of 50 and an initial eccentricity of 1/144 of the effective length failed in six days under a constant load of two-thirds of the short-time ultimate load. A high density green Douglas fir column, 2 inches by $1\frac{1}{2}$ inches in cross section and having a ratio of effective length to least dimension of 30 with an initial eccentricity of 1/360 of the effective length, failed in 28 hours under a constant load equal to 80 per cent. of the short-time ultimate load. A similar column at 60 per cent. of the short-time ultimate load has not failed in over 200 days. Full scale tests are now being planned in species of various strength grades.

(vi) *Aircraft Timber Investigations.*—(*a*) *Solid Timber.*—About 12,000 tests were carried out during the year exclusive of density and moisture determinations. Tests on white birch, Queensland maple, and celery top pine have been completed, and aircraft design stresses prepared for northern and Queensland silver ash. In the case of Queensland maple, analysis is in progress and design stresses will soon be available. Further work has been done to determine the effect of duration of loading on the strength of Queensland maple.

(*b*) *Plywood.*—The effect of different types of gripping devices on the results of tensile tests on plywood has been studied. There appears to be little difference between the results for fixed and self-aligning grips with plywood $\frac{3}{16}$ inch or more in thickness, but with thin plywood ($\frac{1}{32}$ inch thick), the results are likely to prove significantly different and, if this is confirmed, it would appear desirable that the type of gripping device to be used for such tests should be specified. Numerous panel shear tests have been carried out on hoop pine plywood, together with tensile, compressive, and double shear tests on matched samples, in order to relate the results of panel shear tests to other tests. As soon as suitable equipment is available, electrical strain gauge rosettes will be used in conjunction with panel shear tests to estimate the modulus of rigidity of plywood. Other tests, using plywood tubes in torsion have already been carried out for this purpose, but there are many difficulties. A further method, using a flat plywood plate in torsion has been tried and shows promise. Material has been obtained for panel shear tests to determine the effect of defects on the strength of the plywood.

(vii) *Specification Tests.*—Routine specification tests on Australian aircraft timbers and on spruce have been continued as a service to the aircraft industry. About 172,000 tests have been made on about 220,000 super. feet of timber. In future this type of testing will be carried out on Australian timbers only.

The results of tests on mountain ash and spruce are now being analysed. Considerable information on these species is being obtained from these analyses on account of the large quantity of timber involved.

(viii) *Impact Investigations.*—The effect of variation in the form of the Izod specimen has been determined. Similar work is being carried out on the toughness specimen.

Work has recently been commenced to determine, by means of high speed photography, what happens during a toughness fracture. Similar work will be done in relation to the Izod test.

(ix) *Strain Measurement Studies.*—Local manufacture of electrical strain gauges has been continued with improvement of construction, calibration, and rapid measurement of strains.

Lateral sensitivity measurements are now being made to ensure that satisfactory allowance is made for errors due to this cause. Tests to determine the Poisson's ratio were carried out on short compression specimens of spruce, as this timber was readily available in a suitable size.

6. *Timber Seasoning.*—(i) *General.*—Governmental and private annexes and factories made considerable use of the facilities and technical services of the Section throughout the year, particularly with regard to foodstuffs cases, specifications for tropic testing conditions, kiln design, the tropic testing of service equipment, and the drying of timber and veneers. Visits were made to South Australia, New South Wales and Queensland at the request of firms requiring advice in connexion with various phases of their activities.

Supervision of the large scale kiln-drying of timber for defence purposes was maintained at commercial plants, and the selection of special timbers was continued. The practical training of key factory staff was also continued at both the laboratory and appropriate commercial plants.

Demands for timber seasoning plant layouts, for constructional plans for timber seasoning kilns, and for designs for special driers of many types, remained fairly heavy. Numerous minor inquiries included the drying of wood-wool boards; the repair of concrete in faulty kiln

construction ; the design of wood waste burners ; the slicing of case stock ; kiln-drying schedules for Australian and overseas timbers ; drying times and costs ; the manufacture and finishing of smoking pipes ; temperature control equipment ; the drying of miscellaneous timber utility fittings ; moisture content control ; the drying of veneers ; the construction of wooden vats and tanks ; and the design of refrigerated chambers for tropic services.

(ii) *Kiln Schedules.*—Work on the development of special kiln schedules for aircraft timber of Australian origin was finalized, results being issued to the Australian Standards Association for inclusion in appropriate specifications. Commercial drying schedules were also determined for celery top pine and blackwood.

Chemical seasoning principles were used in the development of kiln schedules for several timbers required for specialty purposes, namely, mallee, myall, red gum, almond, and olive. In the drying of treated separators for aircraft batteries intended for reserve storage, a similar technique was found effective in overcoming the incidence of end wrinkling which introduced assembly difficulties.

(iii) *Kiln Design.*—Inquiries under this project were active throughout the year ; specific requests for designs covering the construction of timber seasoning kilns, veneer and plywood driers, drying rooms, and conditioning and drying cabinets, were received from 29 firms, and some 300 drawings were issued. A number of commercial kilns were tested at the request of trade interests and, where necessary, advice was given covering modifications necessary to ensure efficient operation. Tests were made on a vacuum kiln designed for the drying of solid timber. No new principles were found apart from those investigated in various unsuccessful vacuum kilns previously built in Australia or overseas.

(iv) *Building Materials.*—Work designed to test the suitability of combinations of organic substances with binders or cement to form building materials was commenced. Initial work aims at testing the value of " sawdust-cement " (a combination of sawdust, portland cement, and sand) as a flooring surface. As a preliminary step, lines of work developed by the British Building Research Station have been followed particularly with regard to application to Australian hardwoods and softwoods. To date, tests have shown that hydrated lime is valuable in ensuring good setting properties ; calcium chloride is useful in securing high early strength ; water proportions are critical, both in regard to strength and trowelling qualities ; shrinkage is much higher than with normal concrete, and special care must be taken in bonding on to the base aggregate.

(v) *Miscellaneous Seasoning Investigations.*—(*a*) *Weatherproofing Paints.*—Weatherproofing and tropicproofed paints and finishes were tested to determine compatability and their relative efficiencies as moisture barriers—a factor of considerable importance to the weight and dimensional stability of aircraft.

(*b*) *Equilibrium Moisture Content of Timber.*—Several sets of matched e.m.c. samples were prepared from a number of New Guinea timbers. Three sets have been distributed to representative centres in New Guinea, and the remaining sets are maintained at Melbourne to establish comparative values.

An investigation of suspected variation from previously published data on the e.m.c, values attained by spruce when exposed to moderate ambient temperatures, was completed, but data are not yet analysed. Work designed to determine the effect of thickness on rate of change of e.m.c. in timber, and the effect of air drying and kiln drying on the e.m.c. attained by Australian timbers, has been planned.

(*c*) *Moisture Distribution in Wooden Stumps.*—Recent evidence has indicated that an appreciable upwards moisture transfusion occurs in timber having the base sunk in moist ground —a condition which, under certain circumstances, might introduce a decay hazard into certain house-framing members not normally considered exposed to this danger. Experimental work has been put in hand to investigate this point.

(vi) *Correspondence Course.*—An additional 45 students were enrolled during the year. Since the inception of the correspondence courses, 157 students have completed the preliminary course and 36 have completed the kiln operators' course.

7. *Timber Preservation.*—(i) *General.*—In order to cope with more pressing war-time problems outside the scope of timber preservation, but for which indiviual officers had the necessary training, this Section was seriously depleted during the early part of the war. The past year saw the partial restoration of the Section which, although still below strength in trained personnel, has been able to return to something approaching a systematic programme of work. This embraces field tests, laboratory investigations, and dissemination of information concerning decay and insect attack of timber and means of prevention to be adopted.

(ii) *Service Tests.*—Some progress has been made in bringing up to date inspections and reports on long-term service tests, work on which had been allowed to lapse almost completely for several years. Detailed reports on these inspections have now been issued. The following service tests have been inspected during the current year and reports have either been prepared or are in course of preparation.

(*a*) *Treated Pinus radiata Sleepers, South Australia.*—This test was installed in 1936 in co-operation with the South Australian Railways and Woods and Forests Department. The inspection was the third made and gave an interesting indication of the value of mixing crude oil with creosote, the effect of the oil being to reduce moisture change and, therefore, cracking of the sleepers.

(*b*) *Pinus radiata Poles, South Australia.*—This test, also, was installed in 1935–36 and the inspection made was the third. The evidence is that only full length pressure treatment would give satisfactory service life.

(*c*) *Pole Tests, Victoria.*—One test, covering two sites in widely different localities, was installed in 1934–35 in co-operation with the Forests Commission, the State Electricity Commission, and the Postmaster-General's Department. The main test species is *E. obliqua*, a variety of treatments being under comparison. No inspection had been made since 1941 and the influence of a series of dry years in one locality had caused termites to go deep in the soil in search of moisture, attack having developed below the treated zone where this did not embrace the complete butt. Another test, installed in 1936 in co-operation with the same Departments, but at the request of the State Electricity Commission of Victoria, included a more durable species (*E. paniculata*) in addition to *E. sieberiana*, *E. obliqua* and *E. regnans*. In both tests a number of the untreated controls had failed and retreatments, where applicable, were carried out.

(*d*) *Treated Sleepers, Victoria.*—A further inspection of this test was carried out.

(iii) *Laboratory Tests.*—Work undertaken has a bearing on the use of less durable timbers for railway sleepers. This work, commenced at the urgent request of the Victorian Railways Department, has great post-war significance, since the supply of durable sleeper timbers will not be sufficient to meet the anticipated demands of delayed maintenance and new work in connexion with unification of gauges. It is planned to initiate subsequent field tests in Victoria and ultimately to extend these to other States. Two possible means of treatment are being investigated.

(*a*) *Diffusion Treatment of Green Timber.*—A technique, consisting essentially of the use of a diffusion cell with a disc of the green timber as membrane, has been devised by these studies, and in preliminary experiments the effects of concentration and pH of the treating solution and of thickness of the disc were tested. Three subsequent experiments have covered effect of temperature on the rate of diffusion, effect of thickness of the disc, and circulation of the solution, and comparison of block diffusions with the diffusion cell results.

(*b*) *High Pressure Treatments.*—This is an extension of earlier work, but much higher pressures are being used. With pressures of 1,000 lb./square inch, promising results have been obtained with certain eucalypt timbers which are untreatable at normal pressures of 150–200 lb./square inch. Using low temperatures without an initial vacuum no visible damage has been caused and the practicability of the method is being investigated.

(iv) *Dissemination of Information.*—In addition to normal replies to inquiries on fungal and insect attack of timber, lectures have been given to selected Service personnel. Of particular value was the re-establishment of contact with mining interests in Broken Hill, where the durability of timber is of great importance. Aspects of future work were discussed with a representative of one of the companies, who spent some weeks at the Division. Revival of active co-operative work was discussed with representatives of various State Government Departments.

(v) *Miscellaneous Investigations.*—In reference to requests from the Services, the following problems have been investigated and reported upon:—(*a*) Efficacy of certain trade preparations for tropicproofing of boxes, (*b*) decay in wooden craft, and (*c*) preservative treatment of balsa for rafts.

8. *Veneering and Gluing.*—(i) *General.*—Practically the whole of the work carried out under this heading has had a direct bearing on the war effort. Considerable time has been devoted to advisory work for all the Services in connexion with adhesives and problems related to adhesion. This has necessitated, in many cases, laboratory experiments to obtain the required information and actual demonstration of practical techniques under commercial

conditions. Attention was given to a large number of problems submitted by plywood and furniture manufacturers and dealing with various aspects of plywood manufacture and utilization.

(ii) *Peeling.*—The following species have been peeled during the year :—Loblolly pine, slash pine, mountain ash, coachwood, yellow walnut ; the loblolly and slash pines were peeled, dried and bonded into plywood on behalf of the Queensland Sub-Department of Forestry. The coachwood logs were peeled to obtain test material for numerous investigations being carried out within the Division. A number of satinay flitches were half-rotary sliced.

(iii) *Gluing of Australian Timbers.*—Experiments to determine the gluing characteristics of a number of Australian timbers were continued. Advice and assistance were given to the various firms interested. The following examples indicate the nature of the work carried out :—(*a*) The gluing of tea-tree with casein and urea formaldehyde adhesives for use in the manufacture of shoe lasts ; (*b*) the gluing of yellowwood and mountain ash, the former for use in boat construction and the latter for hospital tent poles ; (*c*) the gluing of sassafras with urea formaldehyde cement for use in box construction.

(iv) *Wooden Aircraft Project.*—(*a*) The Section was responsible for supplying technical assistance needed by the manufacturers when changing over from casein cement to urea formaldehyde cements (Beetle A and AF) in the construction of the main plane, fuselage, &c. Exposure tests to determine the comparative durability of Beetle and casein-glued joints were installed at several locations throughout Australia. Acceptance tests of Beetle cement were carried out on behalf of the Aeronautical Inspection Directorate for approximately nine months until other arrangements could be made. Methods for the correct use of Beetle cements were demonstrated at various sub-contractors' plants. In order to facilitate production assistance was given to the local firm producing these adhesives.

(*b*) Gluing difficulties and checking of important structural members due to moisture content changes have been eliminated by the installation of a system of equilibrium moisture content control at the plants of the various sub-contractors. The proper working and control of these installations have been supervised by the Division's liaison officer located in Sydney.

(*c*) Examinations were made and reports prepared on various mainplanes showing faulty adhesion.

(*d*) Experimental work was carried out in order to demonstrate the proper use of casein glue in the fabrication of the mainplane and the exact effect of faulty procedures.

(v) *Marine and Aircraft Plywood.*—Attention was given to problems associated with the bonding of marine and aircraft plywood and the proper use of such material. It was shown that, contrary to statements which have been made, prolonged soaking in salt water does not appreciably affect the strength of the glue joints.

(vi) *Gluing and Impregnated Veneer.*—Experiments have shown that it is possible to impregnate plywood satisfactorily with any of the standard types of wood preservatives. Information was obtained on the limitations of secondary gluing operations due to the presence of these preservatives. This was necessary because of the severe damage to watercraft in tropical waters due to attack by marine borers and decay.

(vii) *Testing of Adhesives.*—In addition to the problems listed above various adhesives for different purposes were tested during the year as indicated below :—

(*a*) In order to conserve casein supplies, considerable experimental work was carried out on the development of substitutes for use in plywood manufacture. It was shown that peanut flour, dried buttermilk, and milk albumen blended with casein would each give satisfactory bonds for plywood.

(*b*) The merits of several proprietary adhesives for fibreboard containers in comparison with sodium silicate were investigated.

(*c*) In conjunction with the National Standards Laboratory, tests were carried out on the variation in viscosity of Beetle cements A and AF over their working life after addition of the hardener.

(*d*) Work was carried out with Australian aircraft casein glues and veneers to examine proposals made to the Standards Association of Australia Aircraft Materials Committee for modification of A.S. No. (E) D. 831 to bring it in line with B.S. No. 4 V 2.

(viii) *Miscellaneous.*—(*a*) Check tests and examinations of various casein cements were carried out on behalf of the Aeronautical Inspection Directorate. Test pieces, according to the various specifications, were prepared for the various testing centres throughout Australia.

(*b*) Several examinations were carried out on behalf of the "Inter-Departmental Committee on Casein" with material imported from the United States of America and also on a damaged consignment from New Zealand.

(*c*) In connexion with certain experiments relating to the thickness of the glue line in laminated spruce spars, the Section of Wood Structure carried out precise measurements under the microscope with the object of correlating the actual width of the glue line with the width as seen by the naked eye. Photomicrographs (75 X) were prepared and comments made on each of the glue lines examined.

9. *Improved Wood.*—(i) *Gluing.*—In co-operation with the Division of Industrial Chemistry a large scale factorial experiment, in which 126 different warm-press (160° F.) resin glues of the cast phenolic type were tested, has been completed. Three acid catalysts were used, viz., toluene-sulphonic, sulphuric, and hypophosphorous acids, and the base resins were modified by the addition of various amounts of resorcinol and novolak. After a six-month accelerated ageing test, joint strengths of improved wood remained relatively unchanged, but those of control specimens made from mountain ash with all-catalysts fell to 50 per cent. of their original values. Of the modifying agents high resorcinol concentrations gave an increase of 20 per cent. in joint strength with improved wood but high concentrations of novolak caused a marked decrease in strength. From the information derived from this experiment, a further series of tests has been planned for the development of a cast phenolic resin adhesive for the bonding of improved wood and other plastic base materials at intermediate and room temperatures. Some preliminary service tests have indicated that a cast phenolic adhesive modified with resorcinol and using a high percentage of toluene-sulphonic acid is quite satisfactory for the cold-press gluing of improved wood.

(ii) *Tego-bonded Improved Wood.*—For certain purposes this type of improved wood in which thin veneers are bonded with a paper-glue film is considered inferior to the fully impregnated material mainly on account of its lower dimensional stability. However, it has approximately twice the impact strength of the latter at the same specific gravity. Compression at higher temperatures (310-320° F.) than usual has shown that not only is dimensional stability improved but that shear, compressive, and tensile strengths are also increased without loss of impact strength.

(iii) *The Use of Methylolurea in Improved Wood Manufacture.*—This resin, an initial condensation product of urea and formaldehyde has been tested on a small scale as an impregnant for veneers in improved wood manufacture and for solid timber with satisfactory results. Improved wood so made has a higher moisture absorption and somewhat lower mechanical properties than improved wood made with phenol formaldehyde resins; it is, however, colourless and will probably be preferred for decorative purposes where retention of the natural wood colour is desired. Solid timber impregnated with methylolurea is appreciably hardened on the outer surfaces but complete penetration is difficult. Other experiments have included the treatment of shoe lasts, textile bobbins, and the use of an impregnated paper for plywood facing.

(iv) *Miscellaneous.*—The utilization of improved wood on a small scale in different industries is still progressing, and much practical advice has been given by the Division. Improved wood products which have been developed recently include gangsaw spacing blocks, nuts and bolts, strain insulators, pedal blocks, textile rollers, table tops, brush backs, and axe handles.

10. *Utilization.*—(i) *General.*—The work of this Section has been primarily of an advisory nature and has been directed towards the solution of problems associated with the utilization of timber to meet essential requirements of the Services, industry, and post-war reconstruction planning. Visitors from every State of the Commonwealth and from New Zealand discussed problems related to timber production and manufacturing processes. Secretarial duties for the Timber Sectional Committee of the Standards Association of Australia were carried out.

(ii) *Liaison.*—Contacts were maintained with the following Commonwealth Departments :—Navy, Army, Air, Aircraft Production, Munitions, Supply and Shipping, Commerce and Agriculture, Post-war Reconstruction, and with the Royal Navy and the various State Forestry Departments. An officer represented the Division at conferences on the standardization of timber for use in building construction, utilization and grading of timber for house construction programmes, forest conservation, materials and methods for post-war furniture manufacture, and wooden aircraft construction.

(iii) *Timber Uses.*—Advice has been given to inquirers seeking information on timbers for agricultural machinery; bent wood and other furniture; boat and ship construction; bridge and wharf construction; briquetting of sawdust; building and prefabricated construction; butter boxes and churns; clog soles; clothes pegs; containers (including boxes, cases, barrels, &c.); corestock; cross-arms; detection of metal in sawmill logs; doors; flooring and flooring profiles; fiber board; grading of timber for various purposes; handles; keel blocks for naval

dockyard; ladders; mauls and mallets; matches; mine detectors; mining timber; oars; patternmaking; picking sticks for textile industry; picture frames; plywood for various purposes; railway carriages and sleepers; sawdust utilization; shuttles; slipways; sporting goods; telegraph poles; water channel timbers; wheels for industrial trucks; wood flour; wood wool; wood waste utilization; wood stave tanks; woollen mill equipment. In addition assistance has been provided on timbers suitable for various uses mentioned elsewhere in this Report.

(iv) *Publicity and Educational Work.*—A display for the "Save the Forests Exhibition" in Melbourne was organized to assist the campaign for forest conservation. The publication of the Division's *News Letter* was recommenced and a number of issues have been prepared. This method of dissemination of information will be continued as opportunity permits.

(v) *Sawmill Studies.*—Preliminary discussions on small dimension stock—production and use—were held with representatives of sawmillers, furniture manufacturers, and Forestry Departments. In conjunction with the State Electricity Commission of Victoria observations were made on the power requirements of various kinds of saws cutting a range of timbers at different rates.

(vi) *Committee on Dimensions of Timber in Buildings.*—The Standards Association arranged for the establishment of a Committee on Dimensions of Timber in Buildings. A representative of the Division attended the first meeting at which two sub-committees, one on timber for framing and general construction in housing, the other on joinery sizes, were formed. Several meetings of the sub-committee on structural timber were held at which representatives of the Division recommended the use of Pamphlet No. 112—"Building Frames—Timbers and Sizes"—as a simple basis for the adoption of rational and economic sizes.

11. *Flax.*—(i) *General.*—In order to keep pace with the requirements of the industry, much of the work, in the past, has been empirical in nature as it was necessary to obtain details of at least reasonably satisfactory techniques in a minimum of time. However, further improvements will depend largely on more fundamental studies of the processes involved and in this direction much remains to be accomplished.

(ii) *Water Retting.*—Further investigations have been carried out on the "double retting" technique as practised at certain Belgian flax mills. It is felt that the production of even limited quantities of really high grade fibre would be extremely welcome to the Australian industry at the present time and every effort is being made to improve processing methods with this end in view. One of the more recent water retting studies has been of the influence of various chemicals, both organic and inorganic, on the progress of the ret. In this work it appears that two factors may be used in controlling the rate of retting—first, the supply of nutrients to the bacteria and second, the maintenance of the optimum pH of the liquor for bacterial activity. A detailed study has been made of the effect of iron on water retting. Further investigations have been made of the effect of various modifications to the standard water retting procedure. In particular, the part played by the preliminary rinse has received attention. Other work has included the study of the effect on retting and on the yield and quality of the fibre produced of (*a*) the evacuation of air from the retting tank, (*b*) the use of wetting agents to facilitate the absorption of water by straw in the early stages of the ret, (*c*) the action of light, (*d*) exposure of straw to sunshine and also storage for various periods.

Water analyses have been made on samples from all the new water retting mills; this information is required for boiler operation as well as retting.

During the year some weeks were spent by officers of the Section at the Strathkellar mill studying the operation and performance of the effluent treatment plant and at the Ballarat mill inspecting water retting operations. The question of effluent treatment is likely to become more and more important as new retting tanks are established in more closely populated areas; the plant at Strathkellar will provide valuable experience on such installations.

(iii) *Chemical Retting.*—For several weeks the pilot plant at Ballarat was operated almost continuously on a standardized treatment. Of the fibre produced, 5 cwt. was sent to England for spinning tests together with the same amount of water-retted fibre from similar straw. Similar matched samples of chemically and water retted fibre were also submitted to three Australian spinners for testing. The results of all these tests are not yet available.

(iv) *Fibre Evaluation.*—The work of retting and evaluating the fibre in straw from Agricultural Department field trials has been continued as in previous years. This has included straw from Victoria, South Australia and Tasmania, and the importance of the variety of flax and the growth conditions on the quality of the fibre produced is becoming more and more evident.

Developmental work has been concerned with the relation of fibre grade to such physical properties as hackling yield and fineness of hackled fibre, shape and area of fibre bundles, and shape and dimensions of the ultimate fibres. Rapid methods of making such measurements have, in some cases, greatly facilitated the work. For example, the direct measurement of fibre fineness is tedious and time consuming but an indirect method has been developed making use of the fact that the fibre surface area depends on the fineness of the fibres and also determines the resistance offered to the flow of air through the fibres.

A special microtome has been designed and constructed for cutting sections of fibre and, making use of this equipment, a careful study has been made of the effect of straw maturity on the microscopic structure of the ultimate fibres. In addition, a very satisfactory technique has been developed for the microscopic study of flax straw. This involves the use of a freezing attachment in conjunction with an ordinary microtome, suitable staining and mounting and, if desired, photographing with a 500 magnification. From sections prepared in this manner a study is being made of the correlation between the straw characteristics and the quality and percentage of fibre.

One investigation made during the year was to determine the optimum moisture content of fibre for grading and from the data obtained to suggest suitable air conditions for the fibre stores.

The chemical analysis of flax straw at various stages of processing has been found to yie d very useful information regarding the changes which occur during treatment. Some of the problems recently considered from this angle have been (*a*) the effect of iron in water retting, (*b*) the progressive action of the bacteria in water retting, and (*c*) variations in fibre from the butt, middle, and top sections of straw.

(v) *Miscellaneous Tests.*—Various material is submitted from time to time for a report on its value as a source of fibre. Such inquiries entail work on methods of extracting the fibre and then an examination of its potential uses. Material dealt with during the past year has included pandanus palm roots, banjine bark, and rubber vine.

12. *Publications.*—The following papers have been published during the year :—

Anon. (1944).—Edge gluing of veneer. *Aust. Timber J.* 10 (6) : 243.

Anon. (1944).—Progressive v. compartment kilns for drying veneer. *Aust. Timber J.* 10 (6) : 247.

Barrow, G. J. (1945).—Survey of houses affected in the Beaumaris fire, 14th January, 1944. *J. Coun. Sci. Ind. Res. (Aust.)* 18 : 27–36 ; *Aust. Timber J.* 11 (4) : 154–155, 158.

Bland, D. E. (1944).—Permanence of Australian vertical retort creosote oils. Correlation of boiling range with leaching losses, evaporation losses, and changes in composition. *J. Coun. Sci. Ind. Res. (Aust.)* 17 : 274–288.

Couchman, J. F. (1944).—Effect of straw maturity on the chemical composition of flax straw and fibre. *J. Coun. Sci. Ind. Res. (Aust.)* 17 : 139–43.

Gordon, A., and Tamblyn, N. (1944).—New wood product enters textile industry—Compressed laminated wood picking sticks. *Aust. Timber J.* 10 (7) : 279, 281.

Greenhill, W. L. (1945).—Flax processing : the need for research. *J. Coun. Sci. Ind. Res. (Aust.)* 18 : 132–140.

Kloot, N. H. (1944).—Tests on the holding power of Titan plain and processed cement-coated nails. *J. Coun. Sci. Ind. Res. (Aust.)* 17 : 156–161.

Roberts, H. D. (1944).—Moisture content distribution in wood used as a partition between water and air. *J. Coun. Sci. Ind. Res. (Aust.)* 17 : 133–138.

Rust, S. F. (1944).—" Wet-Mix " casein glue ingredients. *Aust. Timber J.* 10 (10) : 409, 417.

Whitington, B. (1944).—Protection of split-ring connectors against corrosion. *J. Coun. Sci. Ind. Res. (Aust.)* 17 : 162–166.

IX. FOOD PRESERVATION INVESTIGATIONS.

1. *General.*—While work of importance in the war effort is still the Division's major activity, plans are being made for resuming several projects abandoned early in the war, and for carrying out several new investigations. For instance, at the Division's Brisbane laboratory, it is intended shortly to resume investigations on the preparation and storage of chilled beef, giving particular attention to the problem of the loss of " bloom ". In co-operation with the New South Wales Department of Agriculture, investigations will shortly be started on the quick-freezing of fruits and vegetables, a small laboratory having been built recently for this purpose.

Technical assistance continues to be given to food processors having war contracts. Close liaison with victualling officers of the Royal Navy (Pacific Fleet) has recently been established.

Since the head-quarters of the technical branches of Commonwealth Food Control and of this Division are widely separated, adequate liaison between the two bodies has often been difficult to maintain in the past. This position has lately been considerably improved by holding regular quarterly meetings between representatives of this Division and of the Directorate of Food Manufacture. At these meetings, items of current technical interest, problems awaiting solution, and methods for applying the results of the Division's work are discussed.

Through the courtesy of Professor Eric Ashby space has been made available at the Botany Department, University of Sydney, for one of the Division's investigators to carry out some studies on fundamental aspects of the metabolism of ripening and senescent fruit. Several members of the Department's staff have recently made significant contributions in this field, and it is appropriate that there should be a close association between the investigators in the two laboratories.

Early in 1945, a small party of investigators from this Division was sent to New Guinea to report on the condition and acceptability of Service food supplies, the packaging of foods, and the physical conditions obtaining in stores. This survey, carried out with the full approval and help of the Australian and United States Forces, was organized under the auspices of the Scientific Liaison Bureau, and a full report has been presented through the Bureau to the appropriate authorities. The results should be applicable not only to the particular area surveyed but also to all other wet tropical regions where military operations are in progress.

2. *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 construction of new apparatus, statistical analyses, and to collaboration with other Sections on various problems.

(ii) *Substitute Containers.*—Work has been continued on a reduced scale. Long-period storage tests with baking powder have been continued. It has been shown that cardboard containers with an imported, high melting-point wax give satisfactory performance with jam filled at temperatures up to 205° F. Another wax mixture prepared in the laboratory also gave promising results.

(iii) *Water Relations of Foodstuffs.*—Further measurements have been carried out on a variety of products. Among the most important of these was fruit cake. The Section co-operated with an Army officer and the Microbiology Section in a study of the possibilities of preventing mould attack in fruit cake by the control of equilibrium relative humidity. It was found quite possible to make cakes with an equilibrium humidity of 73 per cent. or lower which were very palatable. These could be stored several months without risk of mould attack.

Apparatus for the measurement of the vapour pressure of dried foods has been designed and constructed. This has been used to obtain data on the relation between moisture content and vapour pressure in dried egg at a series of temperatures. Similar data will be obtained for various dried vegetables.

(iv) *Heat Penetration Studies.*—Some further measurements of heat penetration into cans of food during retorting have been carried out. The products studied were a cabbage pack, a sausage pack, and some fish packs.

(v) *Heat Transfer and Evaporation.*—Some years ago a study of the cooling of a wet body was begun in order to supply information required in chilled beef investigations. Little work on this project has been possible since the outbreak of war, but it has been given some consideration during the year under review. The arithmetical methods developed for integrating the equations involved have been reviewed and the efficiency and economy in time of some possible alternatives investigated. Apparatus for the direct measurement of heat transfer and evaporation from a wet surface under still air conditions has been designed.

(vi) *Electrical Moisture Meters.*—The work reported last year has been completed and a report prepared.

(vii) *Spray Drying.*—The laboratory spray drier has been modified to improve its performance.

(viii) *Freezing of Fish.*—Advice on a number of projects was given to the Controller of Fisheries. A search of the literature was made to collect data on designs which have been used for refrigerated trawlers and the performance of various types.

3. *Microbiology.*—(i) *General.*—As in previous years assistance on matters of food microbiology has been given to Government departments and food processing firms, and instruction in canning bacteriology has been given to visiting bacteriologists.

(ii) *Egg Investigations.*—Experiments on the bacteriology of egg pulp were concluded. A second paper on the resazurin reductase test and its application to the grading of Australian egg pulp was published in the Council's journal, and a third paper on the resazurin-reducing activities of the various bacteria occurring in egg pulp is being prepared for publication.

Some further tests on the storage of shell eggs have been carried out with eggs cleaned on machines with a large capacity. In view of the probable early resumption of export of shell eggs, this work is being continued. The results of experiments during the last six years, in which the major causes of wastage of shell eggs have been defined, will be published shortly.

(iii) *Canning Bacteriology.*—(*a*) *Canned Foods.*—The bacteriological examination of canned foods submitted by food processing firms and Government departments has been continued, but, on a scale substantially reduced from last year. In two products inoculations with bacterial spores of known resistance to heat have been carried out under laboratory and commercial conditions, and the procedures required for safe processing thereby defined.

(*b*) *Clostridium botulinum Experiments.*—Experimental work has been continued with this organism which is of great importance in canned foods that have been inadequately processed. The growth of the organism has been studied in a further series of canned vegetables. The previous finding that some vegetables dissolve tin from unlacquered tin-plate containers in quantities sufficient to inhibit the growth of this organism has been confirmed in additional vegetables. On the other hand growth is not prevented in plain cans of some other vegetables. The different results obtained in the various vegetable products are of considerable importance in canning investigations, and a paper summarizing these results has been prepared for publication. Experiments on the mechanism by which tin and other metals inhibit *Cl. botulinum*, are being continued.

The destruction by heat of *Cl. botulinum* toxin types A and B has been studied in a number of vegetable products. The rate of destruction has been found to vary widely between different vegetable products, and to be influenced by the pH during heating. Some of the differences noted between vegebtables, however, are not due to pH alone but to the protective action of unknown substances. The results have assisted in explaining some of the discrepancies apparent in earlier work by other investigators.

(*c*) *Heat Resistance of Bacterial Spores.*—These studies, which are fundamental to the calculation of the heat processes required for canned foods, have been continued with many types of spores including those of *Cl. botulinum.*

The observation that the cultural requirements of heated spores may be different from unheated spores has been confirmed with a wide variety of bacterial types. Experiments have, therefore, been concerned primarily with discovering the cultural conditions necessary for the reliable detection of spores surviving heat treatment. The response to additions of starch to media has been further confirmed, but the reason for the unique activity of this substance is still unexplained. The significance of several other factors has also been established.

(iv) *Mycological Investigations.*—Experiments have been started, and are still in progress, on the relation between mould growth and the activity of water in fruit cake. The results already available have been applied to problems arising from the storage of fruit cake in tropical areas.

4. *General Chemistry.*—The work of the Chemical Group has included a great variety of investigations and analyses related to canning, fresh and dried fruit storage, and microbiology.

(i) *Tin, Iron and Copper in Foods.*—Many determinations of tin, iron and copper for other workers were carried out and included about 300 determinations of tin in canned vegetables and vegetable media in connexion with the investigations on the bacteriostatic effect of tin. As the inhibitory level of total and dissolved tin was found to be different for different products, preliminary experiments were undertaken to determine whether the bacteriostatic effect was related more closely to the tin fraction which is dialysable, i.e., not in combination with protein or other colloids. No evidence of such relation was found and the work was discontinued.

In connexion with investigations on the bacteriostatic effect of tin in canned products, further information on the rate of tin accumulation was found desirable. It was planned to obtain this information by analysing samples of vegetables in plain cans at various intervals after canning. A preliminary investigation with canned silver beet, using samples of three cans, was initiated. Data on accumulation of iron were obtained at the same time. Although this has given some results of interest, the sampling variation was considerable and indicated that an excessively large unit would be required in future work.

These investigations required a much higher degree of accuracy in the analytical work than has hitherto been obtained, and some work to improve the method of determination of tin was found necessary. The method finally developed includes wet digestion with nitric and sulphuric acids, reduction of tin to the stannous state with aluminium, and titration of the stannous tin with standard iodate. A paper on this work has been prepared for publication in the Council's journal.

(ii) *Tin Coating on Tin-plate.*—A number of determinations of tin coating weight on tin-plate were made in connexion with canning investigations. Methods of determination were compared critically. The most satisfactory standard method was found to be solution of the tin-plate in hydrochloric acid in the absence of air and direct titration of the stannous tin with standard iodine. By making a separate determination of the iodine consumption of the dissolved baseplate, the result can be appropriately corrected.

A number of rapid, stripping methods were compared with the above chemical method. Of these, the most accurate was found to be Clarke's method, in which the sample is weighed before and after stripping the tin with a solution of antimony trichloride in hydrochloric acid.

(iii) *Sulphur Changes in Dried Apples.*—A considerable loss of sulphur dioxide usually occurs during the storage of dried apples, particularly at high temperatures, and even in closed containers. A sample of dried apples, which had lost practically all its sulphur dioxide, was found to contain most of the equivalent sulphur in another form. Most of the sulphur dioxide appeared to be changed into water-soluble substances from which it could not be regenerated by boiling with acid or alkali. About half the equivalent sulphur was recovered as sulphate after alkaline hydrolysis.

(iv) *Curing Ingredients in Bacon.*—Many determinations of curing ingredients (chloride, nitrite, nitrate, and sugar) in raw and processed bacon were carried out. These constituents closely control the growth of spoilage bacteria in this product. It was found necessary to develop an accurate method for determination of low concentrations of sugar, and a modification of the Hagedorn-Jensen ferricyanide procedure was developed and standardized. A correction for non-fermentable reducing material was obtained by yeast fermentation. Fermentation with a strain of spoilage bacillus gave a similar figure, but only under certain critical conditions.

(v) *Sugar in Fruits and Vegetables.*—Total and reducing sugars were determined in various samples of dried peaches and pears in order to obtain correlations with levels of quality. The ferricyanide procedure, after clearing with zinc hydroxide, was found satisfactory for a range of products. Clearing with lead was found to involve almost complete removal of sucrose from carrot extract.

(vi) *Pectin.*—Work on the extraction and purification of pectin from citrus residues was continued. The stability to heat of pectin in crude extracts appears to be greater than is generally reported, and this question is being investigated further. A slight loss of pectin (as measured by jellying power) was found in Navel oranges from Griffith with increasing maturity. No significant change was found in Valencia oranges.

Work on the preparation of solid jams was completed, and a short report prepared for the Division's quarterly. The jams were prepared by boiling 150–200 parts of fruit pulp with 100 parts of sugar to 70–75 per cent. solids and pouring into trays for setting. Crude 5 per cent. pectin extract (quince, 20 parts ; plum, 40 parts ; raspberry and marmalade mixture, 50 parts) was added towards the end of the boil. The jam was cut into 1-lb. blocks, which were wrapped in waxed paper and kept satisfactorily for three months under conditions approximating to those in southern Australia.

Tests were carried out for a commercial firm in connexion with the setting of marmalade and the jellying power of pectin extracts. Samples of marmalade were prepared from dried oranges and grapefruit.

(vii) *Sodium Alginate.*—Tests were carried out on the jellying of fruit juices by a commercial sample of sodium alginate. One per cent. sodium alginate was found to give a weak jelly in pineapple juice without the addition of calcium (which is usually recommended). Further tests showed that at pH 3.4–3.7, such as occurs in fruit juices, jellying is best carried out without calcium. At pH 4.3 and above, jellying was only obtained in the presence of added calcium. A jelly for meat canning was prepared with added calcium. Unfortunately, the jellying power is destroyed by the necessary processing (one hour at 115° C.).

(viii) *Wax Coating of Apples.*—Preliminary investigations on the wax coating of Granny Smith apples, which have been interrupted for three years, were continued this year. The object is to study changes in the wax coating during storage and ripening and to relate such changes, if possible, to the gaseous exchange and storage disorders of the fruit. The work this season has so far demonstrated an approximately 40 per cent. increase in the wax coating during ripening.

(ix) *Ascorbic Acid* (*Vitamin C*).—It has been claimed that a certain amount of " apparent ascorbic acid " can develop in processed foods, particularly after long storage. Various procedures have been suggested for differentiating " apparent " from " true " ascorbic acid. An estimate was made of " apparent ascorbic acid " in canned orange juice stored for twelve months at 37° C. but only about 2 milligrams per 100 millilitres were found. Negligible amounts of such substances were found in an invert syrup of pH 3.2 which had been similarly stored.

The effect of maturity on the ascorbic acid content of Navel and Valencia oranges from Griffith was investigated. The outer rind was found to contain about three times as much ascorbic acid as the inner rind or juice. Both the ascorbic acid and the colour of the rind reached a maximum about August. The ascorbic acid of the juice did not change appreciably early in the season, but fell subsequently. Further work is in progress.

Investigations were completed on the fortification of lemon and orange cordials with synthetic ascorbic acid. The lemon and orange syrups, which were artificially coloured and flavoured, lost about 10 per cent. of the added ascorbic acid in three months. Beverages prepared by dilution with carbonated water lost 30 per cent. in the same period. One difficulty was found to be the instability of many dyestuffs in the presence of ascorbic acid. Of nine dyes tested, only three (tartrazine, orange 2, and carmoisine) were found reasonably stable.

Fundamental studies were made on the oxidation of ascorbic acid in fruit and vegetable tissue suspensions and in various buffers from pH 0.5 to 7.0. Ascorbic acid oxidizing enzymes were found to be extremely active in cabbage, apple and parsley tissue. When enzymes were absent or inactivated by heat, the rate of oxidation appeared to be primarily a function of pH, the concentration of copper, and the concentration of various organic acids, hydroxy and thiol compounds which reduce the pro-oxidant effect of copper. Thiourea and substances occurring in onion tissue were outstanding in their protective effects. This, together with the low enzyme activity, accounts for the excellent retention of ascorbic acid by onion tissue. In orange juice and rose hip tissue ascorbic acid owes its stability to the low pH, as well as other factors.

The pro-oxidant effect of copper was found to decrease continuously with decreasing pH, until at pH 0.5 oxidation was negligible even in the presence of ten parts of copper per 1,000,000. On the other hand, ferrous iron was found to have a considerable pro-oxidant effect at pH 0.5, but not at higher pH levels. The information of the pro-oxidant effect of heavy metals is being used in developing a method for the determination of ascorbic acid in the presence of appreciable levels of tin, iron and copper, such as may occur in canned foods. Protective substances such as oxalic or metaphosphoric acid cause the iron to interfere in the titration, unless used in very low concentrations. By extracting at pH 2–3 with a low concentration of oxalate and lowering the pH before titration, fairly satisfactory results were obtained.

(x) *Miscellaneous.*—A number of miscellaneous analyses and investigations were made for other sections and commercial firms. These included the determination of moisture in meat packs and sweet corn, fat in fruit spreads, methoxyl in pectin, and phosphorus and calcium in commercial phosphates. A detailed analysis of a pickling syrup was undertaken for a commercial firm to assist in utilization of what would otherwise have been a waste product.

A brief investigation was undertaken on the removal of iron from commercial lactic acid. Tests were carried out on precipitation by ferro-cyanide and the use of barium sulphate as an adsorbent for removing colloidal material.

5. *Meat Investigations (Brisbane).*—(i) *General.*—While there was an appreciable lessening in the amount of general consultation work and in the number of requests for assistance from industry during the early part of the period under review, this type of work increased very markedly later to a level greater than at any time during the war period. A number of these requests for help came from various Service authorities, from Government Departments, and particularly from food industries. Much of the work, especially that connected with technical difficulties existing in industry, necessitated surveys and laboratory investigations, physical, chemical, and microbiological in nature.

(ii) *Dried Beef and Collagen-Gelatin Studies.*—The major work in this field has been to study further the cause of the loss of particulate character in dried beef upon its compression into solid blocks. Histological studies, mentioned in the last annual report, have been continued throughout the year supplemented by chemical studies, including the development of a satisfactory technique for the quantitative estimation of gelatin. Early correlations between the amount of gelatin derived from the cooking of muscle tissue, and the histological evidence on the same type of tissue are indicating a very satisfactory correspondence. There still remains a relatively small amount of work to be done in the improvement of certain phases of the histological technique, and some work also in the further refinement of the methods for the quantitative estimation of gelatin. As a result of these studies much new information has been obtained which will be described later in a technical communication. Both the histological and the chemical studies appear to be leading to a much better understanding of the fate of collagen in muscle during the process of cooking and drying for the production of dehydrated meat, and suggest the probability of their being of real assistance in other fields of meat investigation in which this laboratory will be interested in the post-war period.

(iii) *Moisture Content of Meat Extract.*—Various points which needed further elucidation were investigated. Chief of these was the influence of temperature on the density of diluted meat extract. Work was also done on the isolation of creatine and creatinine. Two articles in the series of communications on " The Moisture Content of Meat Extract " appeared in the Council's Journal. It is expected that others, either in this series or dealing with other aspects of meat extract, will appear later.

(iv) *Chloride Determinations.*—In connecion with the work on meat extract, it was desirable to have a quick method which could be employed in industry for the determination of total chlorides. The most promising method seemed to be the silver, silver-chloride electrode method described by Best. Since the application of this method to the meat extract problem gave very unsatisfactory results, further investigations have led to the development of a technique whereby results are now obtainable giving the same figures as those obtained by the ordinary, but time-consuming, standard methods. A paper describing the modified technique is being prepared.

(v) *General Microbiological Work.*—A good deal of miscellaneous microbiological work was carried out, and several microbial population surveys made, chiefly in relation to plant and laboratory problems. Some investigational work was carried out to establish better culture media for certain moulds and yeasts in the reference collection, the growth of which on malt agar in the case of moulds, and on 3 per cent. glucose in 1 per cent. nutrient agar in the case of yeasts had not been entirely satisfactory.

(vi) *Chilled Beef Investigations.*—The laboratory is completing its investigations on dehydrated beef and preparing the results for publication. Preparations are being made to resume the work on chilled beef which was temporarily suspended in 1939 at the beginning of the European war.

6. *Fruit Storage and Dried Fruits.*—(i) *Skin Coatings for Apples.*—Skin coatings of oil and wax have been further tested at cool and atmospheric temperatures on the main varieties of apples grown in New South Wales. Wax emulsions may cause calyx injuries to Jonathan and Granny Smith apples while oil emulsions may injure the lenticels. A medicinal paraffin oil of heavy grade has given better control of wilting and has been less toxic to the fruit than lighter mineral or vegetable oils. Injurious effects have also been caused by excessive amounts of emulsifying agent but injuries due to coating have been considerably reduced by wrapping the fruit.

