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THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

TWENTIETH ANNUAL REPORT

OF THE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

FOR THE

YEAR ENDED 30TH JUNE, 1946.

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CONTENTS.

CONTENTS—*continued*.

COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

TWENTIETH ANNUAL REPORT (FOR YEAR ENDED 30TH JUNE, 1946).

I. INTRODUCTORY.

1. *General.*—The Council for Scientific and Industrial Research was established in 1926 by the reorganization of the existing Institute of Science and Industry. The powers and functions of the Council are defined by the *Science and Industry Research Act* 1920-1945, 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. *Resignation and Death of Sir George Julius.*—At the end of 1945, Sir George Julius, who had been Chairman of the Council since its inception in the year 1926, resigned from that position but was immediately appointed as a co-opted member of the Council, thus retaining his membership in unbroken sequence. Early in 1946, however, he became ill and died on 28th June, 1946. The excellent position in which the Council finds itself at the present time is due largely to Sir George's constructive leadership, wisdom, and wise guidance: he used his great gifts and ability freely and unstintingly in the service of the Council for a period of twenty years. The Council and the nation owe him a debt of deep gratitude for the services he rendered.

3. *Executive Committee.*—(i) *Appointment of New Chairman.*—The former Chief Executive Officer of the Council and its Deputy Chairman, Sir David Rivett, was appointed as Chairman of the Council as from 1st January, 1946.

(ii) *Appointment of New Chief Executive Officer.*—Following the appointment mentioned in (i) above, Dr. A. E. V. Richardson was appointed as Chief Executive Officer as from 1st January, 1946.

(iii) *Appointment of New Members.*—In the previous report, mention was made of an amendment to the Council's Act whereby the Executive Committee would be increased from three members to five. During the year under review, two new members of the Executive Committee were appointed. They are Dr. F. W. G. White and Professor I. Clunies Ross, who will concentrate on the secondary industries and primary industries respectively. Prior to his appointment, Dr. White was Chief of the Division of Radiophysics, which Division he joined in the year 1941. Before coming to Australia he was Professor of Physics at Canterbury College, University of New Zealand.

Dr. Clunies Ross was Professor of Veterinary Science in the University of Sydney from 1940 to July, 1946. He is not a newcomer to the Council for Scientific and Industrial Research as he joined the staff of the Division of Animal Health in the year 1926 to leave it some years later, after a period as Officer-in-Charge of the F. D. McMaster Animal Health Laboratory, to become the Chairman of the International Wool Secretariat, London. He resigned from that position to accept his University chair. He became Chairman of the Council's New South Wales State Committee in 1941.

4. *Change from War to Peace Work.*—During the year under review the war happily ended, thus enabling the Council to concentrate again on a peace-time programme. In some cases the necessary reorganization has meant considerable changes. In the Division of Radiophysics, for instance, the programme of work has been given a distinct bias towards the development of means of assisting the operations of civil airlines. Then again, the Divison of Plant Industry is now devoting much more time to a study of pasture and weed problems and problems of the Northern Territory, and the Division of Soils is concentrating on the examination of the various areas for which large scale schemes of soldier settlement are in mind. The Division of Food Preservation, too, is reverting to its peace-time programme relating to the storage of fresh fruits, vegetables, and meat as distinct from its war-time attention to problems of dehydration and canning. In short, this year has been one of considerable changes.

5. *Wool and Textile Research.*—Brief reference was made in the previous report to the Government's proposals to initiate an extensive programme of research and publicity for the wool industry, and the part to be played by the Council. On the wool production side comprehensive plans, aimed at providing an integrated programme of research expanding to cover eventually all important aspects of the wool-growing industry, have been prepared during the year. The work will be largely carried out in the Council's existing Divisions and field stations and in conjunction with the Universities and the Departments of Agriculture in the States.

On the wool textile side the Council has considered the observations received from the four eminent authorities mentioned in the previous report, who visited Australia to survey the field of wool textile research and make recommendations for its develpment in Australia. They were Mr. B. H. Wilsdon, Director of the British Wool Industries Research Association, Professor J. B. Speakman, Professor of Textile Technology, University of Leeds, Dr. F. T. Peirce, Director of Research, School of Textiles, University of North Carolina, and Dr. A. C. Goodings, Director Textile Section, Ontario Research Foundation.

As a result it is proposed to establish a Division of Textile Research; the position of Chief for such a division is being advertised in Australia and overseas. The Division's head-quarters laboratory will probably be at Geelong and negotiations are at present in hand for the acquisition of a site in that district. It is also proposed that some work in the wool textile field will be undertaken by existing Divisions; in some cases this is already in hand and is discussed in the appropriate section of this report.

6. *New Sections.*—During the year under review the name of the Lubricants and Bearings Section has been changed to the Section of Tribophysics (from the Greek "*tribos*"="rubbing"), and that of the Scientific Liaison and Information Bureau to Information Service. The Building Materials Research Section and the Flax Research Laboratory also came into existence during this period. The latter laboratory is carrying out the flax work formerly undertaken within the Division of Forest Products.

The Council has also decided to carry out investigations into nuclear physics, secondary metallurgy, and meteorological physics; experimental work on the first two of these subjects is being initiated in collaboration with the University of Melbourne.

7. *Land at Highett, Victoria.*—A site of some 18 acres has been acquired at Highett, Melbourne. It is intended to erect laboratories on this site for the Building Materials Research Section and for flax investigations; in the meantime, the work of these Sections has commenced at Highett in a building previously used as a machine shop by the Department of Aircraft Production.

8. *Overseas Training.*—With the return to peacetime conditions the Council is following its earlier practice of sending members of its scientific staff overseas to collect information on new developments and to acquire general experience in research and a training in new techniques. It is expected that some 25 officers will proceed overseas during the next year.

Further, in extending its research activities the Council is finding a need for staff skilled in subjects in which post-graduate training is not catered for in Australia. It has been decided therefore to offer a series of studentships each year to enable recent graduates of Australian universities to obtain general research experience and a training overseas in subjects related to the Council's programme of research and then to return to Australia as members of the Council's staff.

The Council lays particular importance on the above two practices, which it considers to be of considerable value in making Australian scientific laboratories familiar with the latest developments as well as in giving future officers of the Council a breadth of vision and an inspiration that will pay handsome national dividends in years to come. In this connexion it might be mentioned that the British Commonwealth Scientific Conferences mentioned below emphasized the importance of a far greater volume of intra-Empire visits of scientists one with another than in the past.

9. *Overseas Conferences.*—At the end of the period under review a series of Empire scientific conferences was held in London. These included the Royal Society Empire Scientific Conference, the British Commonwealth Scientific Official Conference, and the Imperial Agricultural Bureaux Review Conference. The Australian delegation, representative of scientific interests as a whole in the country, was led by the Chairman of the Council (Sir David Rivett, K.C.M.G., F.R.S.). Representatives were also sent to the British Commonwealth Conference on Aeronautical Research. As a result of the conferences plans have been made for closer co-operation in scientific work between the different units of the British Commonwealth and Empire.

10. *Overseas Liaison Offices.*—At this stage, the existence of the Council's Scientific Liaison Offices in London and Washington can be made public. They were established in 1941 to facilitate the exchange of highly secret information from the United Kingdom and United States of America on the latest developments of scientific research in relation to the war and have proved of great value not only to the Council but to the fighting Services and other Government Departments. They are now being maintained, on a restricted basis, to serve the definite peace-time need of the Council to have "listening posts" overseas.

11. *Finance.*—Section XXII of this Report gives details of expenditure by the Council during the financial year 1945-46 of a sum totalling £1,058,043. Of this amount, £89,774 was contributed other than directly from Commonwealth Treasury. In addition, the sum of £17,094 was expended on wool and textile research from funds derived as a result of the passing of the *Wool Use Promotion Act* 1945. Certain other expenditure, involved in erection costs of buildings, 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 Rural Bank of New South Wales and other co-operative bodies associated with soils and irrigation work, the timber industry, and the pulp and paper industry.

II. PLANT INVESTIGATIONS.

1. *General.*—The Division of Plant Industry is continuing to receive excellent co-operation from kindred institutions, such as were noted in the 19th Annual Report. On this occasion, specific mention is made of the arrangement reached with the Department of Agriculture of New South Wales whereby long-range co-operative pasture and weeds investigations have been established, and with the Department of Agriculture of Western Australian in connexion with studies of crop rotations.

During the war period, the joint State and Council for Scientific and Industrial Research Weeds Co-ordination Committees had to go into recess, but they are now being revived. Already, the Queensland Committee has met to review the weeds problems of that State, and has placed the more important ones into priority categories. During July and August, 1946, the committees for New South Wales, Victoria, South Australia, and Western Australia are scheduled to meet.

The North Australia Development Committee, established by the Commonwealth Government and the governments of Queensland and Western Australia, has the responsibility of determining the best usage of great areas in the Northern Territory, and to this end, plans first to obtain facts from scientific surveys. The first survey to be undertaken is in the nature of a reconnaissance, and it is intended to make a rapid examination in the Katherine-Darwin-coast area, of the vegetation in relation to geology, soils, and climate, the distribution, grazing, and quality of stock, &c., during the 1946 dry season. The party of scientists left during May, 1946, for Katherine to begin the survey. The leader is Mr. C. S. Christian, of the Division of Plant Industry. Soils will be studied by Mr. G. A. Stewart of the Soils Division, vegetation by Mr. S. T. Blake, of the Queensland Department of Agriculture and Stock, geology by Mr. L. C. Noakes, of the Commonwealth Mineral Resources Survey, and mapping will be done by two members of the Army Survey Corps.

A committee representing the Council for Scientific and Industrial Research, the Waite Agricultural Research Institute, and the Departments of Agriculture of South Australia and Tasmania, has been established to supervise investigations of the condition of apricots known as dieback or gummosis, which occasions considerable losses in some areas.

2. *Pasture Investigations.*— (i) Canberra, Australian Capital Territory.—(1) *Management of Sown Pastures.*—(*a*) *Phalaris-subterranean clover.*—Following a demonstration that a system of rotational grazing at fixed intervals is of no benefit on a *Phalaris*-subterranean clover pasture, the work now in progress is aimed principally at determining the period, if any, at which this pasture might benefit from spelling, or, alternatively, be injured by heavy grazing. In 1945, two trials were laid down to provide information on this point, the first an experiment on time of

cutting, the second on time of protection from grazing by sheep. September and October, 1945, were very dry months, and it was necessary to conclude the experiment before the subterranean clover, which was drying off prematurely, was disintegrated and lost. The greatest increases in yield, as the result of spelling for short periods, were obtained by spelling at the beginning of the autumn growing period, but with normal spring conditions this result may not be repeated.

Because of the incompleteness of the data in 1945, these two experiments are to be repeated in 1946.

(*b*) *Wimmera ryegrass—subterranean clover.*—An experiment will be commenced in 1946 to determine factors influencing the re-establishment of Wimmera ryegrass in short-term pasture at the Dickson Experiment Station. This work will be complementary to the study on this subject now in progress in Western Australia. The treatments are designed to enable a study of the influence of the re-seeding rate of the Wimmera ryegrass, the effect of organic litter on the surface at the commencement of the season, the influence of the organic matter content of the soil, and the effect of cover by mechanical means (cultivation in the autumn).

(2) *Management of Natural Pasture.*—A large-scale grazing trial is projected at the Trangie Experiment Farm in co-operation with the New South Wales Department of Agriculture. This lies on the western boundary of the wheat belt in north-west New South Wales. Over much of this area, the perennial cover has been appreciably reduced by over-grazing, and the present trial is intended to determine the influence of rate of grazing and deferment of grazing on the maintenance and improvement of the pasture. Grazing will be at the rate of 1/2, 2/3, and 1 sheep per acre per annum. Continuous grazing, deferment of grazing in spring, and deferment of grazing in autumn will be combined with rate of stocking.

The combination of these two sets of treatments will give a total of nine treatments, each of which will be replicated four times. A total area of 386 acres will be sub-divided into 36 plots for the trial. Data will be collected on both pastures and sheep. The pasture data will include yield of pasture, basal area of perennial species, botanical and chemical composition. Live weight, wool yields, and fibre diameter will be recorded for the flock of six sheep on each treatment.

A survey of the experimental site for uniformity is being undertaken. Difficulties in procuring the requisite fencing material will prevent the commencement of grazing before 1947.

(3) *Mineral Deficiency Investigations.*—The principal item of cost in the maintenance of improved pastures based on subterranean clover is the annual expenditure on the purchase and application of superphosphate. Accordingly, it is desired to determine whether, in this northern part of the subterranean clover belt of Australia, reduced frequency or reduced rates of application of fertilizer is economically sound. A trial is in progress at the Dickson Experiment Station comparing a wide range of annual and biennial applications of superphosphate. The trial is placed on a *Phalaris*-subterranean clover pasture which has received no fertilizer since the original application in 1942. The yields in 1945 showed an upward trend with the heavier rates of application, but none of the differences in yield between treatments was significant. It will be necessary to conduct similar experiments on a range of soils on the Southern Tablelands, and a number of trials, including rates and frequency of application of superphosphate, have been commenced in 1946.

Work has been in progress for some years on the establishment of pasture plants on certain soils in the Australian Capital Territory. It has been established that on the Duntroon loam (pH 5.4), increased yields of lucerne are obtained when the pH is raised, the optimum pH being 6.7. Calcium seems also to have direct effects in stimulating the yield.

As a continuation of this work, and in an endeavour to elucidate the factors involved more fully, a comparison is being made, in pot culture, of plant behaviour on a number of soils carrying in their native state, savannah woodland and dry sclerophyll forest, respectively. The paired soils are derived in each instance from the same rock formation, which is granite, porphyry, quartzite, and slate, respectively. In each comparison the woodland soils have produced significantly higher yields than the forest soils. This remained true when phosphorus, lime, molybdenum, potassium, and nitrogen were added separately, except in two cases. Certain of the forest soils showed extremely poor development in the presence of each of the added nutrients. Continuation of this experiment will enable determination of the significance of multiple deficiencies.

Deficiencies of trace elements are suspected on a number of soils on the Southern Tablelands of New South Wales, and preliminary work already indicates that on at least one site such a deficiency may be the limiting factor in the establishment of clover. A number of field trials has been commenced in 1946.

(4) *Pasture Establishment under Cover Crops.*—A popular means of establishing subterranean clover is to sow with a cereal crop intended for hay or grazing. It is generally found that under these conditions a full cover of clover is rapidly developed during the ensuing years. A trial was sown in 1945 with varying rates of cereal and with various methods of sowing the cereal, the pasture seeds, and the superphosphate. The experiment will be repeated over a number of years, but it is already evident that the method of sowing can be varied to the advantage of the cereal crop or the ensuing pasture.

(5) *Species and Strains Investigations.*—A comparison of the relative values of an introduced perennial grass, *Festuca Mairei*, and the standard perennial pasture species of this area, *Phalaris tuberosa*, each sown in a sward with subterranean clover, is in progress. Establishment in 1945 provided a closely comparable population of each of the species, but mortality of the *Festuca* was somewhat greater during the summer months of 1945-46 than that of the *Phalaris*.

Work is continuing on the relative value, on the Southern Tablelands, of a number of strains of subterranean clover. Following drought conditions in 1944, the variety trial sown in that year produced only a light population of plants in 1945, and useful comparative results will not be available until 1946.

(6) *Danthonia Investigations.*—Work is continuing to determine economic means of artificially establishing *Danthonia* pastures. As harvested, the seed is difficult to handle because of awns and other appendages. It has now been shown that, by treatment of the seed in a modified hammer mill, a naked seed can be secured. Problems of breakage during treatment remain to be overcome, but it appears likely that the production of a sample which can be sown by normal farm machinery will prove commercially possible.

Work is also in progress on some of the factors governing germination. In a soil of 60 per cent. of field capacity, the germination is greatest at the surface or at $\frac{1}{4}$ inch, with a substantial reduction when the seed is buried to $\frac{1}{2}$ inch. (In this experiment, seed sown on the surface was protected from drying out by use of a bell jar.) It is apparent that shallow sowing is of the utmost importance in the establishment of *Danthonia*.

A pot culture experiment was conducted in 1945 to study the occurrence, movement, and storage of food reserves of *Danthonia semi-annularis*. Harvesting of tops, butts, and roots was undertaken at five intervals

between sowing and maturity. The material so harvested is being chemically analysed to determine the quantity and location of the various food reserves.

(7) *Toxaemic Jaundice.*—In co-operation with the Division of Animal Health and Production, which is studying the etiology of toxaemic jaundice, surveys are being made of the pasture of a number of affected properties in the Murray Valley and Woodstock districts of New South Wales. Surveys of the botanical composition of the pastures are to be made, in the spring, summer, and autumn each season. It is hoped that over a period of years the pasture analyses may provide useful supplementary information on the factors leading to outbreaks of this disease. Samples of the principal pasture species of the surveyed properties have been collected and forwarded to the Division of Animal Health and Production.

(ii) *Regional Pasture Laboratory, Deniliquin, New South Wales.*—Good progress is being made in the erection of buildings and other facilities at this centre.

(1) Several trials of a preliminary character have been undertaken on the establishment of pastures and crops under irrigation on selected soils in the Berriquin and Wakool districts. A number of millets, fodder sorghums, maize varieties, and summer-growing pasture species are included in these trials. Work is projected in 1946 to determine the influence of various factors on the establishment of a Wimmera ryegrass-subterranean clover pasture under irrigation on unfallowed land, including the effect of soil type, irrigation before and after sowing, the use of a cover crop, and the use of superphosphate and sulphate of ammonia.

(2) A co-operative trial with the Division of Animal Health and Production is in progress at the Barooga Field Station. The trial is designed to provide information on the effect of applied lime and molybdenum on the copper and molybdenum uptake of natural pasture. Yield and botanical composition are simultaneously under study. To the end of 1945, no significant changes in yield or botanical composition had resulted from the treatments imposed. The pasture material is being analysed by the Division of Animal Health and Production.

(3) A survey of the vegetation of the Falkiner Memorial Field Station was made in October, 1945.

(iii) *Institute of Agriculture, Nedlands, Western Australia.*—(1) *Species and Mixture Trials*—(*a*) *General*—Work has continued on the problem of securing suitable grasses for use in the 15-25 inch rainfall belt of Western Australia. From results of the species mixture experiments, it is becoming increasingly clear that none of the perennial grasses at present available for artificial seeding in this area is likely to prove satisfactory. It appears that the very short season experienced in this region will prevent the successful use of *Phalaris tuberosa* as a sown perennial grass, at least over the greater part of the area. Work is continuing with *Ehrharta calycina,* and, though the species is more successful than *Phalaris tuberosa,* its commercial use may be limited by several factors including the shortness of the season. Attention is therefore tending to move from the study of these perennial species to the problems associated with the use of the annual Wimmera ryegrass.

(*b*) *Ehrharta grazing trial.*—This experiment was commenced in 1943, and in 1945 was in its second grazing year. Regrowth was satisfactory after the opening autumn rains and grazing commenced on 13th June, 1945. At this time, the pasture consisted of 35 per cent. *Ehrharta,* with 60 per cent. subterranean clover. Differences in the mean density of herbage (cwt./acre) between pasture under continuous and rotational grazing, respectively, was small and of doubtful significance. Differences in liveweight and fleece weights between the flocks under each of the treatments were also non-significant. It is of interest that throughout the growing season the sheep grazed almost exclusively on *Ehrharta,* resulting in some weakening of the plants followed by uprooting during the dry summer months.

(*c*) *Wimmera ryegrass trials.*—The most important problem with this species is the rapid decline in production under field conditions. At the outset of the current work, three factors were considered worthy of investigation: (*a*) specific requirements for seed germination; (*b*) *modus operandi* of soil cultivation treatments; and (*c*) grazing management.

In 1945, field investigations were confined to the problem of soil cultivation treatments exclusive of the grazing factor. Results showed that cultivation treatment is by no means universally efficacious in promoting the growth of Wimmera ryegrass in cases where it has grown successfully in the past and subsequently declined in productivity. The result of cultivation appears to be dependent in at least some instances upon adequate seed reserves in the soil.

Two new experiments have been designed to commence in 1946 in which the interaction effects of depth of cultivation, seed rate, and nitrogen status will be further investigated.

(2) *Control of Capeweed—Cryptostemma calendulaceum.*—These experiments have been temporarily discontinued, since it is felt that the problems have solved within the limits of practicability. Late sowing, preceded by destruction of a considerable proportion of the capeweed seedlings, will increase substantially the establishment of sown species and decrease production of the capeweed. However, the development of hormone-like substances as weedicides will warrant a study of their possible value in the control of capeweed.

(3) *Mineral Deficiency Studies.*—The major field plot trials on the Karakatta sands near Perth are concerned with the inter-action of phosphorus and potash on a veldt grass, subterranean clover pasture. Results in 1945 indicated that subterranean clover responded significantly better to phosphorus and potassium together than to either nutrient alone. *Ehrharta calycina* showed no response to potash. Subsidiary trials with wood ashes have strongly indicated that the responses of subterranean clover are entirely due to the potash content of the wood ash. No responses to molybdenum have been recorded.

Pot culture trials on five sandy soils from Gingin with a number of major and minor elements have been given some useful indications of the likely deficiencies on these soils. Among the more marked responses were those to sulphur on two of the soils and to molybdenum on two others. Trials designed for 1946 will aim at the elucidation of some of the points emerging from this trial.

(4) *Pasture Investigations Relating to Sheep Infertility Problems.*—Work is continuing on the relationship of pasture type to the incidence of the reproductive diseases experienced in Merino sheep in certain parts of the south-west of Western Australia. The disease appears to be correlated with a dominance in the pasture of Dwalganup subterranean clover, though there is now evidence that the Dwalganup strain is not the only strain causing the disease. Two experiments of identical design involving a total area of 400 acres were commenced in 1945 to examine the effect of two highly contrasted pastures on the incidence of these diseases. The two treatments are (*a*) "normal" pasture, subterranean clover dominant, and (*b*) oats plus Wimmera ryegrass with a low proportion of subterranean clover.

Although pasture data have been secured during 1945, no vital results will emerge until lambing data are available in the autumn of 1946.

The work on this subject will be extended in 1946 to include the effect of major and trace elements on the growth and potency of Dwalganup subterranean

clover; the examination of a wide range of strains of substerranean clover, and the testing of a number of important pasture species from affected and non-affected areas.

The work on this subject is being undertaken as a co-operative project between the Council for Scientific and Industrial Research and the Western Australian Department of Agriculture, and also with the Institute of Agriculture of the University of Western Australia.

(5) *Fertility Maintenance.*—The role of legumes, primarily in rotation systems for light-textured soils, is becoming increasingly important in Western Australia. The building up of soil productivity in soils low in fertility, whether due to initial poverty or the effects of long cultivation, can probably be most easily accomplished by the use of pastures, particularly those containing legumes. A recent examination by the Western Australian Department of Agriculture of soils on which lupins had been grown for varying periods of time indicated that the total soil nitrogen, and the yield of wheat grown on these soils, increased with the number of years under lupins. There is also field experience to indicate that Dwalganup subterranean clover and field peas, as well as lupins, have a marked effect in improving soil fertility.

A trial was commenced in autumn 1946 at the Wongan Hills Experiment Farm, in conjunction with the State Department of Agriculture, to examine the effect of these legumes on soil fertility and their value for wool production. The three legumes sown with Wimmera ryegrass or oats will constitute the grazing phase in a four-year rotation. Soil examinations will be made; the productivity of, and wool return from, the pastures measured; and the effect on soil fertility examined by the growth of a succeeding wheat crop, and by recording the nitrogen status of the soils.

(iv) *Armidale, New South Wales.*—(1) *Grazing Experiments on Natural Pastures in conjunction with Parasitological Investigations.*—A comprehensive series of experiments to study the effect of various grazing treatments on natural pastures and on the development and parasitic infection of the sheep grazing thereon, has been planned in co-operation with the McMaster Laboratory of the Division of Animal Health and Production. The experiments have been designed to determine the influence of—(*a*) different rates of stocking; (*b*) continuous and rotational grazing; and (*c*) the size of flock, on the health, liveweight, and wool production of the grazing sheep, and on the yield and composition of the pasture. The site selected comprises portion of Saumarez Station near Armidale.

(2) *Pasture Species Trial.*—Preliminary tests of a number of selected pasture species, including recently introduced plants, have been commenced in 1946. Three centres representing the three major soil groups of the Armidale district—lateritic soil, granitic soil, and basaltic soil—have been selected.

(3) *Establishment and Persistency of Subterranean Clover.*—A small trial to test the establishment and persistency of subterranean clover was laid down on granitic soil in 1945. An excellent establishment was obtained, but the stand has deteriorated a great deal because re-establishment in the autumn of 1946 has been poor and patchy. Several strains of this clover are included in the 1946 planting referred to under (2).

(4) *Survey of Natural Pastures.*—A reconnaissance survey of the pastures of New England was made in 1945 to define the principal pasture types. Three such types were recognized and described, viz. *Danthonia,* red grass, and wire grass pastures. A paper covering this work and discussing pasture problems in New England is now in course of publication.

(v) *Cooper Laboratory, Lawes, Queensland.*—(1) *Lucerne-Rhodes Grass Pastures.*—Grazing was commenced in the spring of 1945 on a beef cattle grazing experiment in which comparisons are being made between two strains of Rhodes grass each sown in swards with and without lucerne as the pasture legume. Each treatment is replicated three times, and each plot is subdivided into five sub-plots to permit rotational grazing and the conservation of hay from part of each pasture during the peak growth period. This will be available for winter use. The value of each pasture is being assessed by liveweights of the steers, yield, and chemical and botanical composition of the pastures. The results for the first twelve weeks of grazing are of interest. The steers have gained more weight on the combination of Rhodes grass and lucerne than on Rhodes grass alone, while the local strain of Rhodes grass is giving better liveweight gain than the introduced leafy Kenya strain. This latter difference may be a temporary one—but it is nevertheless unexpected.

A related experiment, in which various methods of establishing Rhodes grass and lucerne in a mixed sward are being examined, has been commenced. The treatments include various times of planting of the two species and various pretreatments of the land.

(2) *Inter-row Cultivation Pastures.*—Three experiments have provided data indicating that a mixture of *Paspalum scrobiculatum* and lucerne grown in inter-cultivated rows can provide adequate feed for stock throughout the year.

An experiment designed to study growth of *Paspalum scrobiculatum* under grazing, has shown that, in a sward, plants lose vigour through competition for available soil moisture, because the supply of available nitrogen in the soil is depleted, and by competition from prolific weed growth. In rows, at increasing spacing from 3 feet-5 feet, competition for water has been of negligible importance and shortage of available nitrogen has been evident only at 3-ft. spacing; weed growth has been effectively controlled. The yield per acre has been greatest from rows at 4-ft. spacing, but there is some suggestion that, given an optimum mixture of grass and lucerne, and an intensity of grazing sufficient to ensure satisfactory nitrogen returns through the animal, 3-ft. rows might give a greater yield.

From an experiment planted to allow comparative evaluation of different mixtures of *Paspalum scrobiculatum* and lucerne, it has been learned that, in the Darling Downs environment, there is competition for water between adjacent rows of lucerne and grass at 3-ft. 6-in. spacing. Root studies of the plants show that the lucerne roots invade the root zone of the contiguous grass roots.

An experiment to determine the efficiency of transpiration of *Paspalum scrobiculatum* at different soil moisture levels, has been designed to gain some knowledge of basic facts regarding the accumulation and utilization of soil moisture in the summer rainfall region. Another experiment in progress will permit determination of the rate of penetration of water through black soil in relation to the initial soil moisture content.

(3) *Other Work with Paspalum scrobiculatum.*—The apparent positive relationship between sheep weight increments and mean maximum temperature is being investigated. Evidence of such relationship was first obtained in 1943 from an experiment designed to determine the periods of food stress in a mixed pasture of *Paspalum scrobiculatum* and lucerne. Subsequently, a variety trial of four grasses (each in combination with lucerne) provided further evidence of this relationship and, in addition, evidence of the superimposed effects of changes in diet. A new experiment has been planned to give more definite information on this question. A small flock of eight sheep is being held in a raised yard, and fed a constant diet of 50 per cent. wheaten chaff, 35 per cent. maize, 15 per cent. cotton

seed meal, Trical-os, and water, all *ad lib.* Records are being kept of the live weight of sheep, wool growth, fibre diameter, and changes in suint.

It has been observed that on certain soils (subject to flooding by run-off from adjacent areas) both on the Darling Downs and at Lawes, plants of *Paspalum scrobiculatum* show deficiency symptoms. Tests with the known trace elements have given contradictory results under pot culture conditions, but both zinc and manganese seem to be of importance.

A new experiment designed to measure the effect of mowing on the vigour of *Paspalum scrobiculatum* has been commenced.

Seed production and harvesting technique, and the requisite conditions for satisfactory germination and establishment of *Paspalum scrobiculatum* have received further attention during the past year.

(4) *Cattle Pasture Investigations.*—The area of beef cattle pastures in Queensland at present under consideration is that portion of the State east of the main east-west divide and south of the Tropic of Capricorn. The major problem in this area is to overcome the acute shortage of protein that exists for about six months of the year. To this end, three experiments have been commenced at Rodd's Bay, near Gladstone. These are designed to give information on:

(1) The possibilities of Townsville lucerne (*Stylosanthes sundaica*) as a pasture legume.
(2) The effect of major and minor elements on the establishment and yield of Townsville lucerne.
(3) The effect of heavy dressings of nitrogen, phosphorus, potassium, and lime on the growth of the native spear grass (*Heteropogon contortus*) pasture.
(4) The value of a light surface cultivation of the native pasture. Several introduced pasture species have also been sown for observation.

Burning of excess growth is a feature of the management of pastures in these areas, but little exact information is available concerning the long-term effects of this procedure. Consequently, an experiment was commenced at Lawes in 1945 to determine the effect of annual burning on the yield and botanical composition of an area of natural pasture.

(5) *Lucerne Investigations.*—Selection for rust resistance has been continued in the F_3 and F_4 generations of crosses between resistant and susceptible plants. Clonal populations of the better material have been established.

A comparison of the persistence under grazing in a lucerne grass sward of a wide range of lucerne types has now concluded. Several strains of *Medicago glutinosa* origin approached the persistence value of the Hunter River variety of lucerne, though no strain exceeded it.

The comparison of a number of lucerne strains under conditions of summer flooding has been commenced. Yield and survival trials, including the evaluation of a number of progenies derived from selections made within Australian material have been continued. A co-operative experiment is being conducted to test the value of, and to multiply, two strains of lucerne evolved from selections made on the Atherton Tableland.

Progenies of material surviving under conditions of heavy and continuous grazing are now being subjected to similar conditions and survivors will subsequently be reselected.

(6) *Phalaris Investigations.*—A strain selected for summer vigour and good persistence under Lawes conditions is now being subjected to a persistence test under grazing in comparison with a commercial strain.

(7) *Native Legumes.*—The collection, observation, and seed multiplication of native legumes have been continued.

(vi) *"Gilruth Plains", Cunnamulla, Queensland.*—(1) *Grazing Management Experiment.*—In this experiment, a Mitchell grass pasture is being grazed by sheep at light, moderate, and heavy rates (one sheep to 7½ acres, one sheep to 5 acres, and one sheep to 2½ acres, respectively) and at three frequencies (continuous grazing, summer grazing with winter spelling, and winter grazing with summer spelling). The experiment has concluded its first term with the fifth shearing of the sheep. The results from this first five years indicate that of the grazing treatments tested continuous grazing at a rate of one sheep to 5 acres is the best grazing treatment for this pasture type.