Skin coatings have not been as effective as gas storage in controlling wastage in Jonathan and Delicious apples and have sometimes resulted in the development of alcoholic flavours and breakdown on removal of the fruit from cool storage to higher atmospheric temperatures.

In tests carried out over a number of years the solution of castor oil and shellac in alcohol has given highly satisfactory results with Granny Smith apples over a range of storage temperatures. This treatment has retarded colour development as effectively as gas storage but in addition has reduced wastage from mould, superficial and late scald. Further experiments are now in progress, and coatings are also being applied by rubbing mixtures of oil and wax on the fruit by hand. Pliofilm liners and wraps are being tested under various storage conditions.

(ii) *Organic Acid Studies.*—The changes in the concentration of organic acids in apples during storage are being determined and their function in the respiration of apple tissue is being investigated in conjunction with the research staff of the Botany Department of the University of Sydney.

(iii) *Dried Apples.*—The factors associated with the deterioration in flavour and colour of dried apples are being investigated. The storage life has been based on the time required for the fruit to develop a brown colour which becomes more intense on cooking and is accompanied by a burnt caramelized flavour. The storage life was directly related to the initial sulphur dioxide concentration and terminated when the content had fallen to 500 parts per 1,000,000.

In addition to the results reported last year, it has been found that the storage life is much greater in fruit of 4–12 per cent. moisture than in fruit of higher moisture content, the increase in life per 1 per cent. reduction in moisture being much less over the range 12–22 per cent. that at lower levels.

(iv) *Dried Apricots.*—The effects of moisture, sulphur dioxide content, and temperature on the deterioration in quality of dehydrated and sun-dried apricots are being further investigated. Blanching in steam prevented the browning of the cut tissue prior to sulphur but did not retard the subsequent deterioration during storage. Dehydrated fruits had the same storage life as the sun-dried of similar sulphur dioxide content.

The apricot differs from the apple in that storage life is not dependent on the level of initial moisture contents above 9 per cent., the length of life being the same over the range 9–24 per cent. The storage life was terminated with the development of a brownish black colour and a burnt caramelized flavour when the sulphur dioxide content had fallen to 500 parts per 1,000,000. The storage life was decreased to about half when the temperature was increased from 86° F. to 98° F. The storage life was directly related to the initial sulphur dioxide content over the range 1,000–8,000 parts per 1,000,000. For instance, the life at 86° F. is about 140 and 210 days respectively for fruit with initial contents of 2,000 and 3,000 parts per 1,000,000 of sulphur dioxide.

(v) *Dried Peaches.*—The dehydration of four varieties of peaches—Elberta, Phillips, Golden Queen and Pullar, has been investigated commercially. The fruit was sulphured for one hour on wooden trays and then dried in a two-stage vegetable dehydrator at a temperature of 170° F. in the primary and 150° F. in the secondary tunnel. Very attractive products, golden in colour and translucent in appearance, were obtained by steam blanching for ten minutes prior to sulphuring, and the blanched fruit did not case-harden during drying. Blanching reduced the drying time by 25 per cent. but had no effect on the retention of sulphur dioxide. Peeled fruit was more attractive and dried much quicker than unpeeled.

For dehydration the fruit should be uniformly ripe, as the green colouring matter of immature fruit is fixed by blanching, yielding an unattractive product. Overmature fruit "slabs" on the trays during drying. Size separation of fruit is necessary to obtain a product of uniform colour, texture, moisture and sulphur dioxide content but size separation is not needed if sliced fruit is dried. Peeled, blanched halves took eighteen hours to dry, while unblanched and blanched slices required only four to five hours. The unblanched slices had an attractive appearance and had a better flavour and texture than the blanched. The slices had a much higher sulphur dioxide content than the halves and therefore a longer potential life. Halves have to be reconstituted by soaking overnight, but slices can be cooked immediately. Subdividing into slices would also considerably increase the capacity of the dehydrator.

Storage tests are being carried out at a range of temperatures to determine the effect of moisture and sulphur dioxide content on keeping quality. The results so far obtained are similar to those with apricots.

(vi) *Dried Pears.*—Attractive products have been obtained by dehydrating William and Packham pears of canning-ripe maturity which have been peeled, quartered and sulphured. Steam blanching gives a more translucent product and reduces drying time but tends to destroy flavour. The only satisfactory method of sulphuring is with fumes of burning sulphur. Dipping in sulphite solutions gives the fruit an unpleasant alkaline flavour.

The factors associated with the deterioration in quality during storage are being investigated; the results indicate that pears have a much longer life than other tree fruits.

7. *Canning and Fruit Products Investigations.*—(i) *Vegetable Canning.*—Variety and maturity investigations of vegetables for canning were extended, most of the work being done with the co-operation of the Departments of Agriculture in New South Wales and Victoria, the Department of Commerce and Agriculture, and with the Vegetable Problems Committee of the Council.

Six carrot varieties from Hurlstone Agricultural College, New South Wales, and nine varieties from Canberra were canned at several maturities. Danvers and long-rooted Chantenay were outstandingly good when canned as whole baby carrots, while Greater Chantenay, Intermediate, and Danvers gave the best results when diced at full maturity.

Tomato canning work was advanced a further stage using material again supplied by the Griffith Research Station. Sixteen varieties were canned at three maturities and the packs subsequently evaluated on the basis of drained weight, texture and flavour. Results indicated that fruit for canning should be mature and fully coloured but still quite firm. Tatura Dwarf Globe, Tatinter and Riverside were notably good, while Bounty and Indiana Baltimore were poor. Since Tatura Dwarf Globe is a bad carrying variety, it should be canned in the area of production.

Data on field conditions for growth of sweet corn from planting to maturity were obtained from work with commercial crops at Windsor, New South Wales. Moisture content and refractive index of grain at time of harvesting were used as indicators of picking maturity. Encouraging results were obtained, and these should be capable of commercial application during the forthcoming season. Demonstration packs of whole-grain sweet corn and sweet corn on the cob were made in the laboratory.

Seven varieties of green beans grown at Leeton, New South Wales, were included in a canning trial. Preliminary indications are that New Zealand Giant and Refugee are suitable canners. Further work on maturity will be necessary. Several varieties of dry beans forwarded by the Victorian Department of Agriculture were tested for suitability as substitutes for navy bean. Baked beans made from Pale Dun variety were of excellent quality.

A trial of sweet potato varieties for canning quality was carried out in co-operation with the New South Wales Department of Agriculture and the Commonwealth Department of Commerce and Agriculture. Eighteen varieties, most of which were grown at the Grafton Experiment Farm, were tested. The golden varieties, Porto Rico and Porto Rico crosses, were outstanding in canning quality, and the varieties White Yam, Yellow Strasburg, Nancy Hall, and McDonald River Red were reasonably satisfactory.

Ten varieties of green peas grown at Camden, New South Wales, under the supervision of the New South Wales Department of Agriculture, and harvested in October, 1944, were tested for canning quality. The varieties Thomas Laxton, Alaska and Profusion were most preferred in flavour, and of these Thomas Laxton was notably superior in colour. Peas grown at Hurlstone Agricultural College were canned in a variety and maturity trial. Additional work is indicated.

The effects of canning procedures and storage on the quality and vitamin C content of canned broccoli have been studied. Canned broccoli is very palatable, and with a vitamin C content of 30–40 milligrams per 100 it is one of the richest of the processed vegetables in antiscorbutic value. This vitamin C content is retained to the extent of 80–90 per cent. during storage at room temperatures for one year.

Further investigation was made of the use of calcium chloride in blanching treatments for canned diced potatoes, attention being paid to maintenance of the desirable concentration in the blanching water under commercial conditions. A continuous drip process was evolved and found to be suitable. Comparison was made of blanching techniques for silver beet with special reference to steam pressure blanching. Pressure-blanching gave much higher ascorbic acid retention in the canned product than existing commercial methods.

Improvement in the quality of canned celery was demonstrated when the material was cold-filled and vacuum-sealed prior to heat treatment.

The investigators are indebted to the managements of Leeton Cannery (New South Wales), Griffith Cannery (New South Wales), Rosella Preserving Company, Windsor (New South Wales) and Balgay Cannery, Mount Druitt (New South Wales), for the use of facilities and for general co-operation in vegetable canning investigations.

(ii) *Meat Canning.*—Experiments were conducted with the object of improving the quality of existing meat packs. Several new packs were developed. The practicability of substituting an open-top sanitary can for the conventional rectangular tapered corned-beef can was explored. The possibility of an improvement in quality by the elimination of the standard precook was also investigated. This work has not been completed.

Canning trials with rasher bacon show that undesirable changes in texture which occur during pressure cooking may be avoided by the use of "pasteurization" temperatures of the order of 212° F. or lower. The comparative storage life of bacon processed by these methods is being determined. The utilization of tripe for canning and the development of discolouration during processing is being investigated. Packs of bacon and blue peas, and pork and blue peas were found to be attractive and provide an additional outlet for dried peas.

(iii) *Fish Canning.*—Experimental canned packs of acceptable quality have been prepared from Australian salmon, flathead, barracouta, bonito, garfish, sea mullet, northern blue-fin tuna, mackerel tuna, kingfish, oysters, cockles and pippies.

The undesirable toughness and dryness of Australian salmon was overcome by preparing and canning it as fish loaf and as fish sausage. Improvement in flavour was obtained by light smoking as a pretreatment. All such packs were found to be commercially acceptable. Bonito which has hitherto been used solely as bait was found to be satisfactory when canned, particularly when given a light smoke as a pretreatment. When fresh, unspoiled, shark flesh was canned, no spoilage due to the liberation of ammonia was encountered. Canned shark was found to be reminiscent of crab in flavour and was commercially acceptable. A study is being made of the influence of freezing and storage in the frozen state on the texture of canned barracouta.

Trimmings from canned Australian salmon and tuna provided material for fish soups and chowders. Similar products of good quality were made from oysters, cockles and pippies. An outbreak of spoilage in canned whitebait from Tasmania was investigated, and heat-penetration studies indicated that the retort process was bacteriologically inadequate. Further laboratory work was undertaken in order to determine a safe heat process for this pack.

(iv) *Fruit Canning.*—Investigations on hydrogen swells in canned pears were continued. Williams and Packham varieties were canned at three vacuum levels to determine the relationship between initial headspace oxygen and the development of swells. Loss of vacuum is being followed by "flip vacuum" readings. The work is proceeding.

Calcium chloride treatment of mature fruit was undertaken to test its effect on the firmness of the canned product. The process produced attractive firmness in pawpaw, but no improvement was obtained with peaches and apricots. An attractive pack of tropical fruit salad was made incorporating pressure-peeled pears and pawpaw treated with calcium chloride prior to canning. Exploratory work is in hand on the apparent discolouration of peaches, pears and pineapples packed in internally lacquered cans.

(v) *Fruit Juices.*—The method of storage of unpasteurized fruit juices by deaeration, addition of small concentrations of sulphur dioxide, and holding at 40° F. under 30 lb. pressure of carbon dioxide was investigated. Late-season Valencia juice of high oil content was held for five months with little change in flavour and without development of bitterness. Further work will be undertaken with Washington navel and Valencia varieties during the forthcoming season. Further modifications in the design of the Homebush fruit juice deaerator were tested, and work is in hand on methods for the determination of minute quantities of residual oxygen in fruit juices after deaeration.

A Wilson-type oil trap was made and tested against the standard distillation method for the determination of citrus oil in canned juices. The trap gave a 20 per cent. higher recovery at relatively high oil contents, and consistently good results at lower levels where the distillation method proved unsuitable. The method has been recommended for inclusion in Service specifications in place of the distillation procedure.

(vi) *Fruit Spreads.*—At the request of the Army supervision of commercial production of rosehip-fortified spreads for inclusion in operational rations was maintained. The rate of loss of ascorbic acid at high temperature (100° F.) storage is being studied. Results show that a steady fall occurs at room temperature, and at 100° F. the loss amounts to 60 per cent. over a ten-week period. When the spreads were fortified with synthetic ascorbic acid the retention was approximately twice as high as when rosehip was used. Rosehip extract has shown good retention of ascorbic acid at room temperature, losses of the order of 2 per cent. in twelve weeks being recorded. At 100° F. the loss was 16 per cent. over the same period.

(vii) *Can Enamels and Lacquers.*—Tests of commercially prepared can enamels were continued. Owing to short supplies of synthetic resins used in accepted citrus enamels and sulphur-resistant enamels, further work has been commenced. A number of enamels from various organizations have been subjected to test. Samples of recognized American enamels have been received for comparison of performance with those manufactured in Australia.

In view of reports that rusting of tinplate containers was a serious problem affecting Service food supplies in tropical areas, an investigation was made of various external protective treatments. A range of commercial external lacquers was tested for rust-preventing properties in laboratory exposure tests and the study is being continued with coated cans exposed in New Guinea.

Laboratory tests indicated that stoved finishes are superior to air-drying finishes in protective value and in resistance to abrasion after exposure to humid conditions. When applied at the same dry film weight, most commercial air-drying finishes give similar protection. The weight of organic film on the tinplate is of greater importance in determining rust-preventing properties than the actual composition of the film. A minimum, dry-film weight of 2–3 milligrams per square inch is recommended. It is considered that present commercial air-drying lacquers give adequate protection to prevent serious losses in Service foods. The immediate practical problems in this field are concerned with methods and equipment for the application of external lacquers in the canneries. Assistance in this direction has been given to several canners. Adhesion of lacquers is poor when the coated cans are cased before the lacquer is completely dry and this difficulty is accentuated when the cases are constructed from timber of high moisture content.

The phosphate-chromate protective treatment developed by the Tin Research Institute, Great Britain, was also studied. It imparted improved rust-resistance to surfaces on which the tin coating was complete, but severe local rusting occurred at discontinuities in the tinplate surface. No significant improvement was noted in the performance of lacquered cans pretreated in the phosphate-chromate bath.

(viii) *Container Investigations.*—Methods employed for the examination and testing of cans have been subjected to further study. An internal, vacuum leak-testing device has been constructed and its results compared with the conventional internal pressure test. A specially constructed microscope of Australian manufacture is now in use for the examination of cross sections of can seams. Further work has been carried out on the efficiency of various can-sealing compounds. Investigation of abnormalities in commercial samples of food cans has been continued and information obtained has been made available both to canners and can-makers. In almost all cases of post-processing contamination it has been possible to demonstrate can faults by the internal pressure test.

A comprehensive report was prepared from the literature on the suitability of aluminium and its alloys for the manufacture of food cans.

(ix) *New Equipment.*—A triple-stage, all-glass, climbing-film evaporator was designed following a series of laboratory tests with temporary materials. Manufacture of this equipment has now been completed. It will be used for further investigation of fruit juice concentrates.

A colour-comparison turntable was made to enable a composite skin colour of a tomato sample to be recorded in terms of Maerz and Paul's colour standards. The comparator has proved valuable in tomato maturity canning trials.

A steam-pressure blancher capable of high-temperature, short-time treatments was designed and constructed at Homebush. For laboratory purposes it is hand-operated but is capable of conversion to mechanical operation. The machine is in constant use for vegetable blanching pretreatments and is also used as a pressure steam peeler for certain fruits and vegetables.

8. *Dehydrated Foods Investigations.*— (i) *Vegetable Dehydration.*— (*a*) *Processing Investigations.*—The suitability for dehydration of different varieties of onions, cabbages, carrots, potatoes and beetroot has been investigated in co-operation with the Council's Division of Plant Industry, and Research Stations at Griffith and Merbein. The results obtained for cabbages and carrots substantiated those obtained in co-operation with the Griffith Research Station in 1943. As a result of these trials, certain varieties of several vegetables have been selected for more detailed study next season. These investigations have not been confined to a study of the reaction of the varieties to dehydration treatments. Data also obtained include culinary quality of the fresh vegetable, dry matter content, reducing and total sugar content, ascorbic acid content of cabbages and potatoes, carotene content of carrots, volatile sulphur content of onions, and density of root vegetables.

Similar investigations have been carried out on samples of potatoes, carrots and onions obtained from commercial growers in a number of districts in Tasmania, Victoria and New South Wales. This work has been facilitated by the co-operation of officers of the State Departments of Agriculture who have arranged the selection and shipment of samples. This material has been used for detailed studies of processing treatments. Variables investigated include sulphite treatments, blanching procedure, drying times and drying temperatures.

The installation of new processing equipment during the year has considerably increased the present and potential scope of the processing investigations. The availability of this equipment has resulted in an improvement in the quality of the work by permitting better handling of the raw material and better control of the processing treatments.

(*b*) *Storage and Packaging Investigations.*—Investigations of the effect of storage at several temperatures have been continued with samples of dehydrated vegetables prepared in the laboratory and in commercial plants. The effect of moisture and sulphite content on storage life has been further studied for several vegetables. These investigations have shown the importance of drying to moisture contents conforming with current Food Council specifications. The storage life of cabbage is considerably increased by drying to even lower moisture contents ; similar investigations with other vegetables are in progress. The storage life of dehydrated potato is considerably increased by sulphiting. With dehydrated potatoes it has been found that the quality of the raw material affects the storage life even more than it affects the initial quality of the dehydrated product.

Dehydrated cabbage and carrot were used in a comparison of the effect on storage life of packing in air and nitrogen. All the material was stored at 86° F. The advantage of packing in nitrogen was considerable for cabbage samples and overwhelming for carrot samples. It was also shown that the storage life of some carrots was improved by sulphiting but that the effect was in no way comparable with that of gas-packing.

Experiments were carried out on the compression of dehydrated vegetables into blocks. The equipment and procedure used was similar to that recommended by United States investigators. Blocks having densities in the range 0.8 to 1.0 could be readily prepared from dehydrated cabbage, carrot, onion and beetroot having moisture contents in the range 3–5 per cent. There was no significant fragmentation of the vegetable and the blocks disintegrated rapidly in hot water. The technique is still under investigation.

(*c*) *Dehydration Tunnel Investigations.*—Investigations commenced at the dehydration plant at Morpeth in April, 1944, were carried to a conclusion. This work continued and extended the investigations carried out in three Tasmanian dehydration plants in 1943. A report was circulated covering the measurements made of air speeds, air temperatures, weight loss, moisture content of product and thermal efficiency. It was shown that there was a large variation in the final moisture content and that this could be attributed to demonstrated

irregularities in air speeds and temperatures. Certain modifications in tunnel design were suggested. Members of the Physics Section of the Division, of the Council's Division of Aeronautics, and of the technical staff of Food Control collaborated with officers of this section in various stages of the investigation.

(*d*) *Factory Manual.*—Officers of the section collaborated with officers of Food Control and technical officers of the United States Army in the preparation of a manual for the guidance of operators of dehydration plants. Methods for processing nine different vegetables were described.

(ii) *Meat Dehydration.*—Experiments were carried out to compare the following methods of cooking mutton before drying:—(*a*) boning out and then cooking in water at atmospheric pressure (British Standard Method), (*b*) cooking at 22-lb. pressure and then boning (Australian commercial method), (*c*) cooking at 10-lb. pressure and then boning, (*d*) cooking at 10-lb. pressure in water and then boning. The main points of comparison were the ease of boning after pressure cooking and the palatability and texture of the dried products before and after compression into solid blocks. The product obtained by the British Standard Method was more palatable than the others and it was the only product which compressed satisfactorily. The only objection to this product was that it required longer cooking before serving than those prepared by the other methods. Products prepared by cooking at 10-lb. pressure, (*c*) and (*d*), were similar in all respects to products prepared by the Australian commercial process and boning was more difficult.

An investigation of the effect of antioxidants on the storage life of granular dehydrated mutton started early in 1944 has been completed. Antioxidants tried were oat flour, wheat germ oil, "Viobin Antioxidant C", soya bean lecithin and ethyl gallate. Three methods of incorporation of the antioxidant were used. Experiments were carried out with dehydrated mutton prepared by the British and Australian processes mentioned above. None of the antioxidants improved the storage life, as judged by palatability tests. All samples had very low peroxide values which did not alter significantly throughout the experiments. Points of interest which emerged from examination of the control samples were that the British Standard Method sample (fat content 35 per cent.) had a considerably longer storage life than the pressure cooked samples (less than 30 per cent. fat), while the life of the latter was improved by the addition of fat to the dried product to give a final fat content of 40 per cent.

(iii) *Egg Dehydration.*—A new storage experiment was started with dried egg. The main aims of the experiment are (*a*) to test the linearity of the tasting score scale, (*b*) to examine further the correlation between the tasting score and the Australian standard method for determining solubility, and (*c*) to obtain further data on the effect of packing dried egg in inert gases. The examination of samples stored at 86° F. has been completed and storage at lower temperatures is being continued. The advantage gained by packing in carbon dioxide was sufficient to warrant further investigation, and problems connected with the quantity of carbon dioxide absorbed on the powder are being investigated as a preliminary to further storage experiments.

(iv) *General.*—Investigations concerned with various analytical methods used in the work on dehydrated vegetables, meat, fat and eggs have been made during the year. Samples of dehydrated vegetables and eggs have been examined from time to time at the request of Service Departments and Food Control. Investigations of the quality-storage life of special Army rations and of individual items from these rations have been continued.

9. *Publications.*—The following papers have been published during the year:—

Riddle, Arthur R. (1944).—The moisture content of meat extract. 1. The nature of moisture content. *J. Coun. Sci. Ind. Res.* (*Aust.*) 17 : 291–298.

Scott, W. J. (1945).—Storage of eggs and egg products. (Presented to the New South Wales Division, Australian Institute of Refrigeration, at the meeting held on 15th January, 1945.) *Refrigeration, Cold Storage and Air Conditioning* 15 : 23–25, 32.

Scott, W. J., and Gillespie, J. M. (1944).—Tests for quality in egg pulp. 2. Further experiments on the resazurin reductase test. *J. Coun. Sci. Ind. Res.* (*Aust.*) 17 : 299–304.

X. FISHERIES INVESTIGATIONS.

1. *General.*—The specialized work performed by certain of the Division's officers for the Department of War Organization of Industry was continued. Late in the year this work was absorbed under the Department of Post-war Reconstruction, concentration being on those aspects which gave promise of being of especial value after the war. With the partial easing of the severity of war-time conditions it was found possible to give increased attention to

research requirements, and the scientific staff was increased. As a result, the programme of research was expanded somewhat. The work was, however, still hampered by the shortage of suitable boats.

2. *Work of the Tasmanian and Victorian Stations.*—(i) *Developmental Work.*—(*a*) *Demersal Fishing.*—Work by the Tasmanian fisheries vessel *Liawenee* in connexion with the testing of the southern Tasmanian trawling grounds, a project in which the Council is collaborating with the State Department of Agriculture, has been continued. The success of operations is being assessed in relation to the catch rate of 9 cwt. (of king flathead, the main species) per day's absence from port, this level being about the minimum at which a commercial Danish-seiner could operate profitably, at the average pre-war price of 4d. per lb.

As reported last year, the catch rate for the whole period between February and June, 1944, was much higher than this minimum payable rate, indicating excellent commercial prospects. However, in July and August the rate of take fell to an unprofitable level, and the vessel was put on to work elsewhere for a time. When she returned, in October, the position had recovered to the extent that operations were just payable, and this continued until the end of the year. A quick improvement to very good conditions in the autumn, similar to that of the autumn of 1944, was then looked for, but instead the position became worse, and for the five months January to May, 1945, there was only one, April, for which the catch rate just bettered the minimum payable rate mentioned above, being 9½ cwt. per day's absence on average (compare previous April with 24 cwt.). It is, therefore, necessary to continue the tests for at least another year before any clear assessment of the value of this area for commercial trawling is possible, since, taking autumn as the optimum period, there have been in succession one very good and one very bad season. There are grounds for believing that the poor condition is the abnormal one, since the scarcity of flathead seems due to a direct reaction of the migrating fish to some change in their environment (*see* Section 2 (ii) (*c*), king flathead), and there have been some unusual features in the Tasmanian fisheries some or all of which may also have been correlated with this change (*see* Section 2 (iii)).

The total catch of all edible fish taken by the *Liawenee* to date is rather more than 250,000 lb. All this has been placed on the markets in Sydney and Hobart ; thus it will be seen that, from the standpoint of contribution to production alone, the experiment has been fully justified.

(*b*) *Pelagic Fishing.*—Initially the more important part of the Tasmanian developmental work, and still likely to prove of much greater final value than the demersal work, the pelagic fishing tests received less attention in the (optimum) autumn season of 1945 than in several previous years. So far as horse-mackerel, the principal species, was concerned, this was due to inability to procure a suitable net. A suitable net was ordered from the United States of America, but it was not possible to have it to hand in time for the 1945 season, although it has been promised for the autumn of 1946. For the sake of continuity it was decided to conduct some mackerel work for a limited period in the 1945 season in any case, using the best net available, in the hope that shoals of large fish might be found under circumstances which would permit successful fishing with it, although it was realized that the chances were rather small. These chances were further diminished by unusually poor weather during the period of the tests (which were made by the private vessel *Mary*), which resulted in very few good shoals being seen, and none at all under the conditions necessary for success with the obsolete net carried. This disappointing result, however, is clearly irrelevant to the main pattern of the effort to date, which on the whole permits of some optimism in the matter of taking mackerel commercially by purse-seine. It might be mentioned that aerial observations indicated that mackerel shoals were no less plentiful than in former seasons in periods of good weather.

The *Mary* and another private vessel, the *Veletta*, also participated, in collaboration with the Council and the Tasmanian Department of Agriculture, in some further fishing trials upon sprats, during the autumn of 1945. Some hauls were made with the lampara net, though catches were smaller than in other years. It can now be said that this species is potentially much less important than the mackerel in these Tasmanian waters, and it is difficult to see how sprat fishing could be payable save as an adjunct to some other form of effort, like barracouta or scallop fishing, in the same waters, a consideration which is now receiving some attention in the trade. The fish seem to occur in but a few rather circumscribed areas, and shoals are found on only about one day out of every nine at the optimum season.

(ii) *Biological Investigations.*—(*a*) *Pelagic Fish—General.*—The general studies upon the abundance of pelagic species in the various waters of south-eastern Australia, mentioned in the last annual report, are approaching finality. The bulk of the data consists of the records of shoals in the logbooks of the *Warreen* and seven other vessels, which at the end of 1944 had spent a total of 1,297 boat-days at sea upon this work (mainly). The waters best studied were those of the north and south coasts of New South Wales, and north-eastern and south-eastern Tasmania ;

only on the New South Wales south coast, where all important pelagic species are affected, do annual fluctuations in abundance seem very important. The general results indicate that an attitude of moderate optimism regarding the potential value of these resources for commercial development is quite warrantable, although everything will depend upon the success of the fishing methods to be used.

(*b*) *Clupeoid Fish* (*Pilchards, &c.*).—The lack of proper boat facilities continued to hold back the programme for the appraisal of these resources (potentially very important for live-bait for tuna fishing) in Port Phillip Bay, and in any case both pilchard and anchovy were unusually scarce during the 1944–45 season there. Some arrangements have, however, been made for fresh fishing trials (by night lampara fishing) upon pilchards in New South Wales waters, and it is hoped that these will be undertaken soon; there are also some possibilities for similar work in South Australia. Once a reasonably satisfactory method for catching these fish is devised, the way will be clear for a fully sustained test of the commercial prospects of tuna fishing with live-bait in south-eastern Australian waters; since the work of the *Warreen* has already shown that this method gives good results when bait is available, the matter is clearly one of extreme importance for post-war development.

Work on the age and growth of the pilchard continues, and similar research has been begun upon the anchovy. Materials for raciation studies on the pilchard are also being accumulated, and there is further evidence that the Victorian pilchards, even those in the east of the State, are a distinct population from those of New South Wales; while the latter themselves now seem divisible into two major populations or groups of populations, referable in general terms to waters north and south of Sydney respectively. As a result of the abundance studies on pelagic fish mentioned above, it has been found possible to ascribe the very abundant runs of pilchards which occurred on the New South Wales south coast in the spring of 1940 and winter of 1941, to what must have been (applying results of age-studies) a particularly good survival of spawn in the winter of 1939 (since the parent population was relatively small in that season). This work indicated the possibility of correlating fluctuations in pilchard abundance with environmental conditions at appropriate previous seasons, and, in consequence, of predicting such fluctuations one or two years ahead; the importance of such research to the potential pilchard and (from the live-bait aspect) tuna fisheries, is obvious.

(*c*) *King Flathead.*—This fish, the principal item in the trawl catches in southern Tasmania, is specifically identical with the tiger flathead taken in the New South Wales trawl fishery, *Neoplatycephalus macrodon.* By continuing to accompany the Tasmanian fisheries vessel on about half the cruises made, the officer conducting this research has been able to amass further data as to size, maturity, &c., thus sampling the catch to an extent and with a regularity not previously achieved in any previous offshore investigation. While the potential importance of the species in these southern Tasmanian waters may possibly be limited, this research should also prove useful in many ways when biological work is begun upon the fish in New South Wales. Actually, such work was begun when the *Liawenee* visited those waters in August and September, 1944, and among other things it was then found possible to tag over 2,000 fish. Age-studies upon the flathead are also due to commence.

The length-frequency polygons of samples taken by the *Liawenee* in the autumn of 1945 were virtually identical with those for samples of the previous autumn. It is known that two and possibly three age-groups are represented. It follows, therefore, that the scarcity of flathead in the 1945 season was almost certainly due to a direct reaction by the fish to some change in the environment, since any previously established "poor-brood" effect in respect of some age-group would have revealed itself in such extensive material (*see* Section 2 (iii)). The same data rule out the suggestion of scarcity due to overfishing, though this is of course a purely theoretical possibility in this instance.

(*d*) *Other species.*—Through co-operation of two canning firms, good series of samples of whitebait were obtained from several Tasmanian rivers during the spring of 1944, and an investigation of this material will be commenced shortly.

An attempt was made to visit north-eastern Tasmanian waters to check upon the scarcity of striped tuna which had been reported from the aerial surveys in the autumn of 1945, but no proper survey was made, and the results, while negative as regards tuna, are inconclusive. If these tuna were scarce or absent it could be regarded as most unusual, since over five successive previous seasons (1938–42) they were very abundant and stable in their level of abundance there from year to year (*see* Section 2 (iii)). Aerial reports of abundant salmon shoals in this area were confirmed.

Some assistance was given to the Victorian Fisheries Department in checking the results of its bream research and helping to prepare the case for increased size limits and other management measures.

Biological data upon sharks have been secured from material fished by the *Liawenee* in Tasmania.

(iii) *Oceanographic Work.*—Arrangements have been made with the Tasmanian Department of Agriculture whereby the *Liawenee* is made available at suitable intervals to resume the hydrological and planktological work previously carried out by the *Warreen* at certain stations off the east coast of that State. This work began in January, 1945, and is continuing. It is particularly valuable to have thus been able to sample the environment under the abnormal conditions that seem to have been prevailing recently, and the probable bearing upon fish-stocks fluctuations is again obvious. Reasons have already been given (Section 2 (ii) (*c*)) for believing that some critical environmental change made its appearance in the summer of 1944–45, if not slightly before, and this may be correlated with the apparent scarcity of striped tuna, the most conspicuous abundance of barracouta, the appearance of the very rare sea-elephant, and possibly other unusual features of the summer and autumn of 1944–45 in Tasmanian waters. Since the flathead and striped tuna are to be regarded as "warm-water" organisms, and the barracouta and sea-elephant as more typical of somewhat cooler seas, one would be tempted to suppose some incursion of colder water into the Tasmanian region, but the position might well prove less simple than this and the results of the hydrological work must be awaited. Moreover, it is not established that the barracouta and tuna fluctuations were actually of the same type as for the flathead.

A special line of hydrology-plankton stations is also being worked monthly in the D'Entrecasteaux Channel, which is the principal scallop ground and area of sprat occurrence.

(iv) *Statistical and Economic Investigations.*—Some imperfections in the system for compilation of statistics of fish catch in Tasmania have been revealed, necessitating revision of earlier compilations and some alterations to the method of obtaining returns. This work, which will eventually form part of a general history of the Tasmanian fisheries, is receiving attention.

(v) *General.*—The services of a fish measurer for the Melbourne market, employed jointly by the Council and the Victorian Fisheries Department, were obtained during the year under review. This work is considerably assisting the barracouta and salmon investigations. Relations with the Tasmanian and Victorian fisheries authorities continue to be very close and fruitful.

New premises, made available by the Tasmanian Department of Agriculture, were occupied during the year by the officer resident at Hobart, enabling the initiation of laboratory work there. However, there is scope for an increased staff at that station, and larger premises will therefore eventually be required. This matter is receiving attention.

3. *Investigations in Western Australia.*—(i) *Western Australian Station.*—This was the second year of operation of the Western Australian station, operating along a section of the Australian coastline which ranks among the least known, as far as marine conditions go, of any in the Australian Commonwealth. It was realized that the first task must be a survey of the resources, and this has been a keynote of the work during the year. Further, in view of the need to step up the production of food, an endeavour has been made to increase canned fish production. Activity in general has been greatly handicapped by a lack of personnel, of boats, and of equipment: the two officers stationed for boat and land work were responsible for a coastline of some 1,500 miles (roughly from Melbourne to Rockhampton) and had no proper sea-going boat.

The Division's resident staff in the State has been increased to two, and in addition specialist work is being carried out from time to time by visiting officers (e.g., on aerial reconnaissance and sharks).

Part-time services were rendered by a research student of the Department of Biology of the University of Western Australia, until his departure on 21st February to take up an appointment at Cronulla. Inspector L. G. Smith of the State Fisheries Department replaced Inspector A. K. Melsom as technical officer attached to the Western Australian station. The other fisheries inspectors continued their material aid to the Council for Scientific and Industrial Research investigations. Boat facilities were again provided by the Fisheries Department, the Royal Australian Navy, the Harbour-Master at Albany and private owners and fishermen. A 56-ft. lugger, *Isobel*, has been chartered for a fisheries survey during the coming year.

(ii) *Hydrography and Plankton.*—The monthly survey of the Swan River system at eighteen stations from the mouth to Upper Swan has now been carried on for a year and a bi-annual survey has been made of Peel Inlet, Leschenault Inlet and its rivers, Vasse and Wonnerup Inlets, Margaret River, Hardy Inlet, Wilson's Inlet, Torbay, the Albany estuaries and certain other waters. Surveys have also been made in the Geraldton, Shark Bay and Abrolhos areas.

(iii) *Ocean Current Investigations.*—The programme outlined in last year's report has been continued regularly.

(iv) *Biological Investigations.*—(*a*) *Southern Bluefin Tuna.*—(1) *Western Australia.*—During the year this species was identified 90 miles north of Fremantle, considerably beyond its known range. Specimens were taken from a naval vessel during January, 1945, and belonged to the second year group. Tuna research is supervised by the officer-in-charge of the Western Australian station, and the following observations are, therefore, added here.

(2) *Eastern Australia.*—New South Wales experienced the second successive good bluefin season in 1944. The season was unusual in that the second year group (the smallest size found in the coastal runs in the east) failed to appear last October as is normal but showed up in January.

(3) *South Australia.*—Sampling was continued by members of the South Australian Big Game Anglers' Club. The relative abundance appeared to be comparable with that of the 1938–39 season, though the season opened with smaller numbers. An unusual event was the finding of an adult female, weighing 116 lb. stranded at Semaphore beach on 2nd May, 1945. The specimen had recently spawned and is interesting in being the first of these large adults reported in recent years away from the King George Sound region in Western Australia.

(*b*) *Other Species of Tuna.*—During the year two further species of tuna have been added to the fish fauna of Western Australia, namely, the albacore (*Thunnus germo*) and the striped tuna (*Katsuwonus pelamis*). A 41-lb. albacore was found washed up on the beach at Quindalup, near Busselton, on 6th March, 1945. This species has not hitherto been recorded outside of south-east Australia and the Quindalup specimen indicated that a population exists off the south-west coast also. Its economic possibilities are as yet unknown. Two specimens of the striped tuna were identified from the Geraldton-Abrolhos area in February, 1945, and evidence was adduced that the species also occurred near North West Cape in January, 1945. Reports of aerial surveys suggested that this species was not abundant during the 1945 season in the Bass Strait region. Unfortunately, boat surveys there could only be made in a very restricted way.

(*c*) *Mackerel and Pilchards.*—Great occurrences to the east of Esperance were observed from the air during June, constituting the largest aggregation of fish ever seen since the inception of the Division's aerial observations in Australia in 1936. The occurrences are dealt with separately in this Report. Considerable occurrences of an unidentified pelagic fish were also seen in Shark Bay during October, 1944, and boat observations by a former inspector of the Fisheries Department (now with the Royal Australian Navy) refer to similar occurrences about the same time in 1942 and 1943. If the observations refer to the same fish, the combined reports indicate a consistency of occurrence of economic significance.

(*d*) *Perth Herring.*—Regular field and cannery sampling of this species continues, and tagging has been added to the field operations.

(*e*) *Sharks.*—*See* Section 5 (i).

(*f*) *Mullet.*—Following on repeated complaints of the fishermen upon the working of the conservation scheme introduced at the instance of the Council for Scientific and Industrial Research in 1942, an investigation into the local problem was made in association with Mr. E. J. Brownfield, the Acting Chief Inspector of Fisheries. A special report has been prepared.

(*g*) *Sea-Bird Fluctuations.*—The co-operation of a group of Sydney observers was continued during the season of 1944–45, and the results confirmed earlier work of a negative correlation between mutton-bird mortality along the Sydney beaches and tuna abundance. Comparatively few dead birds were counted during the critical period, October to December. It is intended to make this work an official laboratory activity henceforth.

(v) *Agar-Agar.*—Samplings of likely areas for *Eucheuma* and *Gracilaria* have continued and samples have been sent to Cronulla for further examination. Cannery requirements of *Eucheuma* agar have been amply met during the year by beach gatherings and there is no commercial exploitation as yet of the *Gracilaria* deposits.

(vi) *Canning Investigations.*—Following on activities by the Division, salmon canning was begun for the first time in the State this year.

(vii) *Charter of the Lugger "Isobel".*—The 56-ft. lugger *Isobel* has been chartered for a period of six months to undertake a preliminary survey of the fisheries resources between Shark Bay and Broome, and is due to begin at the end of June. A variety of fishing gear is being placed on board.

4. *Queensland Investigations.*—(i) *Queensland Station.*—Head-quarters for Queensland investigations comprised the branch laboratory established in Brisbane during February, 1944. Research laboratory accommodation has been made available by the Biology Department of the Queensland University. The Queensland Museum have provided full use of their library and reference collections in respect to taxonomic and developmental studies. Hydrological and plankton equipment has been lent by the Great Barrier Reef Committee.

Owing to war-time restrictions, the 1944–45 programme has been limited mainly to estuarine work centered in southern Queensland and to half-yearly coastal surveys between Brisbane and Sydney. The State Fisheries Department have made available the services of their vessel *Derwent* for work in the Moreton Bay area.

(ii) *Black Bream Investigations.*—Routine measuring and collection of biological data on black bream (*Acanthopagrus australis*) samples has continued. Comprehensive taxonomic and distributional studies are being carried out in respect to this species and all other closely related Australian forms. Results indicate necessary changes in nomenclature and the recognition of at least one new species. Morphological characters exhibiting differences in populations of different localities are being closely studied, and arrangements were made for obtaining samples of key material from all States of the Commonwealth. A paper reviewing the Australian Sparidae is in the course of preparation. Collections of post-larval and juvenile stages of black bream and tarwhine have been secured with the aid of a specially developed type of net. These collections refer to Noosa River and Bribie Passage for one year at approximately monthly intervals. In October similar collections were made at all the principal river entrances and lakes between Brisbane and Sydney. The nursery grounds for young bream and tarwhine have been identified as the shallow grassy flats and creeks within a mile or two of the river entrance where spawning took place. Their growth rate during the first year of life has been studied directly and agrees closely with former conclusions based on age determination by scales, &c. A more precise idea of early movements and the extent of the spawning season has been obtained. Illustrated descriptions of postlarval and juvenile black bream and tarwhine, comprising planktonic, transitory and littoral stages, have been included in a paper prepared for publication.

(iii) *Spanish Mackerel Investigations.*—Studies relating to age determination and growth rate of the barred Spanish mackerel (*Scomberomorus commerson*) and school mackerel (*S. queenslandicus*) have continued and tests were made regarding the use of otoliths for this purpose. It has been shown that it is unnecessary to section or machine-grind according to standard technique, and a special method of clearing has been developed.

Field observations and collection of biological data relating to school mackerel in Moreton Bay were carried out during July, 1944.

Data regarding the occurrences of Spanish mackerels in Western Australia have come to hand and identifications were confirmed. *S. commerson*, *S. queenslandicus* and *S. semifasciatus* have been shown to occur on the west coast as well as the east and distribution maps for the Australian region have been completed. Further information relating to the occurrence of and local habits of, all these species at Fiji and neighbouring islands has come to hand.

(iv) *Golden Perch Investigations.*—A survey of the inland fresh waters of the Thomson and Landsborough Rivers at Longreach and Muttaburra, central west Queensland, in respect to the golden perch or yellowbelly (*Plectroplites ambiguus*) was carried out during May, 1945, on behalf of the State Fisheries Department. Studies were related to the life history, the extent of stocks, the practicability of netting, and the possibility of establishment of inland hatcheries for restocking, either at Longreach or on the head waters of the Murray-Darling system.

(v) *Fish Eggs and Larvae Investigations.*—Routine plankton tow nettings for fish eggs and larvae have continued in estuarine waters. A series of monthly collections from the Noosa River have been assembled over a period of eleven months. These have been supplemented by other comprehensive collections from Caloundra, Moreton Bay, and from all the principal estuaries and coastal lakes of New South Wales as far south as Port Hacking. In addition to p'anktonic material, collections of littoral postlarvae and juveniles have been obtained by netting in all these localities. Sorting and preliminary identifications have been kept up to date, and a number of drawings of the commoner estuarine species have been prepared and some series assembled ready for description. A paper, the first of one of several series on Queensland material, has been prepared describing planktonic and early littoral post-larval stages of eight common estuarine species including four of special economic importance.

Artificial hatching work on the naturally spawned eggs of a number of fish species was carried out at Caloundra during July, 1944, and again in January, 1945. About twenty types were isolated, hatched, and reared to more advanced stages. Preliminary description and illustration has been completed and several common planktonic egg and larval types have been associated with one another. From this fundamental work much useful information has resulted concerning spawning seasons, habits and spawning grounds as well as recognition of larval characters.

Work on the identification and description of the fish eggs and larvae of the *Warreen* oceanic collections of plankton has begun, and detailed systematic studies of some families is under way.

(vi) *Estuarine Plankton and Hydrology Investigations.*—A series of monthly plankton collections has been made at fixed routine day and night stations in the Noosa River, completing a continuous series for one year. Supplementary collections have been made at Caloundra,

Moreton Bay, including a wide survey of fish spawning grounds in the latter area. The first of a series of quarterly collections has been made throughout the principal New South Wales estuaries between Brisbane and Port Hacking.

A programme of observations of estuarine temperatures and chlorinities has been maintained in connexion with plankton collections, principally to give data for correlation with seasonal changes and ecological considerations mainly in connexion with fish spawning-behaviour studies. Apparatus has been installed at Brisbane for the analysis of chlorinity samples.

5. *General Ecological and Associated Investigations.*—(i) *Shark Investigations.*—Shark investigations have continued from Point Cloates to the Bunbury area in Western Australia. A Tasmanian tagged shark (*Flakeus megalops*) was recaptured after two and a half years, close to where it had been tagged; it had not grown perceptibly. In association with the Royal Australian Air Force, tests of shark repellents were made in the field. A list of about 700 species of Western Australian fishes was completed, with an indication of the range of each within the State. Many of these fishes had not hitherto been recorded.

Shark Spoilage.—The bacteria isolated from shark flesh correspond with those obtained from seawater (up to 5 miles offshore) and to those from shark skin immediately after capture and before death. The same types of organism are also obtained from fish holds. Many of these bacteria belong to the genus *Corynebacterium* (*sensu* Jensen), and are closely allied to soil forms. Disinfection of ship holds with chloride of lime was found to be highly satisfactory in destroying spoilage organisms, and is to be strongly recommended.

There is some evidence that the action of shark blood on the flesh increases the amount of ammonia produced. This probably accounts for the partial efficacy of bleeding as a method of control. Dips in sodium nitrate brine up to 0.5 per cent. nitrite have proved successful in delaying bacterial spoilage of shark flesh. In the use of this dip public health standards as regards nitrite would have to be complied with.