Comparing continuous and rotational grazing, no differences in sheep liveweights or in wool production have been recorded, but the amount of forage available under rotational grazing has tended to be less, and the difference between the different rates has been greater, the heavier the rate of stocking. The liveweights of sheep have been considerably lower under heavy stocking than under light stocking, but under medium stocking have been only slightly lower. With a rotational grazing system involving summer grazing and winter spelling, the proportion of Mitchell grass in the pasture has been markedly reduced. No changes in the chemical composition of the pasture due to grazing treatments have been recorded, but the chemical data show fluctuations in the percentage of protein, phosphorus, soluble ash, and calcium, particularly in the miscellaneous or herbage species (non-gramineous species, excluding legumes). The fluctuations have not been regularly seasonal, but are related to incidence of rainfall which has been very erratic. The miscellaneous species, as a group, have had a chemical composition indicative of a superior nutritive value, being higher than the other species groups in protein, soluble ash, and calcium, while their phosphorus content has been relatively high, and cellulose low.

Because of drought conditions during the latter two years of the experiment, considerable supplementary feeding has been carried out. This was practically confined to the heavy grazing treatments. Although the gross monetary return per acre from the sale of wool was greater under this heavy grazing treatment during the first three years of the experiment, the actual cost of supplementary feeding during the following two years more than outweighed the aggregate monetary advantage. This was the case with supplementary fodder at costs inflated by war conditions. At pre-war costs, there is still some advantage in favour of heavy grazing after five years, but the pasture has suffered under this treatment and will probably take years of conservative use to recover.

When the experiment commenced in 1941, it was stocked with sixteen-months-old sheep so that they were still growing. The grazing treatments affected the development of these young sheep as shown by subsequent body measurements. On the heavy grazing treatments, the frame of the sheep was smaller and this effect was more marked under rotational grazing than on the continuously grazed plots.

(2) *Other Investigations at "Gilruth Plains".*—Cutting treatments have been commenced on an artificially established stand of barley Mitchell grass in an experiment to determine the effect of various cutting treatments on yield, chemical composition of the cut material, and persistence of the stand.

A detailed map of the flora of "Gilruth Plains" has now been completed. Ground survey and aerial photography have been combined in making this map. Copies of the map will become available on publication of the survey report.

3. *Weeds Investigations.*—(i) *Galvanized Burr.*—Records of the number of galvanized burr and other plants have been continued on a four-treatment grazing experiment at "Warrie" Station, Queensland. Seasonal conditions constitute the most important factor determining numbers of burr plants at any one time. Since April, 1943, a period of severe drought, burr numbers in terms of grown plants per 25 square links have decreased from 18.60 to 0.17. Differences between grazing treatments have not been consistent, but the unstocked paddock has fewer burr plants at both the high and low peak periods of plant density. However, the evidence available shows that it will not be practicable to control the weed by lowering the rate of stocking by sheep. The results of the eight years study are now being collated with a view to their publication.

(ii) *Mintweed.*—Research into the control of mintweed was recommenced in 1945 after a lapse of five years. Previous work had indicated that chemical sprays and repeated cultivation did not give much scope for control where mintweed is well established. Experiments with competing pasture plants had also been unsuccessful. As a first step to recommencing these investigations, a survey was made of the mintweed areas of Queensland and New South Wales to determine both the geographical distribution of the plant and the distribution in relation to soils and vegetation. This survey indicated that the weed is confined to heavy textured, self-mulching, brown to black soils mainly derived from basalt. Further, although it is already present in several regions of eastern Australia, it has not yet reached its maximum spread on these soils. Field experiments conducted last summer showed that mintweed is not a competitor of summer crops (maize, grain sorghum, sweet sorghum, and Sudan grass) where efficient cultural methods are used.

Experiments with chemical weedkillers showed that 5 per cent. arsenic pentoxide gave a complete kill, Chloroxone, A510, and Dinoc gave an 80 per cent. kill, and Methoxone gave a slightly lower kill of mintweed. Pot experiments are being conducted to determine the growth of mintweed on different soil types.

(iii) *Capeweed in Flax Crops.*—In co-operation with the Australian Flax Committee, an experiment was conducted in 1945 near Colac, in Victoria, to determine the influence of various treatments in reducing the population of capeweed in flax crops. The results obtained indicated that Dinoc (sodium dinitro-o-cresylate) alone, at the rate of ¾ gallon in 100 gallons of aqueous spray per acre, gave a satisfactory control of capeweed without noticeable injury to the flax crop. The addition of sulphate of ammonia to Dinoc sprays injured the flax and reduced its yield without noticeably increasing the weedicidal value of the spray as far as capeweed was concerned. In this instance, the control of the capeweed meant the difference between complete failure and the production of a saleable crop. The commercial yield of flax from the control plot was 0.71 ton per acre, that from the plots sprayed with Dinoc alone 2.12 tons per acre.

(iv) *Skeleton Weed.*—Experiments on the control of this weed by hormone-like poisons were commenced in November, 1945. Results were disappointing. In most instances, only discolouration of the leaves and slight epinasty of the stem was caused, and the most effective concentrations were still considerably less effective than arsenic pentoxide.

Further tests are planned for the spring of 1946.

(v) *Hoary Cress.*—Small spray trials with hormone-like poisons were conducted at Wagga last summer. A more comprehensive experiment is planned for next July.

(vi) *Physiological Investigations.*—Studies are in progress on the action of plant poisons. One of the obstacles to detailed studies of the effect of plant poisons has been the difficulty of identifying dead and live tissue in the field. A simple method has now been devised involving the insertion within the tissues (e.g. roots of plants sprayed with poisons) of a probe and measuring the electrical resistance across its two points. The apparatus is readily portable.

4. *Plant Introduction.*—(i) *General.*—The past year has been one of great expansion in overseas and internal plant exchanges, and of re-organization and development of the facilities for complete testing of the plants introduced. The ending of the war has resulted in the re-opening of many important sources of plant material, and has also led to a greatly increased demand from overseas institutions for seeds of Australian plants to help in the restoration of collections damaged or dissipated during the war years. In helping to supply such seeds, the Section is not only performing a service of direct value to the recipient countries, but is building up a goodwill which will be of great benefit to future exchanges.

During the year, arrangements have been made for the closure of the station at "Fitzroyvale" near Rockhampton, and concentration of initial trials of subtropical plants in southern Queensland, where excellent facilities are available at Redland Bay and Lawes. From this centre it will be possible to organize regional trials in all parts of northern Australia much more efficiently than could be done from "Fitzroyvale". As part of such trials, an introduction garden has been established at Katherine in the Northern Territory, and work there will be greatly expanded as staff and facilities become available. Arrangements are also in hand for the transfer of the main introduction station in Western Australia to Wolkalup, near Harvey, which is more suitable climatically and agronomically than Muresk, where the trials are at present concentrated.

The scientific staff of the section has remained almost unchanged during the year, and staff shortages have restricted developments in certain directions. This position will be rectified in the near future.

(ii) *Introduction and Exchange of Plants and Seeds.*—Some 510 species and varieties of plants were introduced from abroad for trial during the year, a number greater than in any of the previous twelve years. Pasture and forage plants formed the bulk of the introductions, including large collections of Mediterranean pasture species for trial, particularly in Western Australia, and plants from Uruguay for trial in southern Queensland. Other noteworthy introductions include numerous varieties of cantaloupes for trial by the Vegetable Section, opium poppies for the Drug Plants Section, strains of guayule rubber (*Parthenium argentatum*) from California, linseed varieties from Argentina, and several introductions of seed of kudzu (*Pueraria thunbergiana*) which have been much publicized for use in erosion control. Trials with these plants are still in the initial stages.

Over a thousand samples of seeds of Australian native and crop plants have been sent to overseas agricultural and botanical institutions, while 220 introductions have been sent to State Departments of Agriculture and other Australian experimentalists for trial. The preparation and distribution of annual seeds lists and quarterly lists of introduced plants has been continued.

(iii) *Pasture and Forage Plant Trials.*—These trials have been continued at all centres, ranging from small row tests of new introductions to more extensive sward and grazing trials of those which have shown promise in the initial tests.

In Queensland, experimental work has continued with pigeon peas (*Cajanus cajan*) and stylo (*Stylosanthes gracilis*) which were noted as particularly promising in previous reports. Further results have confirmed the superiority of some of the Indian

varieties of pigeon pea, which greatly outyield the controls in leaf and pod material, as well as in grain. Weighings of the residual material after standing plants were grazed by bullocks have shown that a considerable proportion of the smaller stems, as well as the whole of the leaves and pods, were readily consumed in winter.

A recently introduced variety of stylo is of particular interest as it has a more upright growth habit than previously tested strains, as well as an apparent capacity to ripen seeds before frost damage becomes serious. In co-operation with the Department of Commerce and Agriculture, seed supplies of stylo are being built up for wider distribution and grazing trials.

Extensive varietal trials of soybeans have been conducted at Lawes and Redland Bay. While seed production has suffered somewhat from diseases and adverse climatic influences, several varieties of South African and Javanese origin have shown promise as forage plants. It is proposed to initiate soybean trials also at Katherine, Northern Territory.

At Canberra, nearly 200 grass and legume introductions were tested in the nursery area, and, of these, about 40 have been considered to warrant further trial. These include several strains of cocksfoot (*Dactylis*), brome (*Bromus*), and wheat grass (*Agropyron*), as well as vetches (*Vicia* spp.) and other legumes.

The season at Muresk in Western Australia was exceptionally wet, in contrast to earlier years, and several of the perennial grasses have shown up more prominently. Plot trials of both annual and perennial introduced pasture plants will be set down to test their yielding capacity under systems of cutting.

(iv) *Vegetable Oil Plant Trials.*—Trials of introduced linseed varieties at Lawes and Redland Bay have been very successful, the yields at the former centre being particularly promising. As in previous trials at Canberra, some varieties of Indian origin have been outstanding. Experimental work with this crop will be extended, with the inclusion of a number of recently introduced Argentine varieties. It is believed that linseed has good prospects as a commercial crop in southern Queensland.

Other vegetable oil crops under test include sesame (which has made good growth at Redland Bay), safflower, rapeseed, sunflower, and soybean. As noted above, difficulties have been experienced in obtaining satisfactory seed production from the latter crop, and further work is required before any varieties can be confidently recommended for extensive cultivation for oil production in southern Queensland.

(v) *Rubber Plant Trials.*—Experiments with the guayule rubber plant (*Parthenium argentatum*) have been continued at Canberra and Lawes. Analyses made at the Waite Agricultural Research Institute show that plants grown under natural rainfall at Lawes compare more than favorably in yield and rubber content with the best irrigated plantings in South Australia. Waterlogging during an exceptionally wet summer caused some loss of plants from the Lawes plantings.

Experimental work in progress at Canberra is designed to test the influence of annual pruning and associated pasture plants on the yield and composition of the shrubs. Additional strains of guayule have been obtained from California for use in variety trials.

(vi) *Miscellaneous Plant Trials.*—Several introduced barley varieties have again proved superior to the local controls in trials at Muresk, these including, in addition to the Beecher variety noted in last year's report, the varieties Zulu, Tennessee No. 5 Flynn and Duplex.

Yam beans (*Pachyrrhizus* spp.) have made exceptionally good growth at Redland Bay, and promise to give a large crop of seed. Tests to determine the insecticidal value of the powdered seeds are being made by officers of the Division of Economic Entomology.

Varieties of sweet potato have been under trial at "Fitzroyvale" and Redland Bay. In spite of an exceptionally dry summer, the variety Porto Morado has given a high yield of very uniform tubers at "Fitzroyvale", while the Fijian variety, Three Months, is promising at Redland Bay.

In co-operation with the Drug Plants Section, an extensive trial of opium poppy varieties was conducted at Muresk.

(vii) *Herbarium.*—The Divisional Herbarium has continued to expand, the mounted specimens, exclusive of special collections, now totalling 11,818.

As in recent years, routine determinations in connection with the pasture investigations of the Division have formed the main activity. The need for taxonomic research in important groups of economic plants has become increasingly apparent, and will be partly met by the appointment of an officer able to spend full time on systematic problems. The functioning of the Herbarium should also be facilitated by the arrangements made for joint action with other Canberra institutions with similar interests.

5. *Wheat Investigations.—Take-all of Wheat.*—From the results obtained in the experiments on take-all of wheat that were started in 1938 and continued since then, it is clear that plants that are provided with the necessary plant food for optimal growth processes are resistant to the disease and, conversely, plants that are grown in poor soil are very susceptible. The organism that is associated with the disease appears to be present in soil wherever wheat is grown. Like other disease-producing organisms, it is able to invade its host, but the extent of the damage caused by the disease depends on host nutrition. In plants that are grown in soil that supplies an adequate amount of well-balanced available plant food, the effects of the disease are negligible.

At the present time there are two series of experiments in progress in bird-proof cages, in which a total of about 1,000 five-gallon drums is being used. In each experiment the soil is different. One type of soil is from a wheat field in which take-all occurred whenever cropping with wheat was attempted. The other type of soil is from the bed of a river. In contrast to the other, it has proved to be inherently deficient in plant food, even when optimal amounts of water are supplied. In the drums containing the latter soil, the effects of growing wheat continuously, after "fallowing", in rotation with oats, grasses, and an ornamental plant that is reputedly not attacked by the take-all organism, are all being observed and recorded. In the drums in which wheat has been grown continuously since the experiment was started in 1943, the yield has been depressed significantly in those to which nitrate of soda was added. The same trend was observed with some other inorganic fertilizers. The response to added farmyard (sheep) manure was outstanding.

In the other experiment, several variations of treatment have been designed to supply information regarding the influence of some inorganic fertilizers to amendments, farmyard (sheep) manure, leaf mould, heating, drying, and waterlogging of soil, as well as different methods of exposing the plants to infection by the organism that is commonly associated with the disease in this area.

Chemical analyses of plants taken from the different series indicate that there is much to be learned by this method of attack about the effects on the disease of the addition of specific fertilizers. Obviously, it is not to be expected that fertilizers that are effective on soils in the Australian Capital Territory will be equally applicable elsewhere.

6. *Fruit Investigations.*—(i) *In Tasmania.*—The investigations dealing with the physiological disorders of apples and pears in the orchard and the disorders of

these fruits during storage, and for which the laboratory at Huonville was established, were practically suspended during the war. It was necessary for the officer responsible for these studies to engage in war emergency work on behalf of the Department of Commerce and Agriculture. This work included the examination of processed foodstuffs for the Services and the investigation of other immediate supply problems.

During the past year, there has been a reduction in the amount of material passing through the testing laboratory owing to decreasing Service demands. This reduction has been partially counterbalanced, however, by export material ordered by the British Ministry of Food and U.N.R.R.A., which required examination for sterility, quality, and packaging. Special examinations have also been made of surplus Army stocks of food for the guidance of the disposal authorities.

Nevertheless, it has been possible during the past six months for the Huonville laboratory to take up again the study of fruit storage problems, although it was not possible to recommence active experimentation. The greater part of the investigational work on this project was suspended during 1940, although a few experiments were continued as late as 1943. It was not practicable, however, to do more during this period than record results. In addition, a considerable amount of data, accumulated prior to the war and not analysed or collated, awaited attention. The examination of these data and the preparation of reports to cover the results of the pre-war work have been commenced. On the basis of the conclusions which these data provide, and in co-ordination with projected fruit storage investigations by the State Departments of Agriculture, plans for active experimentation during the coming season will be made.

Co-operative work with the Tasmanian Department of Agriculture on the vitamin C content of tomato varieties was continued.

(ii) *At Stanthorpe.*—A general account of the scope and purpose of the apple and pear rootstock investigations at Stanthorpe was given in the Council's Journal for May, 1938, and results obtained during the first ten-year period summarized in the Eighteenth Annual Report of the Council (p. 10, 1944).

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 in nursery and orchard plantings have been continued. The results of a nursery trial in which the Merton apple rootstocks Nos. 793 and 789 gave the best performances were reported in the Council's Journal of November, 1945. Two other Merton rootstocks, Nos. 778 and 779, budded with Jonathan scions in another nursery trial, have, at the end of ten years, given very good results compared with six other woolly aphis immune stocks. Merton stocks Nos. 793, 789, and 778 are now being multiplied, and, during the winter of 1947, a sufficient number of plants should be available to allow a limited distribution to nurserymen. Additional types of reputedly immune apple rootstocks have been secured and are being propagated for testing.

In the first planted nursery trial of pear stocks, which is now six years old, William Bon Chretien pear on *Pyrus calleryana* has produced better and larger trees than on the East Malling selections B1, C7, D3 and D4.

Among other and incidental trials made during the year, one which aimed to test the efficacy of D-D (dichloroethylene and dichloroethane) as a control of woolly aphis in the propagating beds gave very good results. Spraying the young shoots in the stool beds and then covering the bases with 6 inches of soil, or covering the bases of the shoots with 6 inches of soil and then injecting D-D solution into the centre of the stool, gave control of woolly aphis below ground for about four or five weeks.

(iii) *Diseases of Stone Fruits.*—Diseases such as dieback, shot hole, freckle, and brown rot of apricots, peaches and nectarines, rust and brown rot of plums, and disorders of apricots, such as failure to set or to hold fruits to maturity, have been observed in the Australian Capital Territory. These troubles have already been reported from commercial orchards in other parts of Australia. Thanks to the willing co-operation of all householders in the sections of Canberra that it has been possible to survey, much has been learned during the past year about the incidence and the local loss from these troubles. The main purpose of the survey was to study some aspects of the dieback disease of apricots.

Such well-known boron deficiency diseases as brown heart of ordinary and Swede turnips, "hen and chickens" of the grape, brown discoloration of cauliflower, the occasional occurrence of external cork, internal cork, and measles of apple have been observed in gardens in which gummosis of stone fruits, especially apricots, occurs. It has been shown in water culture experiments in the United States of America that gummosis and dieback of peaches occur if boron is withheld, and are eliminated if boron is supplied. In British Columbia, dieback of apricots has been shown experimentally to be due to deficiency of boron, and the disease in the orchards in the province has been controlled during the past few years by applying borax in the fertilizer. As boron deficiency has been observed in the other above-named crops in Canberra, it appears logical to assume that the dieback of apricots in the same gardens might also be a boron deficiency disease. Experiments to test this hypothesis are in progress. The dieback that has been observed in some of the orcharding areas in parts of Victoria, South Australia, and Tasmania appears to be due to more than one cause, among which may be included some simple or compound deficiencies of some major, as well as trace, elements.

It has also been observed that a few trees in Canberra that were treated with borax set and held heavier crops than other trees that have not been so treated. Some other observations suggested experiments that are now in progress. As an example may be cited the absolute or relative freedom from brown rot in some bearing apricots and nectarines in a season in which neighbouring trees lost the greater part of the crop. The circumstances suggested that the differences were hardly likely to be due to mere chance.

7. *Drug Plant Investigations.*—These investigations were commenced during 1940, as a war emergency project at the request of the Medical Equipment Control Committee and the National Health and Medical Research Council; they were designed to determine whether certain essential medicinal drugs of plant origin could be produced successfully in Australia. In addition to the progress notes submitted in previous numbers of the Annual Report, a general description of results obtained during the first three years' experimentation with respect to hyoscine, atropine, morphine, ephedrine, and santonin has been published in the Council's Journal for November, 1945.

During the past two years, investigations with respect to a number of specific drugs such as ephedrine, digitalis, and quinine have been concluded, and effort has been increasingly concentrated on three phases of the project of post-war importance. These phases are: (i) the study of *Duboisia* spp. as sources of hyoscine and atropine; (ii) the study of varieties of *Papaver somniferum* as sources of opium alkaloids; and (iii) the systematic search for sources of pharmacological and insecticidal substances in native plants.

Work on all three phases has continued to be done in co-operation with the Department of Physiology, University of Melbourne, and, in addition, the Department of Physiology, University of Queensland, and the Division of Industrial Chemistry of this Council are now co-operating in the implementation of the native flora studies.

(i) *Duboisia spp.*—A report dealing with the variation observed in the nature and quantity of the main alkaloids of *Duboisia myoporoides* and *Duboisia leichhardtii* among individual trees of natural stands and between comparable types in young plantations throughout the season has been published in the Council's Journal for August, 1945. The conclusions reached closely approximate the summary of findings presented in last year's Annual Report.

Differences in the morphological form of young single tree progenies of both species grown at Nambour and at Canberra have been evident. Analyses of leaf samples of these trees are still proceeding, and it is not possible yet to say how far the nature and quantity of alkaloid produced by these progenies differ and to what extent, therefore, variation previously reported in natural stands and plantation material may be attributed to genetic factors. Several new field occurrences of *Duboisia myoporoides* have been examined during the year, and seed collected from these and other sources (particularly of the southern type). Additional progeny plots from this seed will be established.

Experiments with fertilizers have not yet produced any significant differences in alkaloid content, although the application of ammonium sulphate in a pot experiment materially affected the growth habit and form of both species. No further evidence has so far been obtained regarding the influence of other environmental factors.

With the objective of obtaining information concerning the general problem of the chemical development of the alkaloids of the species, studies of the alkaloids present at successive stages of seedling development were continued. A report on this phase of the work is in the course of preparation. For the same purpose, grafting experiments have been continued. In the leaf of tomato grafted on to *Duboisia* rootstock, hyoscine was produced (*vide* report in *Australian Journal of Science*, August, 1945). The leaf of a tobacco scion grafted on to *Duboisia* contained both nicotine and hyoscine. Various other grafts have been made, and by the analyses of the resulting alkaloids fundamental information on alkaloid synthesis may be derived.

The plots at Nambour and Canberra, which were established for the purpose of discovering the most suitable methods of cultivating and harvesting *Duboisia* when grown in plantation, and which were described in last year's Annual Report, have been maintained. By the end of 1946, sufficient experience and data on cultivation and harvesting should have been obtained to serve as a guide for prospective growers.

(ii) *Opium Poppy.*—The results of studies on the changes in the morphine and dry matter content of the opium poppy during the maturation period were reported in the Council's Journal for November, 1945.

Trials of different varieties were again conducted at three centres and a report on these trials was published in the Council's Journal. Of the 44 varieties so far tested, the average percentage of morphine in the husks has ranged from 0.18 to 0.57 per cent. Certain varieties have been found to be better adapted to conditions in southern Australia than others, but none has combined all desirable characters. Two varieties have produced greater amounts of morphine than the others, one by yielding large amounts of dry matter with a relatively low concentration of morphine, and the other smaller amounts of material rich in morphine.

The breeding and selection programme commenced in 1944, which aims to combine the most desirable characters of promising varieties, has been continued. About 800 single plant selections were made during the past season, and, of these, approximately 100 were assayed for morphine content. Several individual plants produced husks that contained as much as 0.9 per cent. morphine. Thirty of these selections are being tested further in row trials during the present season.

No significant results were obtained from the fertilizer trials at Canberra. The commercial plantings made under the aegis of the Council were only moderately successful, those crops which were grown under irrigation being the most successful. No commercial scale plantings were arranged for the 1946-47 season.

(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, which was commenced in a systematic manner during 1944-45, was continued during the past year. Survey and collection work was concentrated in north Queensland, most attention being given to the examination of species of the tropical rain forests. Of some 450 "field spot tests" made for alkaloids, 50 different species were found to contain substantial amounts of alkaloid, while another 60 species of those tested contained small amounts. It is estimated that at least 10 per cent. of the species of the rain forests contain alkaloid in quantity, and probably about 20 per cent. produce alkaloids in less amounts. Samples of some 40 different species selected on the basis of the field spot tests were submitted to the Physiology Departments of the Universities of Melbourne and Queensland for chemical and physiological testing. Of these, several have given promising results and are the subject now of more detailed investigation by the Division of Industrial Chemistry. A number of species have also been supplied for preliminary insecticidal tests. A compilation of all published and reported references to the poisonous and medicinal properties of Queensland plants is in the course of preparation and will be completed in the near future.

8. *Tobacco Investigations.*—Studies on yellow dwarf of tobacco were continued in the laboratories and plots of the Division in Canberra in co-operation with the Division of Economic Entomology, and in co-operation with the Victorian Department of Agriculture at Myrtleford, particularly with reference to the use of DDT spray. The results are reported under the Division of Economic Entomology.

Other work on tobacco is held up pending the return of an officer from the United States of America and Canada, where he is consulting authorities there on tobacco production, treatment, &c.

9. *Vegetable Investigations.*—(i) *General.*—Short-term investigations covering varietal, strain, and other necessary war-time problems of vegetable crops have now been completed. In this category are included the agronomic studies of variation in varieties and strains of tomatoes, beans, peas, cabbage, red beet, carrot, and onion. As a result of this work, the varietal position is much clearer in these crops. It is apparent that in the genetically unstable cross-pollinated crops, viz. cabbage, red beet, carrot, and onion, intense selection for seed purposes for any particular environment should take place from high-quality commercial crops in that environment. It is only in this way that high-quality uniform vegetables can be produced in the cross-pollinated group. The same does not apply to the more genetically stable self-pollinated crops, viz., tomatoes, beans, and peas. During the year, articles on the work with tomatoes and cabbage have been prepared for publication.

The future work on vegetable crops will concern an intense study of the genetics of disease resistance and quality, and of ancillary problems. It is hoped to elucidate some of the basic principles involved. As a by-product of this work, hybrid material will be produced for use and development by crop specialists in various regions of Australia.

(ii) *Potatoes.*—Genetical work aimed at producing hybrids resistant to the potato viruses A, X, Y, and leaf roll has been continued. Hypersensitivity and hence field immunity to virus Y has been developed for the first time in certain hybrids by intensifying, through genetic means, the necrotic reactions apparent or inherent in certain common potato varieties. A study of the principles involved in this resistance to virus Y is in progress. Two papers have been published in the Council's Journal on this subject.

Work on resistance to common scab (*Actinomyces scabies*) has been begun. This has demonstrated that seven varieties or hybrids tested in Victoria and the Australian Capital Territory give promise of sufficient resistance to scab for breeding purposes.

(iii) *Tomatoes.*—Agronomic studies of selected varieties have been continued with a view to assessing the factors contributing to yield and adaptability to any particular environment. Progress has been made with the Fusarium wilt problem. Isolates of this organism have been obtained from all the important tomato-growing areas in Australia. Although differences in pathogenicity between isolates are not great, there is some evidence for the existence of strains of Fusarium wilt. Susceptibility of a large number of varieties and species to these isolates has been tested under controlled glasshouse conditions. Glasshouse results are closely correlated with field observations. Among tomato varieties a range of susceptibilities is shown. The variety Pan America is outstanding in that it is immune to Fusarium wilt under both glasshouse and field conditions. An article covering this work has been prepared and will appear shortly in the Council's Journal.

(iv) *Peas.*—Varietal studies have been continued. Hybrids combining the desirable agronomic characters found among varieties are being developed. The search for *Ascochyta* blight resistance is being continued in a wide range of varieties.

(v) *Beans.*—Agronomic and disease resistance studies of a comprehensive varietal collection are under way. Varieties possessing superior agronomic characters and resistance to the major bean diseases are being used as parents in a hybridization programme.

Much of this work has been upset by the spasmodic occurrence of a root and stalk rot which has caused heavy mortalities in plantings of the varietal collection. This trouble is probably due to a complex of one or more species of Fusarium, with or without other fungi such as *Macrophomina phaseoli.* Resistance to this disease varied widely both between varieties and between different strains within the variety Canadian Wonder. Certain of the newer American varieties were especially susceptible. Varietal resistance and the etiology and environmental relations of this disease are being investigated.

(vi) *Onions.*—Quality studies of a number of local and overseas varieties are being continued in co-operation with the Division of Food Preservation and Transport. The biochemical factors leading to high quality are apparently heritable. Hybrids are being developed which incorporate the best of these heritable quality factors from existing varieties.

10. *Potato Investigations.*—(i) *FX Scheme.*—Of the six varieties of potato widely grown in Australia, three have not yet been obtained free from virus X. An attempt is being made, by isolating single eyes from tubers of these varieties, to obtain virus-free material. The eyes, with a minimum amount of tuber tissue, are cut from dormant tubers and sprouted on wet filter paper in petri dishes. By examining large numbers of plants grown from these eyes, it is hoped to isolate a few that have escaped virus infection.

(ii) *Growth Studies.*—Work on developmental stages in the growth of the potato plant has been continued. A general plan of growth and development has been published, and this has served as a starting point for further work. As a fuller understanding of the development of the normal plant is attained, the studies are being extended to include the growth and development of potato plants infected with virus diseases. These studies are co-ordinated with the potato breeding work; they are providing information on the factors that determine maturity, yield, and disease resistance in the potato plant.

(iii) *Use of Zinc Oxide as a Disinfectant on Cut Potato Setts.*—A comprehensive field trial was designed to test zinc oxide as a preventive for missing in potato crops caused by the rotting of cut potato setts. Although planting conditions that should have caused missing were nullified by a change of weather, it was shown that zinc oxide applied to cut setts before planting did protect them against premature rotting. It also caused a reduction of *Rhizoctonia* lesions on the stems of young plants, and protected the tubers against common scab (*Actinomyces scabies*). It was shown to have definite possibilities as a seed disinfectant for cut potato setts, because it does not injure tuber tissue; it encourages rather than discourages suberization, and it has a definite fungistatic action.

11. *Tomato Spotted Wilt.*—Further work has been done with the protective inoculation method of preventing disease in the field by infecting the plants in the seedling stage with a very mild strain of the virus. Field plots were established near Sydney and at Canberra. A heavy incidence of spotted wilt abundantly confirmed the previous season's observations that the protection afforded by the mild strain is of too short a duration to be of use in the field. Methods of lengthening the period of protection are being investigated.

Species of Lycopersicon possessing resistance or immunity to spotted wilt were tested in the field and in the glasshouse, and work was begun on a programme of hybridization, in co-operation with the Vegetable Section, with the object of producing a variety tolerant to spotted wilt.

A study of the relationship of the spotted wilt virus to dahlia was begun, both in the greenhouse and the field. Large numbers of seedlings were raised in the greenhouse and inoculated, using virus from different sources to study the effect of the host from which the virus is obtained on the success of infection experiments. In addition, detailed examination for symptoms was made on a large plot of field plants. Dahlia is regarded as the worst carry-over host of this virus.

Late in 1945, severe outbreaks of spotted wilt occurred in potatoes at the Experiment Farm, Canberra, and in the Crookwell district. The virus causing these outbreaks was studied and found to be a variant form which differed from the normal spotted wilt in having lost the most severe strain from the complex. Infection studies on potato showed that by the loss of this severe strain the virus was able to effect systematic invasion of potato with ease, whereas the normal virus did so only with difficulty. The adapted virus was thus capable of causing rapid and widespread infection under favorable condiions. Varietal susceptibility to this form of virus is being studied and material has been collected for a large scale study of the incidence of infection in the tubers.

12. *Other Investigations.*—(i) *Isolation of Chaetomium Species.*—During studies with the hypochlorite method of sterilization of plant tissue for isolation of pathogens, the resistance of spores of the fungal genus

Chaetomium to chlorine gas was observed. This led to a method of isolating pure cultures of *Chaetomium* from mixed populations by exposing plates and then destroying all organisms settling on them, except *Chaetomium,* by the addition of small quantities of chlorine in solution.

(ii) *Control of Culture Mites.*—Experiments to control the ravages of mites which destroy stock cultures of pathogenic and other fungi were done with DDT and gammexane. DDT was found to be ineffective, but gammexane was highly effective, and a simple technique of dipping cotton wool plugs in alcoholic solution of this insecticide was developed.

(iii) *Fertilizer Experiments in Pine Plantations.*—In 1939, broadcast treatments with superphosphate or ground rock phosphate were applied to *Pinus caribaea* and *P. taeda,* planted in 1930, on infertile, sandy soil at Woodburn, on the South Coast of New South Wales. There was no visible result during the first two seasons after treatment, but during the following four seasons, the dressings of 2½ cwt. per acre of ground rock phosphate or of 3 cwt. of superphosphate applied in 1939 produced extra increments totalling over 4,000 super feet of timber per acre for the four-year period from July, 1941 to July, 1945. The average total annual increment in the treated trees was nearly double that in the controls. There is no sign of the treatments losing their effectiveness, and all traces of "needle fusion" have disappeared from the treated plots. Similar treatments of *Pinus radiata* in the Moss Vale district were much less effective, although during the autumn of 1946, the sporophores of mycorrhizal fungi were very much more abundant in treated than in untreated plots, even where the trees themselves showed no response whatever.