(ii) *Australian Salmon.*—Life history studies and routine observations on the stocks of Australian salmon entering the commercial fishery in south-eastern Australia were continued throughout the year. Useful data on the latter subject were received from the Melbourne Fish Market, and from the southern ports of New South Wales. These data are being supplemented by a market measuring system recently reinstituted in Sydney.

Studies on the age and rate of growth of the Australian salmon are progressing, and an improved technique for handling the scales of this fish has been devised.

(iii) *Barracouta.*—Length frequency data from the Melbourne Fish Market, with similar data from eastern and north-western Tasmania have given a useful cross section of the barracouta stocks fished in south-eastern Australia during the past twelve months. The actual occurrences of barracouta have been exceptionally large and wide-spread, although it is certain that, owing to economic factors, these occurrences have not been exploited fully, and this fact must be borne in mind when the catch figures for the several States are analysed. General life history and rate of growth studies are continuing.

(iv) *Scallops.*—The survey of the Tasmanian commercial scallop fishery reinstituted in September, 1944, has yielded valuable data on the life history and rate of growth. Statistical analysis has shown the industry to be stable and capable of marked expansion. The recent development of mechanized dredging equipment has increased production, and the most important limiting factors at present are labour shortage (openers), and restrictions operating directly and indirectly on export of the cleaned shellfish. Just before the opening of the fishing season, 2,000 scallops were tagged and released on several beds in the D'Entrecasteaux Channel. Over 40 tags were returned by 12th June, 1945, and the programme has aroused considerable interest in the industry.

(v) *Oyster Investigations.*—During this year a biologist was appointed to help revive these investigations, the biological side of the work having been on a routine basis for the past few years, although the hydrological section of the programme has been maintained in some strength. In addition, a jetty was constructed at Shell Point to facilitate the observational work there. Stock on the lease has been built up and the Division's holding of cultch has been increased. Arrangements were made for the establishment of an adequate series of material for observation of winter mortality. The programme has now been restored to the point where the following principal lines of investigation may be energetically prosecuted in subsequent years:—
(1) Fundamental studies in the physiology of the oyster with particular reference to reproduction.
(2) Problems in connexion with spatting and the distribution of the spat within an estuary with particular reference to the possibility of devising a system of prediction of spat fall.

(vi) *Fresh Water Fisheries.*—(*a*) *Tasmania.*—On the request of the Tasmanian Salmon and Freshwater Fisheries Commission, a survey of certain trout waters in Tasmania has been undertaken. The primary object of the preliminary phase of the survey has been the determination of rate of growth of trout in the more important waters, and an assessment of the general ecological factors influencing the life and reproduction of the introduced brown and rainbow trout. The area at present under consideration, and from which valuable data already have been accumulated is the Great Lake, and the adjacent Shannon Lagoon.

(*b*) *New South Wales.*—Preliminary discussions were held with the Kosciusko State Park Trust Committee, with a view to devising means for the improvement and expansion of trout fishing in the waters under the jurisdiction of the Trust. The Division advised the Committee of its willingness to act in an advisory capacity and, from time to time as opportunity permitted, to make available the services of its officers for field survey and data analysis.

6. *Oceanographic Investigations.*—(i) *Hydrology.*—(*a*) *Oceanic Investigations.*—Routine onshore investigations have been continued at Jibbon Point, Botany Heads, Ulladulla, Maria Island and other east Tasmanian stations, St. Vincent's Gulf, Geraldton-Abrolhos area. The plotting and analysis of the *Warreen* data have been continued, and the major features of the hydrology of the east Australian onshore area have been established. A relationship between onshore and offshore conditions in the Port Hacking area has been formulated on the basis of these results. This relationship will serve as a working hypothesis for evaluating subsequent changes in onshore conditions.

The onshore station programme in New South Wales will be developed in 1945–46 to include stations in the Port Stephens and Eden area.

(*b*) *Estuarine.*—Routine investigations have been continued in the following areas :—Port Hacking, George's River-Botany Bay, Port Stephens, Lake Illawarra, south-west Australian estuaries, Swan River. A programme of hydrological investigations in Derwent River estuary and associated freshwater lakes in Tasmania has been drawn up and will be commenced early in June.

The investigations into the role of bottom muds in the phosphorus cycle of estuarine waters have been continued. It is now possible to state what mud fractions are responsible for the anion adsorption, and to describe their distribution within an estuary.

Some resistance type thermometers will shortly be installed at Shell Point, and enable a critical evaluation of the possible part played by water and mud temperature in the winter mortality of oysters during the coming season.

(ii) *Marine Plankton.*—The chief catches made by the *Warreen* (1938–42) and later hauls (1942–44) made in New South Wales, Tasmania, South Australia, and Western Australia have now been examined. Adequate series of the dominant food organism (*Nyctiphanes australis ; Euphausiidae*) of the inner neritic waters have been examined. The data obtained are now under review.

The 1944 season in New South Wales was marked by an earlier and more prolific diatom production (1943, July ; 1944, May-June), while the whole season approximated to that of 1938–39.

As in previous years the arrival of the southern bluefin tuna in New South Wales waters coincided with the peak of the salp invasion (*Salpa democratica*) (1943, early September ; 1944, mid-September) and terminated with the disappearance of the swarming phase (1943, mid-October ; 1944, mid-December).

7. *Aerial Observations on Pelagic or Surface Swimming Fish.*—During the year 1944–45, aerial observations were continued as follows. These were made in aircraft specially allotted by the Royal Australian Air Force to the Council for the purpose, whereas previous observations in war-time (1943 and 1944) had necessarily to be made in operational aircraft on missions, some of which were quite unsuitable for the study of pelagic fish.

(i) *22nd August–1st December.*—Flights covered the coast of Western Australia with the exception of that portion of the Great Australian Bight east of Israelite Bay (longitude 123° 50′ E.).

These flights confirmed previous aerial observations of the commercially valuable tuna species in the area broadly between North West Cape and Cape Leveque but the main concentration was between Port Hedland and Cape Leveque. Aerial observations for fish in this part of Australia had not previously extended beyond Cape Leveque, but in the first ten days of November, 1944, a number of flights were made from that point to the State border in the vicinity of Wyndham. Only a few schools of tuna were seen, but records of observations of schools and of actual captures of specimens made by Service personnel in this sparsely inhabited area were obtained ; they show that northern bluefin were numerous from May to July as were also Spanish mackerel. The fewness of the shoals seen from the air is consistent

with the ground reports of the tuna having vacated the area in August. As on previous occasions numerous shoals of herring-like fish, of which there are several species, and atherines were observed in the north-west of Australia broadly between North West Cape and Port Hedland.

A large occurrence of small fish comprising about 1,000 shoals, many of which were large, was observed in Shark Bay in October and in smaller quantities in September and November. Unfortunately, these fish could not be positively identified at the time although their size could readily be determined. It is considered very likely indeed that they belonged either to the mackerel or to the herring families. Though some action was taken by the shore administration to secure specimens of these fish it proved inadequate.

No other notable findings were made on the Western Australian coast during these flights. As usual, records were made of the distribution and the nesting places of important seabirds for which the aeroplane is proving especially suitable. The distribution of such animals as whales, seals and dolphins or porpoises was, as usual, also studied.

During the flights the aircraft was able to direct a Royal Australian Air Force-Council for Scientific and Industrial Research research party engaged in testing a shark repellent to the areas where sharks were more plentiful.

(ii) 21*st March*–27*th April*.—Flights covered the coast of south-eastern Australia from Port Hacking (near Sydney) in New South Wales in the east to longitude 131° 30′ E. (near the head of the Great Australian Bight) in South Australia. The coasts of Tasmania and Victoria were also covered but not the upper parts of Spencer and St. Vincent's Gulfs in South Australia.

These flights were made in an area which, since 1936, has been fairly regularly surveyed either by boat or aeroplane, and; in the absence of the research vessel *Warreen*, were undertaken to see if the various pelagic species which had been found in the past to occur at this time of the year were present in quantity. The opportunity was also taken to assist the ketch *Mary*, which was engaged in purse-seining experiments in the capture of horse mackerel in southern Tasmania, but which had failed to locate these fish in quantity.

The flights soon located large quantities of mackerel in south-eastern Tasmania and the *Mary* was directed to them. Many shoals of Australian salmon were also observed in north-east Tasmania. It is estimated by the aerial observer that some of these shoals contained at least hundreds of tons and possibly thousands of tons. A local fish cannery executive who was given an opportunity to view the shoals observed, "I very much doubt if we could have processed the amount of fish that were contained in some shoals in twelve months' constant operations, they were so large".

Contrary to experience since 1937, no striped tuna were seen in north-eastern Tasmania or in the vicinity of Flinders Island, where they usually occur in great quantities at this time of the year. The area was surveyed on several occasions under suitable conditions and the observer has no hesitation in concluding that the fish were not present on this occasion. It is notable that krill or whalefeed, for which the striped tuna show such a marked preference, was also not observed in this area as is usual at this time. Muttonbirds also were very scarce in the area where it is customary to see them in large flocks.

Observations in South Australia disclosed a fair amount of tuna and a considerable number of pilchard shoals, especially on the west coast. So far as tuna is concerned the impression was formed (as in previous years) that at this time of the year the tuna season is waning.

During these flights opportunities were taken to observe and photograph congregations of seals throughout the whole area. It is evident that the main concentration of these animals is in Bass Strait.

During the flights in Tasmania records were made of the distribution of kelp beds for possible industrial utilization. Some of these beds are quite large and are to be found mostly on the east and south coasts of Tasmania.

(iii) 15*th May*–10*th June*.—These flights are still in progress; their main purpose is to make a further survey of the coastal waters of Western Australia and to co-operate as scout for the lugger *Isobel* which has been chartered by the Council for an investigation of the marine resources of the north-west of Australia following favorable results of aerial observations during 1943 and 1944.

The aircraft for this purpose was made available at Melbourne, and during the flights to Western Australia the opportunity was taken to examine the waters of the south coast of Australia from Melbourne to Perth with the exception of the upper portions of the Spencer and St. Vincent's Gulfs in South Australia and of about 200 miles of the central part of the Great Australian Bight which could not be covered owing to the restricted range of endurance of the aircraft.

At the present time (10th June) this survey has not extended north of Perth. Of outstanding importance is the discovery in the western portion of the Great Australian Bight between Cape Arid (longitude 123° 10′ E.) and longitude 124° 30′ E. of a vast occurrence of fish

comprising pilchards, blue-mackerel and Australian salmon. Of these, blue-mackerel predominated and the number of Australian salmon was relatively unimportant. The aerial observer regards this occurrence as the greatest he has seen and as comprising 10,000 shoals at the barest minimum. He believes that the actual number was very much greater.

Another officer of the Council, who accompanied the aerial observer on a subsequent inspection of the shoals under conditions not so favorable for their appearance, estimates that the shoals numbered tens of thousands. These shoals extended seawards to about 15 miles at most and the predators in the form of birds or dolphins were remarkably few. Numerous shoals of mackerel were also observed at several points on the remainder of the south cost of Western Australia. The pilchard (the sardine of commerce) is well-known for its canning qualities. Tests have established that the blue-mackerel also makes an excellent pack.

At the time this report was prepared the lugger *Isobel* had not commenced her investigations, and there had been no aerial observations in the northern part of the State.

8. *Seaweed Investigations.*—(i) *Taxonomy.*—Studies on algal taxonomy have been continued as an essential adjunct to the Division's work on algal products, so that biological and chemical work will not be vitiated by being based on inadequate or inaccurate identification.

During the present year studies have continued on the taxonomy of certain Rhodophyceae, particularly the genus *Gracilaria*, of especial importance at present because of its agar-producing qualities. This genus is now recognized as consisting in Australia of some nine usually polytypic species, each with a range of forms (one to eight forms per species). Some of the so-called species recorded in Australia by earlier workers are now recognized as being merely forms of other known species. This interpretation of the genus leads to a simplification in identification of the species for the non-specialist, while still retaining form distinction for recognition when more detailed work is required. *Gracilaria* has been the genus on which most interest has centered, but others have also been studied, particularly the agar-rich genera *Gelidium* and *Pterocladia.*

Eucheuma is the genus used for agar production in Western Australia, and three species of this are now known, where only one had been recorded previously from the districts surveyed.

Routine examination has continued of plants collected by officers of the Division. This includes material from Queensland, New South Wales, Tasmania and Western Australia. In addition, a certain number of plants has been submitted by other workers (additional localities being from Western Australia, South Australia, Victoria and New Zealand).

Herbarium examination has been extended so that specimens labelled *Gracilaria* from all University and Herbarium collections in Australia have been examined, in addition to certain exotic plants. This extensive examination has been particularly valuable in yielding information regarding geographic ranges and variations in the different species. During this work it was found that a large number of well-recognized genera have been erroneously labelled *Gracilaria* by earlier workers.

During the year two papers have been published, and a third is in the press.

(ii) *Technology—Agar Production.*—Research on agar has continued in close co-operation with manufacture, and manufactured Australian agar has been reported on very favorably by the Imperial Institute, London, as being satisfactory for food purposes. Its use for bacteriology is not so certain, although it is used satisfactorily for routine work in this laboratory. The only real disadvantage is the high setting point, which is about 40° C. in a 1.5 per cent. sol compared with about 35° C. for New Zealand agar, and 31° C. for Japanese agar under the same conditions.

An adequate method of determining setting points has been worked out, and is now being used to determine the effect of various processes on the setting point of agar. It has been found that despite the high viscosity of *Eucheuma* agar and of *Gracilaria* agar from Tasmania, the setting points of both these agars compares well with Japanese agar, and is lower than New Zealand agar. *Hypnea musciformis* gives a still lower setting point. There seems a possibility at the moment of making satisfactory bacteriological agar from any of these three seaweeds, and sufficient quantity seems available to provide Australia's small needs.

(iii) *Field Surveys.*—Surveys have been continued resulting in the discovery of large areas of *Gracilaria* beds in Moreton Bay. These beds have not yet been examined when mature, so it is not possible to conjecture the amount of seaweed available. The areas are many times larger than those already discovered. It seems possible to establish an agar industry in Queensland based on Moreton Bay seaweed.

9. *Other Work.*—(i) *Netherlands East Indies.*—A tentative plan of development, to assist in the rehabilitation of the native fisheries of the Netherlands East Indies, was drawn up in consultation with the Netherlands East Indies Liaison Office, and submitted for consideration by the Dutch Government. The exigencies of the war situation prevented immediate action on the lines suggested in the plan, and the matter is held in abeyance.

(ii) *Descriptive Material.*—Drawings, keys and descriptions of a number of Western Australian sharks and fishes have been prepared. Hundreds of fishes have been identified from various parts of Australia and the south-west Pacific for servicemen, museums, and the public and many inquiries from individuals and institutions concerning sharks, fish and fisheries have been answered. Work has continued on the vernacular names catalogue which is of added importance now in connexion with the Prices Commission.

10. *Publications.*—During the year the following papers have been published :—

May, Valerie (1945).—Report on systematic work on red algae in Australia. *J. Coun. Sci. Ind. Res. (Aust.)* 18 : 62–68.

May, Valerie (1944).—Studies on Australian marine algae. 1. *Proc. Linn. Soc., New South Wales* 69 : 226–228.

XI. NATIONAL STANDARDS LABORATORY.

In April, 1945, each of the former three Sections of the National Standards Laboratory was given the status of a Division, being known as the Division of Metrology, the Division of Electrotechnology and the Division of Physics. The three Divisions have their head-quarters at the National Standards Laboratory, and the library, drawing office and workshop are continuing as common services.

XII. METROLOGY.

1. *General.*—The Division has continued to assist Production Directorates of the Ministry of Munitions and industrial organizations concerned with Defence activities, in matters relating to inspection, design and examination of gauges, measuring equipment and precision toolroom equipment. It has continued to be responsible for supply of certain measuring equipment ; for periodical calibration of testing machines and accessory equipment ; for the certification of volumetric glassware and weights ; and for the reconditioning of balances and reporting on their performance. The Division issued 879 certificates, reports and statements of examination.

Accommodation problems have become more acute as the initial work on the new wing has compelled evacuation of a number of valuable rooms. The vibration already experienced leads to the expectation of a reduction in the quantity and quality of high grade work for some time.

The Chief of the Division is a member of the Australian Council for Aeronautics, Optical Panel Advisory to the Secondary Industries Commission of the Ministry of Post-war Reconstruction, and the Scientific Instrument and Optical Panel of the Ordnance Production Directorate. In addition, the Division has been represented on Committees of the Standards Association of Australia.

2. *Standards, Gauges and Measuring Equipment.*—Standard end-bars certified by the National Physical Laboratory were recently received, and the opportunity was taken for an intercomparison of the standards of the Division and of end-bars of Munitions Supply laboratories.

The facilities provided by the equipment for making slip gauges permitted a development in the measurement of the pitch of screws in terms of slip gauges. Work has been concluded, and the result is wholly satisfactory. A recent development in technique has been used in an investigation on supply of standards for the calibration of equipment for the measurement of surface finish. The results to date are promising.

Change in the war situation and organization of Ministry of Munitions has been responsible for some reduction in the number of gauges submitted for examination. The work, however, has not eased, as greater complexity compensates for the reduction in numbers. A check gauge centre has been set up to provide a 24-hour facility in the examination of ring screw gauges. The Division continues to advise industrial organizations on the selection, care, use and installation of measuring equipment.

A course of lectures on " Metrology in Engineering " has been supplied for final year engineers of the University of Sydney, and lecturers have been provided for the relevant sections in the new course in Production Engineering, recently established at the Sydney Technical College under the auspices of the Institution of Production Engineers. The Division continues to be visited by educational authorities, manufacturers, inspection services and toolroom staffs.

3. *Manufacture of Measuring Equipment.*—The Ministry of Munitions was supplied with 200 workshop projectors, as well as a considerable number of slip gauges and some bench micrometers, both large and small. An additional order for pitch measuring machines is in progress, and an improvement in design has shown the later machine to be an advancement over those previously supplied. The special facilities of the laboratory have been used to a greater extent by other Divisions of the Council for the design and construction of equipment.

4. *Mechanical Engineering.*—Test houses, their staffs, methods, equipment and accessory devices have been examined regularly on behalf of the various inspection authorities. Gear has been devised to enable special tests on equipment to be made for advising the Services as to suitability under war conditions, and considerable assistance has been given to industrial organizations on elimination of vibration in turbine rotors, machine tools and other equipment. On behalf of the Australian Cement Manufacturers' Association, a survey of the works laboratories is now being undertaken. All equipment used in testing is being examined and calibrated, and co-ordination of tests is being undertaken.

5. *Volumetric Glassware.*—A considerable quantity of high grade volumetric glassware has been received for calibration, and assistance is being given to manufacturers in the development of new products. In general, the calibration equipment of the manufacturers is adjusted at the laboratory, and gauges and other equipment certified before commencement of production. The Division has taken a considerable part in discussions on design and calibration of pharmaceutical measures which, at present, are very unsatisfactory. It is hoped that the Division's efforts will result in a considerable improvement.

6. *Mass.*—The basis of mass standardization has until recently been precarious owing to inability to obtain balances and masses ordered from Britain five years ago. With the assistance of the United States National Bureau of Standards, mass has been put on a satisfactory basis by the acquisition of certain standards of mass. Local manufacturers have made interesting developments and their production shows considerable ability to meet certain demands.

7. *Barometry.*—Inspection services and air-line operators continue to make demands on the Division.

8. *Hydrometry.*—Assistance has been given in the design of special hydrometers and inspection of general local production has been undertaken.

9. *Time.*—Discussions have taken place on the work to be done on the maintenance of time and frequency standards. With the development of the quartz clock, it is now proposed that the standard of frequency to be maintained by the Division of Electrotechnology in conjunction with the Commonwealth Observatory, Stromlo, will be the source of time-keeping to be used by the Division of Metrology. Equipment available, however, enables present demands to be met.

XIII. ELECTROTECHNOLOGY.

1. *General.*—The two major Defence projects in which the Division of Electrotechnology has been engaged since the establishment of the National Standards Laboratory in 1940 have recently been brought to a successful conclusion, and, as a result, it has been possible to intensify the development of the normal facilities of the Division. Consideration has been given to the resumption of the normal work for which the Division was established, and several important items of equipment, which had, of necessity, been neglected during the critical early years of the war are now being instal ed. However, during the period covered by this Report, the major effort of the Division has been concentrated on confidential Defence investigations, and little progress was made in other fields.

The recent formation of an Electrical Research Board under the aegis of the Council for Scientific and Industrial Research should assist considerably in the co-ordination of the Australian effort in electrical research, and doubtless influence the future programme of the Division. The Chief of the Division is a member of that Board.

Preliminary discussions have been held with officers of the Commonwealth Observatory and the Postmaster-General's Department with regard to the proposed establishment of standards of time and frequency, and time distribution, and plans are being made for the establishment of the national standard of frequency. The Division has been represented at many meetings of the Sectional Committee on Radio Materials and Apparatus of the Standards Association of Australia.

The co-ordination of the plans for the extension of the existing National Standards Laboratory building was undertaken by the Division. The final plans and specifications have been carefully examined. Contracts for the building, air-conditioning and ventilating, and temporary garages have been let by the Allied Works Council, and the building contractor has commenced excavating and demolishing operations.

2. *Confidential Investigations.*—The two major Defence projects for the Army and Navy have been completed. Several minor investigations of a confidential nature have been undertaken on behalf of the Services, from time to time, as requested.

3. *Standardization.*—(i) *Direct Current.*—Routine adjustments and calibrations have been carried out on a number of the Division's measuring instruments. In particular, a check of the build-up of standard resistors carried out in 1942 has been completed, and very good agreement has been obtained; the temperature coefficients of several standard resistance coils have been determined.

An electronic voltage stabilizer has been developed for use with the alternating current power supply for loads up to 250 V.A. Test results have been satisfactory, and the final design of the amplifier to be used is in hand. The purpose of this equipment is to avoid the necessity for installing a high voltage storage battery. It has been found that the present equipment for measuring insulation resistance has insufficient range to meet all demands, and a new method is being developed for extending the range.

(ii) *Power Frequency.*—Progress has been made with the frequency and voltage control of the Sine Wave Alternator Set, but considerable effort is still required to complete this work. The major difficulties in setting up the electrostatic voltmeter appear to have been overcome, and it should be possible to put the instrument into service reasonably soon, and so to enable all A.C. measurements to be related to the fundamental standards. Consideration has been given to the methods of calibrating voltage transformers, and a special amplifier and filter unit has been built. This work is proceeding.

(iii) *Audio and Radio Frequencies.*—Further comparisons of laboratory standards and the subdivided mica capacitor on loan from the United States National Bureau of Standards have been carried out. It is proposed to measure inductance in terms of capacitance standards which will be calibrated against resistance and frequency, and a Maxwell-Wien Bridge will be built for this purpose. A dielectric test set is being built for tests at frequencies up to 100 megacycles per second.

4. *Tests and Investigations.*—During the year 95 formal reports of tests have been issued by the Division. The items tested comprised mainly indicating instruments, resistors and resistance boxes, bridges, potentiometers, capacitors, permanent magnets, electrical insulating materials and fire control instruments.

In connexion with the testing of signal generators for the Army, suitable equipment has been obtained from abroad and is being installed in a specially constructed screened room. One outstanding component is awaited before the routine testing of signal generators can be undertaken. A prototype model of a viscometer for opaque liquids has been developed for the Army. At the request of the Division of Physics, three similar detector units have been constructed. Other miscellaneous investigations completed include tests of valve-testing equipment for the Department of Munitions, various magnetic measurements, and the development of fault-finding equipment for the New South Wales Department of Railways.

5. *Tropicproofing Investigations.*—During the year, it has been possible to extend considerably the programme of research and the scope of climatic and durability tests which can be undertaken in this Division on telecommunication materials and components. The appointment of a chemist has enabled research of a chemical nature to be initiated; methods of measuring water vapour diffusion have been established; and several important items of additional equipment have been acquired. In addition to temporary accommodation available in a chemical laboratory in the grounds of St. Andrew's College, University of Sydney, more laboratory space has been found in the main laboratory building for the tropicproofing group. The officer in charge of tropicproofing investigations spent eleven weeks in New Guinea between September and December, visiting Australian and United States Army and Air Force formations, as a member of the Tropical Scientific Section of the Scientific Liaison and Information Bureau, to obtain at first hand a knowledge of the conditions encountered.

The development of standardized humidity chambers and of improved climatic testing procedures in order to achieve reproducibility of test results is regarded as a most urgent project, and the main efforts of the tropicproofing group, in collaboration with the Division of Physics, have been concentrated on this investigation. Information regarding the application in a small humidity chamber of a precise automatic electronic method of control of relative humidity, together with proposed procedures for climatic testing of telecommunication equipment, has been prepared for submission to the Fighting Services, the Standards Association of Australia, and other interested organizations in Australia and overseas. The proposed methods of control and testing are regarded as a considerable advance over those which are used at present.

Qualification testing of telecommunication components and materials has been continued. More effective and immediate use of the results of such tests has been made possible by the formation, within the Inspection Division, Army, of the Chief Inspector of Engineer and Signal Stores Approval Advisory Committee No. 1, which was formed for the purpose of expediting Army approval of satisfactory telecommunication components and materials. Representatives of the appropriate Army Divisions, the Directorate of Radio and Signal Supplies (Department of Munitions), and the Division of Electrotechnology form this Committee.

Consideration has been given to the dependence of surface resistivity of electrical insulating materials on humidity, and preliminary investigations have been carried out on various insulating materials available in Australia. Existing practice in the manufacture of telecommunication and allied types of equipment is based substantially upon the technique of open constructions, using waxes, varnishes, bitumens and plastics as moisture-resistant coatings for the protection of vulnerable insulating materials. Various processes for the hermetic sealing of components and equipments have been examined, and soldered seals of metal to glass and ceramic have been developed by industry. Electrical leakage over the surfaces of these insulating materials is probably the most serious remaining problem in perfecting hermetically sealed components and equipments for use in humid tropical climates. Considerable attention has, therefore, been directed in this Division to the study of " anti-wetting " treatments for the surfaces of glass and ceramics, to ensure that high electrical insulation resistance is maintained under moist conditions.

An extensive investigation on corrosion of copper wires at different potentials in contact with electrical insulating materials has been initiated, and, in particular, a number of chlorinated naphthalene waxes have been tested for their corrosive effects. A limited investigation of waxes and bituminous compounds has been carried out, but a comprehensive programme of work on these compounds has recently been undertaken by the Munitions Supply Laboratories at our request. In addition, Munitions Supply Laboratories will prepare information regarding preferred applications of metals and metal finishes.

The above investigations have been carried out in close co-operation with the Fighting Services, the Department of Munitions, the Standards Association of Australia, Sydney University, other Commonwealth Laboratories and the radio and electrical industry.

XIV. PHYSICS.

1. *General.*—During the past year the bulk of the work of the Division has been directly associated with the war, either in assistance in technical problems connected with munitions or in the solution of problems arising in the Fighting Forces. Plans have been made for post-war assistance to secondary industry, for long-range and fundamental research, and for the maintenance of the fundamental and associated standards of measurement with which the Division will be concerned.

Among the many problems which have been investigated may be mentioned the following :—The optimum visual conditions for radar operators, the photometry of a new type of searchlight arc, the control and measurement of humidity in connexion with tropic proofing of service equipment, and the design of an instrument for the accurate and rapid measurement of haemoglobin for " blood bank " work.

Some fundamental work on the physics of wool fibres was commenced by a small group during the year, and interesting results obtained which bear on the felting and shrinkage properties of wool. Another section of the Division is investigating optical methods of rapidly measuring fibre diameters and their distribution. Equipment has also been designed and constructed for use in the fleece testing work of the Divisions of the Council concerned with primary industries.

A large number of comparatively small investigations have been undertaken for industry, and assistance has been given to other Divisions in the designing and construction of equipment not otherwise obtainable. During the year, 343 reports, statements or certificates of examination giving the results of calibrations of apparatus or measurements of the physical properties of materials were issued.

The Chief of the Division has served as a member of the Scientific Instruments and Optical Panel, and the Division is represented on various Standards Association Committees, for example, on lighting and eye protection in industry. Shortage of accommodation, which has been accentuated temporarily by the building operations for the new extension to the National Standards Laboratory, has become very serious, and the difficulty of obtaining scientific staff, owing to shortage of physicists, has thrown a severe burden on senior staff.

2. *Heat.*—(i) *International Temperature Scale.*—The ability to measure temperatures accurately and in a reproducible manner throughout the world is of considerable scientific and industrial importance. It was to meet this need that the International Temperature Scale was defined. One of the functions of the Division is the maintenance of this scale, and work in this field has continued throughout the year. A number of standard platinum resistance thermometers have been constructed which conform with the requirements of the International Temperature Scale, and these have been used for the calibration of substandard temperature-measuring instruments. Prior to this, the Division had been dependent on calibrations made some years ago at the National Physical Laboratory, London.

Investigations have been made of the accuracy of the techniques in use by the Division for realization of the International Temperature Scale with rare metal thermocouples.

High temperatures are measured on the International Temperature Scale by a disappearing filament optical pyrometer. Following a theoretical investigation of the operation of instruments of this kind, the design and construction of a high-quality instrument of this type intended for use as a substandard has been undertaken by the Light Section of the Division. This instrument will be used in conjunction with equipment set up for the establishment of the melting point of gold, a fundamental point on the International Temperature Scale.

(ii) *Industrial Pyrometry.*—The programme of work undertaken on behalf of the Service Inspection Authorities and the Ministry of Munitions has been continued throughout the year, although on a reduced scale. This work has involved the inspection and testing of virtually all furnaces and associated pyrometric installations used in New South Wales for munitions production where the processes are such as to require close temperature tolerances. In order to encourage industries and instrument service agencies to provide their own facilities for pyrometric testing, the Division has trained technical personnel from seven firms in pyrometric measurement.

A number of special investigations have been undertaken in industrial pyrometry. The most important of these has been in connexion with the measurements of the temperature of molten steel using a quick immersion thermocouple technique, first developed at the National Physical Laboratory, England. Assistance has been given to all the major steel-producing companies of this country in the establishment of this type of measurement, which has already shown itself to be of considerable value in steel production.

(iii) *Measurement and Control of Humidity.*—The measurement and control of humidity in enclosed spaces is a problem of importance in many fields. It has been brought into prominence by the considerable part humidity plays in the deterioration of electrical equipment in the tropics. The tropic proofing group of the Division of Electrotechnology has been intimately concerned with the protection of equipment from such effects, and at its request the Division of Physics accepted responsibility for important physical aspects of this work, namely, the accurate measurement of the humidity and the control of the humidity in chambers used for the climatic testing of equipment.

Following on work reported last year for the measurement of humidity in the atmosphere from aircraft, the first of these two problems was solved by constructing a special thermocouple psychrometer for the measurement of humidities at low air speeds. This instrument proved very valuable in measuring the conditions obtaining in climatic testing chambers, particularly when used in conjunction with specially adapted potentiometric recorders which can be used to give a record of the temperature and humidity conditions inside a sealed chamber over long periods of time.

The second problem was solved by further development of a special type of temperature controller constructed by the Division for other purposes. With this humidity controller, which is now being produced commercially, it has been found possible to control the humidity in testing chambers to within much closer limits than has hitherto been considered practicable. A direct reading humidity meter, operating on a somewhat similar principle to the controller, has also been developed. As a result it has been possible to lay down specifications defining the conditions for the climatic testing of telecommunication equipment which remove serious defects in existing specifications and procedures.

A number of special types of hygrometer have been designed and constructed to meet other special requirements. These have included a dew point instrument in which the formation of dew is detected photo-electrically, for use in inaccessible places, a dew point instrument for determining the humidity of samples of air, two types of aspiration psychrometer, and an instrument for determining the humidity inside sealed electric meter cases. The electrical resistance methods of measuring humidity have also been examined.

(iv) *Viscosity of Urea-formaldehyde Cements.*—At the request of the Division of Forest Products an investigation was made of the viscosities of some urea-formaldehyde wood adhesives, particularly during their setting process. This work arose through difficulties in the use of these cements in aircraft construction, apparently because of a difference between the overseas cements and the locally made product. The opaque nature of the material presented difficulty in these measurements. An electromagnetic device for detecting the position of a steel ball falling freely through the opaque cement was designed by the Division of Electrotechnology for the work.

(v) *Thermal Conductivity.*—Progress was made in the design and construction of equipment for the measurement of the thermal conductivities of materials at ordinary temperatures. There are no facilities for the measurement of the thermal transmissions of wall structures in Australia at the present time, a matter of considerable importance in housing. Equipment is being developed for this purpose.

(vi) *The Temperatures of Estuarine Mud and Water.*—At the request of the Division of Fisheries an instrument which will withstand adverse conditions for long periods of time is at present being developed for the measurement of the temperature of estuarine muds and waters. It will operate on the resistance bridge principle and will be read at a distance.

3. *Light.*—(i) *Optical Instruments.*—The rate of deterioration in tropical areas of optical munitions has been a very serious matter, owing to condensation of moisture on the lenses and fungal attack. A considerable measure of success has been achieved in the solution of this problem by the Scientific Instruments and Optical Panel, on which the Division is represented, the main contribution from the Division being an investigation in the Northern Territory and New Guinea of the relative importances of fungus and condensed moisture.

The urgent need for the survey of Australian soils has led to the Division undertaking the design for a microphotometer embodying special requirements for use in rapid quantitative spectroscopic analysis. This instrument, intended for the Division of Soils, will probably be useful for other spectroscopic work.

To meet the shortage of microscopes for University and other purposes, the Scientific Instruments and Optical Panel has explored the possibility of their local manufacture and has drawn up a specification for student microscopes to be made in Australia. Attention has been given at the laboratory to the performance required for such microscopes and to suitable testing methods, with a view to assisting manufacturers during the initial stages of production.

(ii) *Optical Glass.*—The testing of Australian-made optical glasses, which are incorporated in most Australian-made military and naval optical instruments, has been continued. The tests include refractive indices, optical homogeneity, and transmission properties, while an investigation has been carried out on the tolerances for seed, which at one stage were causing serious delay in gunsight production. Assistance has been given to manufacturers in the setting up of apparatus for selecting glass free from striae, while tests have been made on the optical quality of glass intended for export, to ensure the maintenance of adequate standards. This in itself has provided an excellent opportunity for the Division to supervise the quality of the optical glass being produced, as a result of which big improvements have been made in the standard of annealing.

(iii) *Colorimetry.*—A related subject is the Australian production of coloured glasses for aviation purposes—identification lights, boundary light, warning lights, &c., for which specifications were prepared at the laboratory. These colours must be maintained to within close tolerances to avoid mistaken identification. In this field of colorimetry, previously unknown in Australia, equipment has now been developed for the objective testing of coloured glasses, precision colour gauges have been produced, and such assistance given to the manufacturers that production of glass to closer colour tolerances is now on a satisfactory basis. The photoelectric tricolorimeters developed for this work are now being modified with a view to their use in the paint, paper and textile industries.

(iv) *Photometric Instruments.*—A turbidimeter has been produced for the Division of Food Preservation for the purpose of measuring the concentration of bacterial suspensions, an essential part of its programme on the suppression of bacterial growth in foodstuffs. In connexion with investigations on the effect of light on the growth of plants, being carried out by the New South Wales Department of Agriculture, the necessity arose for a photometer for recording the total integrated daylight intensity. A suitable instrument was developed for this purpose. The expansion of blood transfusion services has emphasized the long standing need for an accurate and rapid method of estimating the haemoglobin concentration in the blood. For this purpose a photoelectric haemoglobinometer was developed in the laboratory which should be of considerable clinical value.

The standards of candle power and luminous flux form the basis of all photometry. Their measurement depends on the ultimate precision of making comparisons of brightness. In the past the eye has been the arbiter in all such comparisons. A photoelectric photometer, with spectral response approximating that of the average eye, has been constructed and is being further developed. It enables a considerable improvement to be achieved in the precision of these measurements. A portable photoelectric photometer, for measuring illumination in the range below one foot candle, has also been constructed, the necessity for this having arisen in the course of investigations on the efficiencies of certain Army searchlights.

(v) *Atomic Hydrogen Arc.*—At the request of the Army Inventions Directorate an investigation was made of the possible use of an atomic hydrogen arc as an improved searchlight source. Although it was established that the beam intensity was not as great as with the high current density arc in use at present, the testing techniques which it was necessary to develop proved of great value in assisting some further work in collaboration with the Division of Industrial Chemistry on the suitability of Australian deposits of rare earths as core materials for searchlight carbons.

(vi) *Spectrophotometry.*—Accurate spectrophotometry is of importance in many scientific and technical fields and is fundamental in photometry. The work carried out in the Division has covered such diverse subjects as spectral reflectances of soils to provide permanent standards of soil colours for rapid classification by the Division of Soils, the preparation of standard colour gauges for aviation colours for the Department of Air, the calibration of standard filters for use in precision optical pyrometry, the absorption curves of various organic compounds, the preparation of filters for use in the colorimetric estimation of β-carotene and lactic acid, and the preparation of filters for modifying the spectral sensitivities of photoelectric cells for use in illumination photometers. The improvised and time-consuming apparatus used at present for this work will be replaced shortly by an automatic recording spectrophotometer of the Hardy type.

(vii) *The Visual Efficiency of Radar Operators.*—At the request of the Director of Radar, Department of Air, a research was made into factors likely to produce visual fatigue. A tour was made of radar stations of the three Services in the Northern Territory and New Guinea to determine the extent and cause of vision troubles, and recommendations concerning desirable visual conditions were made to enable general improvements in efficiency to be obtained.

(viii) *Wool Fibre Diameter Measurement.*—Of the various physical properties of wool which influence the quality of textiles made from it, two considered to be important are the mean diameter of the fibres and their variability in diameter. The exact relationships between these two properties of the fibres and textile quality have never been determined, owing to lack of suitable instruments for carrying out large scale measurements. Several possible optical methods of measuring diameter and variabilities are being tested to see if these properties can be obtained without, as at present, the need for individual measurements on large numbers of fibres.

4. *Jewel Bearings.*—To meet the large Service demand for electrical indicating instruments, the manufacture of vee bearings of glass was developed locally to replace the sapphire vee bearings which are normally used, and which were in such short supply. Tests were carried out on glass bearings of both local and overseas manufacture, to determine their relative resistance to damage by sudden shocks, in comparison with standard sapphire bearings. While all glass bearings were found to be less resistant to shock than sapphire bearings, some modification of process was suggested to one of the local makers which led to an improvement of quality to about the level of imported glass bearings.

A test was made of the suitability of a number of special oils in reducing the damaging effects of sudden shock on pivot-bearing combinations. As was anticipated, they were of little value for this purpose, although they are of maked value in reducing wear on pivots and bearings in a different class of meter.

A possible method of measuring the hardness of glass and other brittle materials was investigated but was found to give essentially the same information as already available by another method, developed by the Bureau of Standards. This work is being completed by a few tests on the effect of oils in pivot-bearing combinations under vibration.

5. *X-ray Diffraction.*—An X-ray diffraction unit for use in a wide range of problems is under construction.

6. *Wool Research.—The Physics of Wool and Other Fibres.*—One of the most important of the Council's activities in the post-war period will be wool research. In anticipation of the programme of research which will be undertaken, the Division has initiated physical investigations along several lines where it seemed that immediate progress was possible. The research undertaken at the moment relates mainly to the frictional properties of textile fibres; these properties greatly influence the handle and strength of fabrics and, in the particular case of wool, are the basic cause of shrinkage and felting, properties which may be a serious disadvantage or may be put to very useful purpose. Already a very interesting field of work has opened up, and some of the results published in *Nature.* This work is being undertaken by a group of two research workers who will shortly be joined by a third, completely dissociated from any of the "standards" work of the Division. Plans for extended work in these fields have been prepared.

Some of the staff of the Division engaged on standards and general investigations in light have also contributed to this work. They have reviewed the usual methods of fibre diameter measurement, and are attempting to devise more rapid methods of determining the diameter and distribution of diameter of fibres in a wool sample. This is probably the most fundamental measurement necessary in fleece testing. One simple instrument for helping to speed up the normal method of making this measurement has been completed and work on two entirely different methods of approach is in progress.

7. *Publications.*—The following papers were published during the year:—

Mercer, E. H. (1945).—The frictional properties of wool fibres. *Nature* 155: 573.

Mercer, E. H. (1945).—A device for studying the frictional properties of fibres. *Aust. J. Sci.* 7: 173–174.

XV. AERONAUTICAL INVESTIGATIONS.

1. *General.*—As in previous years, many projects directly related to the war were undertaken on behalf of the Services, while during the year relationships were established with the British Pacific Fleet with a view to making available any facilities required in aeronautical and other engineering matters. Apart from this work, considerable assistance was given to other outside bodies including a number of industrial organizations. This activity, combined with the Division's own programme of research, has fully extended the available resources.

At the beginning of 1944, developments which had been occurring in secret in England for several years, in the field of jet propulsion and internal combustion turbines for aircraft, were made public. At the invitation of the British Government, four officers of the Division were sent to England to assist in this development and to gain first-hand experience of the new means of propulsion. These officers spent the whole of the year under review on this work.

The entry of Japan into the war in December, 1941, made it imperative that all available resources for aircraft production should be utilized to the utmost. The Director-General of Aircraft Production, on whom this task devolved, formed an Advisory Committee to assist him, and included the Chief of the Division in its membership. This Committee, its main purpose fulfilled, was disbanded towards the end of the year under review.

Officers of the Division have also taken an active part in the work of the Australian Council for Aeronautics and its sub-committees, and, by arrangement, this aeronautical body publishes much of the research done by the Division. During the year eight research reports were published in this manner.

2. *Aerodynamics Section.*—(i) *Applied Aerodynamics—9 ft. by 7 ft. Tunnel.*—(*a*) During the year over 70 per cent. of the running time of the tunnel has been spent on design problems for the Australian aircraft industry.

Work on a single-seater fighter designed by Commonwealth Aircraft Corporation continued on a high priority. Due to non-availability of the engine around which the aircraft was originally designed, tests were made on two alternative proposals. The first incorporated an exhaust-driven turbo supercharger under the fuselage, in a location involving long and rather complicated ducting to carry the supercharged air to the carburettor. A later proposal was to install a liquid-cooled engine instead of the air-cooled engine, and design tests on the under-fuselage radiator duct were commenced and are in progress.

Concurrently with the engine changes, there have been changes in both plan form and basic aerofoil section of the wing. A comprehensive series of tests was made, including drag analysis, maximum lift, pitching moment and wing transition point. In addition measurement was made of the aerodynamic loads assisting and preventing retraction of the undercarriage leg, and of the loads on the elevator tab to determine the critical stressing case.

As an insurance against the possible non-delivery of Hercules engines for the Beaufighter production schedule, the Department of Aircraft Production designed an installation using Wright engines. This new design was investigated in the tunnel, particular results being that, for longitudinal stability reasons, the retention of dihedral in the tailplane was advisable, and that an overall reduction in drag of 10 per cent. on the Hercules-engined version was achieved.

In early flight tests of a twin-engined bomber developed by Commonwealth Aircraft Corporation, severe buffetting of the tailplane was encountered. Concurrent full-scale and wind-tunnel tests showed that this could be overcome by using dihedral in the tailplane and so lifting it above the wake from the wing root and engine nacelles.

(*b*) In addition some non-aeronautical work has been done in the tunnel.

To assist a local firm in the design and development of axial flow water pumps, an investigation of the characteristics of a family of hydrofoils was undertaken. The sections were chosen for constructional simplicity and also to give a pressure distribution free from extensive peaks, and thus not likely to incur difficulties from cavitation.

In the structural analysis of an elevated water tank of wine-glass design by the Structures Section, the question arose as to whether wind loads would present a critical stressing case, and in addition whether the shedding of vortices on the lee side of the tower would excite resonant frequencies in the supporting column. Wind-tunnel tests gave the magnitude of the former, and indicated that as there existed no predominant frequency in the vortex shedding, the excitation of resonant frequencies was not likely.

(*c*) Duct work has retained its position as an ever-present problem to the Section. The fundamental problems of duct design are well understood, and in fact two articles published some years ago by the Officer-in-charge of the Section now constitute a standard reference on the subject. Despite this, there is a steady influx of rectification problems from the commercial world. For the past year the list included dehydration tunnels, egg incubators, paint spray booths, tropical humidity cabinets, and a quick freezing tunnel.

Several miscellaneous tests have been made in the tunnel. These included the measurement of the drag of several forms of radar aerial, of bombs and bomb fairings, and of jettisonable fuel tanks. Strength tests were made on paper parachutes used for supply dropping, and the discharge-pressure characteristics of several petrol storage tank relief valves determined.