(iv) *Maize Disease Investigations.*—Pollen from twelve American inbred lines of maize was used to pollinate single plants of a good commercial open-pollinated strain of Funk's Yellow Dent maize from Gippsland. Twenty of the resultant "top crosses" were tested for yield and agronomic characters against the female parent and two other commercial strains at Canberra. Top crosses from two of the inbreds gave yields 20 per cent. or more above those of the controls, and appeared satisfactory in other respects. Some of the inbreds are claimed by their originators to carry resistance to stalk and ear rots, but for the second time, inoculations of stalks and ears with *Diplodia zeae* failed to reveal any marked resistance to artificial inoculations with this fungus.

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

Anderson, A. J.* (1946).—Molybdenum in relation to pasture improvement in South Australia. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 1-15.

Bald, J. G. (1945).—Effect of rugose mosaic on the yield of potatoes. *Phytopathology* 35: 585-90.

——(1945).—A plan of growth, maturity and yield of the potato plant. *Emp. J. Exp. Agric.* 53: 43-8.

Bald, J. G., and Norris, D. O. (1945).—Virus C from an old Australian variety of potato. *Phytopathology* 35: 591-7.

Bald, J. G., and Oldaker, C. E. W. (1945).—Reactions of Tasmanian Bismark and Brownell potatoes to the commoner virus diseases. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 209-18.

Barnard, C., and Finnemore, H. (1945).—Drug plant investigations.
1. Progress Report. Ibid. 18: 277-85.

Cashmore, A. B., and Campbell, T. G. (1946).—The weed problem in Australia: a review Ibid. 19: 16-31.

Donald, C. M. (1946).—Competition between pasture plants with reference to the hypothesis of harmful root interaction. Ibid. 19: 32-7.

Davies, J. G., and Christian, C. S. (1945).—The establishment and early management of sown pastures: Australia. Imp. Bur. Pastures and Forage Crops, Bull. 34, pp. 73-96.

Hutton, E. M. (1945).—The relationship between necrosis and resistance to virus Y in the potato. 2. Some genetical aspects. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 219-24.

Hutton, E. M., and Bald, J. G. (1945).—Relationship between necrosis and resistance to virus Y in the potato. 1. Greenhouse results. Ibid. 18: 48-52.

Loftus Hills, K. (1945).—A note on the vegetative propagation and tree form in *Duboisia* spp. Ibid. 18: 230-3.

——(1945).—Changes in the morphine and dry matter content of the opium poppy (*Papaver somniferum*) during the maturation period. Ibid. 18: 286-97.

——(1945).—The presence of hyoscine in tomato scions on *Duboisia* rootstocks. *Aust. J. Sci.* 8: 20.

——(1946).—The suitability of a number of varieties of opium poppy for the production of morphine from the ripe capsule. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 177-86.

Loftus Hills, K., Trautner, E. M., and Rodwell, C. N. (1945).—A preliminary report upon variation in the nature and quantity of the main alkaloids in *Duboisia myoporoides* and *D. leichhardtii.* Ibid. 18: 234-53.

Moore, C. W. E. (1946).—The effect of soil moisture content and depth of planting on the germination of dehulled seed of *Danthonia semiannularis.* Ibid. 19: 172-6.

Norris, D. (1945).—Differential isolation of *Chaetomium* spp. from mixed populations by hypochlorite solution. Ibid. 18: 310-3.

Roe, R., and Allen, G. H. (1945).—Studies on the Mitchell grass association in south-western Queensland. 2. The effect of grazing on the Mitchell grass pasture. Coun. Sci. Ind. Res. (Aust.), Bull. 185.

Thomas, L. A. (1945).—Stock and scion investigations. V. A nursery trial with apple rootstocks. *J. Coun. Sci Ind. Res.* (Aust.) 18: 349-54.

* Report of work conducted while on Mineral Deficiency Investigations, South Australia.

III. ENTOMOLOGICAL INVESTIGATIONS.

1. *General.*—During the year, all the special wartime projects of the Division of Economic Entomology, and also certain investigations that arose out of them, have been concluded; and substantial steps have been made toward the reinstitution of a full peace-time research programme.

As in the previous year, considerable attention has been devoted to the study of DDT and 666 (the latter term being retained in this report for the crude product containing 10-13 per cent. of the active gamma isomer of hexachlorcyclohexane, now officially designated "gammexane").

The Division has been particularly interested in the development of a water-miscible DDT preparation which would not suffer from the disabilities associated with the emulsions hitherto used, and therefore immediately recognized the value of a preparation developed by a Sydney firm of chemical manufacters. This preparation, to which the name "Rucide" has been given, contains 50 per cent. para-para DDT, and

on being melted and poured into water forms a colloidal solution which gradually turns into a stable, fine emulsion of DDT particles. "Rucide" has been studied in the laboratory and subjected to small and large-scale field trials, and very promising results have been obtained with it against both horticultural and stock pests.

A conference of entomologists from the several State Departments of Agriculture, the Waite Agricultural Research Institute, and the Council for Scientific and Industrial Research, was held at Canberra, in June, 1945, to discuss the results of the season's investigation into the use of DDT. These investigations formed part of a co-operative programme planned the previous year, when there was a shortage of supplies of DDT for civilian use. The Division's work since this conference has furnished, largely through field trials conducted on a practical scale, very satisfactory confirmation of the promising results obtained during the previous season.

During the dry season, an officer of the Division visited the Northern Territory to carry out a survey of the insect pests attacking fruit and vegetable crops grown by the Australian Army Farm Companies, and to advise on methods of control.

In the field of biological control, special attention has been concentrated on two projects, St. John's wort and potato moth, the first of which is already showing the fruits of success, while the second has now reached a stage at which optimism appears to be justified. So satisfactory has been the multiplication of the potato moth parasites in the laboratory colonies, that further introductions of most of them will probably be unnecessary.

2. *Cattle Tick.*—During the year, biological investigations very largely gave place to direct studies of control measures and especially of preparations that could be used in dips or sprays.

(i) *Preparations Containing Arsenic.*—The standard dipping solution containing 8 lb. arsenic per 400 gallons was modified by adding a variety of other materials, including small amounts of DDT, rotenone, or nicotine sulphate, and by altering the reaction from somewhat alkaline to strongly acid (pH2). No material improvement was obtained, however, under field conditions. Strategic dipping designed to catch all ticks in the most vulnerable stages, and involving three dippings in six days in arsenic plus nicotine sulphate, was tried at Helidon. The cattle were cleared of tick, but the treatment proved severe on the beasts and would probably be too drastic in hot weather.

(ii) *DDT.*—In the various experiments, DDT was applied in the form of a solution, an emulsion in water, or a colloidal suspension. Solutions containing 12, 8, and 4 per cent. DDT, finely sprayed over the body at the rate of 2-4 fl. oz. per beast, killed ticks and gave protection from reinfestation for mean periods of 7, 6¼, and 5½ days respectively. Emulsions were sprayed over the animals in such a way as to wet the whole body thoroughly, the actual amount remaining on the beast not usually being measurable. In a number of experiments, it was found that 1 per cent. DDT gave substantial control, with a protective period of about a week, while 2 per cent. DDT cleared animals completely of ticks and protected them from reinfestation for about twelve days. In a series of seasonal experiments with 2 per cent. DDT emulsions, which are being run at "Gracemere", near Rockhampton, the same kill and protective time has been recorded for early summer, late summer, and late autumn. In a field experiment with a Buzacott spray race at the property of Mr. Guest, near Rannes, 1 per cent. DDT emulsion gave an almost complete kill and nine days protection from reinfestation at a consumption of ½ gallon fluid per beast.

The most interesting results have been obtained with "Rucide", the colloidal DDT preparation referred to in Section 1 above. Following preliminary observations on individually sprayed cattle, three field experiments have been undertaken with "Rucide" to date, two in dips and one in a Buzacott spray race. The fluid used in all three contained 0.5 per cent. DDT (i.e. 1 per cent. "Rucide"), and in every instance, very satisfactory control of ticks was obtained. These experiments are still in progress, but protection from reinfestation seems to be of the order of one to two weeks or more; and in the first experiments (carried out at "Rannes", the property of Mr. J. L. Wilson, with material generously supplied by him), the preparation has remained active in the dipping vat for three months, during which time 5,000 head of cattle have been dipped, and the dip has been topped up with 2,500 gallons of fluid.

These results are highly promising, and it seems possible that cattle tick may be controlled at a cost of about 4d. per head per treatment for materials, but with less frequent dipping than is now necessary with arsenic. This work is being pressed ahead as quickly as facilities for field trials can be made available, and is being extended to include a study of the use of DDT to cleanse cattle moving from ticky to clean country.

(iii) *Toxicity of DDT.*—A long-term experiment, designed to run for three years, has been set up to determine whether there is any cumulative toxicity of DDT to cattle. Two groups of animals are being used, one on a high and the other on a low plane of nutrition, and each beast is receiving, weekly, 22½ grams of DDT applied to the skin in oily solution. No ill effects have been observed up to three months.

3. *Buffalo Fly (Siphona exigua).*—(i) *Dairy Cattle.*—This aspect of the investigation can now be regarded as completed. It has been shown that the fly may be controlled efficiently in dairy herds by any one of three methods: by the use of DDT-treated, glass-walled traps; by lightly spraying the cows while in the bails with 4 per cent. solution of DDT in power kerosene every second or third day; or by more heavy spraying as for the dry stock. Control in dry cattle can be obtained by spraying the shoulders of about half the animals every three weeks during the fly season with 2-4 fl. oz. of a bland 2 per cent. DDT emulsion or 0.5 per cent. DDT as "Rucide".

(ii) *Beef Cattle.*—The same method of spraying with 2 per cent. DDT in emulsion or 0.5 per cent. in colloidal suspension is effective in beef cattle which are handled sufficiently often. It has been found convenient and successful to spray the cattle while still packed in the draining pen after dipping; under these conditions, labour and cost are insignificant.

The effect of 0.5 per cent. DDT as "Rucide" suspensions when used to treat the whole animal has been studied in experiments on cattle-tick control with a dip and spray-race (see Section 2 above). Protection from buffalo fly lasted for a longer period than the life-cycle of the fly, so that it seemed that the whole local population was destroyed and reinfestation occurred only as a result of infiltration from outside the property.

(iii) *General.*—An information circular giving progress results was distributed during the year, and a bulletin describing the completed research is now in preparation.

While the main problem in areas of dense cattle population appears to be solved, work is continuing on possible methods of applying DDT automatically to cattle in the paddocks, and on biological studies of the buffalo fly, designed to elucidate its rate of infiltration into freed areas, and to assess more accurately the probable ultimate distribution of *S. exigua* in Australia. The chief result to be recorded from the current biological studies is the development of a simple method of bio-assay, using adult buffalo flies; this has

resulted in a quicker assessment of toxicity and persistence of different DDT preparations than would otherwise have been possible.

4. *Sheep Blowfly.*—Further tests were carried out to evaluate the effectiveness of DDT for use against the Australian sheep blowfly. Experiments with DDT for protection against body strike took the form of insectary tests in which treated long-woolled sheep were exposed to a dense population of egg-laying flies. Emulsions, suspensions, or solutions of DDT were applied as a coarse spray to limited areas on the back of each sheep. Cotton wool plugs soaked in a solution (indole and ammonium carbonate) which stimulates oviposition were tied in the fleece in treated and adjacent untreated areas, and the relative number of egg batches laid on control and test plugs used as the criterion of effectiveness of the treatment. The sheep were brought into the insectary and tested in this fashion at intervals until there was no difference in the number of eggs laid on test and control plugs.

Emulsions and kerosene solution containing 1 or 2 per cent. DDT gave almost complete freedom from oviposition for four to six weeks. Suspensions were not as effective. Preliminary tests with 666 indicated that it gave considerably less protection than equivalent concentrations of DDT. These insectary tests are now being related by means of field trials to actual conditions of usage.

The effectiveness of DDT as a stomach poison is being evaluated by growth retardation studies of blowfly larvae reared under sterile conditions on an artificial medium containing the poison. DDT is more toxic to young larvae than to older larvae. It is more effective as a stomach poison than sodium arsenite, and considerably more effective than boric acid. The addition of DDT to solvents or emulsions had little effect on mortality in contact toxicity studies in which fully grown larvae were immersed in the fluids for five minutes.

5. *Physiology and Toxicology.*—(i) *Repellent Tests.*—Work is continuing on an attempted correlation of chemical structure and physical properties with repellent activity, using the mosquito, *Aedes aegypti,* as the test insect. The phthalates and a group of phenol ethers which occur naturally in the essential oils of some Australian plants are at present being examined.

(ii) *Biological and Chemical Estimation of DDT and Other Insecticides.*—Fourth instar *Aedes aegypti* larvae, grown under standard conditions, have been used for the bio-assay of DDT and to explore the insecticidal properties of a number of Australian plants. Acetone extracts dispersed in water were used in these studies. Eighteen plant extracts were tested. Of these, four produced more than 50 per cent. mortality in 24 hours at 80° C. in a concentration of 4,000 parts per million (based on original air-dry weight). The most effective extract tested was from the leaves of *Piper novae-hollandiae* Miq.

Work on the estimation of DDT by the adapted method, using Conway micro-diffusion dishes, was continued. Modifications introduced in the hope of making the method more suitable for routine procedure were not very successful. An electrometric titration method was tried out, but was found to be insufficiently sensitive to be of use for the estimation of DDT on cattle hair. It was found that waxes and other extractable materials on cattle hair or vegetable matter interfered with the estimation of DDT by the "xanthydrol" method. A new method depending on the regeneration of colour in decolorized triphenyl methane dyes by the hydrochloric acid split from DDT was investigated, but consistent results could not be obtained. Some promise was shown by a polarographic method for estimating the chloride after dehydrohalogenation, and a study of this technique is continuing.

(iii) *Synergists for Pyrethrum.*—The work on synergists ("activators") for pyrethrum in fly sprays is being terminated and the results prepared for publication. The basis of the synergistic effect of various materials from Australian and other sources has been investigated. Tests have been carried out on further compounds chemically related to synergists which had been investigated previously. New methods of testing synergists have been devised by which it can be determined whether the synergist acts by increasing the quantity of toxic material acquired by the flies during exposure to the spray mist or by rendering more effective the dosage which is received.

(iv) *General.*—After the lapse of war years, work has recommenced on fundamental studies dealing with insect physiology and toxicology. It is hoped that these will open up new approaches to insect control. Preliminary studies have been made on the insect cuticle and cuticular penetration. The effect of poisons on insect enzymes is also being studied to obtain information on the mode of action of insecticides.

6. *Biological Control.*—(i) *General.*—The investigations carried on during the past year have been mainly concerned with the biological control projects already in progress against insect pests of major economic importance. A considerable amount of work has also been carried out on the biological control of St. John's wort and good progress has been made. Assistance has also been given with the introduction to the United States of St. John's wort insects now established in Australia. As in previous years, very valuable assistance was given by officers of the State Departments of Agriculture and the Waite Agricultural Research Institute in liberating insects bred at Canberra for distribution, and furnishing reports on the subsequent history of the liberations.

(ii) *Biological Control of Insect Pests.*—(*a*) *Cabbage White Butterfly (Pieris rapae).*—The introduced Braconid parasite, *Apanteles glomeratus,* was recovered from the field in appreciable numbers during the 1945-46 season, and now appears to be well established under field conditions in the Australian Capital Territory. As a result, additional numbers were available for distribution. A report received from the Waite Agricultural Research Institute (to which consignments totalling over 1,000 were sent for local distribution during the year) gives hope that this parasite may be established in the vicinity of Adelaide.

The Pteromalid parasite (*Pteromalus* sp.), which is closely related to, if not identical with, *P. puparum,* was also found to be attacking *Pieris* quite commonly throughout the Australian Capital Territory. Supplies of this parasite were made available to the Plant Research Laboratory of the Victorian Department of Agriculture.

Although no general survey has yet been made to assess the value of these parasites as controlling agents of the cabbage white butterfly, the ease with which either species can be recovered in the field does suggest considerable activity on the part of both parasites.

(*b*) *Citrus Red Scale (Aonidiella aurantii) and Brown Olive Scale (Saissetia oleae).*—The breeding, at Canberra, of the Encyrtids *Comperiella bifasciata* and *Metaphycus helvolus,* parasites of the red and brown olive scales respectively, has been discontinued owing to difficulties in maintaining supplies of the host material. The latest reports do not encourage much hope that either parasite will establish itself effectively in this country; although the Waite Agricultural Research Institute has reported the recovery of both species in small numbers from the Adelaide area.

(*c*) *Green Vegetable Bug (Nezara viridula).*—Further introductions of the Tachinid parasite, *Trichopoda pennipes,* from the United States are being postponed until more rapid air transport facilities are available. Earlier attempts to establish this parasite here were unsuccessful.

(*d*) *Potato Moth* (*Gnorimoschema operculella*).—The study, breeding, and distribution of parasites introduced from overseas for use against the potato moth has been one of the major biological control projects carried on during the past year. Difficulties associated with the introduction and laboratory breeding of certain of these parasites have been largely overcome, and as a result of the improvement in breeding techniques, it is hoped that further introductions of these species of parasites can be discontinued. As a result of intensified breeding work, it has been possible to make further large distributions of introduced parasites in suitable areas. Substantial liberations have been made, and further evidence has been obtained that certain of the introduced parasites may be making some progress towards establishment following their release.

A further eighteen consignments of *Microbracon gelechiae* were introduced during the 1945-46 season. Laboratory breeding was continued. In all a total of 10,410 adult parasites was liberated. Of these 3,300 were released in the Crookwell district, New South Wales, and the remaining 7,110 on potato crops in the Australian Capital Territory.

Eleven additional consignments of *Chelonus phthorimaeae* were received from overseas during the period under review. Improved methods for the breeding of this parasite enabled much larger distributions to be made than were previously possible. Of a total of 12,706 *Chelonus* distributed during the 1945-46 season, 4,706 were liberated in the Home Hill, Ayr, and Bowen districts, Queensland, 7,200 were released in the Crookwell and Bolwarra districts of New South Wales, and 800 were liberated in South Australia.

A further twenty trial consignments of *Omorgus phthorimaeae* were introduced from California, but efforts to establish a laboratory colony of this parasite have so far been unsuccessful. Only small numbers in any one consignment survived the journey to Australia, and the numbers emerging at any one time were too few to permit the development of a new generation.

What promises to be one of the most outstanding parasite introductions yet made against the potato moth is that of the South American polyembryonic Encyrtid, *Copidosoma koehleri*. This parasite attacks the egg stage of the potato moth, and later emerges from the host larva. From 20 to 30 parasites may develop from a single host. The first consignments of *Copidosoma* were received in July, 1945, and since then, seven liberations totalling 182,100 parasites have already been made. Of these, 181,000 were liberated in the Crookwell district, selected because of its accessibility to Canberra and because potato-growing is a permanent feature of the local agriculture. The remainder was liberated at the Council for Scientific and Industrial Research Experimental Farm, Dickson, Australian Capital Territory. For these liberations, a special cage was devised and used, which facilitated mating and afforded protection against rain and predators. A very encouraging feature has been a 7½ per cent. recovery of *Copidosoma* from host larvae infesting potato plants and tubers collected at Crookwell. It has yet to be determined, however, whether the parasite will be capable of overwintering in the field.

(*e*) *Buffalo Fly* (*Siphona exigua*).—A further consignment of the predatory Hysterid beetle, *pachylister chinensis*, which attacks the larvae of the Buffalo fly, was introduced from Fiji during 1936, and from this material 82 adult beetles were forwarded to North Queensland for liberation.

(iii) *Insect Control of St. John's Wort* (*Hypericum perforatum*).—Inspections were made during November, 1945, of colonies of *Chrysomela hyperici* in the Orange, Sodwalls, Mudgee, Piambong, and Rylstone districts of New South Wales, those in the last two districts mentioned showing the most progress. At Mannus, near Tumbarumba, New South Wales, where 60,000 adults were liberated in December, 1944, the insects had multiplied very well and had produced a marked effect on the weed throughout the area colonized. *C. hyperici* is widespread in the Ovens Valley, adjacent to Bright, Victoria, and is well distributed in the vicinity of German Creek and Harrietville. In this area, it is exercising a worthwhile degree of control. (No inspections were made in the Dargo, Tawonga, or Ovens Vale districts.) Near Mansfield, Victoria, where 20,000 adults of *C. hyperici* were liberated in November, 1944, a recent report indicates that the insects were making some progress. In South Australia, where this species and the related *C. gemellata* were liberated during 1943 and 1944, reports from the Waite Agricultural Research Institute indicate that the colonies are already established and should soon provide material for further distribution.

Chrysomela gemellata is now considered to be the most effective of the three *Hypericum* insects established in Australia. During the past year, the original colony at Baker's Gully, Bright, had made particularly good progress, and is now exercising a very satisfactory degree of control over the weed in this locality. Paddocks which formerly were completely covered by a dense growth of St. John's wort have been cleared in three years, and little or no regeneration of the weed has taken place since the destruction of the original stands. During the year, officers of the Vermin and Noxious Weeds Branch of the Victorian Department of Lands and Survey distributed some half-a-million adult *C. gemellata* to landholders in the weed-infested areas of the Ovens and Kiewa valleys, and a further 103,000 (collected at Baker's Gully) were distributed by officers of the Division of Economic Entomology, the great majority being liberated in the Castlemaine-Campbelltown district of Victoria.

The main colony of *Agrilus hyperici* at Baker's Gully, Bright, appears to be developing steadily, and during 1945 provided further supplies of this insect for despatch to America. Colonies at Piambong and Mudgee, New South Wales, seemed to be making some progress; but the *Agrilus* populations in these localities have not yet produced any appreciable effect on the weed.

It has been possible, during the 1945-46 season, to send further substantial consignments of *Hypericum* insects to U.S.A., on behalf of the Division of Foreign Parasite Introduction of the United States Department of Agriculture. Included in the four consignments shipped were 28,500 *C. gemellata*, 10,000 *C. hyperici*, and about 1,500 *Agrilus hyperici*. Very satisfactory progress has been reported from California in the testing and colonization in the field of the two species of *Chrysomela*, and there is no doubt that the large consignments received from Australia, with very light losses in transit, constituted a very important factor in expediting the results obtained.

7. *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; analysis of the outbreaks from 1940 to 1945; tests of DDT and 666; and taxonomic work.

During the season 1945-46, a widespread outbreak of moderate intensity developed in eastern Australia. All the swarms involved were produced by the multiplication and concentration of non-swarming locusts in the outbreak areas; only two minor infestations had been reported during the preceding season, and these had died out early.

Preliminary observations on the behaviour of locust swarms were made in the Trangie area towards the end of the year. The swarming locusts were found to show the same habitat preferences as non-swarming locusts, but these were reinforced by the gregarious instinct, which leads, for example, to an accumulation of ovipositing females on any small area on which two or three are already at work.

Continued difficulty in establishing the trees and shrubs planted out in connexion with experiments on the ecological control of swarm-formation in the Bogan-Macquarie outbreak area has led to a review of the prospects of this work. Watering of the trees already planted will be suspended, and their reaction noted. At the same time, two new plants, the belah (*Casuarina lepidophloia*), and the coobah (*Acacia salicina*), will be tried in a final attempt to produce the type of vegetation which is required for these tests. They will be used in conjunction with old-man saltbush (*Atriplex nummularia*), the only plant so far used which is completely satisfactory.

The attempt to produce a vegetation cover on scalds (important as oviposition sites of *Chortoicetes*) by seeding selected species of *Kochia* and *Atriplex* in plough furrows has given disappointing results. *Atriplex vesicaria* was the only species to come up in appreciable numbers, and even this plant will be quite ineffective for the purpose in view unless its density is much increased by self-seeding under the protection of the parent plants. A further experiment has been commenced to determine whether branches of the broom-like currant-bush (*Apophyllum anomalum*), when laid on the bare surface of a scald, will accumulate windblown sand and lead to the germination and establishment of native grasses and herbage.

Encouraging results have been obtained from the laboratory tests of DDT and 666 against *Chortoicetes* hoppers and adults. The chemicals have been applied as dusts to a smooth surface at the rate of 100 mg. per square foot. Locusts have been confined on these surfaces for periods varying from five to 125 minutes, and then removed to recovery cages supplied with food. Dusts containing 5, 10, and 20 per cent. of DDT (p-p isomer), and 5 per cent. of 666 (0.5 per cent. gamma isomer), adsorbed on to pyrophyllite, and passing a 200-mesh sieve, were employed. The very high toxicity of 666 is indicated by the fact that a five-minute exposure to the low dosage of 100 mg. per square foot of a dust containing only 0.5 per cent. of the gamma isomer nevertheless resulted in an average mortality (corrected for control mortality) of 80 per cent. of the insects. DDT was considerably less effective. With 666, most of the mortality occurred within 48 hours of exposure; DDT acted rather more slowly.

Work has been continued on the taxonomy and phases of the species of *Chortoicetes* and *Austroicetes*, and on the biology of certain wolf-spiders that prey on *Chortoicetes* hoppers. A survey has been commenced of the parasitic mites found on various locusts and grasshoppers.

8. *Insect Pests of Stored Wheat.*—(i) *General.*—The Division's work on wheat storage problems terminated this year. Further research seemed unnecessary as solutions to most of the important problems had been found, whilst the existing wheat stocks are the smallest since the inception of the Australian Wheat Board. The experience of this year has confirmed the satisfactory character of the measures developed for the control of weevil in bulk depots. In Victoria, some fifteen million bushels of wheat stored in bulk depots were treated by the mineral-dust-cum-fumigation method. Although this wheat was held in store for up to three years, the whole of it has been passed on to the market in excellent condition without any being subjected to a dockage on account of weevil damage or bin-scald. Similarly, the method of fumigating *in situ* entire stacks of bagged wheat which had become weevily, has proved completely satisfactory. Altogether, in South Australia, about four million bushels of wheat have been fumigated by this method, which has solved a problem which had threatened to become acute, particularly in outlying sidings from which the grain could not readily be removed. Experiments have shown that methyl bromide can satisfactorily replace carbon bisulphide for stack fumigation. Used at 1½ and 2 lb. per 1,000 cu. ft., methyl bromide gave good results under adverse temperature conditions. The use of methyl bromide would simplify the problems involved in applying the fumigant (besides being safer) and it is thought that this fumigant will eventually replace carbon bisulphide for stack fumigation.

(ii) *Laboratory Studies.*—The assessment of 70 mineral dusts for the control of *Calandra oryzae* and *Rhizopertha dominica* was completed, and it is now clear that magnesite is the most effective of the dusts available from local sources. In these experiments the dusts were mixed with the grain. Other tests have indicated that a 12-inch band of magnesite forms a highly effective barrier against walking adults of the eight most important grain-infesting Coleoptera.

DDT- and 666- impregnated dusts have proved very effective against both *C. oryzae* and *R. dominica* in laboratory tests. A 1:1,000 dust of crude 666 (13 per cent. gamma isomer) on pyrophyllite, used at the rate of 0.5 and 1 per cent. by weight of the wheat, gave a complete kill of *Rhizopertha dominica* in six to eight days and of *Calandra oryzae* (small strain) in four to six days. A DDT dust of similar strength gave a complete kill of *C. oryzae* in five days, but was less effective against *R. dominica*, giving only 95 per cent. kill after fourteen days. The pure gamma isomer of 666 has proved highly effective, a 1:5,000 dust with a pyrophyllite base giving complete mortality of both *R. dominica* and *C. oryzae* in five days, at the lower dosage rate of 0.5 per cent. by weight of the wheat.

The two strains of *C. oryzae*, both of which occur in this country, have been found to differ in their susceptibility to dusts and fumigants. Using highly effective dusts of the gamma alumina type, there is no significant difference in the speed of kill of the two strains, but with the less efficient dusts, such as magnesite or "katelsousse", the large strain is definitely the more susceptible. Fumigation tests with ethylene dichloride, a 1:3 mixture of carbon tetrachloride and ethylene dichloride, and ethyl formate have shown that with a three-hour exposure at 26° C., the small strain is, in general, more susceptible than the large strain. This agrees with previous experience in both laboratory and field experiments, where the fumigant was carbon bisulphide.

9. *Orchard Pests.*—(i) *Oriental Peach Moth (Cydia molesta).*—The 1945 experiment, in which two applications of a DDT spray were made at an interval of three weeks to protect the late fruit from attack by the moth, was continued on a small block of peaches in Ardmona. This year, instead of a DDT-solvent naphtha emulsion, a spray prepared from "Rucide" was used. The concentration of DDT, however, was the same (i.e. 0.1 per cent.). The degree of control was rather better than that obtained in the previous season, only 2.75 per cent. of the fruit from the treated trees being infested as compared with 9 per cent. on untreated trees.

(ii) *Codling Moth (Cydia pomonella).*—In field experiments carried out in a 10-year-old apple orchard at Jerrabomberra, Australian Capital Territory, two 0.1 per cent. 666 emulsions, and a 0.1 per cent. DDT-solvent naphtha emulsion were compared with a 0.5 per cent. lead arsenate plus 1 per cent. white oil spray. At harvest, after seven applications, the DDT spray

gave as good a control of codling moth as lead arsenate-white oil; the two 666 emulsions were inferior, and appeared to be of little value.

(iii) *Red Spider* (*Tetranychus urticae*) *and Mite* (*Bryobia praetiosa*).—Again evidence was obtained of severe mite infestation of apple trees following DDT treatment. After the experiments referred to in the previous paragraphs, records were taken of the number of over-wintering mite eggs deposited on fruit spurs. Compared with the number on spurs from untreated trees, there were almost twice as many eggs on DDT-treated spurs, half the number on 666-treated, and only one-sixth the number on spurs treated with lead arsenate-white oil. In one of two orchards near Canberra, in which severe outbreaks of mite had occurred following the use of a spray containing 0.025 per cent. DDT plus 0.4 per cent. lead arsenate, mites were controlled by treatment with a 0.75 per cent. white oil; but even the precaution of applying the spray early in the morning did not prevent some oil injury to the fruit. Effective control of mites, in this instance without injury to the trees, was also obtained by the use of half-strength "Dynone" (dicyclohexylamine dinitrocyclohexylphenate) and a mixture of "Dynone" and 0.1 per cent. DDT-solvent naphtha emulsion.

10. *Field Crop and Vegetable Pests.*—(i) *Potato Moth* (*Gnorimoschema operculella*).—The efficacy of a number of mineral dusts, and DDT, for the protection of stored tubers against attack by potato moth larvae was compared; the best results were obtained from a high-grade ferric oxide ore ground to pass 200-mesh B.S.S. impregnated with 1 per cent. DDT. As well as giving protection, this dust imparted a satisfactory colour to the tubers.

In field experiments at Canberra, three sprays containing 0.1 per cent. DDT (DDT-solvent naphtha emulsion, the proprietary emulsion "Pespruf 20", and "Rucide"), 0.6 per cent. phenothiazine, 0.6 per cent. synthetic cryolite, and a 2 per cent. DDT dust were tested for the protection they gave to haulms during the growing period, three applications being given in each case. The 0.1 per cent. DDT sprays were the most effective, followed by the 2 per cent. DDT dust; phenothiazine and cryolite gave little protection to the crop.

In large-scale trials at Crookwell, New South Wales, potatoes were dusted with 2 per cent. DDT three times, at three-weekly intervals. At harvest, the treated plots had no tubers infested with moth; the two control plots showed 12 and 24 per cent. infestation.