(ii) *Stability.*—The close liaison with the Department of Aeronautical Engineering at Sydney University is being continued. The major project, completed during the current year, was on aileron design. An extensive investigation was made on the aileron installation on the C.A.C. fighter, and some work was done on the Boomerang ailerons as a preliminary to flight tests. At present the measurement of the aerodynamic damping moment in roll is receiving attention, an investigation having been made of the method whereby this derivative is determined from an analysis of the decaying oscillation of a model elastically restrained in roll.

In the 9 ft. by 7 ft. tunnel in Melbourne, measurements were made of the contributions to rolling and yawing moments due to sideslip, and to pitching moments in straight flight, of the various component parts of a typical single-engine fighter aircraft. This was done with improvised additions to the existing three-component balance. For future work, alterations to the balance which will allow three forces and three moments about three mutually perpendicular axes to be measured simultaneously are contemplated.

(iii) *Fluid Motion.*—Research work over the last year has mainly developed around the central problem of the effects of turbulence on the size, state, and stability of the boundary layer formed on the surface of solid bodies moving through air. A better understanding of these effects is of considerable importance, since the air resistance of a streamlined body or wing is largely conditioned by the behaviour of its boundary layer. The work has been pursued along both theoretical and experimental lines.

On the theoretical side some knowledge has been gained of the effect of wire screens on the turbulence level of wind-tunnel air streams, and means have been developed for estimating their efficiency in reducing this level to the low value experienced under actual flight conditions. As a result of a detailed study of the mathematical methods available for the investigation of turbulent flow, a theory of axially symmetric turbulence has been developed. This theory throws some light on the behaviour of turbulence in wind tunnels.

The stability of the boundary layer has also received attention, and a review of the overseas work already done on this subject has been prepared. To prevent the early onset of transition to turbulent flow in the boundary layer with the resultant large increase in drag, the intensity of the disturbances which it suffers must be decreased over a certain critical range of frequencies.

Experimentally, efforts have been directed towards the production of turbulent-free air streams and to the development of methods for the measurement of the various characteristics of turbulent flow. An open-return low-turbulence wind tunnel has been designed and built. It contains an unusually large contraction nozzle (25 : 1) and, to allow further reduction of the turbulence, provision has been made in the settling length behind the honeycomb for the insertion of a number of fine-mesh screens. Methods for reducing the noise level in the working section to a minimum have also been investigated, since, when the general turbulence level is so low that the fluctuations are only 0.03 per cent. in velocity, the contribution to the turbulence from noise becomes appreciable. Elimination of the tunnel turbulence will permit the study of the state and stability of boundary layers under controlled conditions.

Specialized electronic equipment based on the hot wire anemometer has been built so that the properties of turbulent flows may be determined quantitatively. This equipment will also be of use in the study of turbulent flow in boundary layers.

(iv) *Gasdynamics.*—With increases in the speed of flight, the air may no longer be considered a perfect fluid; in particular its compressibility, previously ignored, is of vital importance, and so a reconsideration of the fundamental theory of aerodynamics has become necessary. The new subject is known as "gasdynamics", and, in order to study the latest developments in this comparatively new branch of knowledge, the officer-in-charge of the Section has proceeded to America and will spend some months at the California Institute of Technology.

To permit of satisfactory experimental investigations in gasdynamics, a specialized wind tunnel is necessary. In this tunnel not only must high speeds be possible but provision must be made for varying the operating pressure over the range from one-tenth of an atmosphere to six atmospheres and for controlling its humidity. Construction of a variable-pressure wind tunnel of this type is well advanced. After the shell had been transported to the site at Fishermen's Bend and assembled, it was given a pressure test of 160 lb. per square inch and the exposed exterior surfaces, which are cooled by water sprays, were given special anti-corrosion protective treatment. Inside the tunnel the moulded plywood corner vanes and wooden fairing blocks have been fitted, and assembly of the moulded plywood contraction nozzle is well

advanced. The contra-rotating gearbox is installed in the tunnel and the fan drive shaft lined up. Wiring of the motor generator set, of the main tunnel motor, and of the control gear is almost complete. Construction of the balance and fans has proceeded concurrently in the Division's workshops.

3. *Structures and Materials Section.*—During the year the Section has continued its theoretical and experimental work on long-range problems and has also given considerable assistance to the Services, aircraft manufacturers, and other organizations, on a number of matters described below.

(i) *Wood Investigations.*—The programme of work embarked on some years ago to improve the efficiency of wooden aircraft structures and to obtain design data on local timbers which could be used in the event of a failure of overseas supplies of spruce or of light alloys, was continued as far as the more pressing demands in other directions would permit.

(*a*) *Wooden Box Spars.*—This work, largely of an experimental nature, aimed at improving the design methods for, and general efficiency of, wooden box spars which are essential components of any wooden aircraft structure. The experimental work has been completed, and a report covering the work on hoop pine test specimens has been issued. The report draws attention to the necessity for taking into account the relationship between the areas of compression and tension flanges in determining the strength of spars.

(*b*) *Plywood Panels.*—The experimental programme on compression of flat and curved plywood panels has been carried a considerable distance, and for the time being it is not intended to do any more work in this field: The results for the flat panels conformed remarkably well with the theoretical results mentioned below. The agreement in the case of the curved panels, however, was not so encouraging, although the discrepancies noted were only of the same order as those found with metal panels. Empirical relationships which fit the experimental data for the curved plywood panels very well have been evolved ; they should be suitable for design purposes.

(*c*) *Grid Sandwich Panels.*—A type of construction has been evolved in the Section embodying two thin plywood sheets separated by a core consisting of thin strips of solid timber half-lapped together to form a grid. This was evolved in the first instance as an alternative to the balsa wood sandwich panel as used on the Mosquito fuselage, but on investigation it was found to have a number of advantages not possessed by the balsa sandwich. The chief of these is that the weight and disposition of the core material incorporated can be controlled very closely to suit the type of loading to which the panel as a whole is subjected and can be varied without changing the overall thickness of the sandwich to suit the local loads. It is thus possible to obtain optimum structural efficiency at all points of the structure simply by varying the amount of grid material present. This type of construction has been applied very satisfactorily to aircraft flooring, which has been incorporated in a number of transport aircraft with a considerable saving in weight.

(*d*) *Wooden Airscrews.*—As a contribution to the solution of the problem of attaching wood blades to the metal hub sockets of variable-pitch airscrews, some work was undertaken on the design of the screw thread connexion between the " improved " wood blade and the steel hub ferrule. A series of tests has been made on samples of " improved " wood having a single notch of the same form as the thread used in airscrews, the load being applied to the notch by means of a metal tooth corresponding to the steel hub. Notable differences in the strength and stiffness of the joints were found between notches parallel to the laminations and those at right angles to the laminations. It is hoped by the analysis of these results that some light will be thrown on the rather low values obtained in " pull-out " tests of complete blade roots.

(ii) *Theory.*—The theoretical programme on the strength and stability of plywood construction has been continued vigorously, and all the basic equations and special theory evolved in the Section have been collected into a monograph on the subject which will be issued shortly. This theory has been applied with success to the analysis of flat plywood panels in compression as mentioned above and also to the design and analysis of the grid panels.

The stability theory has been extended to include the large deflections of isotropic panels, and a general study of this subject is now being made. The importance of this work lies in the fact that the actual failure of the stiffened skin construction used in aircraft always occurs by large deflection.

A general study is being made of the design and analysis of stiffened shell structures of the type used in aircraft, with a view to comparing the existing methods and examining their limitations and deficiencies. The work so far has included the examination of the literature on flat and curved stiffened metal panels as a preliminary to a consideration of complete structures such as wings and fuselages. A number of stiffened panels representative of the construction used in a fighter aircraft were tested, and an investigation of the column strength of the stiffeners used on the panels was put in hand. This work is now almost complete.

The application of relaxation methods of stress analysis has been extended to include the stability of isotropic plates under various types of edge loading, the torsion of complex cross sections such as splined shafts in the plastic region, and the torsion and flexure of structural shapes such as I-beams. In the torsion and flexure problems, the relaxation solution gives the complete stress contours over the whole of the cross section and has indicated stress variations and the presence of stress concentrations not revealed by other methods.

(iii) *Other Problems.*—A number of other problems of a theoretical nature which were not actually a part of the general programme, but which were submitted by outside organizations, were investigated. These included a stress analysis of a hemispherical elevated water tank supported on a single central tube. In addition to the analysis of the static stresses in the tank, an analysis which involved a considerable amount of complex mathematics, a theoretical estimate of the vibration characteristics of the structure, was also made. This was done on account of the possibilities of dangerous vibration being set up either by steady winds or by gusty conditions.

The plastic deformation of circular rings when compressed by diametrically opposed loads was examined theoretically and experimentally, the main purpose of this work being to assess the significance of the "flattening-test" as a factor in the control of the quality of seamless aircraft tubes.

A theoretical analysis was made of a rigid jointed space frame in the form of an engine mounting for the Beaufighter aircraft. This type of construction is very common in aircraft engine mountings and the analysis revealed that stresses existed at the joints whose magnitudes were much higher than, in some cases may times those ordinarily assumed from a standard engineering analysis. The presence of these high stresses was also confirmed by test.

(iv) *Dynamics.*—The vibration characteristics of an engine-propeller-cooling fan combination was studied mathematically. The question was first raised by the Royal Australian Air Force in connexion with a local engine development but has since been expanded to a general investigation of the methods of dealing with such problems. The mathematical difficulties are considerable, but in spite of this, methods have been found of reducing the amount of numerical work usually required by one-half, without any appreciable loss of accuracy. Certain aspects of the theoretical predictions will be tested experimentally.

A general study of vibrations, particularly in relation to aircraft, was commenced, and certain equipment for resonance testing of aircraft structures has been acquired.

(v) *Electric Strain Gauges.*—The development of equipment and technique for electric resistance strain gauges has been continued and brought to a stage where the instrument is now a thoroughly reliable and extremely useful research tool. Electric resistance strain gauges have been used in a great number of applications including the measurement of the strain distribution in a series of stiffened metal panels, the measurement of the stresses in the wing spars of a new design of fighter aircraft, the measurement of control forces in an aircraft in flight, and the determination of the load distribution in a suspension bridge consisting of a wire grid of the form commonly used for reinforcement in concrete construction.

(vi) *Other Work.*—Full-scale strength and stiffness tests have been conducted on a Mosquito wing manufactured in Australia and drawn from an early series in which there was some doubt as to strength. The stiffness was found to be of the same order as that obtained on wings made in England. The strength test revealed certain deficiencies in the glued joints in various portions of the wing.

As a result of a fatal accident involving the crash of a civil aircraft, and in anticipation of a subsequent public inquiry, a general investigation of the stressing of the aircraft was undertaken. This accident drew attention to a problem which has been exercising the minds of aeronautical engineers for a considerable time, namely, the safe life of an aircraft structure. At present it is not possible to estimate this with any certainty. The main factors involved are the magnitude and frequency of the fluctuating loads occurring in flight and the resistance of the structure to these fluctuating loads. There is extremely little reliable information available at present on either of these aspects of this important problem, and an endeavour is now being made to review the whole position and to formulate a plan of investigation.

With the object of determining the consistency of the results obtained on certain spot-welding equipment available in Australia and also with the view to obtaining data for design purposes, a very extensive series of tests of spot welds in a number of materials was put in hand at the request of the Department of Aircraft Production, Beaufort Division. This has involved the testing and examination of thousands of specimens of spot-welded light alloy and steel sheet and as a result of this work a considerable improvement in the strength and consistency of spot welds has been achieved.

(vii) *Equipment.*—The large testing machine of 600,000 lb. capacity, designed by the Division, which has been under construction for nearly two years is now nearing completion and is being erected at the makers for the acceptance tests. This machine has been especially designed for aircraft work and is capable of applying several component loads to the specimens in different directions simultaneously.

A tyre and undercarriage tester capable of dealing with wheel loads of up to 50,000 lb. was designed by the Section and is now under construction at Newcastle. The machine is intended to simulate the conditions to which tyres and undercarriages are subjected when an aircraft is alighting at speeds up to 140 miles per hour. It consists essentially of a large flywheel the peripheral speed and mass of which can be adjusted to suit the landing speed and weight of the aircraft, on to which is dropped the landing gear of the aircraft suitably loaded. When the tyre makes contact with the flywheel the wheel brakes are applied, and the kinetic energy of the system is absorbed by the brakes.

Several new types of fatigue testing machines have been installed in temporary locations and others have been designed and are in the process of manufacture.

4. *Physical Metallurgy Sub-Section.*—A major activity of the Sub-Section during the past year has been the investigation of production and operating problems submitted by the Royal Australian Air Force, Department of Aircraft Production, Department of Civil Aviation, and various aircraft manufacturers. While none of this work in itself requires special mention, in certain cases it has led to further investigations which are listed among the items of long-term work outlined below.

(i) *Australian Aircraft Steels.*—In continuation of the general programme on Australian aircraft steels, comprehensive testing has been conducted on SAE.2330 (nickel-bearing), SAE.4140 (chromium-molybdenum), BS.S1 (general purpose low-carbon), and BS.S11 (nickel-chromium). The programme has been completed for the first two and is still in progress for the others. Particular attention has been given in conjunction with the steel manufacturers to the characteristics of S1, including the strain ageing effects after cold drawing. This phenomenon affects the Izod value without causing significant change in other mechanical properties. As a general check on Izod testing the investigation has been extended to cover the effects of temperature of testing, method of preparation of test pieces, and the elapsed time between preparation of test piece and testing.

(ii) *Powder Metallurgy.*—A major research and development project in this field has been initiated by a study of the structures and properties of tungsten-chromium alloys which are expected to have some particularly useful properties for high temperature service. The work to date has involved the preparation of sintered compacts of a preliminary group of alloys using as raw materials minus 100 mesh (150 micron) electrolytic chromium and minus 10 micron tungsten powder derived from the chemical reduction of scheelite concentrates. The method of sintering employed was resistance heating, using a technique currently employed as the first step in the production of ductile tungsten. The work carried out has indicated the general nature of the problem involved and has shown more particularly the need for closely controlled high temperature sintering.

As a fundamental contribution in another field, a project is being undertaken to determine the mechanism of sintering in powdered metals, and the effect of such factors as particle size and shape and compacting pressure. In the first instance the work is being done on pure copper, but the experimental apparatus is being designed with a view to general use. It is proposed to use electrical resistivity as a major means of following the progress of sintering, and attention is being given to the design of apparatus for simultaneous measurement of resistivity and certain other properties.

(iii) *Furnace Brazing.*—A study of copper-brazed joints was undertaken in order to obtain information on the mechanism of alloying, the micro-structures developed, and the properties from the design point of view. Mild steel and medium carbon steel were used as the components, separately and together, and pure copper was used as the brazing medium. Check tests were made without copper, and in both cases it was found that when clearances between the component parts were small, complete union was obtained by what is in effect autogenous welding at temperatures far below the fusion point. With clearances greater than a press fit the presence of copper was found to be essential for complete joining. In the continuation of the work attention will be paid to some remarkable alloy structures which have been observed in the presence of copper as a brazing medium.

(iv) *Ethylene Glycol Corrosion.*—The corrosion of aluminium and steel components in liquid-cooled aircraft engines using glycol and glycol-water mixtures has been made the study of both fundamental research and practical investigation aimed at prevention of the corrosive attack which has seriously limited the service life of aircraft in Australia and the islands. The fundamental work has confirmed that dissolved oxygen is the root cause of attack, and that the

presence of copper components in the same circulating system as aluminium and steel parts has contributed by dissolution of the copper and consequent anodic attack, particularly on the aluminium parts. The use of triethanolamine phosphate as an alleged inhibitor of corrosion has been found actually to accelerate greatly the rate of attack on aluminium parts through the formation of copper complexes formed in the first instance owing to the presence of dissolved oxygen. An alternative alleged inhibitor, sodium mercapto-benzo-thiazole, has also been discontinued on the basis of the experimental work, as it serves merely to precipitate dissolved copper compounds which, as stated above, result in the first instance from the presence of dissolved oxygen and are formed at an increased rate in the presence of triethanolamine phosphate. More promising results have been obtained in the recent experimental work by means of an instrument oil containing surface-active compounds. The tests are being continued on the laboratory scale, and also in mock-up units, designed to include all metals and alloys present in the actual circulating system, and to include also those "geographical" features which may contribute to the nature and extent of corrosive attack.

(v) *Fatigue Failures.*—Further cases of fatigue failures in aircraft structures and components have been examined. Instances of failure in light alloy airscrew blades were found to be due to faulty heat treatment which induced susceptibility to intercrystalline corrosion.

A fatigue failure of particular significance from the structural aspect was encountered in the crash of a civil aircraft of welded, tubular, chrome-molybdenum steel construction, in which a wing spar failed by fatigue in mid air after 13,000 hours service. This failure was traced to a welding defect in the original fabrication of the member. The occurrence has focused attention on the problem of establishing some sound basis for limiting the operating life of aircraft, and on the need for adequate inspection by both magnetic and radiographic methods of all aircraft structures at suitable intervals during their service life.

(vi) *Piston Rings.*—At the instigation of the Royal Australian Air Force, Directorate of Technical Services, a study has been made of a selected range of British, American and Australian piston rings for aircraft engines operating in Australia and the islands. An attempt was made to establish a relationship between composition and micro-structure on the one hand and mechanical properties including wear on the other hand. The conclusions can be no more than tentative on the evidence available, which has been limited by considerations of sampling and by inadequate service records, but it has been shown that the British and Australian grey-iron rings examined do not conform to the type of micro-structure which American manufacturers apparently are agreed in regarding as the optimum, namely, fine flake graphite and a dispersed phosphide eutectic throughout a pearlite matrix. The British and Australian samples were characterized in general by a dendritic structure containing some free ferrite, and by a cellular disposition of the phosphide eutectic. The high-duty British rings manufactured to DTD 485 were noteworthy because of their high mechanical properties and the presence of free carbides in the micro-structure.

(vii) *Welding of Steel Tubing.*—A comprehensive review of the weldability of steel tubing used in aircraft has been made. This review indicated that the susceptibility of the steel to cracking during welding increases with the hardenability, although other variables such as the phosphorus and sulphur contents are also important. A review of weldability tests has been initiated and will be followed by experimental investigation of those tests which are indicated as showing most promise.

(viii) *Heat Treatment of Aluminium Alloys.*—An investigation into the overheating during heat treatment of a series of aluminium alloy aircraft forgings indicated a lack of information regarding the effects of small amounts of overheating on the mechanical properties and serviceability of these alloys. In view of this fact, and also because many aluminium alloy components in service may be in a slightly overheated condition, it was decided to check the mechanical properties of aluminium alloys of the B.S. L40 type after purposely overheating by varying amounts. The results to date have shown that slight overheating does not affect the tensile properties adversely but that there is a small lowering of the fatigue limit.

5. *Engines and Fuels Section.*—(i) *General.*—As in previous years, a great deal of the work of the Section has been devoted to problems of the Royal Australian Air Force and the aircraft industry. Contact with the problems encountered by the Royal Australian Air Force in engine operation and maintenance under active service conditions has been facilitated by the visit of an officer to operational areas in Northern Australia. As a direct result of his visit, alterations in engine operating technique have been introduced which have resulted in a considerable increase in the range of certain bomber aircraft.

It is now apparent that the turbine engine, especially in its application to jet propulsion, will play an important part in aircraft propulsion in the future. In order to become familiar with the very rapid development which has taken place in engines of this kind during the last

few years, the Officer-in-charge of the Section visited Britain and America during the year. Plans are being made for carrying out investigational work in the field of turbine engines in this laboratory.

Sound-absorbing splitters have been fitted to the outlet duct of the 2,000 horse-power dynamometer plant. This installation has greatly reduced the noise level outside and has added materially to the comfort and efficiency of workers on the site.

(ii) *Ad Hoc Work.*—The R2000 Twin Wasp engine is being made in Australia by Commonwealth Aircraft Corporation, and the Division has assisted this development in two ways—by submitting the engine to type tests and by carrying out cooling calibrations. A prototype engine was type-tested in accordance with a test schedule laid down by the Department of Air, and the results indicated that certain modifications were necessary. The engine is being submitted for a further type test. Comprehensive cooling calibrations have been carried out both with and without the geared cooling fan which it is proposed to fit to the engine, and the test bed work on the fan has been correlated with flight test results of a similar fan installation in a Boomerang aircraft.

The investigation of chrome plating of aircraft engine cylinder barrels has been carried a stage further. This process is intended primarily for the reclamation of worn cylinders. There are two distinct types of surface which may be used, " porous " and " dense " ; the porous surface is favoured in America and the dense in England. Accelerated tests on the bench have been carried out to determine the relative wear characteristics of the two types and of plain steel barrels in an R1830 Twin Wasp engine. Little difference between the two types of plating was found, but both wore very much less than the original steel barrels. It is being recommended to the Air Force that dense plating be adopted, since the result is apparently as good as that obtained with the relatively complex porous plating process.

Another project of growing importance is the testing and development of small stationary engines. At the present time large numbers of these engines are being produced in Australia and manufacturers are encountering a variety of problems. In many instances it has been possible to suggest alterations which have very considerably improved the performance of the engines. Seven small engines were investigated during the current year, while, in a different category, a 200 horse-power marine diesel engine has been tested for the Navy. It is expected that this work on internal combustion engines other than aircraft engines will increase in the future.

Amongst the work carried out for the Royal Australian Air Force was an investigation of the range of Liberator aircraft. The flying of this aircraft from the Darwin area has been facilitated by the formulation of specific engine operational instructions for pilots. For maximum range it is necessary to select the optimum combination of air speed, engine speed, and boost for the prevailing conditions of aircraft weight, altitude, wind speed and direction. In the past the data supplied have been insufficient to enable pilots to make the best selection. Now, based on approximate test figures obtained in this area, operating instructions which will serve for immediate use have been prepared. The general problem of flying for extreme range occurs for practically every type of operational aircraft and has, therefore, been given high priority by the Royal Australian Air Force ; it will also have application to civil aircraft.

Other *ad hoc* work has included the calibration of a torque nose for measuring engine power in flight for the Royal Australian Air Force, the type test of an Australian-built aircraft engine magneto, tests of a universal joint thrust bearing for the Army, and tests of sparking plugs and fuels.

(iii) *Research and Developmental Investigations.*—(*a*) *Air Filter Investigations.*—The life of engines is largely governed by the quantity of dust introduced with the charge air. Air filters are therefore used, and in the aircraft engine application their design involves a compromise between efficiency and size. In order to provide data for this design and to test existing filters, a plant has been set up and a " standard " dust prepared. The plant has been calibrated and work is now beginning on the collection of design data. This problem may become very acute with the advent of turbine engines which use about five times the quantity of air used by a comparable reciprocating engine.

(*b*) *Rotary Valve Engine.*—Work on the McLaren rotary valve engine has been proceeding in the Section for some time. Arising out of these investigations a small air-cooled single-cylinder rotary valve engine has been built to investigate the possibility of using a floating junk head instead of the floating cylinder which is an essential but complicating feature of the McLaren design. A new type of rotary valve was employed and the results so far have been very encouraging. The power per unit displacement of the engine is about 50 per cent. higher than that of a normal poppet valve engine of comparable size and the fuel economy is 25 per cent. better. Development of the valve lubrication system is proceeding, together with modification of the valve to make it suitable for operation in multi-cylinder in-line engines. The present engine with a compression ratio of 8 : 1 operates without detonation on 70 octane fuel.

(c) *Piston Ring Lubrication Investigations.*—Following the development of a technique by the Lubricants and Bearings Section for determining the thickness of lubricating oil films between piston ring and cylinder wall of an engine by means of electrical conductivity measurement, it was arranged that the work should be extended in this Division to the practical operating conditions of power, speed, and temperature prevailing in an actual engine. The problem involved in taking out electrical leads from the piston rings in an engine operating at high piston speed is a matter of no little difficulty, and an experimental set-up for this purpose has been devised. It is expected that data will be available at speeds up to at least 2,000 revolutions per minute on full-scale aircraft engine cylinders. It is intended to study the lubrication between the ring and cylinder and to observe its effect on wear, oil consumption and piston cooling.

6. *Instruments Section.*—Though most of the work of the Instruments Section has been devoted to the problems submitted by the Services and other outside bodies, considerable assistance has also been given to other sections of the Division of Aeronautics. The problems submitted by outside organizations have been of great variety, and some of the more interesting are now mentioned.

The flight level indicator, a local invention submitted by the Department of Civil Aviation, was developed and tested. It combines the readings of a sensitive altimeter and a remote-indication compass so as to denote the prescribed height of flight for any particular course.

At the request of the Army a package release unit for scattering leaflets from tied bundles in aeroplanes was developed. It is operated by atmospheric pressure and can readily be set to operate at any predetermined height in the range 0–6,000 feet. Also for the Army, an omni-directional hot-wire anemometer was developed for experimental work.

The premature operation of crash-actuated inertia switches was investigated for the Royal Australian Air Force. Flight and laboratory tests revealed that the cause was resonant vibration of the mounting brackets. The brackets were modified so that no resonance occurred within the operating speeds of the engine.

A magnetic comparator was developed for the Department of Aircraft Production, which rapidly and non-destructively sorted alloy steel bars by comparative measurements of one physical quantity, in this case permeability. It was also effective as a crack detector and in detection of carbon segregation in turnbuckles.

An intervalometer test set was developed for the Royal Australian Air Force. The instrument is used for testing aircraft intervalometers used in aircraft for spacing bomb drops.

The work for other Sections of the Division consisted largely of the development of research instruments for special purposes. The more important were—

(i) A surface finish meter for optically measuring the surface smoothness of aeroplanes was produced. This measures the ratio of the specularly reflected to the diffusely reflected light from the surface, this ratio being an index of the surface finish.

(ii) Self-balancing magnetic force units were designed and built for the measurement of model forces in the variable-pressure tunnel. This being a closed pressure vessel, a remotely indicating self-balancing type of force recorder is needed.

(iii) A spot gluer using dielectric heating for tacking veneer sheets to the mould before curing was developed for the moulded woodwork in the Structures Section.

(iv) A supersonic sound source and a time ratiometer for returning a fixed fraction of condensed liquid were constructed for the Division of Industrial Chemistry.

In addition a host of minor projects were undertaken for both the Division itself and for outside bodies. These were of wide variety and included calibrations, elucidation of operational troubles, construction of electronic equipment and development of special instruments and apparatus.

7. *Publications.*—The following papers were published during the year :—

(i) *Division of Aeronautics*—

Batchelor, G. K. (1944).—Transition to turbulence within the boundary layer. *Aust. J. Sci.* 6 : 108–112.

Batchelor, G. K. (1945).—Power series expansions of the velocity potential in compressible flow. *Quart. Appl. Maths.* 2 : 318–328.

Batchelor, G. K., and Townsend, A. A. (1945).—" Singing " corner vanes. *Nature* 155 : 236.

Green, J. R., and Southwell, R. V. (1944).—Relaxation methods applied to engineering problems—

VIIIA. Problems relating to large transverse displacements of thin elastic plates. *Phil. Trans. Roy. Soc. Lond.* Series C, Math. Phys. Sci. 1 : 137–176.

IX. High-speed flow of compressible fluid through a two-dimensional nozzle. Ibid. Series A, Math. Phys. Sci. 239 : 367–386.

Osborn, C. J. (1944).—Transformations in ferrous alloys. *A'asian Eng.* 44 : 26–29 (Dec.).

Rowe, F. D. (1945).—The spot-welding of light alloys. Ibid. 44 : Sci. Sheet 8–16 (June).

Townsend, A. A. (1945).—A magnetic comparator for sorting of ferrous alloys. Ibid. 44 : 42–3 (March).

(ii) *Australian Council for Aeronautics*—

Batchelor, G. K. (1945).—On the concept and properties of the idealized hydrodynamic resistance. Report ACA–13.

Patterson, G. N. (1944).—Ducted fans : Design for high efficiency. Report ACA–7.

Patterson, G. N. (1944).—Ducted fans : Approximate method of design for small slipstream rotation. Report ACA–8.

Patterson, G. N. (1944).—Ducted fans : Effect of the straightener on overall efficiency. Report ACA–9.

Patterson, G. N. (1944).—Ducted fans : High efficiency with contra-rotation. Report ACA–10.

Scholes, J. F. M., and Patterson, G. N. (1945).—Wind tunnel tests on ducted contra-rotating fans. Report ACA–14.

Shaw, F. S. (1944).—The torsion of solid and hollow prisms in the elastic and plastic range by relaxation methods. Report ACA–11.

Smith, R. C. T. (1944).—The buckling of flat plywood plates in compression. Report ACA–12.

XVI. INDUSTRIAL CHEMISTRY.

1. *General.*—During the year under review the Executive Committee and the Council have given further consideration to the proposals of the Division's officers with respect to its post-war work and development. It has been decided that, while the head-quarters of the Division will remain in Melbourne, much of its work will ultimately be carried out in other States. It is intended that the Melbourne laboratory will be equipped with sections in most of the main branches of chemistry—as enumerated below—and that officers stationed in other States should from time to time spend short periods at this central laboratory. In this way it is hoped to combine the benefits of decentralization with the advantages of a research laboratory with very wide interests. Decentralization is particularly desirable where the industries to be served or the latent resources to be developed are centred in another State.

There has now been established in Melbourne a Section of Chemical Physics. This Section will have two main functions, the first being to apply modern physical methods in the solution of chemical problems arising in other Sections of the Division's activities, the second being to conduct independent research. It is intended that extra-mural work will also be undertaken by the service side of the Section. Techniques which will be established in the near future are electron microscopy and diffraction, X-ray diffraction and spectroscopy—including mass spectroscopy and infra-red spectroscopy. The introduction of some of these techniques for the first time in Australia should be of service to both primary and secondary industry.

Advisory work has been continued for other Government Departments, and closer relationships are being established with industry. An example of the latter is that the Wool Scourers, Carbonizers and Fellmongers' Federation of Australia has recently made a substantial donation to assist the work designed to help the fellmongering industry.

The pressure of work for the Services and the munitions industry is diminishing, but much of the investigational work of the Division is still of direct application to the war effort. Contributions are also made in other ways ; thus the Rubber Industry Technical Committee, of which the Chief of the Division is Chairman, is passing through the most difficult period of its existence as Australia turns from natural to synthetic rubber.

At the instigation of the Division a Committee has been set up by the Council to advise it on the position in Australia of research on the production, preparation and utilization of coal.

The Division has also arranged for shipment of certain Australian hardwoods to the United States of America so that their suitability for alcohol production may be assessed in a pilot plant operated by the Forest Products Laboratory at Madison. The species of hardwoods to be tested were selected by the Council's Division of Forest Products, and the project as a whole is being co-ordinated with the work of the Chemistry Department of the University of Tasmania.

During the year a course of lectures on Chemical Thermo-dynamics was delivered to scientific officers of the Division by Dr. E. J. Heymann of the University of Melbourne; some members of other Divisions of the Council and of the Munition Supply Laboratories also attended.

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 completion or extension of existing projects rather than the initiation of much new work has characterized the year's programme. This work has been directed chiefly to the development of improved methods for obtaining industrially important products from, and finding new uses for, a number of minerals of Australian origin. In addition to these investigations, the Section has dealt with a considerable number of inquiries from persons and firms interested in the chemical processing of minerals and in this and other ways has maintained and extended its industrial contacts.

(i) *Chromite.*—Chemical work on this mineral was begun originally with the object of devising a new method for the processing of chrome ore which would, if possible, avoid some of the difficulties inherent in the treatment by the conventional alkaline method of the lower grade Australian chrome ores for the preparation of sodium dichromate and related chemicals. As mentioned in earlier reports some success has attended the development of an original process based on the catalytic solution of the chrome ore in sulphuric acid followed by electrolytic oxidation of the dissolved chromium to chromic acid and its isolation as such. Attention has been devoted to certain phases of the work which required reconsideration as a result of pilot plant tests of the process conducted by the Chemical Engineering Section. Chromic anhydride is a versatile intermediate, and the optimum conditions for its transformation into a number of useful industrial derivatives have also been studied. These substances include green chromic oxide pigment, sodium dichromate, sodium chromate, " viridian " pigment, chromic ammonium alum, and chrome tanning salts of varying basicity.

(ii) *Monazite.*—This mineral is the chief industrial source of cerium and thorium, the compounds of which have a variety of important uses. It also contains several other rare metals of potential or actual industrial value. A limited tonnage of monazite is produced in Australia as a by-product in the separation of zircon and rutile from beach sands and also from alluvial tin-mining operations. Originally, investigations on this mineral were undertaken in connexion with the production of pyrophoric cerium alloys and cerium fluoride required as an ingredient of searchlight carbons. This work has been completed.

A method has been perfected for the production of the special grade of rare earth oxides required for polishing optical lenses and prisms. Improvements have been devised leading to a reduction in cost of this important product compared with the imported material. A substantial quantity of the polishing powder has been supplied to the Scientific Instruments and Optical Panel of the Ministry of Munitions for distribution to optical establishments throughout the Commonwealth. This material, which filled an urgent need, was produced in a pilot plant constructed by the Chemical Engineering Section for the purpose of testing an improved process for the manufacture of rare earth hydroxides. This work is being continued, since these hydroxides form a convenient intermediate for the preparation of a wide variety of important rare earth derivatives.

(iii) *Rutile.*—Rutile consists essentially of titanium oxide, and the New South Wales and Queensland beach sand deposits of this mineral are among the most extensive known. Apart from the local production of welding rod flux, for which the separated mineral is specially adapted, extensive export of the unprocessed material has chiefly characterized the Australian production. This work was originally undertaken in connexion with the local manufacture of titanium tetrachloride for use as a smoke screen. The titanium tetrachloride was prepared on a pilot plant scale, and the data so obtained provided the basis for its production by an industrial firm. Coincident with the lessening requirements for this substance, attempts have been made to devise new industrial uses for chemical derivatives based on titanium tetrachloride. As a result, heat-resistant inorganic paint films of promising characteristics have been developed. The possibilities are considerable and this aspect of the work is being further investigated.

(iv) *Fluorite.*—This mineral is the chief source of fluorine compounds, a wide variety of which are finding increased industrial uses. There is considerable scope for research into methods of obtaining useful derivatives from fluorite by methods other than those involving the intermediate production of hydrofluoric acid. For chemical purposes contamination with silica and other impurities usually necessitates rejection of much fluorite, as mined, because no selective flotation is employed by the Australian producers. The purpose of this work is to

develop methods of converting the mineral into useful intermediates without necessarily requiring the highest grade ore. Synthetic cryolite, used in aluminium production, has been the chief intermediate studied in this connexion, but other derivatives have also received attention during the past year.

(v) *Graphite.*—Australian deposits yield grades of graphite which, in general, have been considered inferior to those obtained from Ceylon and Madagascar, but war conditions twice necessitated partial substitution of the local product for the imported. This fact, coupled with the desirability of defining the scope for the domestic material for a variety of uses in normal times, has led to the investigation of further chemical purification of graphite concentrate produced by selective flotation; this product usually contains interleaved impurities which may limit its usefulness in certain fields. This work has, during the past year, been chiefly concerned with the requirements of the electrical dry-cell industry. The beneficiation of South Australian graphite by two different chemical methods has been successfully achieved on a laboratory scale. The products obtained by combined chemical and physical methods have been proved to be as satisfactory as Ceylon graphite when used in dry cells. Work was also begun on the testing of dry cells for the purpose of assessing the value of the prepared graphite and pyrolusite. The latter mineral is the basis of an affiliated project.

(vi) *Pyrolusite.*—The manufacture of electrical dry cells usually involves the incorporation of natural manganese dioxide, or pyrolusite, and the efficient functioning of the cells is largely dependent on certain of its chemical and physical characteristics. The factors which determine the efficacy or otherwise of the pyrolusite are at present imperfectly understood, and consequently manufacturers of dry cells are restricted to using pyrolusite which experience has shown to be satisfactory. Deposits in this category are rare in Australia. The resulting dependence on overseas supplies has indicated the need for research into the fundamental characteristics of certain Australian pyrolusites with a view to their chemical or physical "activation". The use of synthetic manganese dioxide and of the artificial manganese dioxide obtained as a by-product of the electrolytic zinc industry, where it is formed as an anodic deposit, are also being investigated. Co-operation has been established with the Australian dry cell industry, and a large number of natural pyrolusite ores and chemically prepared artificial manganese dioxides, and mixtures of these, were tested as dry-cell depolarizers. In addition, the samples are being examined in the laboratory in an attempt to relate physical and chemical properties with cell behaviour. X-ray diffraction studies have been conducted by the Munitions Supply Laboratories, Maribyrnong.

(vii) *Zircon.*—The beach sands of northern New South Wales and southern Queensland contain an important assemblage of detrital minerals of which zircon, a silicate ore of zirconium, is a major component. The industrial utilization of zircon and its many derivatives is at present largely confined to overseas countries. During the past year investigations related to chemical derivatives of zircon were commenced, and it is expected that work on this subject will be continued for a considerable time. The investigation has not yet reached a stage that merits detailed consideration.

(viii) *Torbernite.*—At the instigation of the Department of Supply and Shipping, a comprehensive examination of the optimum conditions for the chemical concentration of uranium from the low-grade secondary phosphatic ores from South Australia was undertaken. An acid leaching process for the differential solution of torbernite from manganiferous ironstone, and other gangue minerals, was devised, and methods were developed for the recovery of the dissolved uranium by selective precipitation.

4. *Cement Section.*—The work of this Section is carried out with the co-operation and financial assistance of the Australian Cement Manufacturers' Association.

(i) *Cement-Aggregate Reaction.*—A number of aspects of the problem of the deterioration of concrete through expansive reaction between aggregates and cement are being investigated. A large collection of Australian aggregates has been examined mineralogically, and the behaviour of each aggregate, when used with a number of cements of differing composition, has been observed over a period of one to two years. The results of this work are now sufficiently complete to suggest that reasonable care in the selection of aggregates should minimize the dangers of expansive reaction. Other investigations dealing with controlling factors of the same problem are being made. These include chemical and petrographic examination of some of the components of cement clinker and an investigation of the mechanics of the expansive processes. Some work on preventive measures has also been done.

A qualitative test, developed in the laboratory, has been found to give reliable and comparatively rapid indications of expansive cement-aggregate combinations.

Cements of carefully controlled composition for experimental purposes are being made in the laboratory.

(ii) *Standard Sand for Cement Testing.*—Sands from a number of Australian sources have been examined. After sand from one locality had been selected as the most suitable, the deposit was mapped and estimated, and a large sample treated in the laboratory. The prepared sand will be distributed to a number of laboratories for thorough testing, the results of which should lend themselves to statistical treatment. This work has been done at the request of the Standards Association of Australia in order to find an Australian sand which, in an emergency, can be used as a standard in cement testing.

(iii) *Refractories.*—Preliminary work has been started on some problems connected with refractory materials in cement kilns.

5. *Biochemistry Section.*—(i) *Fellmongering Research.*—Closer contact with the fellmongering industry has been established during the past year. The members of each of the State branches of the Wool Scourers, Carbonizers and Fellmongers Federation of Australia have been addressed on the results of the Division's fellmongering research, and the Federation has provided financial assistance for the continuance of this work.

(*a*) *Wool Loosening with Sulphide Depilatories.*—One of the main objections to the painting method of fellmongering is that the wool becomes slightly harshened through contamination with the depilatory and thus depreciates in value. Attempts are being made to develop a paint which has a depilatory action equal to or better than that of the lime-sulphide paint now used, but which is less harmful to the wool, that is, has less effect on the keratin of the wool. The keratin-solvent action of various solutions is being studied by estimating the cystine and cysteine which they detach from wool fibres; the results obtained are being correlated with the reduction in breaking load of single fibres, measured in a newly designed breaking-strength apparatus. Depilatory action is determined by measuring the depilation load, that is, the force required to detach a standard sample of wool from the skin after applying various mixtures to the flesh side of the skin and covering it with a glass plate.

(*b*) *Wool-loosening Action of Ammonia and Related Compounds.*—It has been observed that ammonia is evolved from sheepskins during fellmongering by the sweating process. It is important to ascertain whether it contributes to the release of the wool and therefore whether it should be allowed to accumulate. In this work it has been established that the rapid but incomplete wool-loosening activity of 0.2 per cent. ammonia solutions becomes more pronounced in alkaline solutions, but even after treatment for 48 hours the wool is insufficiently loosened for easy pulling by hand. It is unlikely that the ammonia produced during the sweating process is the principal cause of wool loosening. The effect of primary, secondary and tertiary amines, which are chemically related to ammonia, is similar, but in general it is less pronounced and decreases with increase in molecular size.

(*c*) *Proteolytic Enzymes.*—Proteolytic enzymes are likely to assume considerable importance in the fellmongering industry. Already they are used for bating sheep pelts, and it is hoped that the laboratory investigations now in progress will lead to the development of a new method for the recovery of wool from heads, shanks and skin pieces which yield some 15–20 per cent. of Australia's fellmongered wool. The method is based on an enzyme digestion of the skin proteins after shrinking the skin in hot water. This method not only involves less damage to the wool but it gives promise of being quicker and more efficient than those now in use.

Papain from the pawpaw, and a protease produced by a mould of the group *Aspergillus flavus-oryzae*, have been successfully employed in the laboratory, and the optimum conditions for their action on the collagen of the skin have been studied. The mould which produces this protease is being grown on bran on a pilot-plant scale, and work is continuing on its purification and characterization.

Euphorbain 1, the protease occurring in the latex of *Euphorbia lathyris*, has also been studied, and it has been shown to exhibit optimum activity at pH values of approximately eight. Unlike papain, it was rapidly inactivated at temperatures above 60° C. and was not activated by reducing agents such as hydrogen sulphide. Limited supplies have so far precluded investigations of its use in the fellmongering industry.

In the development of this method, a simple and rapid means of estimating the proteolytic activity of the enzyme was essential, and a method has been devised which allows of rapid and accurate determinations of gelatinase activity in a specially designed micro-viscometer.

(*d*) *Studies on Collagen.*—In view of its important bearing on the recovery of wool from heads, shanks and skin pieces, investigations are in progress of the influence of various treatments on the shrink temperature of collagen.

(ii) *Industrial Fermentations.*—Industries based on fermentation processes are likely to become increasingly important in Australia since they provide a means of utilizing materials such as sugar, starch and cellulose derived from primary industry for the production of a wide range of valuable organic chemicals.

Limitations of staff and space have so far made it necessary to confine investigations to the known fermentations mentioned below. However, it is hoped to examine micro-organisms and substrates available in Australia with a view to the development of new industrial fermentations.

(*a*) *Lactic Acid.*—In a wide variety of industries lactic acid has become important. It is used in the leather industry for deliming hides and adjusting the pH values of tanning extracts, in the dyeing industry as a mordant, for controlling acidity in yeast manufacture and other fermentation industries, and for acidifying foodstuffs and beverages. The investigations concerning its production from cheese whey, which is normally regarded as a waste effluent, were continued during the year with particular reference to the control of pH value and the agitation of the fermentation liquors, and the most suitable strain of organism. The advantages of using mixtures of long and short strains of *Lactobacillus bulgaricus* over single strains has been demonstrated. Germinated cereals have been investigated as a souce of nutrients, growth factors, and additional carbohydrate for fermentation.

(*b*) *Power Alcohol.*—A method has been explored of increasing the rate of converting sugar to alcohol by agitating the fermenting yeast suspension thoroughly under completely anaerobic conditions. The rate was only slightly improved by these modifications.

(*c*) 2 : 3–*Butandiol.*—Although the production of 2 : 3–butylene glycol by the fermentation of sugar with *Aerobacter aerogenes*, or of starch with *Aerobacillus polymyxa*, was originally undertaken because it is convertible through butadiene to synthetic rubber, it may have many other industrial applications. Thus its derivatives may find application in the manufacture of lacquers, inks, flavouring agents, and as lipoid solvents.

The effect of adding sugar to the wheat mash medium on the yield of 2 : 3–butandiol and on the ethanol : glycol ratio obtained during fermentation with *A. polymyxa* has been studied. The stimulating and inhibiting influence of certain metal ions on the fermentation, and the influence of the conditions of cultivation and the method of sporing on bacterial variation, have also been explored. Studies have been initiated on the carboxylase and respiratory enzyme systems of the organism using the Warburg manometer assembly.

6. *Physical Metallurgy Section.*—(i) *Investigation of Corrosion in Aircraft Cooling Systems.*—An intensive study is being made of the corrosion problems associated with the use of ethylene glycol-water mixtures in liquid-cooled military aircraft. While the electrochemical analysis of the problem has been continued, the main effort has been directed towards the development and trial of means for retarding corrosion. In this connexion, some success has been achieved, and the investigation has been extended with a view to establishing the practical merits of the more promising remedial measures.