(ii) *Cabbage Moth* (*Plutella maculipennis*) *and Cabbage Butterfly* (*Pieris rapae*).—Field trials involving a total of 26,000 cabbages and 4,000 cauliflowers were carried out at Canberra during the year to compare DDT and 666 dusts and sprays, and to study the effect of the addition of various aphicides for the control of the cabbage aphis, which is relatively resistant to DDT. Two sprays containing 0.1 per cent. DDT (DDT-solvent naphtha emulsion and "Rucide"), at approximately 100 gallons per acre, and 1 per cent. DDT dusts at 30-40 lb. per acre, gave excellent control of butterfly and moth larvae in spring, summer, and autumn crops of cabbages when applied at fourteen-day intervals, the sprays being somewhat superior to the dusts. A 4 per cent. 666 dust and a 0.2 per cent. 666 spray proved as good as the DDT treatments, but 2 per cent. 666 dust and 0.1 per cent. 666 spray were not so effective. Lead arsenate, as a 20 per cent. dust, or 0.3 per cent. spray, and a 40 per cent. synthetic cryolite dust were markedly inferior to the DDT and 666 treatments. Some promising results were obtained with a combined 0.5 per cent. DDT-1 per cent. 666 dust, and a 0.025 per cent. DDT-0.3 per cent. lead arsenate spray.

(iii) *Cabbage Aphis* (*Brevicoryne brassicae*).—During the spring and summer months, predators and parasites kept the aphid population at a low level, and in only three of the eight trials was the aphis infestation sufficiently high to provide the basis for reliable comparative results. The 666 dusts and sprays proved to be outstanding. Nicotine sulphate added to DDT dusts in which pyrophyllite, kaolin, magnesite, calcium carbonate, and activated alumina were the diluents, gave excellent control, and the addition of nicotine did not affect the efficacy of the DDT against cabbage moth and butterfly. The DDT-nicotine dust in which hydrated lime was used as the diluent, however, although giving good control of aphis, gave unexpectedly poor results against moth and butterfly larvae. It was thought that this might be due to a reaction between the lime and DDT. The addition of 0.5 and 1 per cent. rotenone (in the form of Timbo) and "Lethane B71" to DDT dust gave good control of aphis. Nicotine sulphate and soft soap were added to two forms of DDT spray, and gave good results, but the addition of "Lethane B60" and "Lethane B72" did not give satisfactory control.

11. *Insect Vectors of Plant Viruses.*—(i) *Yellow Dwarf of Tobacco.*—The investigation of yellow dwarf disease recommenced in 1941, in co-operation with the Division of Plant Industry, was continued at Canberra and Myrtleford, Victoria. The Victorian Department of Agriculture collaborated in the field experiments at Myrtleford. The object of the tests undertaken was to determine whether the incidence of diseased plants in the crop could be substantially reduced by controlling the vector (the brown jassid, *Thamnotettix argentata*), using a 0.1 per cent. DDT-solvent naphtha emulsion. The results at Myrtleford were rendered inconclusive by a mass infestation of jassids following the development of conditions favoring their multiplication. In the Canberra experiments, however, the disease was reduced by 16 per cent. in the treated plants. In comparison with the controls, there was an increase of ten inches in the average height of the treated plants, and a slight increase in the length of the longest leaf. There was a marked increase in the number of leaves sixteen inches and over, indicating a significant increase in yield of commercial leaf.

(ii) *Potato Virus Diseases.*—The survey, begun in 1941, of 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, Australian Capital Territory. The records obtained were closely comparable to those of the previous season. The spring population was low; there were no mass flights of winged forms, and no winged forms were caught in the mechanical nets after the end of October until a small autumn generation appeared in March and April.

12. *DDT Emulsions.*—In the continuation of the experiments undertaken to develop a type of DDT emulsion suitable for horticultural purposes, which would be an improvement on the solvent naphtha emulsion hitherto used, 63 different mixtures, with and without 0.1 per cent. DDT, were tested for phytotoxicity on French bean and tobacco seedlings. Twenty-five of the mixtures had no adverse effect on the seedlings; and four of the DDT preparations, namely, emulsions made from toluene, xylene, *Eucalyptus dives* oil, and the proprietary "Rucide", appear very promising for practical purposes. Of the four, the first and last mentioned seem likely to be the most useful. Two DDT solvents, known to be good acaricides and thus of possible value for the control of the mite (*Bryobia*) and red spider (*Tetranichus*) on fruit trees, were also tested, but proved to be phytotoxic. All the cationic wetting agents tested were phytotoxic.

13. *Termites.*—Investigational work on termites has not yet been resumed on a large scale, and during the past year the only activity, other than the annual routine examination of the samples in the International

Termite Exposure Test, has been the study of a building infestation by a tree-dwelling colony of *Coptotermes frenchi*. Positive evidence was obtained showing the connexion between the workings of this species in the building and a tree-nest some 70 feet distant, and the colony appeared to have been almost completely destroyed by treating main runways under the building with a small amount of white arsenic.

14. *Miscellaneous Pests.*—(i) *Red-backed Spiders* (*Latrodectus hasseltii*).—Tests with mature female spiders have shown them to be very susceptible to pyrethrum sprays. A rapid knockdown with no recovery was obtained with a spray containing 0.1 per cent. pyrethrins, indicating that any good-quality household fly spray should be effective for the control of this spider.

(ii) *Meat Ants* (*Iridomyrmex detectus*).—Three series of experiments were carried out during the year in the Australian Capital Territory to determine the efficacy of DDT and 666 for the control of meat ants. Using a knapsack duster, with a conical adaptor fitted to the discharge tube, 111 nests in one Canberra suburb were treated with a 2 per cent. DDT dust, applied at the rate of ½ oz. to each entrance hole. A complete kill was obtained in every instance, but the treatment did not prevent the repopulation of the nests by ants from colonies outside the treated area. The 2 per cent. DDT dust, besides being comparatively cheap and more effective than the insecticides previously used and recommended (i.e. carbon bisulphide, calcium cyanide, and solvent naphtha), is much more pleasant to handle. One hundred colonies in another part of the Canberra district were treated with a dust containing 5 per cent. 666, also at the rate of ½ oz. per entrance hole. A high initial kill was obtained, and the 666 prevented the colonies from building up numbers to pest proportions during the summer months: but this treatment was less effective than the DDT.

15. *Systematic and General Entomology.*—During the year, a considerable number of insects have been identified for entomologists and institutions in Australia, New Zealand, and other countries, and assistance has been given in various systematic problems.

Many useful additions have been made to the Division's reference collection, the outstanding acquisition being a collection of mosquitoes from the Australian region, presented to the Division by Mr. D. J. Lee and Major A. R. Woodhill, of Sydney University. This collection, which includes many type specimens, comprises a substantial part of the material collected by Australian Army entomologists and others in the South-West Pacific area during the war.

Some time has been devoted to rearrangement of certain sections of the Divisional collection, and preliminary revisions of the Australian species of two orders, the Mecoptera and Megaloptera, have been completed.

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

Cashmore, A. B., and Campbell, T. G. (1946).—The weeds problem in Australia. *J. Coun. Sci. Ind. Res.* (Aust.). 19:16-31.

Gay, F. J. (1946).—The effect of temperature on the moisture content-relative humidity equilibria of wheat. Ibid. 19: 187-9.

Gilmour, D., Waterhouse, D. F., and McIntyre, G. A. (1946).—An account of experiments undertaken to determine the natural population density of the sheep blowfly *Lucilia cuprina* Wied. Coun. Sci. Ind. Res. (Aust.), Bull. 195.

Greaves, T. (1945).—Experiments on the control of cabbage pests in North Queensland *J. Coun. Sci. Ind. Res.* (Aust.). 18: 110-20.

Hackman, R. H. (1946).—The preparation of some emulsions containing DDT. Ibid. 19: 77-85.

Helson, G. A. H., and Greaves, T. (1945).—The use of DDT as an agricultural insecticide. Results of trials, 1944-45. Ibid. 18: 301-9.

Helson, G. A. H., and Waterhouse, D. F. (1945).—The present status of DDT as an insecticide. *J. Aust. Inst. Agric. Sci.* 11: 172-8.

Key, K. H. L. (1945).—The general ecological characteristics of the outbreak areas and outbreak years of the Australian plague locust (*Chortoicetes terminifera* Walk.). Coun. Sci. Ind. Res. (Aust.), Bull, 186.

Mackerras, I. M., and West, R. F. K. (1946).—DDT poisoning in man. *Med. J. Aust.*, March 23, p. 400.

Norris, K. R. (1946).—The testing of the American horn fly trap, and a new type of trap involving the use of DDT against the buffalo fly, *Siphona exigua* (de Meij.). *J. Coun. Sci. Ind. Res.* (Aust.). 19: 65-76.

Waterhouse, D. F. (1945).—Studies of the physiology and toxicology of blowflies: 10. A histological examination of the distribution of copper in *Lucilia cuprina*. 11. A quantitative investigation of the copper content of *Lucilia cuprina*. Coun. Sci. Ind. Res. (Aust.), Bull. 191.

IV. ANIMAL HEALTH AND PRODUCTION INVESTIGATIONS.

1. *General.*—During the year the work of the Division of Animal Health and Production has been conducted at the two main laboratories in Melbourne and Sydney and at the major field stations at Cunnamulla (Q.), Badgery's Creek (N.S.W.), and Werribee (Vic.). Co-operative work with State Departments of Agriculture has been continued. The period has been notable for the commencement of active work in several new lines of investigation in connexion with animal production.

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. During this period funds from the Wool Research Trust Account were made available for the first time. These have permitted the planning and partial development of a greatly expanded research programme for the sheep and wool industry.

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 continued and the first stages of completion were begun. During the year 318,000 doses of vaccine were distributed to centres in Queensland and the Northern Territory mainly. Antigen for the complement-fixation test was supplied to Kenya as in the past, and 1,600 tests were carried out for the Queensland Department of Agriculture and Stock.

(ii) *Enterotoxaemia of Sheep and other Diseases Due to Clostridia.*—Attempts were made to determine the conditions which permit the absorption of epsilon toxin of *Cl. welchii* type D from the bowels of sheep. It was found that the main factors are a very high concentration of toxin (minimum 2,000-3,000 intravenous m.l.d.), its presence at a high level of the small bowel, and some means of localizing the toxin for a sufficient period. No clear evidence was found that alpha or theta toxins, histamine, or egg white facilitated penetration of epsilon toxin. Epsilon toxin introduced into the ligated small intestine disappears at a fairly rapid rate by some unidentified mechanism. In a study of the pathogenicity of *Cl. chauvoei* for guinea pigs it was found that the pathogenicity could be strikingly

enhanced by admixture with 0.1 milligram of adrenaline. The study of strains of *Cl. botulinum* A. isolated by the Division of Food Preservation and Transport was concluded.

(iii) *Caseous Lymphadentis of Sheep.*—The importance of shearing wounds in infection with *Corynebacterium ovis* was strikingly demonstrated by the finding that amongst 824 shorn lambs 128 or 15½ per cent. were rejected for export because of infection, whereas amongst 2,212 lambs which had not been shorn only 22 or 1 per cent. were similarly rejected. The results obtained at slaughter with wethers, some of which had been vaccinated yearly since 1941, showed that vaccination appreciably raised the level of resistance to infection; on the other hand, there was proportionately a higher incidence of prescapular-precrural lesions in the vaccinated than in the controls.

(iv) *Tuberculosis of Cattle.*—Complement fixation (C.F.) was continued on the lines described in the last report. The results with tuberculin-positive cattle to date may be summarized as follows: of 595 which were found to be tuberculous at autopsy, 87.9 per cent. reacted positively to the C.F. test, whereas of 139 in which tuberculosis could not be demonstrated at autopsy 68.4 per cent. reacted positively to the C.F. test. With cattle which had not been tuberculin-tested, all of 5 found infected at autopsy reacted positively to the C.F. test, whereas of 251 not found to be infected, all reacted negatively to the C.F. test.

During the year 156 serum samples were tested for the Queensland Department of Agriculture and Stock.

(v) *Mastitis in Dairy Cattle.*—The systematic epidemiological studies were continued on the experimental herds. The three small herds referred to in the last report have either completed or nearly completed their lactation periods. The results have not yielded evidence that the ingestion of *Strep. agalactiae* during calfhood leads to the development of streptococcal mastitis during the first lactation period; no evidence of infections other than a very rare occasional isolation of *Strep. agalactiae* has been obtained in the two herds which ingested the organism as calves. As a control to the susceptibility of this line of calves, the control herd has subsequently been introduced into an infected herd for its second and third lactation periods; to date, only 6 occasional isolations have been made.

Much attention has been given to investigating the value of penicillin in bacterial infections of the udder. The good results discussed in the last report have been confirmed and extended. The most efficient treatment consistent with practicability was found to be three doses of 25,000 units at intervals of 24 hours; in a large series of cases of clinical streptococcal mastitis, including acute, sub-acute, and chronic, penicillin was over 90 per cent. efficient and was not demonstrably more so if the penicillin were suspended in peanut oil instead of dissolved in distilled water. A single large dose, e.g., 100,000 units, was much less efficient.

Good results (over 90 per cent. efficient) were obtained also with subclinical persistent infections. Streptococcal infections due to non-group B streptococci also responded well.

As before, staphylococcal infections responded poorly to the standard treatment, although the strains were shown to be susceptible, a temporary fall in the number of staphylococci was followed by a rise when treatment ceased. However, there are some indications that better results may follow a more prolonged course of treatment.

(vi) *Toxaemic Jaundice in Sheep.*—Observations on the second flock of ewes at Barooga have been continued in co-operation with officers of the Veterinary Research Station at Glenfield, New South Wales. The experiment in which these sheep were used was designed to determine the effect upon them of grazing on the summer-growing annual *Heliotropium europaeum*. This study will be concluded after weaning of this year's lambs by slaughter of all remaining ewes. The final interpretation of results will rest upon the pathological examination of material collected.

A more detailed survey of the pastures in the enzootic areas from the point of view of copper content and species distribution as affected both by seasonal conditions and geographical position has been embarked upon. For this purpose the active co-operation of the Divisions of Plant Industry and Soils has been obtained. Regular surveys are being conducted on nine properties on which are also placed "pilot" flocks of wether weaners some of which will be slaughtered at intervals for the determination of liver copper and correlation with the pasture surveys.

At the laboratory, studies were continued on copper assimilation and storage in the liver. The limiting effect of molybdenum on copper storage has been confirmed, but the evidence available does not suggest that a deficiency of molybdenum is associated with the etiology of the disease in the field. Further, calculations from the figures now available suggest that top-dressing of pastures with molybdenum salts would not be an effective or economic method of controlling the disease.

A more detailed progress report on the work on toxaemic jaundice has recently been submitted to the Australian Wool Board for publication.

(vii) *Haematuria Vesicalis of Cattle.*—Methods for estimating various groups of urinary phenolic bodies in cows have been perfected during the year and systematic observations have been begun.

(viii) *Contagious Abortion of Cattle.*—During the year about 11,260 doses of "Strain 19" vaccine were prepared and supplied to the Victorian Department of Agriculture. Manufacture ceased on 6th February, 1946, and was taken over by the Commonwealth Serum Laboratories, Royal Park.

The experiment designed to test the resistance of vaccinated calves to natural infection continues. To four have calved, of which three had infected dis- date, out of 29 controls fifteen have developed infection, charges, and seven had aborted; on the other hand, out of 27 vaccinated only one developed infection, nine have calved of which none had infected discharges and none has aborted. During some field trials of vaccine in adult lactating herds it was observed that when the plane of nutrition was high, milk loss was minimal or might not occur at all, whereas when it was low, the transient milk loss might reach 12 per cent. over a period of six days.

(ix) *Toxicity of Wheat for Stock.*—The histidine-decarboxylating organism referred to in the last report has been isolated in pure culture and is being studied. It is a lactobacillus which grows luxuriantly only on special media and in the presence of sufficient carbon dioxide. An attempt is being made to assess indirectly, by the use of the anti-histamine drug N-dimethyl aminoethyl N-p-methoxybenzyl α-aminopyridine, the role of alimentary histamine in the causation of laminitis of horses which have gorged upon wheat.

(x) *Anaplasma centrale and Haemobartonella bovis.*—It was found that the strain of *A. centrale* had become mixed with *H. bovis*, hitherto not recorded in Australia. The contamination can be traced to a locally-bred passage calf, and there seems little doubt that the infection was not introduced from South Africa with the original imported calves in 1933, but exists unrecognized in Australia. It is of no pathogenic significance. *A. centrale* has successfully withstood sixteen months at −80° C. so far, whereas *H. bovis* survived for nine months but after sixteen months was no longer viable. In this way the *A. centrale* has been freed of the contamination with *H. bovis*.