(ii) *Production of Beryllium-Copper Alloys.*—A start has been made on the development of a technique for producing beryllium copper alloys required in the manufacture of springs and diaphragms for aircraft instruments. The process is essentially the reduction of beryllium oxide with carbon in the presence of molten copper in an arc furnace.

(iii) *Stabilization of Slip Gauges.*—Thermal treatments for ensuring dimensional stability in slip gauges have been investigated, the chief aim being to determine the best stabilizing procedure for each type of steel used. This investigation is designed to help the Division of Metrology develop more accurate gauges for secondary industry.

(iv) *Miscellaneous.*—A number of minor investigations were undertaken to assist other Government Departments, the Services and private companies with munitions contracts. The embrittlement of ferro-chrome, the extrusion of aluminium alloy for aircraft production, the tinning qualities of various grades of sheet steel used in the manufacture of tinplate for food containers, and problems associated with excessive tin on cooking utensils for the fighting Services, were investigated.

Many corrosion problems were investigated, and methods were developed for the prevention of corrosion of radio equipment used in the tropics, containers for blowfly dressings and galvanized-iron ice cans in brine. The suitability of columbium-bearing austenitic stainless steel for photographic equipment in military hospitals was explored, and temporary corrosion preventives for aluminium sheet were developed.

7. *Physical Chemistry Section.*—(i) *Separation of Minerals by the Flotation Process.*—Much time has been devoted to the development of small-scale methods for the testing of flotation reagents with natural ores. Considerable progress has been made during the year on the problem of correlating these laboratory tests with batch flotation in the small cells used for practical testing. Factors such as consumption of reagent, surface alteration of one mineral by soluble salts derived from other minerals, and the effect of minor constituents of ores were studied. Much of this work was done with tin ores; it was used in drawing up a final specification of a patent in which is described a process for separating cassiterite from its ores. The optimum conditions for operation of this process were determined, and it was shown that

good recoveries of tin could be obtained from samples of a large marginal-grade Tasmanian deposit which has not been exploited by conventional methods of concentration and separation; this work has been done in collaboration with the Tasmanian Department of Mines.

Flotation of fluorite, the chief industrial source of fluorine compounds, was investigated using a number of new reagents. For most fluorite ores these reagents possess no advantage over the usual flotation reagent (oleic acid), but in special instances they could be of value. The flotation of the tungsten mineral, scheelite, has similarly been studied, but no reagent combination better than that at present employed was found.

Progress on a fundamental investigation of some of the factors which influence the separation of the sulphides of copper, lead and zinc has been slow, owing to the complex reactions which the sulphides undergo on exposure to air or aerated water. A number of the rarer sulphides (lollingite, marcasite, bornite, covellite, chalcocite, marmatite, tetrahedrite, orpiment, bismuthinite), when allowed to oxidize, behaved in essentially the same way as do the more common sulphides (pyrite, sphalerite, galena, chalcopyrite) when they too are oxidized.

(ii) *Emulsions.*—At the request of the Division of Economic Entomology the preparation of oil-water emulsions of D.D.T. was investigated. Emulsions having the required stability and having no injurious effects on plants were developed, and the more promising of these are now being submitted to field tests.

Emulsions of carbon tetrachloride in strong copper sulphate solutions were investigated with a view to their use for the control of parasites in sheep. A stable emulsion having the required characteristics was developed, and it has been submitted for test to the Division of Animal Health and Production from whom the request originated.

(iii) *Drugs.*—Certain physico-chemical properties of a number of drugs of the acridine series have been measured, and these are being correlated with bacteriological tests. This work has been done in collaboration with the Universities of Sydney and Melbourne.

(iv) *Surface Areas of Solids.*—Reactions with solids are governed by the extent of their surface; in studies of the reactivity of solids, therefore, a knowledge of the surface area is essential. Measurements of surface area may be based upon the capacity of solids to absorb gases such as oxygen, argon, and nitrogen at the temperature of liquid air. Such measurements are already being used in the study of the finely ground minerals separated in flotation processes, and may be used for other projects of the Division such as the variation in the activity of different samples of pyrolusite when used as depolarizers in dry cells, and the setting properties of cements prepared and ground under different conditions.

(v) *Miscellaneous.*—In response to a request by the Royal Australian Air Force, a chemical method for removing carbon deposits from aluminium engine parts was developed, and successful tests were conducted with a pilot plant designed by the Chemical Engineering Section. The United States Army Air Force has undertaken further testing.

Considerable trouble due to corrosion of compass pivots has been experienced by the Royal Australian Air Force, and the Division was asked to develop a method for the complete de-aeration of the compass fluid. This was successfully accomplished.

8. *Chemical Physics Section.*—The scope and future activities of this Section have been planned in some detail, and steps have been taken to acquire staff and equipment to provide for the application of certain physical techniques such as electron microscopy, X-ray diffraction, spectroscopy, electron diffraction and mass spectrometry, to internal and extra-mural researches; the provision of these techniques for use on the problems of other of the Sections and Divisions of the Council will constitute a major part of this Section's activities.

An electron microscope, which it is planned to apply extensively to the problems of both primary and secondary industry, has been installed and is now undergoing final adjustment and calibration. An electron diffraction camera, to be used in the study of surfaces, has been designed and is under construction in the Division's workshops. X-ray diffraction equipment is also being installed and will be employed immediately for phase identification in metals and alloys, minerals and inorganic solids.

9. *Foundry Sands Section.*—(i) *Moulding Sands.*—Surveys of the moulding sands of Australia are being conducted in collaboration with the Mines Departments of the several States.

The survey of the Melbourne sands originally published in 1942 is now being extended to ensure continuity of supply of sands of certain grades, present sources of which are in danger of depletion.

The testing of South Australian, New South Wales and Western Australian sands has been completed. The results of this part of the survey have been issued as interim reports and made available to foundrymen. Lectures on these results have been delivered to Foundrymen's Associations in South Australia and Western Australia; their interest in this work is evident from numerous inquiries concerning substitute sands and the improvement of foundry practice.

Good deposits of nearly all the grades of sand required for foundry use are available in Victoria. In the other States, excellent deposits of some grades are available but others are lacking. In some instances, these disabilities have been overcome as the result of recommendations that new deposits should be opened up, or that improved methods of working sands already available should be employed.

(ii) *Testing of Clays.*—Tests have been conducted on a number of Australian clays to determine their suitability as substitutes for American bentonite or as binders in synthetic sand. Most clays are unsuitable as direct substitutes for bentonite, but some of those examined produced green strengths which indicate that they would be suitable as binders for synthetic sands. There are three main clays which, for certain purposes, may be considered as direct substitutes for American bentonite: the Trida clay of New South Wales which develops approximately half the green strength of American bentonite; and the Marchagee and Yarraman clays from Western Australia and Queensland respectively, samples of which have, in synthetic sands, produced green strengths equal to that from American bentonite. In practice, however, these clays have given variable results, apparently owing to variability of the clay at its source and to lack of care in processing. Despite these difficulties it is evident that the use of the Australian bentonites is steadily gaining ground.

The Division acted in an advisory capacity to the Controller of Materials Supply when, as a result of the acute shipping position, the Ministry of Munitions sponsored an agreement among suppliers to market a mixture of equal proportions of bentonite and Trida clay.

(iii) *Synthetic Sand.*—During the survey of the South Australian moulding sands, it was recommended that a synthetic sand based on a fine-grained free sand from Noar'unga would produce better results for light iron and brass castings than the poorly graded river loams which were being used. Tests on the sand were conducted, the immediate difficulties were overcome, and the optimum conditions for producing a synthetic sand for this type of casting were determined. The results of this work should be readily applicable in other States where similar difficulties exist.

(iv) *Miscellaneous.*—The advisory service to foundries and other Government Departments has been continued, and a large number of tests have been conducted in connexion with the solution of problems of individual foundries having munitions contracts.

10. *Organic Chemistry Section.*—Two major investigations were completed during the year, namely, the analysis of cracked tar gases by low temperature fractional distillation which was sponsored by the National Gas Association, and the development of a continuous process for the production of ethylene chlorohydrin. This last process was developed to a stage where sufficient knowledge had been obtained to permit the construction of a large-scale plant. At the same time, data were collected for the preparation of the closely related dichlorodiethylether, and concerning the conversion of the chlorohydrin to ethylene oxide. Requests for quantities of these chemicals have been received from a number of companies and research workers for use in the examination and synthesis of drugs, pharmaceuticals and insecticides.

Other major problems on which the Section has been engaged are the following:—

(i) *Direct Oxidation of Ethylene to Ethylene Oxide.*—This important oxidation process, which has been regarded by some as the outstanding discovery in the field of catalysis during the last two decades, had until just recently been described only in the patent literature so that no adequate picture of the reaction was available. The systematic study of the reaction was undertaken partly because it can be the fundamental step in the preparation of a wide range of chemicals closely related to ethylene glycol and about which knowledge in Australia is highly desirable, and also because at the same time it is a convenient medium for the study of heterogeneous catalysis. In May, 1945, a description was published of work carried out at Purdue University at the request of the Monsanto Company which has in part duplicated some of our work. Nevertheless, further systematic work is needed and the investigation is still proceeding.

(ii) *Butadiene from* 2 : 3–*Butandiol.*—2 : 3–Butandiol can be obtained directly from starches or sugars by a fermentation process and, if successively acetylated and de-acetylated, it is convertible to butadiene in good yield. Butadiene is in turn convertible to synthetic rubber. These processes constitute a method for producing butadiene from wheat or sugar, but a more attractive method would emerge if it were possible to dehydrate the butandiol directly to butadiene.

Yields obtained in direct dehydration mentioned in reports of overseas work are disappointingly low and, as mentioned in the previous Annual Report, first investigations by the Section gave equally low yields. Further work has shown that it is possible to raise these yields, and values exceeding 60 per cent. of the theoretical have been obtained, so that it may yet be possible to avoid the acetylation and de-acetylation steps. A provisional patent has been taken out covering these advances.

(iii) *Furfural and Its Derivatives.*—It is well recognized that whereas in the laboratory using 12 per cent. aqueous hydrochloric acid it is possible to obtain almost complete conversion of the pentoses of such materials as oat-hulls and corn-cobs to furfural, in the commercial pressure processes which employ dilute sulphuric acid as catalyst the conversion rarely reaches 60 per cent. During the past year some factors controlling this conversion have been examined, but the work is still incomplete.

Furfural is a relatively cheap chemical, potentially available in enormous quantities. For this reason another phase of the work has been the preparation of a wide range of derived chemicals in order to test their value for various uses including those of insecticide and insect repellents.

(iv) *Insect Repellents.*—In addition to the derivatives of furfural, work has begun on the synthesis of a series of organic chemicals for testing as insecticides and insect repellents by the Council's Division of Economic Entomology.

(v) *Mannitol.*—The cause of the mannitol exudation from the tree *Myoporum platycarpum* is still obscure. In collaboration with the Botany Department of the University of Melbourne, the two bacteria which predominate among the organisms present in the exudate have been characterized, but shown not to produce mannitol in detectable quantities from the commoner sugars. Neither do they bring about exudation of the mannitol-bearing liquid when healthy trees are inoculated with preparations of them. Mannitol has been shown to be present in quantity in the leaves and bark of the tree, so that its presence in the exudate is probably due to some concentration of mannitol from this source.

A short survey of the variation of yields of mannitol with tree and with season has been completed.

(vi) *Microanalysis.*—During the year a laboratory for micro-organic analysis has been equipped and operated.

(vii) *Synthetic Resin Adhesives.*—The older types of glue—casein, gelatin and blood albumen—suffer from several disadvantages, notably from their lack of resistance to moisture and susceptibility to fungal attack, so that in recent years there has been a trend to replace them by resin adhesives, especially those of phenol-formaldehyde and urea-formaldehyde types. The phenol-formaldehyde adhesives suffer from the limitation that heat is needed to set them unless strong acids are employed to catalyse the setting process. In conjunction with the Division of Forest Products, a series of cold-setting glues has been prepared and tested. These have been shown to have certain disadvantages for the gluing of wood, since over a period of six months a considerable loss in bond strength occurs owing to destruction of the wood at the bond line by the acid catalyst employed. These disadvantages are not apparent when employed for the gluing of compregnated wood, and for this purpose such glues are suitable.

The substitution of phenol by resorcinol leads to a glue, corresponding to commercial glues, such as Penacolite, and this can be set without the use of a powerful acid catalyst and is applicable to the gluing of either wood or compregnated wood. The study of these glues is being extended to the bonding of moulded and laminated plastics.

(viii) *Moulding and Testing of Plastics.*—The plastics laboratory is now provided with most of the apparatus needed for the moulding of test specimens of the thermosetting resins and for the assessment of flow properties. This equipment has been used on a number of occasions to appraise the properties of samples of commercial resins and moulding powders submitted to the Division.

The specifications covering the physical and electrical properties of moulding powders differ considerably from country to country, and work has been started to assess the various factors involved in such testing in order to aid in the compilation of Australian specifications. It is intended to apply the experience gained in this work to the development of new plastics.

(ix) *Aniline-Formaldehyde Resins.*—The starting materials in the production of aniline-formaldehyde resins are roughly comparable in cost with those for the production of phenol-formaldehyde resins; moreover, the Australian capacity for aniline production is now considerable.

Aniline-formaldehyde resins have some very desirable properties, especially their superiority to phenol-formaldehyde resins in electrical properties, and their low moisture absorption and transmission. For some time work has been in progress on the preparation of these aniline-formaldehyde resins, and materials can now be readily prepared which approximate fairly well to the mechanical and electrical properties of the overseas commercial materials (Panilax, Cibanite and Dielectene). Such materials suffer from two well-recognized defects. First, they are obtained as spongy voluminous solids containing large quantities of water which makes their preparation protracted and costly; secondly, resins having useful mechanical strengths are hard-flowing thermoplastics not easily adapted to the present moulding techniques. Work with these resins is now being directed to attempts to overcome or eliminate these two defects.

(x) *Miscellaneous.*—Many shorter investigations have been undertaken, including the examination of a sample of oil from Cessnock No. 2 Colliery; the deterioration of cable coatings used in aircraft, including polyvinyl chloride coatings; the preparation of brittle lacquers for use as stress-indicators; the modification of methods of printing on celluloid sheet, in order to render the print scratch-resistant; the moisture vapour transmission of commercial propeller-blade coatings; a report to the Department of Supply and Shipping on the plant used at Cowra, New South Wales, for the production of absolute alcohol; the design of flow meters for a Western Australian alumina plant; and various preparations of organic chemicals for other organizations.

11. *Chemical Engineering Section.*—(i) *General.*—In addition to a number of chemical engineering research projects, the work of the section has included the design and installation of small-scale chemical processing equipment of general utility, the design and construction of equipment for other Sections, and the installation and maintenance of services in the Division's laboratories.

(ii) *Production of Non-felting Woollen Goods by the Freney-Lipson Process.*—The pilot-plant tests of the Freney-Lipson process, in which woollen goods are treated with a solution of caustic alkali in alcohol to render them felt-resistant, was completed during the year and a report of the work is being prepared for publication. In the final large-scale tests, 900 dozen pairs of woollen socks were treated at an estimated cost of 4.0 pence per lb. or approximately 0.6 pence per pair.

The quality and felting shrinkage of the treated wool were good, and no adverse effects were observed on dyes or lastex yarns. The pilot-plant and its operation were demonstrated to nearly 200 members of the textile trade during the year.

(iii) *Pilot-Plant Production of Chromic Anhydride.*—The pilot-plant investigation of the process developed by the Minerals Utilization Section for producing chromium compounds from chrome ores has been continued. This process involves the catalytic solution of the ore in sulphuric acid followed by electrolytic oxidation of the dissolved chromium to chromic acid. It was found necessary to introduce certain modifications in the original process to operate it successfully on a pilot-plant scale, and these modifications are now being tested. Suitable equipment and satisfactory operating conditions for most of the unit processes have been determined, and a quantity of chromic anhydride has been produced.

(iv) *Pilot-Plant Production of Furfural.*—There has been a growing demand for furfural for a variety of purposes; it is a cheap chemical and is potentially available in enormous quantities from agricultural waste materials. Its production by a pressure digestion of oat-hulls with sulphuric acid has been the subject of an investigation in collaboration with the Organic Section. Based on a pilot-plant which had been operated successfully, a larger plant with a capacity of 250 lb. of oat-hulls and producing 30 lb. of distilled furfural per batch was erected and operated during the year. Its main purpose was to provide data for the design of a commercial production unit, but the furfural has been used for the study of furfural derivatives, for the production of phenol-furfural resins, and to meet the increasing demand by essential industries in Australia until a commercial unit is in operation. Active interest in this developmental work has been shown by a number of private companies.

(v) *Production of Rare Earth Oxides from Monazite.*—In conjunction with the Minerals Utilization Section, an improved process for the manufacture of rare earth hydroxides from monazite has been tested in a pilot-plant having a capacity of 100 lb. of monazite per batch. A considerable quantity of the hydroxides were converted to a special grade of mixed oxides used for polishing lenses and prisms, and supplied to the Scientific Instruments and Optical Panel of the Ministry of Munitions which was unable to import sufficient for its requirements. Careful testing and costing have shown that the product from this plant compares favorably both in quality and cost with imported polishing powders. The Division's process for producing these powders has been compared with the patented method used in England and is superior in many respects. The project has now been completed, and full details of the investigation are awaiting publication; in the meantime, however, they have been made available to several companies contemplating local manufacture.

12. *Alunite Investigations.*—Officers of the Division have, under the direction of Professor N. S. Bayliss of the University of Western Australia, worked since early in 1941 as members of a team investigating the utilization of alunitic clay, extensive deposits of which exist at Lake Campion, Western Australia.

The process developed for the production of potash fertilizer from alunite is now operating on a commercial scale. For some time past, investigational work has been concentrated on processes for the production of high-grade alumina from residues resulting from the potash extraction process. Two acid processes are receiving consideration. The first of these, involving hydrochloric acid leaching and subsequent precipitation of aluminium chloride which is then

calcined to alumina, was being operated on the pilot scale at the end of the period under review, and it is anticipated that adequate data to enable the economics of the process to be assessed will shortly have been assembled.

The second process, involving the leaching of the residues with sulphurous acid, has been further investigated on the laboratory scale. This investigation has been suspended because both the officers engaged on alunite investigations are assisting with the pilot scale testing of the chloride process.

13. *Publications.*—The following papers were published during the year :—

Dixon, P. (1944).—Formation of sulphamic acid during the thermal decomposition of ammonium sulphate. *Nature* 154 : 706.

Ellis, W. J. (1945).—Fellmongering investigations. V. The removal of dissolved oxygen from soak water by sheepskins. Coun. Sci. Ind. Res. (Aust.), Bull. 184, pp. 117–123.

Ellis, W. J. (1945).—Fellmongering investigations. XII. Histological studies on the wool root. Ibid., pp. 227–232.

Goldacre, R. J. (1944).—Mode of action of benzylamine sulphonamide (" Marfanil "). *Nature* 154 : 796.

Lennox, F. G. (1945).—Fellmongering investigations. I. A review of the fellmongering industry in Australia. Coun. Sci. Ind. Res. (Aust.), Bull. 184, pp. 9–44.

Lennox, F. G. (1945).—Fellmongering investigations. II. A physical method of following the loosening of wool on sheepskins. Ibid., pp. 45–55.

Lennox, F. G. (1945).—Fellmongering investigations. IX. The wool-loosening activity of ammonia and some related compounds. Ibid., pp. 167–193.

Lennox, F. G. (1945).—Fellmongering investigations. X. Treatments which tighten the wool on sheepskins. Ibid., pp. 195–206.

Lennox, F. G. (1945).—Fellmongering investigations. XI. The recovery of wool from skin pieces by digestion with mould protease or papain. Ibid., pp. 207–226.

Lennox, F. G., Ellis, W. J., and Maxwell, Margaret E. (1945).—Fellmongering investigations. VI. Studies of the soaking operation. Ibid., pp. 125–141.

Lennox, F. G., and Maxwell, Margaret E. (1945).—Fellmongering investigations. VII. The effect of temperature on the rate of sweating. Ibid., pp. 143–153.

Lennox, F. G., Maxwell, Margaret E., and Ellis, W. J. (1945).—Fellmongering investigations. VIII. Ammonia in relation to the sweating of sheepskins. Ibid., pp. 155–165.

McTaggart, F. K. (1945).—Mineral chlorination studies. I. Production of titanium tetrachloride from Australian rutile sand. *J. Coun. Sci. Ind. Res. (Aust.)* 18 : 5–26.

Maxwell, Margaret E. (1945).—Fellmongering investigations. III. The bacterial flora of sheepskins. Coun. Sci. Ind. Res. (Aust.), Bull. 184, pp. 57–87.

Maxwell, Margaret E. (1945).—Fellmongering investigations. IV. Bacteria responsible for the loosening of wool on sheepskins. Ibid., pp. 89–116.

Maxwell, Margaret E., and Lennox, F. G. (1944).—Bacteria responsible for the loosening of wool on sheepskins. *Nature* 154 : 118.

Murray, K. E. (1944).—Ethylene chlorohydrin : A laboratory investigation of a continuous process for its production on a commercial scale. *J. Coun. Sci. Ind. Res. (Aust.)* 17 : 213–221.

Plante, Enid C., and Sutherland, K. L. (1944).—The physical chemistry of flotation. X. The separation of ergot from rye. *J. Phys. Chem.* 48 : 203–223.

Scott, T. R. (1945).—The utilization of fluorine resources. *Aust. J. Sci.* 7 : 106–111.

Wark, I. W. (1944).—New materials and their possible influence on Australia's industrial future. Inst. Ind. Management, Aust., No. 11.

XVII. RADIOPHYSICS.

1. *Introduction.*—This is the first occasion on which an account of the work of the Radiophysics Laboratory has appeared in the Council's Annual Report. From the time of its foundation until the termination of hostilities, this laboratory has been engaged solely on secret work for the Australian and United States Fighting Services, and it has not been possible hitherto to publish in an open way any account of the work done. The end of the war has come at an opportune time to permit, on this occasion, an account of the work of the Radiophysics Laboratory to be included.

2. *The Beginning of Radar Work in Australia.*—On 24th February, 1939, a secret telegram was transmitted from the United Kingdom Government to the Prime Minister of Australia asking for a physicist to be sent to England to whom could be communicated

information relating to important secret developments of interest to the Armed Forces. In response to this request Dr. D. F. Martyn, a senior physicist on the staff of the Council's Radio Research Board, went to England. The first information about the developments of radar in the United Kingdom was communicated to Dr. Martyn, and he was able to bring back to Australia a comprehensive account of the work that had been going on in England for several years.

It is interesting to note that all the initial work on radar was carried out in Great Britain during the period 1935 to 1939, before the war actually broke out, and that six months before the war broke out the United Kingdom Government had made a great deal of information available to Australia.

As a result of Dr. Martyn's visit, and of a visit to the United Kingdom at a later date by Sir John Madsen, a plan was prepared for the formation in Australia of a sub-centre for research, development, and production of radar equipment in anticipation of a situation arising in which Australia and New Zealand might be cut off from the United Kingdom and Europe. The expressed intention of the two Governments was to bring into being facilities needed for the development of radar equipment for the Australian Services, and to maintain in Australia a storehouse of equipment; also to build up a production industry as a safeguard against such a contingency as mentioned above.

Since active work on radio research had been in progress in Australia for several years under the auspices of the Radio Research Board, the Council was able to start work immediately on this new radar project. Under the direction of Sir John Madsen, a beginning was made in the laboratories of the Department of Electrical Engineering at the Sydney University. At the same time, plans were prepared for the completion of an extension to the National Standards Laboratory building which was then in the course of erection. In fact, that part of the whole building in the grounds of the University of Sydney, which was to house the Radiophysics Laboratory, was completed before the National Standards Laboratory, and a small staff commenced work in the new building in March, 1940.

3. *The Radiophysics Advisory Board.*—Following on the earlier negotiations with the United Kingdom authorities, there was set up in Australia the Radiophysics Advisory Board. On this Board were representatives of the three Australian Fighting Services, the Council for Scientific and Industrial Research, the Postmaster-General's Department, and, later, the Ministry of Munitions. The work of the Radiophysics Laboratory was from the outset to be devoted to research and to the development of special equipment for war-time use. It became a function of the Board to formulate the general policy to be followed in this work. At a later stage, when the production of equipment in Australia was possible, the Board also maintained a close watch on the supply position, and was able to bring about the necessary adjustment of the research facilities and production between the three Services.

4. *Liaison Abroad.*—As part of the original arrangements made with the United Kingdom, an officer of the Radiophysics Laboratory was stationed in London to facilitate liaison arrangements with the corresponding research organizations in the United Kingdom. The success of the work carried out in Australia was to a large measure due to the very generous way in which the United Kingdom authorities provided facilities for close collaboration. The laboratory in Australia was able to keep in very close touch with the progress made overseas, so that its work did not overlap work carried out elsewhere to an undesirable degree.

In August, 1940, before the United States of America entered the war, the United Kingdom Government sent a Scientific and Military Mission to that country to communicate to the United States Services the whole of the results of the work being carried out in England in any important aspect of science. Thus, by the time the United States of America entered the war, there had been built up there exceptional facilities for radar developments. In May, 1941, the liaison arrangements between Australia and the United Kingdom were improved and new arrangements brought into being for a similar liaison service with the United States laboratories. This was started by a second visit by Sir John Madsen to the United States of America and Great Britain to arrange an increase in the size of the liaison office in London and to establish a similar office in Washington. By this time the United Kingdom authorities had established the British Central Scientific Office in Washington. The presence of this office greatly facilitated Australian arrangements in Washington, for it was agreed both by the United Kingdom and United States authorities that Australian liaison officers would work in very close touch with the British Central Scientific Office, and, in fact, that the channel for obtaining information should be from the United States organizations through the British Central Scientific Office.

This arrangement has been of very great service to the Radiophysics Laboratory, and it is hoped that it has been of some service also to the United States Forces in this area. When General MacArthur came to Australia to assume supreme command of the Australian and United States Forces in the South-West Pacific Area, the Radiophysics Advisory Board promptly invited his head-quarters to be as closely associated as possible with its activities.

The principal laboratory in the United States of America concerned with radar research was the Radiation Laboratory established at the Massachusetts Institute of Technology by the Office of Scientific Research and Development. This laboratory very generously provided facilities in its own building for a liaison officer of the Radiophysics Laboratory, and, besides giving full information as to its activities in the form of research reports, was able from time to time to assist the Australian effort very greatly by supplying samples of equipment. In fact, for several years there has been a special lend-lease arrangement permitting Australia to obtain special experimental equipment of the latest design. The liaison arrangements with the United States of America extended also to the research activities of the United States Services. The War Department and the Department of the Navy generously made available any information which was needed, and in addition were able to provide a number of complete radar equipments of the latest design for the information of the Radiophysics Laboratory and of our Fighting Services.

Radar research and development was also taking place in Canada. The Washington office of the Council for Scientific and Industrial Research provided a channel for liaison with the National Research Council, the organization responsible for research, and with Research Enterprise Ltd., the special organization brought into being for the production of radar and other war-time equipments.

5. *Training Facilities.*—Although, before the war, scientists and engineers knew a great deal about the generation and detection of radio waves of the order of 5 metres wavelength and of longer wavelengths, radar has used very much shorter wavelengths. The early equipments in Great Britain used wavelengths of the order of 3 to 5 metres, but very soon 1 metre wavelengths were being used, and at a later stage the research developments permitted the use of centimetre waves of the order of 3 to 10 centimetres or shorter. These very revolutionary changes in radio technique presented the Fighting Services with a difficult training problem. The building up of a large fighting force in this war demanded the establishment of technical training schools by the Services. The Radiophysics Laboratory was able to assist the Services very considerably in this work, since it was the centre for the collection of all the most recent data of a scientific nature. In the early stages the Laboratory provided a number of training courses, first for operators and maintenance personnel and then for the instructors of the Services' training establishments. As the technique used in the more modern radar equipment changed, provision was also made for refresher courses in which the Service instructors were given the more up-to-date data.

As the war went on, larger and larger quantities of radar equipment were used by the Fighting Services. The Radiophysics Advisory Board was responsible for an arrangement with the University of Sydney for an initial training course in the fundamental principles of radio. This initial training school, under the charge of Professor Bailey, provided great assistance to the Services in handling the very large number of men required for the operation of radar equipment in the operational areas.

6. *Special Valve Developments.*—The technical advances resulting from the use of very short wavelengths in radar equipment proved to be considerable. The use of these wavelengths became possible with the design of special types of magnetrons and klystrons, the initial development of which occurred in the United Kingdom. Although before the war both of these types of valves were known, they were at that stage only in an elementary form, as compared to the valves which have been designed during the past few years. Due to the impossibility of obtaining large supplies of these special components, and also because Australian radar developments demanded special designs, it was obviously necessary that the research arrangements should include facilities for the study of these important components of radar equipments.

The need for research on vacuum tube devices had been anticipated in the original arrangements for setting up the Radiophysics Laboratory. With the help of senior officers of the University of Brisbane, and later of the Physics Department of the University of Melbourne, working in close collaboration with certain of the valve-producing firms in Australia, a number of different types of magnetrons and klystrons were designed and put into production in this country. As this field of work became more comprehensive and the facilities for additional space in the Radiophysics Laboratory were strained to their utmost, an arrangement was made to move the whole of the vacuum research work to the University of Melbourne. This took place in October, 1942, and the work was continued in Melbourne from then onwards.

7. *Radar Work of the Laboratory.*—In accordance with its responsibilities, as defined by the Radiophysics Advisory Board, the Radiophysics Laboratory has been engaged since its inception on—(i) Fundamental researches associated with the design of radar equipment. (ii) Investigation, development, design and manufacture to the prototype stage of radar and associated equipment required by the Armed Forces. (iii) Provision of assistance to the Armed Forces in the training of personnel and in the testing, adaptation and use of both local and imported radar equipment.

Since early in 1940, the Laboratory has been actively concerned with a large number of Service projects, full details of which will be published in due course. It is appropriate, however, that the more important accomplishments of the Laboratory should be briefly reviewed here. No mention is made of the large number of calls for advice and minor assistance made on the Laboratory's technical facilities, nor of those projects which did not proceed beyond the development stage; as was inevitable, a number of projects, which were undertaken initially as insurance policies at a time when the possibilities of overseas procurement were quite uncertain, did not go into production as a result of improvement in the supply position in the meantime.

Those items of major interest in which the Laboratory has been concerned are touched upon below; for convenience, these have been grouped under the respective Services on behalf of which the development was undertaken.

(i) *For the Army.*—The Radiophysics Laboratory's first project was the development of a radar set capable of providing accurate range and bearing of ship targets for the use of coast defence batteries. An experimental station was designed and erected at Brookvale and full information passed to the Postmaster-General's Department for production. These sets, which were initially known as "Sh.D.", finally as "C.A. No. 1 Mk. 2 (Aust.)", were installed at all major ports around the Australian coast. Later, a new prototype set, known as "C.A. No. 2", was built and installed near Sydney. This used a centimetric wavelength and was intended to allow a Fire Commander to keep watch on all actions taking place in his Command. Assistance was given to a Sydney manufacturer in adapting centimetric radar equipment, which had originally been developed by the Laboratory for naval purposes, for use as a portable coast surveillance unit. These were known as "C.D. No. 1 Transportable (Aust.)" and "C.D. No. 1 Mk. IV."

For use in directing anti-aircraft fire, an Australian design of G.L. (gun-laying) equipment was prepared, capable of feeding accurate slant range to a predictor. With the arrival of a comparable overseas equipment, however, production of this set was not proceeded with.

Finally, following the entry of Japan into the war, an urgent requirement arose for a radar-controlled searchlight. Four prototype models of an "S.L.C." (searchlight control) equipment were produced, built around a standard 90-centimetre searchlight, for use by the Army until production sets became available.

As the war progressed and the danger of direct attack on the Australian mainland receded, the Laboratory's radar effort on behalf of the Army was reduced and applied increasingly to projects on behalf of the Navy and Royal Australian Air Force.

(ii) *For the Royal Australian Air Force.*—Perhaps the Laboratory's most successful single achievement was the design and construction of a light-weight radar set for the Royal Australian Air Force for air warning purposes. This set, which subsequently became the basis of the LW/AW Mk. I. equipments, was urgently required following a series of devastating raids on Darwin, and the first equipment was actually built in five and a half days. Large numbers of production sets of this type have performed outstandingly well in various parts of the Pacific theatre.

This set, which was considerably lighter than and more than comparable in performance with similar equipment in use overseas at that time, was capable of being transported in a standard aircraft. It proved rugged and reliable in service and was easy to erect and maintain. All these factors made it of particular value for use under the special conditions of warfare existing in the Pacific, and it came into widespread use both by the Australian and United States Forces in this theatre. The Laboratory built four prototype sets, and upwards of 200 were subsequently produced by a Sydney manufacturer.

Further prototype equipments, using higher-powered transmitters and provided with adjustments designed to reduce interference from enemy jamming, were completed by the Laboratory later, while at the cessation of hostilities a complete new type of air warning station on a decimetric wavelength (providing, in addition, a measure of the height of aircraft) had been developed, and the radar gear for a prototype station was in an advanced stage of construction. Included in this project was the development of two unique valves to suit the new wavelength used.

A series of light-weight sets on metre wavelengths to provide assistance to our fighters in intercepting enemy raiders, i.e., to allow ground control of interception, was designed and built; these were the LW/GCI Mk. I. and LW/GCI Mk. II. In addition, the complete design of a new LW/GCI equipment operating on much shorter wavelengths was available at the end of hostilities. Two special aerial systems were designed for use in conjunction with appropriately mod fied imported microwave radar gear, to allow the height of aircraft to be determined (CMH) and also to provide warning against low-flying raiders (LW/LFC).

Although development of an Australian-designed ASV equipment (airborne device for the detection of surface vessels) was completed early in 1941, it was eventually decided for military reasons that Australian manufacturers should copy closely the British Mk. II. design. The Laboratory developed and produced three prototype "ASV Beacons" which provided valuable navigational aids for aircraft fitted with ASV equipment.

Prototype models of Rebecca-Eureka equipment were made in close collaboration with the final manufacturer. The former is an airborne set and the latter a ground beacon, the two being combined to provide a system designed to allow aircraft to locate with accuracy specific ground positions, either for guidance in supply dropping or to allow delineation of our forward lines for close support bombing.

(iii) *For the Navy.*—The Laboratory's first work on behalf of the Navy was the production of two portable equipments known as "R.M." and intended for use on battle practice targets to increase the range at which these could be "seen" by radar means.

Considerable assistance was provided, mainly in the design of the necessary aerial systems, in adapting locally produced radar sets (Sh.D and ASV) for use on ships to provide air warning. Since the performance of this equipment in a role for which it was not intended was inadequate, a high-powered air warning equipment with greatly improved performance (A286Q) was designed and built and a number of Australian vessels were fitted with sets of this type.

For sea search purposes, a microwave set was developed, and several prototypes were completed (an early model of this equipment being fitted to the ill-fated H.M.A.S. *Canberra*). The Radiophysics Laboratory also collaborated closely with the manufacturer in the design of a high-powered version of this set which was subsequently fitted to a large number of Royal Australian Navy ships.

(iv) *For General Head-quarters.*—Work for General Head-quarters was carried out in collaboration with a group of American workers based at the Radiophysics Laboratory and sent to this theatre by the Office of Field Service of O.S.R.D. Development of a light-weight microwave GCI equipment and of an air warning set designed particularly for detecting aircraft in difficult country was completed. The rapid advance of our forces northwards and the increasing availability of United States equipment, following the completion of the European war, made it unnecessary for this equipment to proceed to the production stage.

8. *Radio Countermeasures.*—A special section of the laboratory was fully occupied, during the last few years of the war, in developing equipment to determine the actual frequencies being used by the enemy and the precise location of his radar stations, and with the special problems in connexion with the provision of measures to prevent effective use of his radar by the enemy and to minimize the effects of enemy "jamming" of our own equipment.

9. *Work on Propagation.*—Throughout the war the Radiophysics Laboratory has been actively engaged on researches on the propagation of radio waves, particularly those aspects concerned with the use by the Armed Forces of radio and radar communication and detection networks. The work in these fields may be treated under the following broad subdivisions:—

(i) *Super-refraction.*—As the techniques of generating and using shorter and shorter wave-lengths were developed and applied during the war, ample evidence was accumulated that these waves were not always propagated in straight lines, as had been generally assumed. They were frequently subject to appreciable refractions, and sometimes were strongly reflected at relatively low heights in the atmosphere. This phenomenon is due to the fact that the refractive index of air from high frequency radio waves is appreciably modified by its water vapour content, and hence variations of the latter may easily give rise to non-rectilinear propagation.

The effects of abnormal propagation of microwaves were of direct interest to the Armed Forces, since the useful range of our own radio and radar equipment, and also the range at which detection of our Forces was possible by the enemy, was no longer fixed and predictable but was subject to large variation. Early in 1944, therefore, the Radiophysics Laboratory undertook to carry out experimental and theoretical investigations into the cause and incidence of "super-refraction" as this phenomenon has been named. An immediate object of this work was to make available to the Services such advice and information as would allow them to appreciate the effect of this phenomenon on their detection and communication networks, and possibly

to forecast its occurrence from a knowledge of the meteorological situation. The problem to be investigated has three main aspects; firstly measurement of radio transmission conditions over known paths; secondly, precise determination of the meteorological conditions over these paths; and, finally, correlation and interpretation of the results in terms of the general meteorological situation.

Investigations have proceeded along the following main lines:—

(*a*) By analysis of regular daily observations made at a large number of Royal Australian Air Force and Army radar stations situated around the coastline of Australia and in New Guinea.

It was decided to make use of this extensive radar reporting network to obtain information as to the incidence of super-refraction around Australia. With the ready co-operation of the Services, a series of simple observations was devised for each station and the resulting data regularly reported to the Radiophysics Laboratory for analysis and correlation with the known meteorological situation prevailing. By this means, an exceedingly valuable mass of information on frequencies around 200 Mc/s, more than comparable with that collected in any other part of the world, has been obtained. The final interpretation of these results is actively proceeding.

(*b*) By the direct measurement of meteorological conditions over a specific path, together with simultaneous observations of radio transmission conditions over the same path.

These observations were made in the Darwin area. A special expedition, equipped with radar gear and equipment for making the necessary meteorological measurements in the lower atmosphere, was sent to Darwin for this purpose, and observations were made during the dry season, over the period September to December, 1944.

(*c*) By observations of the physical conditions existing in the lower atmosphere in the vicinity of Sydney during the existence of meteorological conditions giving rise to "radiation inversions".

Such inversions have been found to be prominently associated with super-refraction conditions, and it was necessary to examine the behaviour of inversions which formed over land and subsequently drifted out to sea. Special equipment has been devised and fitted to an aeroplane to enable these measurements to be made.

As a result of the information so far derived, the conditions under which super-refraction occurs around Australia are now generally understood, and a complete description of the "radio climatology" of Australia is being undertaken.

(ii) *Noise Level due to Atmospherics.*—In planning radio communication channels, a knowledge of the interference level which can be expected at the terminal points due to prevailing atmospherics, is of considerable importance. The scarcity of such information on noise levels, particularly in equatorial regions, was, in fact, a source of embarrassment to the Armed Forces operating in this theatre.

Assistance has been given to a United States Radio Propagation Unit in setting up noise recording equipment in northern areas, and to the Royal Australian Air Force with similar equipment in the Darwin area. The results of these observations are being analysed at the Laboratory and made available for general circulation throughout the Services.

The Laboratory has also acted as the checking and distributing centre for further noise recorders being sent to the Pacific theatre by the British Radio Board as part of a world-wide plan for the collection of data on noise levels due to atmospherics.

(iii) *Ionospheric Observations.*—In the operation of radio communication circuits in which reflection from the ionosphere is involved, knowledge of the height and density of the reflecting "layers" is of vital importance, since this determines the maximum radio frequency which may be used. Early in the war a world-wide organization was set up, under the Inter-Services Ionospheric Bureau, Great Britain, the Inter-Services Radio Propagation Laboratory, United States of America, and the Radio Research Board of the Council for Scientific and Industrial Research, to collect basic ionospheric data and issue regular predictions of optimum communication frequencies for all circuits in all parts of the world. At that time the number of regular ionospheric "observatories" was limited, and it was accordingly decided to establish additional recording stations. The Radiophysics Laboratory, therefore, designed and built six automatic ionospheric recorders of the P′-f or multi-frequency type. Three of these have been delivered to the Royal Australian Air Force for use in the Australian area, two to the Department of Scientific and Industrial Research, New Zealand, and one to the United States Signal Corps for installation in the Central Pacific. Following the need for further stations, work has commenced on the construction of an additional seven automatic recorders. These are of generally similar design but are provided with an extended frequency range, to cover, as far as is practicable, the increased ionospheric densities to be expected following the commencement of a new sunspot cycle.

The Laboratory has made use of special observations of signals from certain navigational equipment ("LORAN") in use by the Services, with a view to obtaining further information on the ionosphere. The observations are such that, not only is valuable information being obtained on the properties of the navigational system, but much scientific information is also being derived, which is contributing to our knowledge of absorption processes in the ionosphere and the behaviour of the abnormal "E" region.

10. *Post-war Application of Radar Techniques.*—As it became clear that the war was approaching a successful conclusion, consideration was given to the way in which the knowledge and experience of modern radar techniques might be applied to some of the immediate post-war problems of Australia. The Laboratory, although heavily involved in projects for the Armed Forces up to the cessation of hostilities, was able to initiate some work in other directions and has, in fact, made considerable progress in possible applications to the field of navigational aids for civil aviation, described below.

An Australian Aviation Radio Research Committee was formed early in 1945 comprising representatives of the Council for Scientific and Industrial Research, the Department of Air, the Department of Civil Aviation, Postmaster-General's Department, Airline Operators, and the Australian Air Pilots Association. The purpose of this Committee is—(i) To advise the Council for Scientific and Industrial Research on the requirements for research in the field of radio and radar aids to aviation. (ii) To act as a meeting ground for all those interested in the activities of C.E.R.C.A. and to assist in co-ordinating the Australian approaches to this body.

Meetings of C.E.R.C.A. (or the Commonwealth and Empire Conference on Radio for Civil Aviation) were held in London and Ottawa during 1944 under the sponsorship of the Radio Board of Great Britain. The C.E.R.C.A. organization has since come under the sponsorship of the Air Transport Council and is now recognized as the co-ordinating body within the Empire on all matters appertaining to radio and radar aids to civil aviation.

The following development programme was recommended to the Council for Scientific and Industrial Research by the Aviation Radio Research Committee for prosecution by the Radiophysics Laboratory. Work was commenced during the early part of 1945 and is being extended as staff become available following the completion of Service projects.

(i) *Short Distance Aids to Navigation.*—(*a*) *Distance Measuring Equipment.*—This provides the pilot with a visual indication of distance up to 100 miles from a selected airport. Successful preliminary flight trials have already been carried out.

(*b*) *Multiple-Track Radar Range.*—The Radiophysics Laboratory has proposed an alternative solution to the radio range aids used extensively in Australia and America for short-range navigation purposes. It will define up to ten tracks of high accuracy on main air routes with, however, tracks of moderate accuracy for a full 360 degrees around the terminal airport. There is at present no comparable overseas development. Experimental ground and airborne units developed by the Radiophysics Laboratory have already performed very successfully in flight trials.

(ii) *Aids to Airway and Airport Control.*—The function of this equipment is to provide an Airport Control Officer with information on the position of all aircraft within a range of about 100 miles, together with precise plan position, height and identity of all aircraft within close range. Two separate radar equipments are involved and arrangements are in hand for the installation of preliminary models at an airport near Sydney.

(iii) *Long Distance Aids to Navigation.*—Consideration is being given to the long-range navigational problems peculiar to outback areas in Australia. The problem of light aircraft travelling over vast uninhabited areas does not exist in comparable form in England or America, and a solution is unlikely to come from overseas activities.

XVIII. LUBRICANTS AND BEARINGS.

1. *General.*—During the past year, the general basic attack on problems associated with friction, lubrication, bearings and wear has continued. The pressure of more immediate war work, however, and urgent *ad hoc* problems arising from industry, have prevented the fundamental work from being carried very far. Assistance has been given to industry as in the past, but the greater part of the work has been for the Services and this can only be partially described here. The University of Melbourne and its Departments of Chemistry, Engineering, Mathematics, Metallurgy and Physics are continuing to give active and valuable collaboration, and Professor Hartung continues to make available the laboratory space and facilities of the Chemistry buildings. The Physics Department of the University of Adelaide has also given valuable assistance.

2. *Lubrication.*—Earlier investigations on the physical and chemical properties of lubricants and lubricating oils have been continued.

(i) *Mechanism of Boundary Lubrication.*—Further work has been carried out to clarify the mechanism of boundary lubrication. According to the theory discussed in earlier reports, the boundary lubrication of metals is effected by interposing between the rubbing surfaces a thin rigid film, capable of reducing the amount of metallic contact and possessing a relatively low shear strength. These 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 general evidence indicated that the lateral adhesion between the lubricant molecules was at least as important as their strength of attachment to the metal surface. A further investigation has been carried out on the lubricating properties of pure fatty acids, hydrocarbons and soaps deposited on metal surfaces in layers of increasing thickness. This has been combined with electron diffraction studies of the structure of these films. The results show that in some cases a single molecular layer may provide effective lubrication; in other cases appreciably thicker films are necessary. The frictional behaviour may also be profoundly affected by the presence of superincumbent oil or solvent. The investigation is incomplete, but the results already obtained are of interest both from the fundamental and from the practical point of view.

(ii) *The Development of a Soluble Extreme-Pressure Cutting and Drawing Lubricant.*—Apart from their properties as coolants, cutting oils and drawing fluids function mainly as extreme-pressure lubricants between the work and the tool or die. On account of the high temperatures developed at the rubbing surfaces, these lubricants must maintain their properties at elevated temperatures. Under extreme conditions the ordinary type of mineral oil or soap is inadequate, and it is usual to add compounds containing sulphur, chlorine, or other active ingredients. In conjunction with the oil companies, a systematic analysis of the effect of different active ingredients and their method of incorporation has been carried out. This work has led to the development of lubricants which have proved successful in severe drawing and machining operations.

(iii) *Temperatures Developed between the Piston Ring and Cylinder Wall of a Running Engine.*—The previous report described an investigation into the conditions of lubrication between the piston rings and cylinder wall of a running engine. It was shown that metallic contact between the cylinder wall and piston ring can never be completely eliminated. Even with the best lubricants, intermittent breakdown of the lubricant film occurs with consequent metallic seizure and wear. This investigation has been extended to a measurement of the surface temperatures developed between the piston ring and cylinder wall of a running engine. The method consists of using a constantan piston ring and measuring the thermal e.m.f. developed between the rubbing surface of the ring and cylinder wall. The work is at an early stage, but the results already show that extremely high temperatures may occur. The surface temperature fluctuates extremely rapidly throughout the stroke, and the results confirm the earlier conclusion that intermittent metallic contact occurs through the lubricant film.

These observations are of direct practical interest, since it is clear that the performance of a lubricant will largely depend on the highest temperatures reached at the real points of contact. The observations are also of interest from the fundamental point of view, since they shed additional light on the detailed processes occurring between metal surfaces rubbing under conditions of boundary lubrication.

(iv) *Corrosion Prevention of Ball Bearings.*—The problem of corrosion of small ball bearings of aircraft instruments is a serious one, particularly when they operate under tropical conditions. An investigation carried out in the laboratory under hot humid conditions showed that suitable anti-corrosive agents may produce a marked reduction in the corrosion. An appropriate recommendation has been made to the Air Force.

3. *Thickened Fuels for Flame-Throwers.*—In order to increase the range and efficiency of flame-throwers, it is usual to use petroleum as the fuel and to thicken it into a stringy tenacious gel. Until recently the thickening agent used in the southern Pacific area consisted of an American product containing materials not available in Australia. As a result of investigations undertaken by the Section, a fuel thickener from locally available raw materials has been successfully developed for use in temperate and tropical climates.

4. *Friction and Wear.*—Previous reports have described investigations into the physical processes which occur during the wear of metals and other materials. This work has been continued.

(i) *Surface Damage of Lubricated Metals.*—The previous report described a technique for examining the contours of metal surfaces by cutting a taper section at a very oblique angle to the surface under examination. This yields a contour of the surface with its vertical component magnified about ten times. This technique has been applied to an investigation of the wear of rubbing metal surfaces; the results show that with clean surfaces there is marked metallic seizure and the metals are torn and highly distorted at the points of real contact. When the

surfaces are lubricated the amount of metallic interchange and surface damage is greatly reduced, so that its detection, even by taper section methods, is very difficult. In a recent investigation, an electro-micrographic method has been developed to record the minute quantities of metal transferred from one surface to the other as sliding takes place. The method not only gives a measure of the total amount of metal transferred but indicates the way in which the metal is distributed over the surfaces. It is extremely sensitive and in some cases quantities less than a millionth of a gram may be readily detected. The results show that in the presence of a lubricant the amount of metallic pick-up is greatly reduced and that in general it is not spread as an even film but is distributed irregularly over the surface of the track in a number of small discrete particles of varying size. These results confirm in a simple and direct manner the view that metallic adhesion, seizure and tearing occur even through the best lubricant films. The investigation sheds considerable light on the mechanism of metallic wear and the boundary lubrication of metal surfaces.

(ii) *The Structure and Wear Properties of Cast Iron.*—During the last few years the need for locally produced aircraft piston rings has greatly increased, particularly in view of the expansion of the aircraft industry and the uncertainty of regular supplies from abroad. Most of these piston rings are made of cast iron, and it has been found that quite minor alterations in the composition or casting technique may have a profound effect on the wear properties of the rings. For this reason it has been difficult to obtain locally produced rings of a consistently high quality. A long-range investigation has been commenced on the relation between micro-structure and wear properties of cast irons. The results already indicate that small changes in the distribution of the graphite constituent may have a very marked effect on the wear. It is hoped by extending this investigation to determine the micro-structure and composition which give the best wear properties and to translate these results into terms of foundry practice. The investigation will also yield further information on the basic mechanism of wear between metal surfaces.

(iii) *The Effect of Abrasive on Wear.*—In many parts of Australia and in other dry dusty regions extremely high rates of wear are often observed in aircraft and other types of engines. This is largely due to dust particles drawn into the engine during running, and for this reason aircraft engines are usually supplied with air filters. Although the use of filters results in increased life of the engine, the detailed way in which the dust particles produce increased wear is by no means clearly understood. An investigation has been carried out on the effect of abrasive particles on the wear properties of steel surfaces, sliding under conditions of boundary lubrication. The results show that in the absence of abrasive particles the wear is extremely small and the surfaces will run indefinitely without seizure occurring. In the presence of abrasive particles the rate of wear rises appreciably and there is a slight increase in friction. The most marked effect, however, is on the life, i.e., the length of time the surfaces will run together before seizure occurs. Once seizure occurs the friction rises and the wear increases enormously. It is found that the life is shorter the greater the concentration of the abrasive, the larger the particle size, the greater the load, the higher the surface speed, and the rougher the surfaces. In addition, the life is influenced very markedly by the amount of active ingredient in the lubricant. Whichever of these variables is considered, it is usually found that there is a critical range over which a small change in the variable produces a very large change in the life.

It is suggested that the life of the surface depends essentially on a competition between the rate of breakdown and the rate of re-formation of the lubricant film. The abrasive particles cause a marked roughening of the surfaces and a great increase in the number of points at which the lubricant film is broken down. If the breakdown of the lubricant film is more rapid than the rate at which it can re-form large-scale seizure will occur.

Although this investigation is essentially a laboratory one, the results may be expected to be applicable to most sliding mechanisms operating under conditions of boundary lubrication. It is clear that, in general, extremely small quantities of abrasive particles may profoundly affect the running behaviour of sliding surfaces.

(iv) *Frictional Properties of Bronzes.*—In recent years there has been a tendency to use manganese bronzes as bushes, bearings, gears, &c., in place of ordinary phosphor bronzes and gun metals, on account of their superior mechanical properties. The frictional properties of a number of locally-produced manganese bronzes have been compared. In particular their frictional behaviour in the presence of various lubricants at elevated temperatures has been investigated. Similar experiments have been carried out to compare the frictional properties of locally-produced porous bronzes with those of imported materials.

5. *The Development and Manufacture of Aircraft and Other Bearings.*—During the last few years there has been a steadily increasing demand for locally-produced aircraft bearings as a result of the growth of the aircraft industry and Air Force needs in Australia. The Section has

continued to assist industry in developing techniques for the manufacture of aircraft and other types of bearings. These include electrolytically deposited bearings as well as those involving stationary or rotary casting methods. The techniques so developed have been handed on to the Services and the manufacturers. This part of the work of the Section has been carried out 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.

Parallel with this developmental work, the Section has carried out a more basic investigation into the properties of bearing alloys, and the influence of structure and composition on these properties. A study has also been made of the factors responsible for the development of defects in manufacture or failure in service.

(i) *Casting Conditions and Structure of Copper-Lead Bearing Alloys.*—One of the most common types of bearings in use in high-powered aircraft to-day is the copper-lead bearing. This alloy consists of a hard matrix of almost pure copper in which are dispersed fine particles of lead. The distribution of the lead and the structure of the copper have a profound effect on the physical and bearing properties of the alloy. Investigations have been carried out on the influence of composition, casting temperature, atmosphere, rate of quenching, &c., on the general properties of the bearings. A recent investigation into the effect of small quantities of other metals, in particular tin and silver, on the structure and properties of copper-lead alloys has been carried out. The results show that small quantities of these metals may have a very marked effect on their structure and in particular on their casting characteristics. This may lead to a much greater efficiency in the manufacture of this type of bearing. Systematic investigations of this type make it possible to specify and standardize more precisely the conditions necessary for the successful manufacture of such bearings.

(ii) *Silver-Lead Bearings.*—A more recent development in aircraft engines is the silver-lead bearing. This consists of a steel backing coated with a comparatively thick layer of silver. A thin film of lead is then deposited on top of the silver, and an extremely thin film of indium is then flashed on to the lead. This combination of a hard substrate, possessing high thermal conductivity, covered by a thin film of a very soft metal, provides a bearing which gives excellent performance under the extreme conditions obtaining in aircraft engines.

When these bearings were first manufactured locally, the silver was centrifugally cast on to the bearing shell. A much cleaner and more convenient method which was developed in the laboratory consists of depositing the silver layer electrolytically. When suitable precautions are taken, this method is extremely effective, and a number of successful bearings have already been made by this technique in the laboratory. A larger pilot plant constructed by D.A.P. in collaboration with the Section is now in operation and has produced its first production batch of silver-lead-indium bearings for the Air Force. The method has also been applied to the production of silver-lead bearings for other types of engines.

(iii) *General Sleeve Bearing Design.*—As a result of numerous requests from the Services and others, a report has been prepared describing the main features to be considered in the choice of a suitable sleeve bearing.

(iv) *Bearing Testing: The Lubrication Between a Journal and Bearing.*—Apparatus has been constructed to examine the performance of bearings under various conditions of load, speed, type of lubricant, &c. As part of this work a preliminary investigation has been carried out on the conditions of lubrication between a journal and a typical bronze bearing. The experimental method consists of an analysis, by a cathode ray technique, of the electrical conductance between the journal and the bearing. The results show that even if the running surfaces are very finely finished and the initial alignment and fitting of the journal and bearing are of the highest order of accuracy, there is always considerable metallic contact between the journal and bearing in the early stages of running. As the surfaces are run in, the amount of metallic contact decreases, and after a well specified preliminary period there is an almost complete film of lubricant separating the metal surfaces. However, even under the most favorable conditions a certain amount of metallic contact may occur through the lubricant film. These results emphasize the importance of the running-in period and the extent to which the boundary lubricating properties of the lubricant and the bearing alloy may determine the ultimate performance of the bearing. The method may also be used to investigate the effect of load, speed, temperature, and oil viscosity on the lubrication of the bearing.

The results obtained are of great interest practically, since they provide a simple and direct method of investigating the running-in treatment that a given bearing may need. The investigation also sheds light on the basic mechanism of lubrication of typical journal bearings.

6. *Thermal Stresses in Metals.*—(i) *Bearing Alloys.*—Earlier work has shown that when metals slide on each other, the surface temperature may become very high in localized areas, leading to softening and plastic flow of the surface. This heating is confined to the summits

of the surface irregularities and to a very thin layer at the surface. However, certain metals and alloys in practice are subjected to a bulk heating and cooling, particularly with bearings which are subject to frequent heating and cooling during use. This cyclic thermal treatment will produce thermal stresses of the bearing alloy which is bonded to a steel backing, and under certain conditions this will lead to cracking in the soft bearing alloy, particularly in the vicinity of the bond with the steel.

Subsequent experiments have revealed that cracking also occurs in certain types of bearing alloy when it is unattached to a steel shell. Cyclic thermal treatment between 30° C. and 150° C. has been shown to produce surface cracks in tin-base bearing alloys even after twenty cycles, whilst the surface distortion is marked after 200 cycles. On the other hand, this phenomenon is not shown by lead-base alloys. The effect was attributed to the change in thermal expansion with direction within the grains of the alloy.

A systematic study of the phenomenon in the tin-antimony alloys has revealed that the magnitude of the effect decreases with antimony content, and is not very pronounced in the alloys of high antimony content where much of the antimony is present as a hard second phase. This may be of significance in the development of bearing alloys less susceptible to deformation by cyclic thermal treatment.

(ii) *Pure Metals.*—To determine the origin of the effect found in bearing alloys, the work was extended to a study of the behaviour of pure metals. The non-cubic metals, tin, cadmium and zinc, showed marked signs of plastic deformation (as indicated by the appearance of slip lines) even after a very small number of thermal cycles. In fact, slip lines have been detected in cadmium after a single heating and cooling. On the other hand, the cubic metals, lead and aluminium, showed no signs of plastic deformation after a large number of cycles. Plastic deformation has also been produced in tin, cadmium and zinc by repeated cooling in liquid air, whereas lead, when subjected to similar treatment remained undeformed. The deformation is thus dependent on the change in temperature and not on its absolute value. Further experimental work has confirmed the theory that the phenomenon occurs as a result of the anisotropy of thermal expansion in the 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 have shown that the deformation exists throughout the whole bulk of the metal, and accumulates as the number of cycles is increased. In some cases recovery occurs after a large number of cycles.

The effect, which has not previously been observed, 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 investigations have shown that considerable stresses can exist in both annealed and cast non-cubic metals, and this has led to a logical explanation of such well known phenomena as grain growth in cast metals. The results suggest that the effect may have practical applications to the failure of certain metals and alloys in service, and may explain some observed differences in the behaviour of lead-base and tin-base bearing alloys.

7. *The Deformation and Recrystallization of Duplex Alloys.*—A programme of work has been initiated on the deformation and subsequent recrystallization of alloys consisting of two phases. In the first place, experiments are being made on duplex (60-40) brass. The investigation of relative deformation and work hardening of the two phases in such an alloy may elucidate the problem of the interaction between crystals of different physical properties in a polycrystalline material. An investigation of the annealing of such a deformed duplex alloy is being made with a view to determining where, and in what manner, recrystallization of the cold-worked phases occurs. This work may have an important bearing on the industrial working and forming of complex alloys and may suggest new methods of treatment.

8. *The Study of Transient Phenomena.*—Additional photographic and electrical 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, lubrication and wear, and the rapid changes which occur during impact. They are also being used to investigate explosive reactions and the mechanism of initiation and detonation.

9. *Detonation of Explosives by Impact and Friction.*—During the last few years the Section has carried out a fundamental investigation into the mechanism of initiation and propagation of detonation in explosives. The work shows that with certain liquid explosives, the initiation is usually followed by a comparatively gentle process followed by a much more violent type of propagation. The processes involved are very complex and of extremely short duration of the order of millionths of a second; their investigation has been greatly facilitated by the development of high speed electrical and photographic techniques.

Earlier experiments have shown that under certain conditions the impact sensitivity of liquid explosives can be enormously increased. Extensive investigations suggest that this effect is due, at least in part, to the sudden temperature rise produced by the adiabatic compression of minute air pockets trapped between the colliding surfaces.

A parallel investigation has been carried out on the effect of friction on the detonation of liquid and molten explosives. The results suggest that under suitable conditions the explosive may be detonated by local temperature flashes developed between the rubbing surfaces.

These investigations into the general mechanism of initiation and propagation of explosive waves and the detonation of explosives by impact and by friction are of basic interest and are being continued. The results are of practical interest in the safe handling of explosives and the prevention of accidents during manufacture.

10. *Muzzle Velocity of Projectiles.*—A portable equipment has been developed in the laboratory for measuring the muzzle velocity of projectiles to a high degree of accuracy. It consists of two main parts; a sky-screen which detects the position of the projectile at two points exactly 10 feet apart in its trajectory, and a high precision chronometer which measures to within a few millionths of a second, the time the projectile takes to travel between these two points.

The whole equipment fits into an army truck and can be driven to forward areas or elsewhere and velocity determinations made *in situ*. A number of these equipments have been made for the Australian Army and a special model has been produced for the British Admiralty as standard equipment.

11. *Miscellaneous.*—Assistance and advice have been given to the Department of Aircraft Production, to Government organizations, and to industry on a variety of prob'ems Members of the Section are assisting or are acting on various committees such as the Bearing Control Committee, the Aero Engine Cylinder and Piston Ring 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 with the Scientific Liaison Bureau, the Directorate of Technical Practice, and the Munitions Supply Laboratories on a number of problems.

12. *Publications.*—The following papers were published during the year:—

Boas, W., and Honeycombe, R. W. K. (1944.).—Thermal fatigue of metals. *Nature* 154: 338.

Bowden, F. P., and Moore, A. J. W. (1945).—Adhesion of lubricated metals. Ibid. 155: 451.

Courtney-Pratt, J. S., and Tudor, G. K. (1944).—Lubrication between the piston rings and cylinder wall of a running engine. Coun. Sci. Ind. Res. (Aust.), Bull. 179.

Honeycombe, R. W. K. (1944).—The preparation of sections of copper-lead alloys for metallographic examination. *Proc. A'asian. Inst. Min. & Met.* N.S., No. 133: 29–33.

Mulcahy, M. F. R., and Yoffe, A. (1944).—Explosive reactions. 1. Chain reactions and gaseous explosions. *Aust. Chem. Inst. J. & Proc.* 11: 106. 2. The propagation of gaseous explosions. Ibid. 11: 134.

Mulcahy, M. F. R., and Yoffe, A. (1945).—Explosive reactions. 3. The initiation of explosion in solid explosives. Ibid. 12: 198.

Tabor, D. (1945).—The frictional properties of some white-metal bearing alloys. The role of the matrix and the hard particle. *J. App. Phys.* 16: 325.

XIX. BUILDING MATERIALS RESEARCH.

For some years, requests had been received from various branches of the building industry for the establishment of a Building Research Station, and in 1943 a Building Research Committee was formed; it consisted of Council for Scientific and Industrial Research officers, its functions be'ng to investigate the desirability of undertaking building research in Austra'ia. This Committee presented its report in August, 1943, and recommended that building research work be started as soon as possible. The report of the Committee was endorsed by the Council, and it was decided to proceed with the appointment of an Officer-'n-Charge, whose duties would be to make detailed survey of the building industry and to decide which of its problems were the most urgent and capable of being investigated by existing laboratories. Mr. I. Langlands, who had been Officer-in-Charge of the Timber Mechanics Section of the Division of Forest Products for thirteen years, was appointed to the position in December, 1944.

Concurrently with the investigations of the Council for Scientific and Industrial Research Building Research Committee, the Commonwealth Housing Commission and the Department of Post-war Reconstruction had investigated the need for building research in Australia and had come to the conclusion that an Experimental Building Station should be established for the purpose of experimenting with new ideas in building construction. The Director and Assistant Director of this Station were appointed in July, 1944.

A joint meeting of representatives of the Council for Scientific and Industrial Research and of the Board of Management of the Commonwealth Experimental Building Station (on which the Council for Scientific and Industrial Research is represented) was held in July, 1944, in order to define the relative functions of the two organizations. It was decided that the Commonwealth Experimental Building Station should be responsible for investigations into the design, construction and performance of building, and that the Council for Scientific and Industrial Research should be responsible for investigations into building materials and their uses. It was agreed that there would necessarily be an overlap but, provided there was close co-operation between them, this should not be harmful, and on the other hand was likely to be beneficial. Experience has shown that this viewpoint was correct, and, in practice, there has been the utmost harmony and co-operation which has aided materially the progress of the work.

Following his appointment, the Officer-in-Charge made a survey of the building industry in Queensland, New South Wales, Victoria and South Australia, contacting associations and individuals representing all branches of the industry—housing authorities, Government departments, architects, engineers, builders and manufacturers. He also visited New Zealand to investigate matters of common interest to Australia and New Zealand. As a result of this survey (which has not yet been completed) a list of urgent problems was prepared. It was found that, although many of the problems could well be handled by existing laboratories, in a number of them a considerable amount of preparatory work was required which could best be handled by Building Materials Research staff. It was, therefore, decided to appoint two research officers to undertake this work. One of these officers, who will specialize in concrete, started duty in June, 1945, but the other has yet to be appointed.

A few of the problems listed could be investigated without intensive preliminary study by Building Materials Research staff. For example, the Division of Forest Products is investigating the crazing of exterior plywood, the development of sawdust cement floor surfaces, and the properties of adhesives. The Division of Physics is making an investigation into the thermal properties of building materials. The Division of Soils has started an extensive investigation into the physical properties of soils in the building estates of the Victorian and New South Wales Housing Commissions in an endeavour to provide data for the more rational design of building foundations. The same Division is also co-operating with the Commonwealth Experimental Building Society in a joint investigation into the whole problem of the design of foundations of small houses. The Munitions Supply Laboratories and the Victorian State Rivers and Water Supply Commission have also kindly assisted in investigation on paints and sands.

As in most industries, research has, in many cases, greatly out-distanced its application in the building industry, and the Building Research Committee in its report recommended that an Information Officer be appointed to the Building Materials Research staff, his duties being to keep in touch with the technical literature relating to the building industry, to digest it, and issue it in a form suitable for use by the industry. This officer started duty in June, 1945, and is now engaged in indexing and classifying the great volume of existing literature. He will be assisted in this by the appointment of a trained librarian in the near future.

XX. OTHER INVESTIGATIONS.

1. *Dairy Research.*—(i) *General.*—The work of the Section has again been devoted chiefly to problems arising out of the war. Close collaboration has been maintained with the Services, Government departments, and numerous members of the dairy industry, and the advice of the Section has frequently been obtained on problems of immediate urgency relating to dairy products. Steady progress has been made with investigations on the manufacture and properties of several products.

(ii) *Concentrated Hardened Butter.*—The last report described a hardened butter substitute designed for use in the tropics. This consisted of dry butterfat containing 3 per cent. hydrogenated peanut oil and a small proportion of salt and skim milk powder. It was found that increasing the proportions of salt and skim milk powder to 2 and 4 per cent. respectively improved the flavour of the product, and when this formula together with modifications in the method of manufacture were adopted the product was named " butter, concentrated, hardened ". It is being produced in large quantities for the Armed Forces. Experiments have shown the

types of butter used in manufacture which give the most desirable flavour to the product. Certain taints are concentrated in the final product while others are eliminated in the process of manufacture. The toffee-like flavour which sometimes appeared in the dry butterfat, even with careful melting at the lowest practicable temperatures, has been found to be due to the effect of heat on the traces of milk solids left in the dry butterfat. These are now removed by a mechanical clarifier. On storage of the finished product at temperatures of about 100° F. a toffee flavour sometimes, but not invariably, develops. Because of its erratic nature the reason for this is obscure. Analyses have shown that an apparent loss of sweetness on storage is not related to the destruction of lactose. Considerable attention has been given to reducing the air content of the product, because this has become of increasing importance in controlling the keeping quality as other reasons for oxidation have been eliminated. More efficient machinery has been designed and installed for de-aerating the product before tinning, and the air content is now regularly below 0.2 per cent. by volume. This work has involved the development of methods of estimating very small proportions of dissolved air and oxygen in the product. Attention also had to be given to methods of estimating the small amount of moisture of the order of 0.2 per cent. in such a material. The texture of the product has been studied. An apparatus was devised for measuring the "lower yield value" at temperatures below the melting point. The method is based on the force required to drag a wire through the mass. The influences of the proportion of hardened fat, the method of cooling, and of storage on this value have been determined. When examined soon after manufacture, the yield value was found to be determined more by the method of manufacture than by the proportion of hardened fat present. Agitation of the fat during cooling decreased the yield value and rapid cooling caused an increase. After some months storage at tropical temperatures the initially high yield values of some samples fell and the yield values were then found to be related to the proportion of hardened fat rather than the method of cooling. The structure of the fat phase has been studied microscopically. In some samples of the fresh product only an interlocking mass of fine needle crystals, too small to be distinguished individually, could be seen. In others a considerable proportion of the fat was non-refracting between crossed nicols and apparently consisted of an unstable non-crystalline or sub-crystalline phase. After holding for some months pronounced changes occurred. These were characterized by the disappearance of the anisotropic phase of the fat, a general coarsening of crystal structure and at the higher temperatures the development of numerous comparatively large free fat crystals up to 0.015 millimetres in length.

(iii) *Oxidation of Butterfat.*—The last report drew attention to the importance of fat oxidation in causing deterioration of flavour in dairy products and work has been continued on the problem, with particular reference to its occurrence in concentrated hardened butter and milk powder. A degree of oxidation which would be insignificant in most edible oils or fats can be disastrous in dairy products. The sensitive test for oxidation mentioned in the last report has been further improved and has been of considerable use in investigating the problem. The minimum proportion of oxygen in butterfat which will give the characteristic flavours usually associated with oxidation has been found to be 0.2 per cent. by volume, a considerably lower amount than that reported by other workers. At lower concentrations, butterfat sealed in glass containers developed peculiar and objectionable flavours on holding for some months. These flavours were different to any that have been encountered in the presence of oxygen. Mention was made in the last report of the pro-oxidant effect of Australian dairy salt or dry butterfat. The action could be eliminated by roasting the salt or by extraction with certain solvents. It has now been found to be due to the presence of magnesium chloride. This acts as a pro-oxidant on dry butterfat. The degree of hydration is important and the action is not exhibited by the salt in solution and is considerably less with the anhydrous salt. The phenomenon appears to be one of surface catalysis. Apart from roasting or washing the magnesium chloride from the salt, the pro-oxidant action could be eliminated by grinding the salt with sodium carbonate. This finding has been applied to the manufacture of concentrated hardened butter, and the results of storage trials on the commercial product have fully confirmed the laboratory findings. Other di- and trivalent metallic chlorides mixed in small proportions with dry sodium chloride have been found to act as pro-oxidants on dry fat. Aluminium chloride was particularly active, and this finding may be of some value in view of the use of aluminium in food processing equipment. It has been known for some time that salt has pro-oxidant effect on butter held in cold storage, and experiments were made on the use of roasted salt in such butter. The treated salt was no better than untreated salt, a result which was not surprising in view of the fact that magnesium chloride in solution had been found to be inert. A combination of salt and acidity in the aqueous phase has been known for many years to lead to the development of fishy flavours in butter, although the mechanism of the reactions occurring is still in doubt. It is interesting to note that, in concentrated hardened butter, similar flavours have been found when the proportion of fatty acids present has been

unusually high or when citric acid has been added to the mixture. Several anti-oxidants have been tried with concentrated hardened butter, but the only practicable one which showed promise was soya bean lecithin.

(iv) *Cheese.*—Experimental process cheeses have been made containing *C. welchii* and *C. sporogenes* separately and together. These have demonstrated that the characteristic discoloration in patches, gas formation, and putrid odour which occasionally occur in process cheese are produced by *C. sporogenes*. *C. welchii* produces a sour butyric acid odour and gas. Development is most rapid when both organisms are present and it is typical of that caused by *C. sporogenes*. The presence of lactose favours development.

Experiments have been commenced on the maturing of cheese in special wrapping materials which are claimed to be sufficiently permeable to the gases normally liberated on ripening but impermeable to water vapour. Such wrapping would be valuable in eliminating loss caused through rind formation, and if used on small packages would enable the cheese to be kept without the objectionable drying and hardening which usually occurs on the surface.

(v) *Keeping Quality of Milk Powder.*—The comprehensive survey of the keeping quality of milk powder mentioned in the last report has now been completed and the full results written up for publication. Roller and spray dried skim and whole milk powders were stored at various temperatures and under various conditions of packing. Gas packing (i.e., packing in an atmosphere of nitrogen) did not materially improve the storage life of skim-milk powders but greatly increased the life of whole-milk powders. In commercial practice the advantages of gas packing were largely nullified by the presence of leaking tins. Skim-milk powders, when reconstituted after storage with fresh flavoured butterfat, were no better in flavour than reconstituted gas-packed whole-milk powders stored under identical temperature conditions. Variations in the keeping quality of powders made at different times by any one factory were considerable, and great differences in the keeping quality of whole-milk spray-dried powders from different factories were noticed. The roller-dried whole-milk powders examined were inferior in flavour to the better quality spray-dried whole-milk powders. The influence of storage temperatures (15°, 30° and 37° C.) was not marked either with the skim or whole-milk powders. No correlation between bacterial counts and initial quality or conditions after storage was observed.

(vi) *Compressed Sugar and Full-cream Milk Powder.*—About 1,000 lb. of compressed whole-milk powder containing 20 per cent. added cane sugar was prepared during the year and forwarded to a firm of confectionery manufacturers in Great Britain who desire to explore its possibilities with a view to use after the war. A report has not yet been received from Great Britain, but samples held in Australia for six months kept excellently and were favorably reported on by the local branch of the firm.

(vii) *Lactic Acid from Whey.*—Advice has been given to several manufacturers on the production of lactic acid from whey. Experimental work was done on the isolation of lactic acid by solvent extraction. Ethyl acetate gave promising results in the laboratory, but it was decided that difficulties due to hydrolysis and liberation of acetic acid would make difficult its large-scale adoption. No other readily available solvent was found which was suitable or as effective as isopropyl ether which is used in the United States of America. The production of whey is seasonal and in autumn and winter difficulty is experienced in maintaining production of lactic acid from this source. Under some conditions the use of cane sugar to fortify whatever whey is available, in order to increase the yield of acid, is economically feasible. The main difficulty is that the organism *L. bulgaricus* normally used in whey fermentation does not attack sucrose. A laboratory investigation to determine the best means of utilizing cane sugar in the whey fermentation has been conducted. Preliminary acid inversion of the cane sugar was successful, up to 7 per cent. extra sugar being fermented in this way without otherwise altering the conditions of fermentation. It was also found possible to ferment cane sugar directly in whey by using a mixed culture of *L. bulgaricus* and *L. delbruckii*. Strains of the latter organism suitable for this purpose have been isolated from natural sources. The two organisms together gave particularly fast results also in unfortified whey.

(viii) *Publications.*—The following papers were published during the year :—

Pont, E. G. (1944).—Lactic acid from whey. *Aust. Milk Dairy Prod. J.* (August).

Pont, E. G. (1945).—The keeping quality of tinned butter. *J. Coun. Sci. Ind. Res.* (*Aust.*) 18 : 53–61.

2. *Radio Research Board.*—During the year the Radio Research Board continued its programme of investigations into the propagation of radio waves via the ionosphere. This programme has been carried out under the general direction of the Australian Radio Propagation Committee which was set up as a Committee of the Radio Research Board in November, 1942. This Committee has a membership representative of all the Fighting and Civil Services and all the Government research organizations carrying out work on radio propagation and allied phenomena.

The programme includes the installation and operation of additional ionospheric recording stations and the use of the information so obtained in the preparation of radio propagation data for use in connexion with the problems of high-frequency radio communication. The scope and volume of the work have steadily increased, particularly as the result of an International Radio Propagation Conference which was held in the United States of America during the year and which was attended by the Board's representatives.

The results of the programme of investigation and the application of the results have proved increasingly valuable to the Services and to civil radio communication organizations. More important still are the new discoveries that have been made regarding the nature of the ionosphere and the new lines of research that have been opened up by the developmental programme now that it has been thoroughly organized on a co-operative world-wide basis. Significant advances are expected to follow further research now being planned, but for security reasons the details of the present and future programmes cannot be given here.

The Board's work has been carried out principally in the Electrical Engineering Department of the University of Sydney as in previous years. A second group has been working in the Physics Department of the University of Queensland for the past two years, and the Commonwealth Solar Observatory at Canberra has continued its long association with the Board's research programme.

3. *Mineragraphic Investigations.*—Fourteen investigations have been carried out into the mineral association of rocks, ores and mill products submitted by mining companies and institutions. Each investigation was complete in itself and was directed to some specific problem relating to the use of recovery of the economic minerals.

Two investigations were connected with ore-dressing research on tin ore from the Greisen Lode at Mount Bischoff. The tin occurs chiefly as fine particles of cassiterite, seldom exceeding 0.1 millimetre in diameter, which are imbedded in a talc gangue with associated pyrrhotite; traces of stannite are sometimes found as films on cassiterite, but losses of tin in a sulphide concentrate are due mainly to grains of cassiterite with a thin coating of talc and only in a minor degree to composite grains of cassiterite and sulphide.

A detailed examination of the copper ore from the Black Star ore body at Mount Isa was concerned not only with the relationship of the copper-bearing minerals to pyrite and pyrrhotite, but also with the rarer minerals containing the minor elements in the ore. The rare copper-iron sulphide, valleriite, was found to occur as microscopic inclusions throughout chalcopyrite. Small amounts of arsenic are due to minute crystals of arsenopyrite. Small amounts of antimony are due to small inclusions of jamesonite in galena. Silver is attributed to exceedingly minute prisms of dyscrasite in the galena, while traces of gold were found in particles and veinlets between small areas of sphalerite and pyrrhotite in chalcopyrite.

Quarrying operations at the Angaston Marble Quarry, South Australia, have revealed extensive amounts of friable marble which is rejected as waste, and an examination of a number of bore cores was undertaken to determine the cause of the friability. It indicated that the most common cause of friability is the presence of introduced, secondary phosphate deposited along joints and narrow veins. The alteration of the marble is thus related to the downward extension of superficial phosphate deposits that are now largely eroded.

Comparison of some commercial talc powders from South Australian talc was made with Indian talc. The results indicated that impurities are retained in grinding raw talc from South Australia and they must be reduced by dressing, before the local talc powders can equal the quality of imported Indian talc. An investigation of the origin of the occurrences of talc in South Australia is now in progress.

The investigations mentioned in the preceding paragraphs 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.*—The co-operative investigations in which the Kalgoorlie School of Mines, the South Australian School of Mines and Industries, and the Metallurgy School of the University of Melbourne were continued throughout the year.

At Kalgoorlie, the majority of the twenty projects undertaken dealt with various problems of gold recovery. The remainder were investigations into the treatment of cassiterite-tantalite ores, the most important of which was in connexion with the economic commercial separation of the two minerals from concentrates produced at Greenbushes. One of the gold projects concerned the problem of high-grade gold-antimony ore, the object being to determine the most suitable method of obtaining a maximum recovery of gold other than in the form of a gold stibnite concentrate. In addition to the laboratory investigations, work on the small-scale smelting of copper ores directly to blister copper has been continued in the field.

In Adelaide, investigational work has mainly concerned special requests for the Minerals Committee of the Department of Supply and Shipping. In addition, however, some work has been done on fluorspar, graphite, sillimanite for refractories, and talc. The beneficiation of local talc rock to cosmetic-grade material has now been undertaken.

In Melbourne, work for the year was again mainly confined to base metal ores of strategic importance. Extended testing was also carried out on the zircon, rutile and ilmenite bearing beach sands of northern New South Wales and southern Queensland.

5. *Mathematical Statistics.*—(i) *General.*—A major problem over the period under review has been that of meeting the growing demands made upon the Section as a natural outcome of expansion of activities within the Council. Co-operation with the several Divisions has been maintained, and the major contributions in this field appear later under the Divisions concerned.

As a result of a proposal by the University of Adelaide to promote close association between the Section and its own School of Mathematics, the Section's head-quarters were transferred, in November, 1944, to Adelaide, from its former location in the Commerce School at the University of Melbourne. The University of Adelaide generously offered to house the Section until such time as permanent accommodation became available in the proposed building of the Division of Biochemistry and General Nutrition. When this plan becomes fully operative the Council hopes for an improvement in the supply of graduates for the field of mathematical statistics. The move involved certain adjustments in personnel, and, with the increased output to be expected from it, further additions to the staff were necessary.

Assistance has been given to various external organizations, including Commonwealth and State departments, the Universities, research organizations, commercial bodies and private individuals. In addition, the arrangement with the University of Adelaide provided for courses of lectures in mathematical statistics to be delivered in its School of Mathematics.

(ii) *Division of Animal Health and Production.*—The Section has continued with its analysis of data involved in parasitological experiments at Armidale, including the influence of parasitism on fly-strike, tests of anthelmintics and dips and epidemiology trials. Analyses of egg counts were made for a Canberra grazing trial. Work has proceeded on analyses of classing trials, progeny testing and production studies at "Gilruth Plains", and the analysis of the third "peg-leg" trial at Helenslee has been completed.

In connexion with the Adelaide experiment for the Wool Biology Section, interest has centred in the fitting of curves of a complex exponential form to growth measurements. Other work for this Section has included analysis of data from progeny testing trials at "Noondoo", Queensland, and fleece sampling, which is concerned with the determination of optimum size of wool samples from a defined area, and a study of the distribution of the various measurements over the body of the sheep for different strains and breeds.

Miscellaneous work has included the preparation of nomograms, from which can be read the constitution of a flock of sheep at the end of a given time, assuming certain conditions.

(iii) *Division of Biochemistry and General Nutrition.*—Analyses made for this Division have been concerned with the frequency distribution of wool fibre diameter, the temporal trend in the vitamin A content of the blood of sheep, and trace element deficiencies affecting sheep in South Australia.

(iv) *Division of Economic Entomology.*—The year's work for this Division has mainly consisted of the designing and analysis of dust and spraying trials against a variety of fruit and vegetable pests, such as potato moth, codling moth, peach moth, green vegetable bug and grasshoppers. Assistance has also been given in a trial to test the effectiveness of eelworm control.

(v) *Division of Food Preservation.*—Assistance has been provided in the planning of experiments and the statistical treatment of data concerned with the ascorbic acid and vitamin content of cabbage varieties.

(vi) *Division of Forest Products and Building Materials Section.*—The Section has continued to assist the various sections of this Division with the planning of investigations and the analysis of experimental data.

For the Chemistry Section, studies have been made of the effects of sheet-making technique and of water composition on paper properties; and tests on moisture barrier materials and lignin determinations carried out. Effects of temperature on strength properties of wood and studies of factors affecting the compression of wood were among the experiments of the Physics Section; and those of the Timber Mechanics Section, the effect of position in tree on strength properties of timber, the correlation between strength properties, and the comparison of plywood testing machines. Diffusion studies were carried out for the Preservation Section, and the work for Improved Wood and for Veneering and Gluing included factorial experiments on the effect of glue composition and joint treatment on joint strength, miscellaneous experiments on effect of glue composition and veneer surface treatment on shear strength of joints, and comparison of

methods of testing resistance of glued joints to fungal attack. Work for flax processing has involved experiments on retting technique, on retting results from agricultural trials, on the relation between microscopic properties and quality of fibre, and chemical analyses of fibre. Finally, for the Building Materials Research Section, assistance has been given in its experiments on the effect of composition of sawdust-cement on strength.

(vii) *Division of Industrial Chemistry.*—Advice has been provided for this Division on curve-fitting and numerical integration in the analysis of data from flotation studies; in the sampling of wool for tensile tests and in testing the effect of various treatments on properties, recommendations have been made and assistance given in the designing of experiments.

(viii) *Irrigation Research Station, Griffith.*—Work for the Station has been concerned with cabbage fertilizer, and tomato variety and time-of-sowing trials; also with the analysis of data on the regeneration of sick citrus groves. Analyses have been made of static soakage rates, using different designs of instruments, and suggestions made in an attempt to link such work with irrigation flows. The results of the Griffith survey, and techniques for project farms, have been discussed, as well as the designing of fertilizer and frequency of irrigation trials on Junior Farmer projects.

(ix) *Division of Plant Industry.*—During the year, the records and report on a long-term rotational grazing trial were completed, and at "Gilruth Plains" records have been maintained for a grazing trial. Assistance was given in the design of a series of experiments on methods of establishment, fertilizers, &c., for improved pastures in the Australian Capital Territory. Analyses of many establishment, fertilizer and varietal trials were made on behalf of the Plant Introduction Section, while designs and analyses of a series of experiments on germinations and varietal comparisons of vegetable crops were made for the Vegetable Section. Further work was done on the relation of take-all disease of wheat to soil treatment.

(x) *Division of Soils.*—For this Division, data concerning the expectation of rainfall in twelve-day intervals at Dookie Agricultural College have been statistically treated.

6. *Standards Association of Australia**.—Whilst continuing to deal actively with specifications for general industrial needs and for service requirements, a series of specifications has been undertaken by the Association to assist post-war housing schemes, particularly for plumbing fittings and builders' hardware.

The release of additional technical staff to the Association is now permitting the resumption of subjects in a wide field for civil engineering, which had to be held in abeyance because of urgent war-time tasks.

The total number of Australian standard specifications is now 800 of which over 220 are special war-time publications. A further new series, referred to as "Interim Specifications", now number 65; they deal with subjects for which co-ordination was essential to meet the needs of various fighting services. They are not Australian standards, but have been issued by the Association in collaboration with the Service Departments. The co-ordination which the Association has thus assisted is believed to have been of very great value for operational tropical areas.

The original policy of establishing and maintaining a standards and technical library has been fully justified, as is proved by the continuous demands for information in the main industrial areas, not only on standard specifications as such, but for the technical information which has been accumulated and is made available freely.

During the past twelve months, sales of standard specifications by the Publications Department have increasingly confirmed that great dependence is now placed on Australian standards. The value of the Association's service as the sole source of British standard specifications in Australia is manifest by the use made of it by industry, and the technical branches of the Services including the large Royal Navy fleet in the Pacific.

XXI. SCIENTIFIC LIAISON AND INFORMATION BUREAU AND LIBRARY.

A. Scientific Liaison and Information Bureau.

1. *General.*—Following representations made by the Council, War Cabinet decided during the year that the Scientific Liaison Bureau, which it had established in November, 1942, should be transferred to the Council and merged with the Council's Information Section. This merger took place on 16th April, 1945, and the joint organization then assumed the title of the Scientific Liaison and Information Bureau. Following the amalgamation, the head-quarters of the Bureau have been located at the Council's Head Office, though the former offices of the Scientific Liaison Bureau in Melbourne and Sydney have been retained for the time being.

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

In order to ensure continuity of the work in hand, and until such time as the functions of the new body are defined, the existing organization of the two units has been temporarily retained. As a result it has been considered desirable to report the activities of the two units separately for this year.

2. *Information Section.*—(i) *General.*—The Section has received increasing demands for its services from the Council's own staff, the Services, Government Departments, industrial and commercial organizations and private individuals. In the early part of the year, the Section's activities were concerned mainly with inquiries relating to problems associated with the war effort, but in the latter part there was a greater emphasis on problems of a post-war nature. The major part of the work has been devoted to the compilation of summaries and bibliographies related to various aspects of technical production, the utilization of Australian materials, and of industrial matters generally.

(ii) *Information for Council.*—Once again the Section has assisted the Executive Committee and the various Divisions and Sections of the Council with the compilation of data and the preparation of literature surveys, particularly in relation to exploratory work associated with projected lines of research. In connexion with the consideration being given by the Council to the best way in which technical assistance may be given to secondary industries after the war, a summary was prepared of the organization and operation of the Industrial Research Associations in Great Britain.

During the year, as a result of the serious drought conditions prevailing throughout Australia, the Council's attention was directed towards the possible utilization of waste products and other materials as stock feeds, and the Section prepared a summary of available information on the uses of wheat, straw, and vegetable and fruit wastes as sheep and cattle fodders.

At the request of the Division of Industrial Chemistry the Section prepared a summary of information and a bibliography on the preparation and manufacture, through the controlled oxidation of paraffins, of synthetic ester waxes. Further summaries from the literature were prepared for the Division on the manufacture of iron pentacarbonyls and on the construction of an electromagnet capable of producing a uniform field of high intensity. Following upon consideration being given to the possible post-war revival of Australian whaling activities in the southern seas, a survey was made at the joint request of the Divisions of Industrial Chemistry and Fisheries, of the literature dealing with the commercially valuable whales inhabiting these waters and of the products particularly oils, which are derived therefrom.

A number of other summaries and literature surveys have been prepared, and information obtained from sources outside the Council, and from overseas, for the other Divisions and Sections of the Council.

(iii) *Information for Government Departments, Manufacturers, &c.*—The usual demand from Government Departments, manufacturers and private individuals has been experienced during the year. In this phase of its work the Section has not confined its activities to literature surveys alone but has referred inquirers to authorities or laboratories, both within and without the Council, best fitted to deal with the inquiries concerned.

Many inquiries relating to post-war development have been received from private individuals, and particularly from Service personnel, whose thoughts are turning to their rehabilitation following demobilization. On the secondary industry side many requests for information have related to possible future developments of plastics and other new materials referred to in scientific journals and the press. On the agricultural side, servicemen in particular have been interested in the possible development of New Guinea and the Northern Territory, and information has been requested concerning the cultivation of such crops as rubber, coffee, cocoa, ginger, soya bean, tung oil tree, kudzu, pyrethrum, sunflowers, and passion fruit.

With the increased publicity given recently to D.D.T., the Section has been flooded with requests for information on this new insecticide from firms interested in the manufacture of the compound itself, from firms interested in utilizing it in sprays and dusts, and from the public interested in its use. As a result, following consultation with the Division of Economic Entomology, a report was prepared and circulated on the present and possible uses of D.D.T. During the year attention was directed both overseas and locally to the Australian native plant *Duboisia Hopwoodii* as a source of the alkaloid nor-nicotine to replace the insecticide nicotine sulphate, which has been in short supply since early in the war. A survey was made of the distribution of *D. Hopwoodii* in Australia, and a report prepared concerning its possible economic value as a source of nor-nicotine.

A selection of other matters which have been dealt with include :—

Preparation of Chemicals.—Elaidic acid, phenylacetic acid, chlorthymol, cetyltrimethyl ammonium bromide, symmetrical dichloro-acetone, phenyl mercuric nitrate, p-aminoacridine, propyl gallate, resorcinol monoacetate. *Manufacturing.*—Pectin, metol, dinitrocresol, potato starch, alcohol from potatoes, titanium tetrachloride. *Metallurgical.*—Extrusion of zinc and

lead, production of zinc in Australia, durability and finishing of aluminium ware, chemical lead and tellurium lead, chromium and gold plating, columbium and tantalum, corrosion of ferrous metals in mixed acids, photoengraving aluminium, drawing silver solder wire, corrosion of copper-zinc and copper-manganese alloys by sea water. *Mineralogical.*—Bentonite and vermiculites for insulation purposes, preparation of radium and other luminous paints, mica insulating boards, pottery clays, autunite and torbernite. *Food.*—Dehydration and utilization of cannery waste, peanut meal, maize oil, cows milk *v.* goats milk, effect of copper on vitamin C, tainting by phenolic resins. *Agriculture.*—Artificial foods for bees, sewage as a fertilizer, bibliography on rat control, animal diseases in North Australia, organic farming, phosphate fixation, plant growth substances, biological surveys in Australia. *Building.*—Magnesium oxychloride cements, acid proofing concrete, treatment of concrete floors in sugar, cake and jam factories, bitumen cement flooring, manufacture of sun-dried bricks, cell-concrete, soil cement for building purposes, mould on walls and ceilings. *Fuels, &c.*—Underground gasification of coal, liquid fuels from farm waste.

Miscellaneous.—Utilization of sewage, pearl culture, stability of ether, descaling compounds, pharmacological uses of lanoline, wool carbonizing, industrial uses of spider webs, waterproofing fishing lines.

(iv) *Publications, Abstracts, &c.*—Officers of the Section have continued to act as an abstracting panel for the preparation of the "Australian Chemical Abstracts"; these are confined entirely to reports and articles published in Australia and to Australian patents and are published by the Australian Chemical Institute.

During the year the Section, in collaboration with the Secretariat, commenced the preparation and issue of a "Digest of Current Activities" of the Council for Scientific and Industrial Research. Four issues of the digest, which aims at providing members of State Committees and officers of the Council with items of research, &c., and major policy decisions of the Council and the Executive Committee, have been made so far, at approximately two-monthly intervals.

(v) *Overseas Liaison, Foreign Journal Service and Photographic Copying.*—The Section has continued to assist in the receipt and distribution of a large volume of unprinted reports, many of a secret or confidential nature relating to the war effort, from the Council's Scientific Research Liaison Offices in London and Washington.

As mentioned in previous reports, a great part of the overseas material has been sent airmail in the form of photographic film and included in this microfilm service from London are about 200 German, Italian, Russian and French scientific journals covering many aspects of science and industry. The Foreign Journal Service which was established in 1942 as a means of bringing the information contained in journals to the organizations likely to benefit therefrom has continued to function.

3. *Scientific Liaison Bureau.*—(i) *General.*—As this is the first occasion on which the Bureau's activities have been included within the Council's annual report it is perhaps appropriate to sketch briefly its previous history and the work to which the present phase of its activities is necessarily related.

The principal function of the Bureau has been to familiarize itself with the facilities for scientific work in Government and non-Government laboratories in Australia and to ensure that scientific problems arising in the Services, certain Government Departments, and war industries, and not otherwise provided for, were promptly brought to the notice of appropriate scientific authorities and that, where necessary, experimental work was carried out to solve such problems. In addition the Bureau was charged with the promotion of the application of science to war needs in the Services and war industries.

To this end, offices were set up in Melbourne, Sydney and Brisbane, and Honorary Liaison Officers were appointed in Adelaide, Brisbane, Hobart, Newcastle and Perth. A directory of scientific resources in Australia, entitled "Science on Service", was compiled and published early in 1943; a second revised edition followed in 1944. Subsequently, a series of bi-monthly technical supplements to this directory giving greater detail on various scientific establishments and facilities has been published. These publications have been given a wide distribution and may be considered to have contributed to a better general appreciation of scientific facilities available in Australia.

To assist in the co-ordination of scientific work affecting the war effort and reduce duplication, indexes were compiled of the relevant research projects being carried out in Australian laboratories and of problems referred to the Bureau. These indexes are available in all States, and thus provide ready reference to work in hand or already carried out, when a new problem is received.

The Australian Services co-operate closely with the Bureau and have officially recorded its establishment and status in Service Orders. In addition the Army appointed an Army Scientific Liaison Officer to maintain direct liaison between the Bureau and the Army.

In order to determine the nature and extent of the various problems associated with tropical deterioration of stores and equipment, the Bureau convened a Conference in May, 1943, which recommended that a party of civilian scientists should visit operational areas. As a result, a Scientific Mission organized by the Bureau, and with the approval and close co-operation of the Services, visited New Guinea shortly afterwards. A report, "The Condition of Service Material under Tropical Conditions in New Guinea", was published in October, 1943, and widely distributed. This report provided a basis for corrective action both in Australia and overseas, and the extensive demand from overseas necessitated an early reprinting.

A further conference was called by the Bureau to consider the report and to provide for the co-ordination of the necessary research work and for the preparation of Australian specifications to effect a uniformity of procedure in demands for tropicalization. Six Inter-Service Committees were established under the aegis of the Bureau to cover (1) Packaging, (2) Corrosion Preventives, (3) Electrical Equipment, (4) Organic Materials, (5) Optical Instruments, and (6) Underwater Protection of Ships and Small Craft. Subsequently the responsibility for work on electrical equipment was undertaken by Committee "L", General Head-quarters, South-West Pacific Command, and the work on optical instruments by the Optical Panel of the Ordnance Production Directorate, Ministry of Munitions. At the same time a Mycological Panel was formed by the Bureau to co-ordinate and undertake work on moulds and fungicides.

Early in 1944, with the approval of the Services, a Tropical Scientific Section was inaugurated by the Bureau, to function in operational areas with head-quarters in New Guinea. The Section maintains a "permanent" nucleus in the field, comprising a chemist, a physicist and a biologist. From time to time specialists are temporarily attached thereto to cover special assignments. The Section is particularly concerned with matters associated with the deterioration of stores and equipment under tropical conditions, and has been active in the examination of materials in the field and in the testing out, and advising the Services on the implementation of the success of measures formulated by the Inter-Services Committees to prevent deterioration in forward areas.

(ii) *Tropicalization of Stores and Equipment.*—(*a*) *Inter-Services Committees.*—The principal activity of these committees has been the formulation of common specifications concerning the requirements, methods, and procedures for tropic-treatment and tropic packing of Service stores and equipment. These specifications are based on information contained in existing specifications where such were available, and also on experimental data obtained from collaborating laboratories and from tests conducted in New Guinea by the Tropical Scientific Section. The varied nature and scope of the work will be evident from the following list of specifications, 27 in all, which have been issued or were in preparation during the past year: Packaging Code for Service Stores; Temporary Corrosion Preventives; Water-displacing Fluids; Wrapping Materials; Moisture Barrier Materials; Water-proof Adhesives; Adhesive Tapes; Silica Gel (Packaging Quality); Compounds, Dip Sealing; Crates, Steel Fabric; Crates, Fully Sheathed up to 3,000 lb.; Crates, Open or Sheathed up to 1,000 lb.; Cases, Wood, Nailed; Cases, Wood, Stitched Wire; Resin-Bonded Plywood for Boxes; Fibreboard Inner Containers; Procedures to be adopted in Testing Materials for Resistance to Mould Attack; Fungicides and Associated Materials; Application of Fungicides to Specified Types of Material; Preservative Treatment of Timber (excluding Timber for Small Ship Construction, Packing Cases and Structures); Preservation of Structural Timbers; Rot-proofing Treatment of Fabrics, Webbing, Threads and Cordage; Rot-proofing and Water-proofing Treatment of Cotton, Jute and Flax Fabrics; Sheathing of Wooden Vessels with Timber of High Natural Resistance to Marine Borer Attack; Application of Hard Setting Plastic Compositions (Chemical Hardening Type) to the Bottoms of Wooden Ships; Sheathing of Wooden Vessels with Copper; Adhesives and Paying Compounds for use in Wooden Ship Construction.

Following approval by the Services, such specifications have been published by the Standards Association of Australia in an Interim Specification Series. Periodical surveys are made of the field performance of stores and equipment, packed and treated according to these specifications; reports based on these surveys are considered by the relevant Committee, and, where necessary, modifications in procedure have been adopted and specifications amended accordingly.

(*b*) *Reports and Information.*—The Bureau has acted as a clearing house for information on tropicalization, and in this connexion many laboratories in Australia have provided valuable reports for circulation both locally and overseas; 160 Australian reports, in addition to copies of specifications and recommendations relating to tropicalization, have been sent to Great Britain and the United States of America, where their distribution is affected through the Council's Liaison Offices in London and Washington. Also, 1,480 reports received from overseas through the Council's Liaison Offices were distributed in Australia by the Bureau. Bi-monthly summaries of work on tropicalization carried out in Australia have been compiled for inclusion in Technical Letters of the Master-General of the Ordnance.

Where inquiries are received on special aspects of tropicalization they have been directed to the particular laboratory or individual most concerned with the problem.

(iii) *Tropical Scientific Section.*—In collaboration with the Inter-Services Committees the Section has carried out a number of field tests on materials and procedures for tropic-treatment. These tests include :—Exposure and wet storage trials on tentage and fabrics ; storage trials on cork gaskets in conjunction with various fungicides ; exposure and storage trials on treated leather goods, e.g., instrument cases ; exposure trials on optical instruments which have been tropic-treated ; exposure and storage trials on multiwall sacks for flour ; tests on lubricating and corrosion preventive oils for small arms ; burial tests on identification discs ; reconditioning of tentage with liquid tent patching cement ; and the resistance of various New Guinea timbers to marine organisms with a view to the use of such timbers in wharves and small craft in island waters.

In response to requests from the Services, surveys or investigations have been made on various aspects of tropical deterioration of aircraft fuels and lubricants ; wear on aircraft tyres ; conditions of wharves and harbour installations ; condition of stores and equipment at an island base (for the Royal Navy) ; tropic-treatment of telecommunication equipment in armoured vehicles, automotive electrical equipment ; deterioration of boots and clothing ; conditions of ordnance stores in forward depots with particular reference to the more recent methods of packing and storage recommended by the Inter-Services Committee ; jungle survival of pilots forced down in northern areas ; Japanese gardens ; and many operational matters.

In certain instances civilian scientists have been attached to the Tropical Scientific Section for particular investigations, or in order to extend and complete programmes of work which have been developed from the earlier activities of the Section itself. Projects of this type include the following, the personnel in all cases being attached to the Tropical Scientific Section :—

(*a*) *Electrical and Telecommunication Equipment.*—An officer of the Council's Division of Electrotechnology studied the performance of electrical and telecommunication equipment, so that, in particular, field conditions could be correlated with laboratory investigations. Preparations were also made for a comprehensive investigation of temperature and humidity distribution in typical buildings used as stores in New Guinea and of the conditions existing inside packing cases under such conditions of storage. Further, in co-operation with a member of a private firm supplying automotive electrical equipment to the Services, a special report was prepared on telecommunication and electrical equipment in armoured fighting vehicles.

(*b*) *Ammunition and Explosives.*—An officer of the Munitions Supply Laboratories carried out a comprehensive survey of ammunition and explosive stores in New Guinea and adjacent areas. A report has been prepared on the condition and deterioration of these stores.

(*c*) *Scrub Typhus.*—The biologist of the Section collaborated with Army Medical Services and with the United States of America Typhus Commission operating in New Guinea on problems associated with the spread of scrub typhus. Later the mammalogist from the Australian Museum followed up the work of the United States of America Commission and in particular studied the mammal reservoirs of scrub typhus in the New Guinea and adjacent areas.

(*d*) *Food.*—Three officers of the Council's Division of Food Preservation and Transport examined the conditions of foodstuffs in storage in New Guinea and reported on various aspects of food supply, handling and storage in forward areas.

(*e*) *Underwater Protection of Timber.*—To assist the Army in a survey of wharves, harbour installations and small craft, particularly in regard to the incidence of attack by marine organisms, a marine biologist of the Maritime Services Board, New South Wales, was attached to the Section for a period of four months.

(*f*) *Dental Materials.*—In response to a request from the Army an officer of the Melbourne Dental Hospital spent about six weeks investigating the condition of dental supplies and requisites ; particular attention was paid to the deleterious effects of tropical storage.

(*g*) *Performance and Maintenance of Water Craft.*—An engineer from the Australian Shipbuilding Board investigated alleged defects in certain Army vessels, in operational areas. A report dealing with the performance, maintenance and repairs on the various types of small water craft has been issued.

(*h*) *Radio and Signals Equipment.*—Following representation to the Army by the Institution of Radio Engineers, arrangements have been concluded for the attachment to the Section of three selected members of the radio industry. This visit is planned to enable the industry to study the operation and maintenance of radio and signals equipment and its resistance to deterioration in tropical operational areas, so that it will be able to assess the effectiveness of the newer industrial materials and manufacturing methods.

(iv) *Industrial Liaison.*—With the limited staff available, liaison work has been rather restricted, though contact has been maintained with the various technical arms of the Services, war contractors and Government Departments. The Bureau has continued to work in close co-operation with certain of the Divisions and Sections of the Council, Munitions Supply Laboratories, Universities, Technical Colleges and Commonwealth and State Departments.

In addition to the problems associated with tropical warfare with which the Bureau has been concerned, some 800 miscellaneous inquiries have been dealt with in the past year. About 400 of these inquiries originated in Government Departments, and in New South Wales a considerable number of these came from the New Manufactures Section of the Directorate of War Organization of Industry. Many inquiries were received regarding the availability and sources of supply of special chemicals or materials. Compared with previous years the number of inquiries from private individuals and industry has increased.

The nature and scope of the inquiries and problems handled has varied considerably. In some cases inquiries of a simple nature were dealt with by consulting a recognized authority; other problems required reference to several quarters and occasionally entailed a programme of experimental work by an appropriate laboratory. In certain special cases existing facilities were inadequate and scientific workers were enlisted and special investigational work was financed by the Bureau. Two such projects initiated earlier were completed during the year, while a third is still current and may be referred to briefly.

The problem concerns the "Underwater Protection of Ships and Small Craft", and has become a very serious one as a result of the protracted warfare in tropical island regions, with the consequent rapid increase in the use of water craft, wharfage and handling facilities. Following a comprehensive survey, the Scientific Co-ordinating Panel of Inter-Services Committee No. 6 recommended that certain marine biological aspects of the problem should be investigated at once, and that consideration should be given to the testing out and selection of suitable underwater protective paints and the determination of the suitability of treated and untreated timbers for use as sheathing or planking in wooden craft.

The project is a co-operative one, with the Maritime Services Board of New South Wales dealing with the marine biological aspects of the problem, Munitions Supply Laboratories with metallurgical and chemical aspects, the Council's Division of Forest Products with timber and timber preservation treatment, and the Tropical Scientific Section with testing work in New Guinea. The Department of Navy's Testing Laboratory at Garden Island will correlate the experimental results with ship's practice. The Bureau is financing the extra laboratory work involved.

(v) *Staff.*—It is with profound regret that the death is recorded of Dr. H. F. C. Davis who was killed in an aircraft accident while on duty with the Tropical Scientific Section in New Guinea in December, 1944. Dr. Davis was a biologist of conspicuous ability and in placing on record his good work while a member of the Tropical Scientific Section, it is fitting also to acknowledge the loss to Australia of a brilliant young scientist.

During the year, Professor F. Goldby, previously Honorary Liaison Officer for South Australia, accepted an appointment in England and Mr. I. W. McDonald of the Institute of Medical and Veterinary Science, Adelaide, kindly agreed to act as Honorary Liaison Officer in that State.

The work of the branch office in Brisbane decreased considerably with the movement further north of Allied General Head-quarters and, early in 1945, the staff was withdrawn. Representation in Queensland is maintained by the Honorary Liaison Officer, Professor T. G. H. Jones.

B. Library.

The past year has not been quite as difficult a one for libraries as the previous war years, and the easing in the war situation has led to an improvement in the supply of library material. Various institutions in the United Kingdom and the United States of America, which had suspended publication or had temporarily ceased overseas distribution, are once again forwarding material. Also, as there are no shipping losses, journals are coming to hand more regularly and the problem of imperfect volumes is not so acute as formerly.

The Head Office library continues to be used extensively by the general public, as well as by the Council's staff. With the increase in the number of technical libraries in Melbourne, there has been a proportionate increase in the use that is being made of technical literature everywhere. Where formerly the officers of a department or company did without the references that they required, now that they have a librarian attached to their staff, a much more determined effort is made to locate these, and it is here that the help of the older and larger libraries is required in order to trace the references and to make them available on loan. The Council has always been glad to assist the smaller libraries, not only by making material available when required to do so, but also by giving any advice that is required in regard to organization.

The lack of trained personnel available for appointment to positions in the Council for Scientific and Industrial Research and in all other libraries continues to be acute.

Work on the new edition of the Catalogue of Scientific and Technical Periodicals has continued steadily throughout the year. Revised entries have now been received from 50 of the 139 libraries which co-operated in the first edition, and, of the 73 new libraries which have been approached, nearly all have expressed desire to be included and 33 have already forwarded lists. It will be some time yet before the revised edition will be sufficiently advanced for consideration to be given to the best method of publishing, but it should not be so very long before a sufficient number of cards have been assembled and sorted to allow limited use of the catalogue in card form. Judging from the entries received to date, there is likely to be something in the order of 100 per cent. increase in the holdings of all the more important libraries.

XXII. FINANCIAL MATTERS, STAFF AND PUBLICATIONS.

1. *Finance.*—The statement of expenditure from 1st July, 1944, to 30th June, 1945, is as follows :—

	£	£	£
(1) Salaries and contingencies			68,412*
(2) Remuneration of Chairman and Members of Council			2,619†
(3) Investigations—			
(i) Animal Health and Production Problems		55,709	
Less contributions from—			
Commonwealth Bank	4,100		
Department of Agriculture and Stock, Brisbane	1,000		
George Aitken Pastoral Research Trust	1,100		
University of Sydney	250		
Australian Cattle Research Association	3,750		
Australian Wool Board	4,566		
Australian Meat Board	101		
Revenue Funds—			
Vaccine	1,118		
Pleuro Pneumonia	126		
Mastitis	1,344		
Toxaemic Jaundice—Barooga	472		
F. D. McMaster Field Station	300		
Parasitology	105		
"Gilruth Plains" National Field Station	4,315		
Oestrus Experiment	18		
		22,665	
			33,044
(ii) Biochemistry and General Nutrition Problems		20,708	
Less contributions from—			
Commonwealth Bank	1,400		
George Aitken Pastoral Research Trust	900		
Australian Wool Board	3,904		
Nutrition Laboratory Revenue Fund	156		
		6,360	
			14,348
(iii) Plant Problems—Division of Plant Industry		47,232	
Less contributions from—			
Australian Wool Board	1,500		
Department of Supply and Shipping	1,072		
Department of Commerce	950		
		3,522	
			43,710

* 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.

(3) Investigations—*continued.*	£	£	£
(iv) Entomological Problems—Division of Economic Entomology		24,668	
Less contributions from—			
Australian Wheat Board	1,485		
		1,485	
			23,183
(v) Horticultural Problems of the Irrigation Settlements—			
(*a*) Citricultural—Research Station, Griffith	21,024		
Less contributions	6,401		
		14,623	
New South Wales Water Conservation and Irrigation Commission	2,413		
New South Wales Department of Agriculture	607		
Yenda Producers Co-op. Society Ltd.	81		
Leeton Fruit Growers' Co-op. Society Ltd.	81		
Griffith Producers' Co-op. Coy. Ltd.	242		
Rural Bank of New South Wales ..	809		
Leeton Co-op. Canneries Ltd. ..	485		
Griffith Revenue Fund	1,683		
(*b*) Viticultural—Research Station, Merbein	7,888		
Less contributions	4,255		
		3,633	
			18,256
Dried Fruits Control Board ..	830		
Irymple Packing Proprietary Limited	229		
Mildura Co-op. Fruit Company ..	229		
Red Cliffs Co-op. Fruit Company..	229		
Aurora Packing Pty. Ltd. ..	229		
Department of Supply and Shipping	453		
Merbein Research Station Revenue Fund	2,056		
(vi) Soil Problems		17,197	
Less contributions from—			
Commonwealth Bank	3,000		
		3,000	
			14,197
(vii) Food Preservation and Transport Problems		34,920	
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	79		
W. Angliss Ltd.	48		
Department of Commerce	2,822		
A. Lawrence & Coy.	61		
Food Preservation Revenue Fund ..	114		
Citrus Preservation Revenue Fund ..	102		
		9,501	
			25,419

		£	£	£
(3) Investigations—*continued.*				
(viii) Forest Products Problems			64,094	
Less contributions from—				
Commonwealth Bank		3,250		
Veneer and Woodworkers' Supply Co.		1,000		
Australian Paper Manufacturers Limited		500		
Associated Pulp and Paper Mills Limited		500		
Australian Newsprint Mills Limited		500		
Department of Supply and Shipping		1,004		
Miscellaneous contributions		1,715		
			8,469	
				55,625
(ix) Mining and Metallurgy			5,978	
Less contributions from—				
Australasian Institute of Mining and Metallurgy			368	
				5,610
(x) Radio Research			13,498	
Less contributions from—				
Postmaster-General's Department		4,512		
Departments of Army, Navy and Air		6,000		
			10,512	
				2,986
(xi) Information Service, including Library			10,083	
Less contributions from—				
Foreign Journal Service			835	
				9,248
(xii) Industrial Chemistry			88,639	
Less contributions from—				
Australian Cement Manufacturers' Association			1,500	
				87,139
(xiii) Fisheries Investigations			18,105	
Less contributions from—				
New South Wales Government			187	
				17,918
(xiv) Aeronautical Research				92,712
(xv) National Standards Laboratory			143,249	
Less contributions			54,430	
				88,819
(xvi) Radiophysics Laboratory				135,902
(xvii) Lubricants and Bearings			21,584	
Less contributions from—				
University of Melbourne			700	
				20,884
(xviii) Miscellaneous—				
(*a*) Dairy Research			3,968	
(*b*) Mathematical Statistics			6,321	
(*c*) Building Materials Research			1,071	
(*d*) Various			4,887	
				16,247
Total of Item 3—Investigations				705,247

2. *Contributions and Donations.*—The following statement shows the receipts and disbursements during the year 1944–45 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled "The Specific Purposes Trust Account":—

	Receipts 1944–45 and balances brought forward from 1943–44.	Expenditure 1944–45.
	£	£
Commonwealth Bank (Animal Health and Production, Horticultural, Food Preservation and Transport, and Forest Products Investigation)	15,591	15,500
Australian Wool Board (Animal Health and Production Investigations—Sheep Research)	13,218	10,047*
Australian Cattle Research Association (Mastitis Investigations)	6,000	6,000
George Aitken Pastoral Research Trust (Animal Health and Production Investigations—Sheep Research)	2,500	2,000
Queensland Government Cattle Research (Animal Health and Production Investigations)	1,000	1,000
University of Sydney (Animal Health and Production Investigations)	250	250
Australian Meat Board (Toxaemic Jaundice Investigations, Barooga, New South Wales)	135	135†
C. P. P. Fairbairn (Animal Health and Production Investigations—Foot-rot Control)	30	..
Estate of the late Captain Ian McMaster (Animal Health and Production Investigations)	1,206	..
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)	12,013	950
Department of Supply and Shipping—Medicinal Plants (Plant Industry Investigations)	1,520	1,072
Commonwealth Bank—Bee Research (Entomological Investigations)	92	..
Australian Wheat Board—Wheat Infestation (Entomological Investigations)	1,554	1,554‡
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	2,000	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)	1,180	607
New South Wales Water Conservation and Irrigation Commission (Soils and Irrigation Extension Service, Griffith)	802	413
Griffith Producers' Co-op. Coy. Ltd. (Soils and Irrigation Extension Service, Griffith)	472	242
Rural Bank of New South Wales (Soils and Irrigation Extension Service, Griffith)	1,573	809
Yenda Producers' Co-op. Society Ltd. (Soils and Irrigation Extension Service, Griffith)	157	81
Leeton Fruit Growers' Co-op. Society Ltd. (Soils and Irrigation Extension Service, Griffith)	257	81
Leeton Co-op. Canneries Ltd. (Soils and Irrigation Extension Service, Griffith)	944	485
Mildura Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	241	229
Irymple Packing Company (Dried Vine Fruits Investigations, Merbein)	241	229
Carried forward	63,176	43,684

* Includes £77 on account of 1943–44 expenditure.
† Includes £34 on account of 1943–44 expenditure.
‡ Includes £70 on account of 1943–44 expenditure.

	Receipts 1944–45 and balances brought forward from 1943–44.		Expenditure 1944–45.
	£		£
Brought forward	63,176	..	43,684
Red Cliffs Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	241	..	229
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	241	..	229
Dried Fruits Control Board (Dried Fruits Investigations)	1,000	..	830
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	168	..	..
Department of Supply and Shipping (Production of Pyrethrum)	598	..	545*
Australian Meat Board (Meat Investigations) ..	500	..	500†
Metropolitan Meat Industry Commissioner of New South Wales (Meat Investigations)	500	..	500
Queensland Meat Industry Board (Meat Investigations)	850	..	850
New South Wales Department of Agriculture (Food Investigations)	800	..	800
A. Lawrence & Co. (Division of Food Preservation and Transport)	135	..	61
W. Angliss Ltd. (Division of Food Preservation and Transport)	300	..	48
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)	167	..	79
Egg Producers' Council (Watery Whites in Eggs) ..	2	..	..
Department of Commerce and Agriculture (Division of Food Preservation and Transport—Dehydration Investigations)	2,764	..	2,764‡
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	..	1,000
Bureau of Forestry, Canberra, and Forest Services of Queensland, Victoria, New South Wales and Western Australia—Wood Structure (Forest Products Investigations)	50	..	..
Tar Distillers' Research Committee (Creosote Investigations)—Division of Forest Products	30	..	30§
Sundry Contributions (Forest Products Investigations)	3,394	..	1,715
Australasian Dairy Council (Wood Taint in Butter Investigations)	11	..	..
Department of Supply and Shipping—Flax Processing (Forest Products Investigations)	1,021	..	1,004
Carried forward	78,513	..	56,368

* Includes £92 on account of 1943–44 expenditure.
† Includes £125 on account of 1943–44 expenditure.
‡ Includes credit £58 on account of 1943–44 expenditure.
§ Includes £30 on account of 1943–44 expenditure.

	Receipts 1944–45 and balances brought forward from 1943–44.	Expenditure 1944–45.
	£	£
Brought forward	78,513	56,368
Brisbane Timber Merchants' Association (Division of Forest Products—Veneer and Gluing Work) ..	8	..
Australasian Institute of Mining and Metallurgy (Minera-graphic Investigations)	368	368
Postmaster-General's Department (Radio Research) ..	4,749	4,512
Departments of Army, Navy and Air (Radio Research)	6,000	6,000
Sundry Contributions (Foreign Journal Service) ..	835	835
New South Wales Government (Fisheries Investigations)	241	241*
National Gas Association (Gas Investigations—Industrial Chemistry)	58	..
Australian Cement Manufacturers (Cement Investigations—Industrial Chemistry and Standards) ..	1,650	1,500
Department of Commerce (Apple and Pear Investigations)	272	..
Ministry of Munitions	56,492	55,564†
Department of Navy	6,479	6,479
Army Inventions Directorate	239	239‡
Department of Army	2,515	2,515§
Sundry Contributors (Council for Scientific and Industrial Research—Publications)	23	..
Amalgamated Textiles (Aust.) Ltd. (Division of Industrial Chemistry)	35	..
Amalgamated Wireless (A'sia.) Ltd. (Division of Industrial Chemistry)	31	..
F. Walton & Co. (Division of Industrial Chemistry) ..	10	..
Pope Products (Division of Industrial Chemistry) ..	25	..
Associated Woollen and Worsted Textile Manufacturers of Australia (Division of Industrial Chemistry) ..	500	..
Wool Scourers, Carbonizers and Fellmongers Federation 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) ..	10	..
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Production Investigations) ..	231	..
Revenue Fund—Contagious Pleuro-pneumonia Investigations (Animal Health and Production Investigations)	230	126
Revenue Fund—Helenslee Field Station (Animal Health and Production Investigations)	451	..
Revenue Fund—Oestrus Experiment (Animal Health and Production Investigations)	403	18
Revenue Fund—Sale of Contagious Pleuro-pneumonia Vaccine (Animal Health and Production Investigations)	2,888	1,118
Revenue Fund—Sale of Strain 19 Vaccine (Animal Health and Production Investigations)	370	..
Revenue Fund—Anaplasmosis Investigations (Animal Health and Production Investigations)	60	..
Revenue Fund—Parkville Laboratory (Animal Health and Production Investigations)	666	..
Carried forward	165,707	136,583

* Includes £54 on account of 1943–44 expenditure.
† Includes £1,291 on account of 1943–44 expenditure.
‡ Includes £165 on account of 1943–44 expenditure.
§ Includes credit of £2,431 on account of 1943–44 expenditure.

	Receipts 1944–45 and balances brought forward from 1943–44.		Expenditur 1944–45.
	£		£
Brought forward	165,707	..	136,583
Revenue Fund—Werribee Farm Mastitis Investigations (Animal Health and Production Investigations) ..	1,048	..	*Cr.* 889*
Revenue Fund—Drought Feeding Investigations, Werribee (Animal Health and Production Investigations)	63	..	..
Revenue Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Production Investigations)	4,828	..	4,315
Reserve Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Production Investigations	1,132	..	..
Revenue Fund—Bacteriological Investigations (Animal Health and Production Investigations)	112	..	..
Revenue Fund—Parasitological Investigations (Animal Health and Production Investigations)	654	..	105
Revenue Fund—Infertility, F. D. McMaster Field Station (Animal Health and Production Investigations)	1,542	..	300
Revenue Fund—Toxaemic Jaundice Investigations, Barooga, New South Wales (Animal Health and Production Investigations)	472	..	472
Revenue Fund—Nutrition Laboratory (Biochemistry and General Nutrition Investigations)	716	..	156
Revenue Fund—Plant Industry Investigations ..	1,384	..	..
Revenue Fund—Entomological Investigations ..	689	..	..
Revenue Fund—Griffith Research Station (Citricultural Investigations)	5,482	..	1,683
Revenue Fund—Merbein Research Station (Viticultural Investigations)	8,575	..	2,056
Revenue Fund—Citrus Preservation Investigations ..	102	..	102
Revenue Fund—Division of Food Preservation and Transport	201	..	114
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	768	..	..
Revenue Fund—Fisheries Investigations	28	..	..
Revenue Fund—Oyster Investigations	216	..	..
Revenue Fund—Division of Aeronautics	65	..	..
Revenue Fund—National Standards Laboratory ..	400	..	..
Revenue Fund—Dairy Investigations	6	..	..
Revenue Fund—Industrial Chemistry	186	..	..
	194,522	..	144,997

3. *Staff.*—The following is a list of the staff of the Council as at 30th June, 1945. The list does not include clerical staff, typists, laboratory assistants and miscellaneous workers.

1. Head Office Staff.

(Head-quarters : 314 Albert-street, East Melbourne.)

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.
Assistant Executive Officer—F. W. G. White, M.Sc., Ph.D.
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.
Consultant—G. Lightfoot, M.A.

* Includes debit of £17 on account of 1943–44 expenditure.

Library—

Chief Librarian—Miss E. Archer, M.Sc.
Assistant Librarian—Miss A. L. Kent.
Assistant Librarian—Miss F. V. Murray, M.Sc.
Assistant Librarian—Miss J. Philip, B.Sc.

Scientific Liaison and Information Bureau—

Director—J. E. Cummins, B.Sc., M.S.

Information Section—

J. S. Hosking, M.Sc., Ph.D.
D. T. C. Gillespie, M.Sc.
N. H. Olver, M.Sc.
A. L. Gunn.
Miss M. E. Hamilton, B.Sc.
Miss F. Dumaresq, M.A., B.Sc. (part-time).

Scientific Liaison Bureau—

Melbourne—

F. A. Priest, A.S.A.S.M.
S. T. Evans, B.Sc.
Miss J. Baldwin, B.Sc., Dip.Ed.

Sydney—

A. R. Penfold (part-time).
R. O. Chalmers, A.S.T.C.
A. M. Andrews, B.Sc.

New Guinea—

M. R. Alexander, B.Sc. (Hons.).
B. McKervey, B.Sc.
C. Kerr Grant, B.A., B.Sc.

Honorary Liaison Officers—

Adelaide—I. W. McDonald, B.Sc., B.V.Sc.
Brisbane—Professor T. G. H. Jones, D.Sc.
Hobart—J. Pearson, D.Sc.
Newcastle—R. Basden.
Perth—G. L. Sutton, D.Sc.Agr.

Accounts, Stores—

Accountant—D. J. Bryant, A.F.I.A.

Orders and Transport—

J. M. Derum.

Staff—

Staff and Industrial Officer—H. E. Waterman, A.F.I.A.
R. D. Elder.

Records—

P. Domec-Carre.
Head Typist—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.

Liaison Overseas—

London—

G. B. Gresford, B.Sc.
W. J. Ellis, A.S.T.C.
J. Warner, B.Sc.

Washington—

G. H. Munro, M.Sc.
N. A. Whiffen, F.S.T.C.
M. Beard, B.E., B.Sc.
M. F. Day, B.Sc., Ph.D.

Head Office—

Miss J. Dunstone, B.Sc., Dip.Ed.

2. Secretaries of State Committees.

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

Victoria—
F. G. Nicholls, M.Sc., 314 Albert-street, East Melbourne.

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

South Australia—
J. Ward Walters, Division of Biochemistry and General Nutrition, University of Adelaide.

Western Australia—
R. P. Roberts, M.Sc. (Agric.), Institute of Agriculture, University of Western Australia, Nedlands, Western Australia.

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

3. Australia House, London.

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

4. Division of Plant Industry.

(Head-quarters : Canberra, Australian Capital Territory.)

At Canberra—

Administration—
Chief—B. T. Dickson, B.A., Ph.D.
Librarian (half-time)—Miss A. Nicholson.
Senior Clerical Officer (half-time)—D. Banyard (acting).

Pathology—
Principal Research Officer—H. R. Angell, O.B.E., Ph.D.
Senior Research Officer—J. G. Bald, M.Agr.Sc., Ph.D.
Senior Research Officer—W. V. Ludbrook, B.Ag.Sc., Ph.D., (on service leave—Royal Australian Air Force).
Assistant Research Officer—D. O. Norris, M.Sc.(Agric.).
Assistant Research Officer—Miss M. Mills, B.Sc.
Chemist—Mrs. H. T. Conway.

Plant Improvement—
Principal Research Officer—J. R. A. McMillan, D.Sc.Agr., M.S. (seconded).
Assistant Research Officer—F. W. Hely, B.Sc.Agr. (seconded).

Plant Introduction—
Research Officer—W. Hartley, B.A., Dip.Ed.
Assistant Research Officer—S. G. Gray, B.Sc.Agr.

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

Vegetable Fibre Investigations—
Senior Research Officer—A. V. Hill, M.Agr.Sc.
Research Officer—J. Calvert, D.Sc. (on service leave—Royal Australian Air Force).

Agrostology—
Principal Research Officer—J. G. Davies, B.Sc., Ph.D.
Senior Research Officer—C. S. Christian, M.Sc.
Research Officer—C. M. Donald, M.Ag.Sc.
Assistant Research Officer—R. M. Moore, B.Sc.Agr. (on service leave—Royal Australian Air Force).
Assistant Research Officer—T. Wilkinson, B.Sc. (on service leave—Australian Imperial Force).
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.

Weeds Investigations—
Principal Research Officer—J. G. Davies, B.Sc., Ph.D.
Senior Research Officer—A. B. Cashmore, M.Sc.
Research Officer—C. G. Greenham, M.Sc. (seconded).

---

* A. M. Andrews, B.Sc., Phillip House, 119 Phillip-street, Sydney (Box 4061, G.P.O., Sydney), as from 17th April, 1946.

Tobacco Investigations—
Senior Research Officer—A. V. Hill, M.Agr.Sc.
Assistant Research Officer—K. F. Plomley, B.Sc.Agr. (on service leave—Royal Australian Naval Voluntary Reserve).
Drug Plant Investigations—
Principal 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 (T. Kok-saghyz)—J. G. Davies, B.Sc., Ph.D.
Research Officer (guayule)—W. Hartley, B.A., Dip.Ed.
Technical Officer (T. Kok-saghyz)—C. W. E. Moore, B.Agr.Sc.
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.
Assistant Research Officer (vegetable investigations)—D. C. Wark.

At Queensland Agricultural High School and College, Lawes—
Research Officer (agrostology)—T. B. Paltridge, B.Sc.
Assistant Research Officer (agrostology)—R. Roe, B.Sc. (Agric.).
Assistant Research Officer (agrostology)—N. H. Shaw, B.Agr.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 "Gilruth Plains", Cunnamulla, Queensland—
Technical Officer—G. H. Allen, G.D.A.

At Deniliquin, New South Wales—
Research Officer—R. W. Prunster, B.Sc. (Agric.).

At Muresk, Western Australia—
Assistant Research Officer (plant introduction)—E. T. Bailey, B.Sc.

At Huonville, Tasmania—
Research Officer (fruit investigations)—D. Martin, B.Sc.

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

5. Division of Economic Entomology.

(Head-quarters : Canberra, Australian Capital Territory.)

At Canberra—
Administration—
Chief—A. J. Nicholson, D.Sc.
Librarian (half-time)—Miss A. Nicholson.
Senior Clerical Officer (half-time)—D. Banyard (acting).
Wheat Pest and Termite Investigations—
Principal Research Officer—F. N. Ratcliffe, B.A. (on service leave—Australian Imperial Force).
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—Australian Imperial Force).
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—Royal Australian Air Force).
Assistant Research Officer—R. W. Kerr, B.Sc.
Biological Control Investigations—
Research Officer—T. G. Campbell.

Toxicology Investigations—
Assistant Research Officer—R. H. Hackman, M.Sc. (seconded from Division of Industrial Chemistry).
Assistant Research Officer—R. F. Powning, A.S.T.C.
Vegetable Pests Investigations—
Research Officer—G. A. H. Helson, M.Sc.
Assistant Research Officer—T. Greaves.
Technical Officer—N. Grylls, Dip.Agr.
Locust Investigations—
Senior Research Officer—K. H. L. Key, M.Sc., Ph.D., D.I.C.
Assistant Research Officer—L. R. Clark, M.Sc.

At Trangie, New South Wales—
Technical Officer (locust investigations)—L. J. Chinnick, Dip.Agr.
Technical Officer (locust investigations)—D. L. Hall, Dip.Agr. (on service leave—Royal Australian Air Force).

At Melbourne, Victoria—
Research Officer (wheat investigations)—F. Wilson.

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)—A. T. Mills.
Technical Officer (buffalo-fly investigations)—R. A. J. Meyers, Q.D.A.H., Q.D.D.

6. Division of Animal Health and Production.

(Head-quarters : Cnr. Flemington-road and Park-street, Parkville, Melbourne.)

At Animal Health Research Laboratory and Divisional Head-quarters, 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.
Principal Research Officer (bacteriology)—T. S. Gregory, B.V.Sc. (on service leave—Australian Imperial Force).
Senior Research Officer (pathology, bacteriology, dairy cattle)—D. Murnane, B.V.Sc.
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 (chemical pathology and bacteriology)—A. T. Dick, M.Sc.
Assistant Research Officer (bacteriology, anaerobic infections)—A. W. Rodwell, M.Sc.
Assistant Research Officer (chemical pathology and analytical chemistry)—J. B. Bingley, D.A.C.
Assistant Research Officer—Miss C. E. Eales, B.Sc.
Assistant Research Officer—Miss M. J. Monsbourgh, B.Sc.
Assistant Research Officer—H. G. Turner, B.Agr.Sc.
Technical Officer—E. Wold.
Technical Officer—A. E. Wright.
Technical Officer—J. J. Spencer (on service leave—Australian Imperial Force).
Technical Officer (animal husbandry)—L. C. Gamble.
Librarian—Miss F. V. Murray, M.Sc. (part-time).

At F. D. McMaster Animal Health Laboratory, Sydney—
Officer-in-Charge—D. A. Gill, M.R.C.V.S., D.V.S.M.
Senior Reseach Officer (parasitology)—H. McL. Gordon, B.V.Sc.
Senior Research Officer (biochemistry)—M. C. Franklin, M.Sc., Ph.D.
Senior Research Officer (field investigations, ectoparasites)—N. P. H. Graham, B.V.Sc.
Senior Research Officer (chemistry of wool)—M. R. Freney, B.Sc. (seconded).
Senior Research Officer (wool biology)—H. B. Carter, B.V.Sc.
Research Officer (parasitology, field studies)—I. W. Montgomery, B.V.Sc. (on service leave).

Research Officer (field studies, blowfly strike)—I. L. Johnstone, B.V.Sc.
Research Officer (biochemistry)—C. R. Austin, M.Sc., B.V.Sc.
Assistant Research Officer (parasitology, field studies)—J. F. Barrett, B.V.Sc.
Assistant Research Officer (biochemistry)—R. L. Reid, B.Sc.Agr.
Assistant Research Officer (ectoparasites)—Miss T. M. Scott, B.Sc.
Assistant Research Officer (parasitology)—Miss P. M. Sambell, B.A.
Assistant Research Officer (wool biology)—Miss M. H. Hardy, M.Sc.
Technical Officer—E. A. Parrish.
Technical Officer—J. L. Hill, A.S.T.C.
Technical Officer—H. A. Offord (on service leave).
Technical Officer—F. J. Hamilton.
Technical Officer—H. V. Whitlock.
Librarian—Mrs. R. McGill, B.A.

At F. D. McMaster Field Station, Badgery's Creek, New South Wales—
Principal Research Officer and Officer-in-Charge (animal genetics)—R. B. Kelley, D.V.Sc.
Assistant Research Officer—J. A. Robotham.
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. Division of Biochemistry and General Nutrition.

(Head-quarters : At University of Adelaide.)

Chief—H. R. Marston.
Divisional Secretary—J. Ward Walters.
Senior Research Officer—E. W. Lines, B.Sc. (on service leave).
Senior Research Officer—J. W. H. Lugg, Ph.D., D.Sc., F.R.I.C.
Senior Research Officer—A. W. Peirce, M.Sc.
Senior Research Officer—H. J. Lee, B.Sc.
Senior Research Officer—D. S. Riceman, B.Agr.Sc.
Research Officer—F. V. Gray, B.Sc.
Research Officer—R. H. Watson, D.Sc., B.Sc.Agr. (seconded).
Assistant Research Officer—I. G. Jarrett, B.Sc.
Assistant Research Officer—T. A. Quinlan-Watson, B.Sc.
Assistant Research Officer—Miss S. H. Allen, B.Sc.
Assistant Research Officer—Miss P. Macbeth, B.Sc.
Assistant Research Officer—A. Pilgrim, B.Sc. (on service leave).
Technical Officer—D. W. Dewey.
Technical Officer—G. W. Bussell.
Technical Officer—C. E. Sleigh.
Technical Officer—R. F. Trowbridge.
Technical Officer—D. Graham.
Technical Officer—V. A. Stephen.
Technical Officer—J. O. Wilson.
Assistant Librarian—Miss I. Sanders, B.A.

8. 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.).

9. Division of Soils.

(Head-quarters : At Waite Agricultural Research Institute, Adelaide.)

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.
Research Officer—R. Smith, B.Sc. (Agric.).
Assistant Research Officer—J. G. Baldwin, B.Agr.Sc., B.Sc. (on service leave—Australian Imperial Force).
Assistant Research Officer—R. Brewer, B.Sc.
Assistant Research Officer—B. E. Butler, B.Sc. (Agric.).
Assistant Research Officer—E. J. Johnston, B.Sc.Agr. (on service leave—Royal Australian Air Force).
Assistant Research Officer—T. Langford Smith, M.Sc. (seconded).
Assistant Research Officer—K. H. Northcote, B.Ag.Sc.
Assistant Research Officer—J. H. Shepherd, B.Sc.
Assistant Research Officer—G. A. Stewart, B.Ag.Sc.
Assistant Research Officer—K. D. Nicholls, B.Sc., B.Ag.Sc.
Technical Officer (cartography)—P. D. Hooper.
Technical Officer—E. A. N. Greenwood, D.D.A.
Technical Officer—L. W. Pym, R.D.A.

Soil Physics Section—
Senior Research Officer—T. J. Marshall, M.Ag.Sc., Ph.D.
Assistant Research Officer—G. D. Aitchison, B.E.
Assistant Research Officer—G. B. Clarke, B.Sc.
Technical Officer—C. G. Gurr.

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, B.Sc.
Assistant Research Officer—H. C. T. Stace, B.Sc.
Assistant Research Officer—B. M. Tucker, B.Sc.
Assistant Research Officer—Miss B. E. Welbourn, B.Sc.

Soil Microbiology—
Assistant Research Officer—T. H. Strong, M.Agr.Sc. (on service leave—Royal Australian Air Force).

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.

10. Irrigation Settlement Problems.

At Irrigation Research Station, Griffith—
Officer-in-Charge—E. S. West, B.Sc., M.S.
Chemist—N. G. Cassidy, M.Sc.
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.
Horticulturist—R. Jardine, B.Agr.Sc.
Orchard Superintendent—B. H. Martin, H.D.A.
Technical Officer—T. J. Masters.
Secretary, Soils and Irrigation Extension Service—Miss E. M. Eagle, B.Agr.Sc.

At Commonwealth Research Station, Merbein—
Officer-in-Charge—A. V. Lyon, M.Agr.Sc.
Senior Research Officer (chemist)—E. C. Orton, B.Sc.
Research Officer—D. V. Walters, M.Agr.Sc. (seconded).
Research Officer—A. L. Tisdall, M.Agr.Sc. (on service leave—Royal Australian Air Force).
Assistant Research Officer—P. Dixon, M.Sc. (seconded).
Assistant Research Officer—W. J. Webster, B.Sc.
Assistant Research Officer—G. B. Stirk, B.Sc.

Technical Officer—J. E. Giles.
Research Officer—R. C. Polkinghorne (part-time).
Research Officer—H. Jackson (part-time).

11. Division of Forest Products.
(Head-quarters : 69 Yarra Bank-road, South Melbourne.)

Administration—
Chief—S. A. Clarke, B.E.
Assistant to Chief—C. S. Elliot, B.Sc.
Librarian—Miss M. I. Hulme.

Wood Structure Section—
Principal Research Officer-in-Charge—H. E. Dadswell, D.Sc.
Assistant Research Officer—H. D. Ingle, B.For.Sc.
Assistant Research Officer—Miss A. M. Eckersley, M.Sc.
Assistant Research Officer—G. W. Tack, B.Agr.Sc.
Technical Officer—Miss F. V. Griffin.
Technical Officer—Miss M. Clemenger, B.Sc.

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

Wood Chemistry Section—
Principal Research Officer-in-Charge—W. E. Cohen, D.Sc.
Research Officer—Miss T. M. Reynolds, M.Sc., D.Phil. (seconded).
Research Officer—D. E. Bland, M.Sc. (seconded).
Assistant Research Officer—A. J. Watson, A.M.T.C.
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.

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—K. L. Cooper, M.A., B.Sc.
Research Officer—R. S. T. Kingston, B.E., B.Sc.
Research Officer—C. E. Dixon, M.Sc.
Assistant Research Officer—N. H. Kloot, B.Sc.
Technical Officer—J. J. Mack.

Timber Seasoning Section—
Research Officer-in-Charge—G. W. Wright, B.E.
Assistant Research Officer—A. C. Pond, B.E. (on service leave—Royal Australian Air Force).
Assistant Research Officer—J. W. Gottstein, B.Sc.
Assistant Research Officer—I. J. W. Bisset, B.Sc.
Technical Officer—J. T. Currie.
Technical Officer—H. D. Roberts.

Preservation Section—
Principal Research Officer-in-Charge (acting)—C. S. Elliot, B.Sc.
Assistant Research Officer—N. Tamblyn, M.Sc. (Agric.).
Assistant Research Officer—H. B. Wilson, B.Sc.
Assistant Research Officer—G. Christensen, B.Sc.
Technical Officer—A. Rosel.

Veneering and Gluing Section—
Senior Research Officer-in-Charge—S. F. Rust, B.Sc., M.S.
Assistant Research Officer—A. W. Rudkin, B.Sc.
Technical Officer—R. C. Deeble.
Technical Officer—G. T. O'Loughlin.

Timber Utilization Section—
Senior Research Officer-in-Charge—R. F. Turnbull, B.E. (seconded).
Senior Research Officer—A. J. Thomas, Dip.For. (seconded).
Acting Research Officer-in-Charge—A. Gordon, B.Sc.
Technical Officer—G. Barrow.

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.

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

12. Division of Food Preservation and Transport.

(Head-quarters: At State Abattoir, Homebush Bay; Postal Address: Private Bag, Homebush Post Office.)

Administrative and General—
Chief—J. R. Vickery, M.Sc., Ph.D.
Librarian—Miss B. Johnston, B.Sc.
Maintenance Engineer—B. Goodhew.

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

Microbiology Section—
Senior Research Officer—W. J. Scott, B.Agr.Sc.
Senior Bacteriologist—D. F. Stewart, B.V.Sc., Dip.Bact. (seconded from New South Wales Department of Agriculture).
Assistant Research Officer—A. M. Olsen, B.Sc.
Assistant Research Officer—M. R. J. Salton, B.Sc.Agr.
Technical Officer—P. R. Maguire.
Technical Officer—D. F. Ohye.

General Chemistry Group—
Research Officer—F. E. Huelin, B.Sc., Ph.D.
Assistant Research Officer—H. A. McKenzie, B.Sc.
Assistant Research Officer—Mrs. I. M. Stephens, B.Agr.Sc.

Fruit Storage Section—
Senior Research Officer—S. A. Trout, M.Sc., Ph.D.
Assistant Research Officer—J. F. Turner, B.Sc.

Canning and Fruit Products Section—
Senior Research Officer—L. J. Lynch, B.Agr.Sc.
Senior Research Officer—W. A. Empey, B.V.Sc.
Research Officer—J. F. Kefford, M.Sc.
Assistant Research Officer—R. S. Mitchell, M.Sc.Agr.
Assistant Research Officer—V. C. Lewis, B.Sc.Agr.

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.
Assistant Research Officer—H. S. McKee, B.A., D.Phil.
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.
Assistant Research Officer—H. G. Golding, B.Sc.
Assistant Research Officer—Miss A. White, B.Sc.
Technical Officer—A. Bonnet.

At Brisbane Abattoir—
Research Officer—A. R. Riddle, A.B., M.S.
Assistant Research Officer—Miss D. M. Haenke, B.Sc.

At Fisheries Research Laboratory, Cronulla—
Assistant Research Officer—C. G. Setter, B.Sc. (seconded).

At Australia House, London—
Senior Research Officer—N. E. Holmes, B.E.E., M.Mech.E.

13. Division of Fisheries.

(Head-quarters : Cronulla, New South Wales.)

At Head-quarters—

Chief—H. Thompson, M.A., D.Sc.
Research Officer (bacteriologist)—E. J. Ferguson Wood, M.Sc., B.A.
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)—J. M. Thomson, M.Sc.
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.

14. Australian National Standards Laboratory.*

Clerical—

Senior Clerical Officer—R. F. Williams.

Drawing Office—

Chief Draughtsman—C. Williamson.

Library—

Librarian—Miss M. Barnard, B.A.
Assistant Librarian—Miss B. Mortlock, B.A.
Assistant Librarian—Miss M. McKechnie.
Assistant Librarian—Miss E. Andrews, B.A.

Workshop—

Foreman-Supervisor—J. Hanna.

15. Division of Metrology.

(Head-quarters : National Standards Laboratory at University of Sydney.)

Chief—N. A. Esserman, B.Sc.
Research Officer—P. M. Gilet, B.Sc., B.E.
Research Officer—C. G. Greenham, M.Sc.
Research Officer—H. H. Davis, B.Sc., B.E., Ph.D. (Cantab.).
Research Officer—G. A. Bell, B.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—C. F. Bruce, M.Sc.
Assistant Research Officer—W. A. F. Cunninghame, B.E.
Assistant Research Officer—Miss I. E, 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—A. V. Dicker, B.E.

* The services shown hereunder are common to the Divisions of Metrology, Electrotechnology and Physics, housed in the Laboratory.

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.
Assistant Research Officer—Miss M. M. Douglas, B.Sc.
Assistant Research Officer—P. V. Moran, B.E.
Testing Engineer, Grade II.—R. A. Holloway, B.Sc., B.E. (on loan from New South Wales Railways).
Assistant, Clerical—Miss P. L. Vider, B.Ec.

16. Division of Electrotechnology.

(Head-quarters: National Standards Laboratory at University of Sydney.)

Chief—D. M. Myers, B.Sc., D.Sc.Eng.
Research Officer—W. K. Clothier, B.Sc., M.E.
Research Officer—L. G. Dobbie, M.E. (seconded from Division of Radiophysics).
Research Officer—R. J. Meakins, B.Sc., Ph.D., D.I.C. (seconded from Division of Industrial Chemistry).
Research Officer—A. M. Thompson, B.Sc.
Assistant Research Officer—B. V. Hamon, B.Sc., B.E.
Assistant Research Officer—P. A. Champion, B.E.
Assistant Research Officer—D. J. Cole, B.E.E.
Assistant Research Officer—F. A. Edwards, B.E.
Assistant Research Officer—G. J. A. Cassidy, B.E.E.
Assistant Research Officer—H. W. Stokes, B.Ec.
Assistant Research Officer—P. T. Wilson, B.E.
Assistant Research Officer—J. S. Dryden, M.Sc.
Assistant Research Officer—N. A. Gibson, M.Sc. (seconded from Division of Industrial Chemistry).
Assistant Research Officer—R. C. Richardson, B.E.
Draughtsman—L. Nade, B.Sc.
Technical Officer—R. W. Archer.
Technical Officer—F. C. Brown.
Technical Officer—Miss H. Taylor, B.A., Dip.Ed.

17. Division of Physics.

(Head-quarters: National Standards Laboratory at University of Sydney.)

Administration—
Chief—G. H. Briggs, D.Sc., Ph.D.
Technical Secretary—D. S. Woodward.

Heat—
Research Officer—A. F. A. Harper, M.Sc.
Assistant Research Officer—W. R. G. Kemp, B.Sc.
Assistant Research Officer—R. G. Wylie, B.Sc.
Assistant Research Officer—W. A. Caw, B.Sc.
Assistant Research Officer—Miss R. Scott, B.Sc.
Technical Officer—E. S. Denny.
Technical Officer—A. Romer.

Light—
Research Officer—R. G. Giovanelli, M.Sc.
Assistant Research Officer—H. F. Pollard, B.Sc.
Assistant Research Officer—J. W. Pearce, B.Sc.
Assistant Research Officer—W. H. Steel, B.Sc.
Assistant Research Officer—W. I. B. Smith, B.Sc.
Technical Officer—V. R. Schaefer.

Electrical Standards—
Assistant Research Officer—N. A. Faull, B.Sc.

Wool Research—
Assistant Research Officer—E. H. Mercer, B.Sc.
Assistant Research Officer—Mrs. K. R. Makinson, B.Sc.

Technical Services—
Technical Officer—J. E. Thompson.
Technical Officer—R. Sweet.

18. Division of Aeronautics.

(Head-quarters : Lorimer-street, Fishermen's Bend, Melbourne.)

Administrative—

Chief—L. P. Coombes, D.F.C., B.Sc.(Eng.).
Secretary—F. M. McDonough, B.C.E.

Structures and Materials Section—

Principal Research Officer—H. A. Wills, B.E.
Senior Research Officer—E. R. Love, B.A. (Camb.), B.A., Ph.D. (on loan from University of Melbourne, part-time).
Research Officer—F. S. Shaw, B.E.
Research Officer—J. R. Green, D.Phil., B.E.
Research Officer—A. D. Rutherford, 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.
Assistant Research Officer—N. B. Joyce, B.E.
Assistant Research Officer—R. W. Traill-Nash, B.E.
Assistant Research Officer—M. S. Patterson, B.Sc.Eng.
Assistant Research Officer—Miss D. A. Lemaire, B.Mech.E.
Assistant Research Officer—J. P. O. Silberstein, B.A.
Technical Officer—F. A. Dale.
Technical Officer—N. A. Pickering.
Technical Officer—J. H. Straw.

Metallurgy Sub-section—

Officer-in-Charge (on loan from North American Cyanamid Co.)—G. B. O'Malley, B.Met.E. (part-time).
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.
Assistant Research Officer—N. McKinnon, M.Sc.
Assistant Research Officer—H. T. Greenaway, B.Met.E.
Technical Officer—F. G. Lewis, B.Sc.
Technical Officer—L. M. Bland.

Aerodynamics Section—

Principal Research Officer—G. N. Patterson, B.Sc., M.A., Ph.D.
Research Officer—T. F. C. Lawrence, B.Sc., B.E.
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.
Assistant Research Officer—F. G. Blight, B.Sc., B.E.
Assistant Research Officer—Mrs. R. W. Cumming, M.A.
Assistant Research Officer—A. F. Pillow, B.A.
Assistant Research Officer—R. H. Adair, B.E.
Assistant Research Officer—D. C. Collis, B.Sc.
Assistant Research Officer—J. M. Evans, B.E.*
Assistant Research Officer—E. R. Johnson, M.Sc.
Assistant Research Officer—A. N. McCleave, 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.*
Technical Officer—H. F. J. Gerrand.
Technical Officer—R. A. Wallis.

Engines and Fuels Section—

Principal Research Officer—M. W. Woods, D.Phil., B.Sc., B.E.
Research Officer—T. S. Keeble, B.E., B.Sc.

* Working at Sydney University.

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.
Assistant Research Officer—R. L. Brooks, B.Sc.Eng.
Technical Officer—D. Pescod.

Instruments Section—
Research Officer—A. A. Townsend, M.Sc.
Assistant Research Officer—W. S. Cugley, B.Sc.

Workshops—
Workshops Supervisor—D. W. Eaton.

Drawing Office—
Sectional Draughtsman—J. M. Morgan.

Photography—
Technical Officer—Miss E. F. Lightfoot.

Library—
Librarian—Miss H. P. Meggs (part-time).

19. Division of Industrial Chemistry.

(Head-quarters : Lorimer-street, Fishermen's Bend, Melbourne.)

Administrative—
Chief—I. W. Wark, Ph.D., D.Sc.
Divisional Secretary—L. Lewis, B.Met.E.
Assistant Secretary—A. E. Scott, M.Sc.

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).

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—R. C. Croft, B.Sc.
Assistant Research Officer—P. Dixon, M.Sc. (seconded from Commonwealth Research Station, Merbein).
Assistant Research Officer—G. B. Gresford, B.Sc. (seconded).
Assistant Research Officer—F. R. Hartley, M.Sc. (on service leave—Royal Australian Air Force).
Assistant Research Officer—I. C. Kraitzer.
Assistant Research Officer—F. K. McTaggart, M.Sc.
Assistant Research Officer—E. S. Pilkington, A.S.T.C.
Assistant Research Officer—T. R. Scott, M.Sc., B.Ed.
Assistant Research Officer—A. D. Wadsley, M.Sc.
Technical Officer—V. A. C. Bertrand.
Technical Officer—H. R. Skewes.

Cement Section—
Senior Research Officer—A. R. Alderman, Ph.D., D.Sc.
Assistant Research Officer—R. H. Jones, B.Sc.
Assistant Research Officer—H. E. Vivian, B.Sc.Agr.
Technical Officer—H. T. Philippe.

Biochemistry Section—
Senior Research Officer—F. G. Lennox, D.Sc.
Assistant Research Officer—W. G. Crewther, M.Sc.
Assistant Research Officer—W. J. Ellis, A.S.T.C. (seconded).
Assistant Research Officer—J. M. Gillespie, M.Sc., A.M.T.C.
Assistant Research Officer—Miss A. M. McArthur, M.Sc.
Assistant Research Officer—Miss M. E. Maxwell, M.Sc.

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—Miss R. I. Shoebridge, B.Sc.
Technical Officer—K. R. Hanna, F.M.T.C.
Junior Research Officer—D. A. Cunningham.

Physical Chemistry Section—

Research Officer—K. L. Sutherland, M.Sc.
Assistant Research Officer—Miss E. C. Plante, B.Sc.
Assistant Research Officer—J. Rogers, M.Sc.
Technical Officer—H. F. A. Hergt, A.M.T.C.
Technical Officer—J. A. Corbett.

Chemical Physics Section—

Senior Research Officer—A. L. G. Rees, M.Sc., Ph.D., D.I.C.
Assistant Research Officer—J. Cowley, B.Sc.(Hons.).

Foundry Sands Section—

Assistant Research Officer—H. A. Stephens, B.Sc.(Hons.).
Technical Officer—G. V. Cullen.
Technical Officer—J. E. Marshall, F.M.T.C.

Organic Section—

Principal Research Officer—H. H. Hatt, B.Sc., Ph.D.
Research Officer—J. S. Fitzgerald, M.Sc., Ph.D.
Research Officer—M. E. Winfield, M.Sc., Ph.D.
Assistant Research Officer—D. J. Clark, M.Sc.
Assistant Research Officer—R. G. Curtis, M.Sc.
Assistant Research Officer—L. K. Dalton, D.S.T.C.
Assistant Research Officer—A. G. Dobson, M.Sc.
Assistant Research Officer—N. C. Hancox, M.Sc.
Assistant Research Officer—R. J. L. Martin, M.Sc.
Assistant Research Officer—K. E. Murray, B.Sc.(Hons.).
Technical Officer—R. B. Bradbury, Dip.App.Chem.
Technical Officer—W. E. Hillis, A.G.Inst.Tech.
Technical Officer—W. J. Troyahn, A.M.T.C.

Chemical Engineering Section—

Principal Research Officer—E. J. Drake (seconded).
Research Officer—D. R. Zeidler, M.Sc.
Assistant Research Officer—I. Brown, B.Sc.(Hons.).
Assistant Research Officer—J. F. Pearse, B.Sc.(Hons.).
Assistant Research Officer—R. W. Urie, B.Sc.
Assistant Research Officer—E. H. Waters, M.Sc. (seconded).
Assistant Research Officer—B. W. Wilson, M.Sc.
Technical Officer—J. L. Clay, A.M.T.C.
Technical Officer—J. Coutts, A.M.T.C.

Workshops—

Foreman—E. C. Addison.

At University of Western Australia—Alunite Investigations—

Assistant Research Officer—W. E. Ewers, M.Sc.
Assistant Research Officer—F. C. Johnson, B.Sc.
Assistant Research Officer—G. H. Payne, M.Sc. (on service leave—Royal Australian Air Force).

At Division of Electrotechnology, Sydney—

Research Officer—R. J. Meakins, B.Sc., Ph.D.
Assistant Research Officer—N. A. Gibson, M.Sc.

At Division of Economic Entomology, Canberra—

Assistant Research Officer—R. H. Hackman, B.Sc.(Hons.).

Library—

Miss H. P. Meggs (part-time).

20. Division of Radiophysics.

(Head-quarters : At University of Sydney.)

Chief—J. N. Briton, B.Sc., B.E.
Deputy Chief—E. G. Bowen, O.B.E., M.Sc., Ph.D.
Principal Research Officer—D. F. Martyn, D.Sc., Ph.D. (seconded).
Principal Research Officer—O. O. Pulley, B.Sc., B.E., Ph.D.
Principal Research Officer—J. L. Pawsey, M.Sc., Ph.D.
Principal Research Officer—J. H. Piddington, M.Sc., B.E., Ph.D.
Principal Research Officer—T. B. Alexander, B.Sc., B.E.
Senior Research Officer—A. J. Higgs, B.Sc.
Senior Research Officer—V. D. Burgmann, B.Sc., B.E.
Research Officer—W. L. Price, B.Sc., B.E.
Research Officer—L. L. McCready, B.Sc., B.E.
Research Officer—M. I. G. Iliffe, B.Sc.
Research Officer—F. J. Kerr, M.Sc.
Research Officer—H. C. Minnett, B.Sc., B.E.
Research Officer—L. U. Hibbard, B.Sc., B.E.
Research Officer—M. Beard, B.Sc., B.E.
Research Officer—J. Warner, B.Sc., B.E.
Research Officer—B. F. Cooper, B.Sc., B.E.
Assistant Research Officer—J. Knight, B.Sc., B.E.
Assistant Research Officer—J. P. Eagles.
Assistant Research Officer—D. F. King.
Assistant Research Officer—G. J. Parker, B.Sc., B.E.
Assistant Research Officer—G. P. Brown, B.Sc.
Assistant Research Officer—J. H. Gerrand, B.Sc., B.E.
Assistant Research Officer—A. A. Taylor, B.Sc., B.E.
Assistant Research Officer—J. W. Reed.
Assistant Research Officer—G. C. Dewsnap, B.E.E.
Assistant Research Officer—R. F. Treharne, B.Sc., B.E.
Assistant Research Officer—O. L. Wirsu, B.Sc., B.E.
Assistant Research Officer—E. McCarthy, B.Sc., Dip.Ed.
Assistant Research Officer—J. A. Fry, B.Sc., B.E.
Assistant Research Officer—E. B. Mulholland, B.Sc., B.E.
Assistant Research Officer—H. N. Edwards, B.Sc., B.E.
Assistant Research Officer—R. A. Smith, B.Sc.
Assistant Research Officer—I. A. Evans, B.Sc.
Assistant Research Officer—B. Y. Mills, B.Sc., B.E.
Assistant Research Officer—R. N. Bracewell, B.Sc., B.E.
Assistant Research Officer—J. S. Gooden, B.Sc.
Assistant Research Officer—R. K. Oliver, B.E.
Assistant Research Officer—G. I. Lister, B.Sc., B.E.
Assistant Research Officer—R. P. Coulson, B.Sc., B.E.
Assistant Research Officer—J. P. Ryan, B.A.
Assistant Research Officer—E. K. Inall, B.Sc., B.E.
Assistant Research Officer—C. A. Shain, B.Sc.
Assistant Research Officer—H. L. Humphries, B.Sc., B.E.
Assistant Research Officer—D. E. Yabsley, B.Sc., B.E.
Assistant Research Officer—T. R. Kaiser, B.Sc.
Assistant Research Officer—J. K. Strachan, B.A., B.Sc.
Assistant Research Officer—N. A. Munro, B.Sc.
Assistant Research Officer—D. F. Urquhart, B.Sc.
Assistant Research Officer—D. B. Fraser, B.Sc.(Eng.).
Assistant Research Officer—G. Gibson, B.Sc.
Assistant Research Officer—Miss R. Payne-Scott, M.Sc.
Assistant Research Officer—Miss J. M. Freeman, M.Sc.
Assistant Research Officer—Miss L. F. Plunkett, B.Sc., Dip.Ed.
Assistant Research Officer—Miss B. Lippmann, B.Sc.
Technical Officer—K. A. Page.
Technical Officer—T. D. Newnham.
Technical Officer—H. A. Marshall.
Technical Officer—J. G. Duthoit.
Technical Officer—O. C. Turner.

Technical Officer—R. C. Baker.
Technical Officer—A. K. Falson.
Technical Officer—G. A. Wells.
Technical Officer—P. T. Hedges.
Technical Officer—E. W. Murray.
Technical Officer—D. C. Dunn.
Technical Officer—J. V. Hindman.
Technical Officer—F. G. Geddes.
Technical Officer—C. S. Higgins.
Technical Officer—K. R. McAlister.
Technical Officer—F. C. James.
Chief Draughtsman—F. M. Carter.
Mechanical Engineering Designer—P. G. Need.
Workshop Foreman—H. Byers.

21. Lubricants and Bearings Section.

(Head-quarters : At University of Melbourne.)

Acting Officer-in-Charge—D. Tabor, Ph.D. (Cantab.).
Research Officer (physics)—J. S. Courtney-Pratt, B.E.
Assistant Research Officer (chemistry)—E. R. Ballantyne, B.Sc.
Assistant Research Officer (chemistry)—E. B. Greenhill, M.Sc.
Assistant Research Officer (chemistry)—J. N. Gregory, M.Sc.
Assistant Research Officer (chemistry)—M. F. R. Mulcahy, M.Sc., A.G. Inst. Tech.
Assistant Research Officer (chemistry)—J. R. Richards, M.Sc.
Assistant Research Officer (chemistry)—M. A. Stone, D.A.C.
Assistant Research Officer (chemistry)—R. G. Vines, M.Sc.
Assistant Research Officer (chemistry)—A. Yoffe, M.Sc.
Assistant Research Officer (engineering)—T. V. Krok, B.E.
Assistant Research Officer (engineering)—G. K. Tudor, B.E.
Assistant Research Officer (electrical engineering)—A. E. Ferguson, B.E.E.
Assistant Research Officer (electrical engineering)—R. W. R. Muncey, B.E.E.
Assistant Research Officer (metallurgy)—M. E. Hargreaves, B.Met.E.
Assistant Research Officer (metallurgy)—R. W. K. Honeycombe, M.Sc.
Assistant Research Officer (metallurgy)—A. J. W. Moore, B.Sc.
Assistant Research Officer (physics)—L. W. Williams, B.Sc.
Technical Officer—T. S. Holden.
Physical Metallurgist—W. Boas, D.Eng.(Berlin), M.Sc. (part-time).

22. Building Materials Research.

(Head-quarters : At Division of Forest Products Laboratory.)

Officer-in-Charge—I. Langlands, B.E.E., M.Mech.E.
Research Officer—W. H. Taylor, M.C.E.
Research Officer—J. R. Barned, B.Sc., A.M.T.C.

23. Section of Mathematical Statistics.

(Head-quarters : At University of Adelaide.)

At Sectional Head-quarters—
Senior Research Officer—E. A. Cornish, M.Sc., B.Agr.Sc.
Assistant Research Officer—A. T. James, B.Sc.(Hons.).
Sectional Secretary—Miss E. M. G. Goodale.

At Division of Animal Health and Production, Sydney—
Assistant Research Officer—Miss H. A. Newton Turner, B.Arch.
Assistant Research Officer—Miss V. M. Botham, B.Sc.

At Division of Forest Products, Melbourne—
Assistant Research Officer—E. J. Williams, B.Com.

At Division of Plant Industry and Economic Entomology, Canberra—
Assistant Research Officer—G. A. McIntyre, B.Sc., Dip.Ed.
Assistant Research Officer—R. T. Leslie, B.A. (Hons.), B.Sc.

24. Radio Research.

(Head-quarters : C/o Electrical Engineering Department, University of Sydney.)

Senior Research Officer—F. W. Wood, B.Sc.
Assistant Research Officer—L. S. Prior, B.Sc.
Assistant Research Officer—L. H. Heisler, B.Sc.
Assistant Research Officer—C. B. Kirkpatrick, B.Sc.
Assistant Research Officer—D. G. Stewart, M.Sc.
Assistant Research Officer—Mrs. M. Harrison, B.Sc.
Technical Officer—Miss M. Evans, B.A.
Technical Officer—Miss B. Hardwick, B.A.
Technical Officer—Miss V. Henderson, B.Sc.
Technical Officer—Miss A. McClure, B.A.
Technical Officer—Miss C. Peach, B.Sc.
Technical Officer—Miss G. Polden, B.A.

25. 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).

26. 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).

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. 177.—A Soil Map of Australia, by J. A. Prescott, D.Sc., A.A.C.I.
No. 178—Food Composition Tables, by Hedley R. Marston and Mary C. Dawbarn.
No. 179—Lubrication between the Piston Rings and Cylinder Wall of a Running Engine, by J. S. Courtney-Pratt, B.E. and G. K. Tudor, B.E.
No. 180—Studies on Deglutition in Sheep. 1. Observations on the Course Taken by Liquids through the Stomach of the Sheep at Various Ages from Birth to Maturity, by R. H. Watson, D.Agr.Sc. 2. Observations on the Influence of Copper Salts on the Course Taken by Liquids into the Stomach of the Sheep, by R. H. Watson, D.Agr.Sc. and I. G. Jarrett, B.Sc.
No. 181.—Sheep Blowfly Investigations : The Attractiveness of Sheep for *Lucilia cuprina*, by I. M. Mackerras, M.B., Ch.M., B.Sc. and M. J. Mackerras, M.B., M.Sc.
No. 182.—The Effectiveness of Various Mineral Dusts for the Control of Grain Pests, by J. S. Fitzgerald, M.Sc., Ph.D., A.A.C.I.
No. 183.—Experimental Determination of the Influence of the Red-legged Earth Mite (*Halotydeus destructor*) on a Subterranean Clover Pasture in Western Australia, by K. R. Norris, M.Sc.

No. 184.—Fellmongering Investigations—Papers I. to XII., by F. G. Lennox, D.Sc., Margaret E. Maxwell, M.Sc., and W. J. Ellis, A.S.T.C.

No. 185.—Studies on the Mitchell Grass Association in South-Western Queensland. 2. The Effect of Grazing on the Mitchell Grass Pasture, by R. Roe, B.Sc.(Agric.) and G. H. Allen, Dip.Agric. (Lawes).

(ii) *Quarterly Journal.*

Vol. 17, No. 3, August, 1944.
Vol. 17, No. 4, November, 1944.
Vol. 18, No. 1, February, 1945.
Vol. 18, No. 2, May, 1945.

(iii) *Annual Report for the year ending 30th June, 1944.*

XXIII. ACKNOWLEDGMENTS.

In various sections of this Report reference has been made to the valuable assistance afforded by many State Departments and other organizations and individuals. The Council desires to express its gratitude for the help given by these bodies and persons in providing laboratory accommodation and other facilities and in many other ways. The Council also wishes to acknowledge the assistance it has received from its State Committees and other Committees, the members of which have placed their knowledge and experience so freely at its disposal.

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

G. A. COOK, Secretary.

September, 1945.

APPENDIX.

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

COUNCIL (AS AT 30TH JUNE, 1945).

EXECUTIVE.

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

CHAIRMEN OF STATE COMMITTEES.

Professor I. Clunies Ross, D.V.Sc. (New South Wales).
Professor E. J. Hartung, D.Sc. (Victoria).
R. J. Donaldson, D.S.O., B.C.E. (Queensland).
Professor Kerr Grant, M.Sc. (South Australia).
P. H. Harper, B.A. (Western Australia).
F. H. Foster, B.C.E. (Tasmania).

CO-OPTED MEMBERS.

Professor E. Ashby, D.Sc. (on leave of absence).
N. K. S. Brodribb, C.B.E., F.R.I.C.
Sir Harry Brown, C.M.G., M.B.E.
Professor W. J. Dakin, D.Sc.
M. T. W. Eady.
W. S. Kelly.
E. H. B. Lefroy.
G. Lightfoot, M.A.
Professor Sir John Madsen, B.E., D.Sc.
Professor H. C. Richards, D.Sc.
J. P. Tivey, B.A., B.Sc., B.E.
Professor S. M. Wadham, M.A., Dip.Agr.

STATE COMMITTEES (AS AT 30TH JUNE, 1945).

NEW SOUTH WALES.

Professor I. Clunies Ross, D.V.Sc. (*Chairman*).
Professor E. Ashby, D.Sc.
Professor Sir Henry E. Barraclough, K.B.E., V.D., B.E., M.M.E.
Sir Harry Brown, C.M.G., M.B.E.
Professor W. J. Dakin, D.Sc.
Professor J. C. Earl, D.Sc., Ph.D., F.R.I.C.
A. J. Gibson, M.E.
W. R. Hebblewhite, B.E.
L. J. Jones.
Hon. Sir Norman W. Kater, M.B., Ch.M., M.L.C.
Sir Frederick McMaster.
Professor Sir John Madsen, B.E., D.Sc.
J. Merrett.
R. J. Noble, B.Sc.Agr., M.Sc., Ph.D.
R. G. C. Parry Okeden.
J. G. Peake.
A. R. Penfold, F.R.I.C.
Professor J. D. Stewart, F.R.C.V.S., B.V.Sc.
E. H. F. Swain, Dip.For.
J. P. Tivey, B.A., B.Sc., B.E.
W. L. Waterhouse, M.C., D.Sc.Agr., D.I.C.
Professor R. D. Watt, M.A., B.Sc.
C. M. Williams.

VICTORIA.

Professor E. J. Hartung, D.Sc. (*Chairman*).
Professor W. E. Agar, M.A., D.Sc., F.R.S.
R. S. Andrews, B.Sc.
W. Baragwanath.
N. K. S. Brodribb, C.B.E., F.R.I.C.
Professor F. M. Burnet, M.D., Ph.D., F.R.S.
M. T. W. Eady.
Sir Herbert W. Gepp.
Russell Grimwade, C.B.E., B.Sc.
H. Herman, D.Sc., M.M.E., B.C.E.
G. G. Jobbins.
Sir Dalziel Kelly, LL.B.
G. Lightfoot, M.A.
H. A. Mullett, B.Agr.Sc.

N. Taylor, B.Sc., F.R.I.C.
Professor J. S. Turner, M.A., M.Sc., Ph.D.
Professor S. M. Wadham, M.A., Dip.Agr.
W. E. Wainwright, A.S.A.S.M.
L. J. Weatherly, M.A.
Professor H. A. Woodruff, B.Sc., L.R.C.P., M.R.C.S., M.R.C.V.S.

SOUTH AUSTRALIA.

Professor Kerr Grant, M.Sc. (*Chairman*).
A. J. Allen.
C. E. Chapman, F.R.I.C.
S. B. Dickinson, M.Sc.
T. E. Field.
J. H. Gosse.
Professor T. H. Johnston, M.A., D.Sc.
W. S. Kelly.
F. T. Perry.
Professor J. A. Prescott, D.Sc.
W. J. Spafford, R.D.A.
L. K. Ward, B.A., B.E., D.Sc.

QUEENSLAND.

R. J. Donaldson, D.S.O., B.C.E. (*Chairman*).
Professor H. Alcock, M.A.
Professor E. J. Goddard, B.A., D.Sc.
V. G. Grenning.
J. B. Henderson, O.B.E., F.R.I.C.
Professor T. G. H. Jones, D.Sc.
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A. McCulloch, M.E.
A. G. Melville.
J. F. Meynink.
Professor J. K. Murray, B.A., B.Sc.Agr.
Professor T. Parnell, M.A.
Professor H. C. Richards, D.Sc.
R. P. M. Short.
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R. Veitch, B.Sc.Agr., B.Sc.For.

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H. Bowley.
F. G. Brinsden.
W. G. Burges.
Professor E. DeCourcy Clarke, M.A.
Professor G. A. Currie, D.Sc., B.Agr.Sc.
S. L. Kessell, M.Sc., Dip.For.
A. L. B. Lefroy.
E. H. B. Lefroy.
B. Meecham.
Professor G. E. Nicholls, D.Sc.
L. W. Phillips, M.Sc., M.Ed.
Professor A. D. Ross, M.A., D.Sc.
G. L. Sutton, D.Sc.Agr.
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Hon. R. O. Shoobridge, M.L.C.
S. W. Steane, B.A.

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B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R. (*Chairman*).
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P. Malloch, Commonwealth Dried Fruits Control Board.
E. J. Casey, Commonwealth Dried Fruits Control Board.
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B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R. (*Chairman*).
Professor J. A. Prescott, D.Sc., Waite Agricultural Research Institute, University of Adelaide.
H. N. England, B.Sc., Water Conservation and Irrigation Commission, New South Wales.
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A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
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A. G. Kubank, M.I.A. pastoral interests.
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J. H. Alexander, W. Jacka — Leeton Fruitgrowers' Co-op. Society Ltd.
A. G. Enticknap, M.L.A., H. J. Williams — Leeton Co-op. Cannery Ltd.
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O. McL. Falkiner, Boonoke Station, Conargo.
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S. West, B.Sc., M.S., Irrigation Research Station, Griffith, New South Wales.
Spencer, B.Sc.Agr., Irrigation Research Station, Griffith, New South Wales.
J. Lynch, B.Agr.Sc., Division of Food Preservation and Transport, C.S.I.R.
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H. Thompson, M.A., D.Sc., Division of Fisheries, C.S.I.R.

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(*Formerly the Interdivisional Blowfly Committee; its function is to co-ordinate certain activities of the Divisions of Economic Entomology and of Animal Health and Production.*)

L. B. Bull, D.V.Sc., Division of Animal Health and Production, C.S.I.R.
A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R.
A. W. Turner, O.B.E., D.Sc., D.V.Sc., Division of Animal Health and Production, C.S.I.R.
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E. J. Bowater, Messrs. Angliss and Co. Pty. Ltd., Sydney.
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J. Merrett, Metropolitan Meat Industry Commissioner, Sydney.
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Professor T. Parnell, M.A., University of Queensland.
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B.—COMMITTEES CONCERNING WORK IN WHICH THE COUNCIL IS CO-OPERATING.

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R. v.d. R. Woolley, M.A., M.Sc., Ph.D., Mount Stromlo Observatory.

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John Metcalfe, B.A., M.L.A., Principal Librarian, Public Library of New South Wales.
C. A. McCallum, B.A., Senior Assistant, Public Library, Melbourne.
Ellinor Archer, M.Sc., Chief Librarian, C.S.I.R.

IRRIGATION AND DRAINAGE COMMITTEE FOR SOUTH AUSTRALIA.

C. M. Fowles, Lands Department, South Australia (*Chairman*).
A. G. Strickland, M.Agr.Sc., Department of Agriculture, South Australia.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein, Victoria.
A. C. Gordon, Lands Department, South Australia.
E. R. Lawrie, Engineering and Water Supply Department, South Australia.

CURLWAA AND COOMEALLA HORTICULTURAL ADVISORY COMMITTEE.

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F. P. H. Barrett, Water Conservation and Irrigation Commission, New South Wales.
C. T. Lasscock, Rural Bank of New South Wales.
S. Heaysman, representing Coomealla Producers.
J. Bailey, representing Coomealla Producers.
S. P. Taylor, representing Curlwaa Producers.
W. Reeves, representing Curlwaa Producers.
F. S. Oldham, Department of Agriculture, New South Wales (*Secretary*).

WAKOOL DISTRICT RESEARCH COMMITTEE.

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Chairman*).
G. B. Gibbs, Water Conservation and Irrigation Commission, New South Wales.
F. Matthews, New South Wales Rural Bank.
M. St.C. McInnes, New South Wales Rural Bank.
E. Bowmaker, Department of Agriculture, New South Wales.
A. Varcoe-Cocks, Wakool Shire Council.
H. J. Robinson, L. Jeffers, W. R. A. Smith, E. E. Toll — representing Wakool District Landowners' Executive.
H. Jackson, representing Wakool District Landowners' Executive (*Secretary*).

IRRIGATION RESEARCH EXTENSION COMMITTEE (MURRUMBIDGEE IRRIGATION AREAS).

C. G. Savage, Department of Agriculture, New South Wales (*Chairman*).
R. G. S. Kebby, Department of Agriculture, New South Wales.
B. O. French, Department of Agriculture, New South Wales.
J. G. Youll, Water Conservation and Irrigation Commission, New South Wales.
H. N. England, B.Sc., Water Conservation and Irrigation Commission, New South Wales.
H. J. Braund, Water Conservation and Irrigation Commission, New South Wales.
E. R. Iredale, Rural Bank, New South Wales.
C. T. Lasscock, Rural Bank, New South Wales.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith.
R. R. Pennefather, B.Agr.Sc., Irrigation Research Station, Griffith.
D. V. Walters, M.Agr.Sc., Irrigation Research Station, Griffith.
V. C. Williams, M.I.A. Co-operatives Executive, Griffith.
O. J. Longhurst, M.I.A. Co-operatives Executive, Yenda.
W. Jacka, M.I.A. Co-operatives Executive, Leeton.
J. H. Carter, Rural Bank, New South Wales (*Secretary*).

VITICULTURAL COMMITTEE FOR NON-IRRIGATED AREAS.

Chas. Russell, Dried Fruits Board, for South Australia (*Chairman*).
A. G. Strickland, M.Agr.Sc., Department of Agriculture, South Australia.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein, Victoria.
W. N. Twiss, Dried Fruits Board, South Australia (*Secretary*).

COMMITTEE ON OENOLOGICAL RESEARCH.

Professor J. A. Prescott, D.Sc., representing C.S.I.R. (*Chairman*).
C. Haselgrove, representing the Federal Viticultural Council.
Professor J. B. Cleland, M.D., Ch.M., representing the University of Adelaide.
L. N. Salter, representing the Australian Wine Board.

COMMITTEE ON DRIED VINE FRUIT PROCESSING METHODS.

A. V. Lyon, M.Agr.Sc., E. C. Orton, B.Sc. — representing C.S.I.R.
A. R. Hampton, Mildura Packers' Association.
W. Heaysman, Merbein Advisory Committee.
W. R. Jewell, M.Sc., B.Met., F.R.I.C., Department of Agriculture, Victoria.

Growers' Representatives.

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

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C. G. Savage, Department of Agriculture, New South Wales (*Chairman*).
H. Broadfoot, Department of Agriculture, New South Wales.
Professor E. Ashby, D.Sc., Department of Botany, University of Sydney.
J. R. Vickery, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.
S. A. Trout, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.

ADVISORY COMMITTEE ON FRUIT COOL STORAGE INVESTIGATIONS.

(*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.*)

S. Fish, M.Agr.Sc., Department of Agriculture, Victoria.
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.

COMMITTEE FOR CO-ORDINATION OF FRUIT COOL STORAGE RESEARCH.

E. G. Hall, B.Sc.Agr., Department of Agriculture, New South Wales.
F. M. Read, M.Agr.Sc., Department of Agriculture, Victoria.
A. G. Strickland, M.Agr.Sc., Department of Agriculture, South Australia.
T. D. Raphael, M.A., Dip-Hort. (Cambridge), Department of Agriculture, Tasmania.
W. M. Carne, Department of Commerce, Melbourne.
S. A. Trout, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.
D. Martin, B.Sc., Division of Plant Industry, C.S.I.R.

ADVISORY COMMITTEE ON ORIENTAL PEACH MOTH INVESTIGATIONS.

A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R. (*Chairman*).
F. M. Read, M.Agr.Sc., Department of Agriculture, Victoria.
H. J. Williams, Leeton Co-op. Cannery Ltd., New South Wales.
G. A. H. Helson, M.Sc., Division of Economic Entomology, C.S.I.R.
S. Fish, M.Agr.Sc., Department of Agriculture, Victoria (*Secretary*).

JOINT BLOWFLY CONTROL COMMITTEE.

(*Appointed as a means of co-ordinating the activities of the New South Wales Department of Agriculture, the Queensland Department of Agriculture and Stock, and of C.S.I.R.*)

L. B. Bull, D.V.Sc., Division of Animal Health and Production, C.S.I.R. (*Chairman*).
A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R.
~~W. L. Hindmarsh, M~~.R.C.V.S., B.V.Sc., D.V.H., Glenfield Veterinary Research Station, New South Wales.
T. McCarthy, Department of Agriculture, New South Wales.
H. G. Belschner, D.V.Sc., Department of Agriculture, New South Wales.
F. H. S. Roberts, D.Sc., Department of Agriculture and Stock, Queensland.
D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Production, C.S.I.R. (*Secretary*).

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P. A. Brown, Queensland United Graziers' Association.
P. A. Elliot, Queensland United Graziers' Association.
G. A. Fairbairn, Queensland United Graziers' Association.
J. F. Meynink, Queensland United Graziers' Association.
R. C. Philp, Queensland United Graziers' Association.
L. J. Landsberg, Queensland United Graziers' Association.
J. L. Wilson, Queensland United Graziers' Association.
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J. Legg, D.V.Sc., Department of Agriculture and Stock, Queensland.
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