(xi) *Effect of Administration of Thyroxin upon Cattle.*—In collaboration with the Department of Biochemistry, University of Melbourne, an experiment has been carried out to determine the effect of administration of thyroxine upon cattle on open pasture. During a period of eight weeks nine cattle received thyroxine subcutaneously every two to three days. It was found necessary to increase the daily administration to 40 mg. per day in order to cause significant depression of weight gains as compared with control animals.

The materials collected at autopsy are being analysed and will be reported in a publication.

(xii) *Possible Toxicity of DDT for Cattle.*—In order to determine if DDT is likely to become toxic to cattle when applied to the skin for very long periods, fifteen cattle are being subjected to a severe test which will last for three years. Every week 22.5 grams of DDT dissolved in 300 ml. of peanut oil is applied to the skin of the chest and back. It is proposed to examine at autopsy four animals at the end of each year. These animals are maintained on a low plane of nutrition, whereas in a similar experiment being carried out in Queensland by the Division of Economic Entomology the animals are maintained on a high plane of nutrition.

3. *The McMaster Animal Health Laboratory.*—(i) *Parasitological Investigations.*—(*a*) *Study of anthelmintics against Haemonchus contortus.*—The following were found to be ineffective when injected into the rumen:—Dinaphthyl-thiourea, chloranil ("Spergon"), ethyl cresolinate, naphthylthiourea, hexachlorocyclohexane ("666"), benzyl chloride, alpha-terpineol, trichlorbenzene tetrachlorbenzene, para-tertiary-butylphenol (Butylphen), and hexane. When injected into the abomasum dinaphthyl-thiourea and chloranil were ineffective but some anthelmintic effect was obtained with thiocarbanilide, 2,3-dichloronaphthyl-quinone, para-tertiary-butylphenol, and hexane.

Calcium fluoride in relatively large doses injected into the rumen or abomasum had some erratic and generally temporary effect on egg counts. Nicotine bentonite, at non-toxic doses, was ineffective when injected into the rumen.

Copper sulphate was moderately to highly effective against *Haemonchus contortus* when two or three grams were injected into the rumen but one gram was ineffective.

(*b*) *Study of anthelmintics against Trichostrongylus spp.*—Para-tertiary-butyl phenol was ineffective when injected into the rumen and moderately effective via the abomasum. Phenothiazine, even in relatively small doses, was no less effective via the rumen than via the abomasum. The addition of alkaline compounds to anthelmintics including phenothiazine, as recommended by certain overseas workers, did not increase efficacy.

The efficacy of phenothiazine in doses ranging from 10 to 50 grams was tested in a comprehensive experiment involving 80 young sheep which were killed for autopsy 25 days after treatment. Data from this trial are still being analysed, but it is clear from the curve plotted through points representing dose rate/anthelmintic efficiency that efficiency increased directly with dose rate and was still rising at the 50 grams level. The customary dose for sheep of this age and weight has been 20 grams.

(*c*) *Study of anthelmintics against Oesophagostomum columbianum.*—Micronized phenothiazine was compared with commercial phenothiazine in a trial involving 54 sheep. Using 10-gram, 15-gram, and 20-gram doses, the micronized product appeared to be slightly more effective but the difference compared with the commerical product was not statistically significant.

(*d*) *Administration of phenothiazine in salt-lick, and in small repeated doses.*—A further field trial at the McMaster Field Station again showed that when 1:15 and 1:30 phenothiazine/salt mixtures were available the daily phenothiazine intake per sheep seldom reached 0.2 gram and was generally much less. Such treatment had no apparent anthelmintic effect except occasional interference with development of larvae in cultures. A field trial with 1:15 phenothiazine salt mixture was also conducted in the Stanthorpe district of Queensland, 400 sheep being involved for ten months. The daily phenothiazine intake was somewhat higher in this trial but never exceeded an average of 0.25 gram per sheep. There was no detectable benefit and in both trials conspicuous phenothiazine staining of the wool was observed.

When small doses of phenothiazine were administered to sheep daily, 0.25 gram prevented development of larvae in faecal cultures, continued daily dosing with 0.5 or 1.0 gram, although appearing to eliminate *H. contortus*, was without conspicuous effect on *Trichostrongylus* spp. It was also observed that these doses did not suppress *Strongyloides* larvae in faecal cultures. It is concluded that the adminstration of phenothiazine in salt-lick mixtures is ineffective under Australian conditions.

(*e*) *Effect of worm parasites on body weight and wool growth.*—Reference to the adverse effects of oesophagostomiasis was made in the previous report. The appetite of sheep dosed with larvae of *O. columbianum* decreased by about 50 per cent. within three weeks of infestation, with a 20-30 per cent. loss of body weight which was not regained for seven to eleven months. These sheep were in pens and on good rations. This indirect result of infestation with the nodule worm probably deprives infested sheep of much of the benefit they would otherwise obtain from plentiful feed in the summer and autumn, and accentuates the effects of nutritional stresses they endure in winter when oesophagostomiasis is chiefly manifested.

(*f*) *Observations on the oesphageal groove reflex.*—Copper sulphate solution administered from drenching syringes brought this reflex into operation in only a small percentage of sheep throughout several groups, whereas similar solutions used previously under similar conditions, but administered from a bottle, were highly effective. This may have considerable significance in practice and will be investigated further.

(*g*) *Haematological studies of helminth infestations.*—Work has recently commenced.

(*h*) *Epidemiology.*—This work is continuing in Queensland, New South Wales, and South Australia and requires no special comment. Information on the daily faecal output of sheep of different ages and types on various rations is being collected as opportunity offers. In regard to *H. contortus* it has been observed that heavily infested sheep can be further infested; sheep which have thrown off an initial infestation or from which this parasite has been eliminated by phenothiazine can be reinfested within a few days.

(*j*) *Parasitological studies at Armidale.*—In a further trial of the effects of improved nutrition on weaners during their first winter, very promising results were obtained from grazing on green oats, particularly with a group grazed thereon continuously from May until September. Among this group of 45 weaners there were no deaths, and body weight increased by some 18 lb. The average weight of greasy wool shorn was approximately 4.75 lb. per head and valuation off shears was 12s. 6d. per head. This has to be compared with a similar group on natural pasture supplemented with 4-oz. per sheep per day of a meat-meal, maize, and chaff mixture. In this latter group eight died, weight increased only 2.5 lb., greasy wool averaged 3.5 lb., and valuation off shears was 7s. 6d. The sheep grazed on green oats continuously, quickly threw off infestation with *Oesophagostomum columbianum* and, although *Haemonchus contortus* egg counts

increased throughout the winter, there were no clinical symptons. Several additional observations of interest were made and a further trial is being undertaken. The epidemiology trial has been continued. Further evidence of the "self cure" phenomenon mentioned in the previous report was obtained on different properties. Work on lamb marking dressings is referred to under (iii) (*c*). A good deal of preliminary survey work was done on a new experimental area of some 4,500 acres which it is hoped to acquire for experiments on parasite control and pasture management. An Ian McMaster Research Scholar was appointed in April and is studying the bionomics of the snail, *Limnea brazieri*, in the vicinity of Armidale.

(*k*) *Parasite physiology and toxicology.*—An experienced officer who has worked and studied in this field for some years in England, joined the McMaster Laboratory staff in February, and is in charge of this work. Much of the necessary equipment and facilities are still to be provided but delays have been unavoidable. In the meantime infestations with nematode species that are particularly suitable for this work are being established. Experiments have commenced on the metabolism of *Trichostrongylus* spp. and on the detoxication mechanisms in the gut of normal and nematode-infested sheep.

(ii) *External Parasites of Sheep—B. ovis and M. ovinus.*—(*a*) *Arsenic.*—Studies on the distribution of arsenic in the bodies of sheep after dipping in sodium arsenite solution revealed appreciable quantities in the rumen content although none was swallowed. It was found that this could be attributed to a rapid rise in the arsenic content of the blood and its subsequent excretion in saliva. Eight hours after dipping, the arsenic content of saliva was 30 times that of the blood.

(*b*) *DDT.*—Emulsion used in field trials declined in concentration as sheep passed through the dip bath. In one trial with sheep in full wool there was a decline of about 50 per cent. in DDT concentration after 24 sheep had passed through 30 gallons of the dip. With a concentration of 1:2,000 DDT, adult keds were destroyed on the first few sheep dipped but some survived on sheep dipped thereafter.

(*c*) *Hexachlorocyclohexane* ("666").—In six small field trials "666" in a 1:3,000 to 1:6,000 emulsion killed all keds present at the time of dipping. Keds emerging from pupae present at dipping survived on the later dipped sheep in each trial, indicating a decline in "666" concentration as dipping proceeded. The emulsion was effective against *B. ovis* at a concentration of 1:2,000.

(*d*) *Rotenone.*—8-oz. timbo root powder per 100 gallons water, giving a rotenone concentration of 1:40,000 was effective against adult keds, but residual action was insufficient to destroy keds emerging from pupae subsequently. Moreover, concentration declined progressively as sheep passed through the dip bath. This dip was relatively ineffective against *B. ovis*.

Further trials are pending with arsenic for control of *B. ovis*, DDT and "666" for control of *B. ovis* and *M. ovinus*, and rotenone products for control of keds. Present indications are that the efficacy of these agents is largely dependent on the choice of appropriate times and methods of application. Field work this year has clearly shown that depletion of the active ingredients of the dip bath as sheep pass through it is an important factor when suspensions or the usual types of emulsions are used.

(*e*) *Studies on the life history of Bovicola ovis.*—The life cycle of *B. ovis* on the sheep has now been observed to approximate that found *in vitro* at 36.5° C. and 50-70 per cent. relative humidity. The period from first-stage larva to adult is 22 days; there is then a pre-oviposition period of four days; the incubation period of the egg is eight to ten days, making the complete cycle from egg to egg 34-36 days.

(*f*) *Studies on the life history of Linognathus pedalis.*—This work commenced towards the end of the year.

(iii) *The Blowfly Strike Problem.*—(*a*) *Modified Mules operation and optimal tail length.*—No further trials have been undertaken during the year, the efficacy of these two methods being now clearly established.

(*b*) *Operation to reduce tail strike.*—Further work has indicated that surgical removal of skin from the tail will withdraw wool-bearing skin from the sides and tip thus avoiding urine staining. No field trials have yet revealed the effect this may have on tail strike incidence. Such treatment may prove valuable for individual sheep with tails particularly predisposed to urine staining, or in flocks where the tails have been docked shorter than the recommended length.

(*c*) *Lamb-marking dressings.*—Further trials have confirmed the value of dressings containing boric acid, citronella, and bentonite. The value of the citronella did not depend on high citronella or geraniol content. Additional information on the quantity of dressing to use and the best method of application must be obtained before any recommendation can be made. DDT emulsion was not effective.

(*d*) *Studies on body strike.*—Assistance was given to the Division of Economic Entomology in preliminary trials of DDT preparations applied to the fleece of sheep to prevent oviposition by *Lucilia cuprina*. In the Stanthorpe district of Queensland, field studies have commenced on a property where body strike occurs annually. Some 700 weaners have been examined in detail regarding conformation, fleece characters, and incidence of fleece rot. Preliminary trials are in hand there concerning the preventive effect of spraying with DDT emulsion and calcium arsenite, respectively. Opportunities will be sought to extend this work in the field.

(iv) *Biochemical Studies.*—(*a*) *Studies on the mineral metabolism of sheep.*—The series of experiments on the effect of low calcium/high phosphorus imbalance in rations for sheep have now terminated and data from several years of work are being assembled for publication.

Analyses of water, feedstuffs, and teeth of sheep on low calcium, high phosphorus rations, which have shown dental abnormalities resembling those seen in fluorosis, have shown that fluorine is not responsible. Moreover, despite the marked superficial resemblance, there are, microscopically, distinct differences.

Investigation of the metabolism of phytic acid phosphorus in sheep has continued and has shown that phytates are almost completely broken down in the rumen.

(*b*) *Studies of poisonous plants.*—A force-feeding experiment with locally grown *Oxalis cernua* (soursob) confirmed the previous finding that severe hypocalcaemia can be induced by as little as 600 grams of the undried plant, owing to its high oxalate content. It was found that blood from sheep affected with oxalate poisoning may contain enough oxalic acid to precipitate the serum calcium as oxalate, for many hours after the serum is collected. Unless this is realized serum calcium estimations in such cases may be misleading.

(*c*) *Field experiments in relation to drought feeding.*—A series of observations was made in collaboration with a well known Merino stud in the Riverina, where severe drought conditions had prevailed, concerning the rate at which undernourished ewes could be restored sufficiently for safe transport to agistment and the efficacy and economics of various mixtures of concentrates and roughages for feeding ewes severely affected by drought conditions. A group of ram weaners which were also severely affected were completely handfed for

some three months. The information obtained emphasized the financial losses which result from failure to appreciate the relative food values of differently priced foodstuffs, and show where appreciable savings can be made. Data collected during this work were used by the Australian Wool Board in connexion with a film on drought feeding, and a full discussion for the benefit of extension workers has been prepared for publication.

(*d*) *Ram-feeding experiments.*—An experiment was undertaken at Boonoke concerning the effect of different levels of protein intake on wool production, fleece characters, and growth of stud Merino rams. Readily available foodstuffs were used. The starch equivalent values of the rations were comparable, but their protein content ranged from approximately 11 per cent. to 28 per cent. This preliminary experiment, which will terminate shortly, may pave the way for more exact investigation.

(*e*) *Miscellaneous.*—Assistance was given in investigating losses among horses after trucking. Subnormal serum calcium was detected in affected horses and recovery followed the generous feeding of lucerne hay. In preparation for further work on pregnancy toxaemia of ewes, liver samples have been collected, using the biopsy method devised by A. T. Dick, and have been analysed for fat and glycogen to establish the sampling errors. Attempts have been made to set up an uncomplicated ketosis in sheep, so far unsuccessfully. Very numerous blood and serum analyses have been carried out in connexion with experiments on the relation of nutritional level to wool production. Many complex organic compounds have been synthesized for colleagues in the parasitology and endocrinology departments. Lately work in the biochemical laboratory has been hindered by structural alterations which will take several months to complete under present conditions.

(v) *Endocrinological Studies.*—(*a*) *Pregnancy toxaemia.*—A detailed experiment was conducted to determine whether excessive production of oestrogens, or of toxic phenolic compounds derived from them, was the primary cause of pregnancy toxaemia in ewes. Some 30 ewes were studied intensively, under different regimes, during the last few weeks of pregnancy. The experiment occupied several months and some urine specimens still remain for oestrogen assay. A number of interesting observations were made, but it appears that intoxication by paracresol or other phenolic compounds derived from oestrogens plays no part in this disease.

(*b*) *Studies on oestrogens.*—The urine of ewes in the latter half of pregnancy was found to contain 5-20 micrograms of "oestrone" per day, the bile about 1,000 micrograms per litre and the wool grease negligible amounts. Hence it appears that pregnant ewes excrete oestrogens principally in the bile. The bile of pregnant ewes has been fractionated to investigate the nature of the principal steroids. Attempts are being made to devise a relatively simple and specific method for assaying oestrogens by means of a precipitin reaction. An experiment with virgin heifers to determine whether the lactation induced by hexoestrol could be augmented by simultaneous injection of thyroxin is proceeding, but results to date are not encouraging. Investigations on the relation between chemical structure of compounds related to synthetic oestrogens and their influence on mammary development are continuing. Some sixteen such compounds have been synthesized in the biochemical department and await examination.

(*c*) *Miscellaneous.*—Several trials have shown fairly conclusively that pregnandiol is not present in the urine of rams or of pregnant or dry ewes, although it is present in both bull's and cow's urine. It is concluded that the end product of progesterone metabolism in the ewe must be some sterol, probably related to pregnandiol.

(*d*) *Physiology of reproduction with special reference to the sheep.*—For the present, facilities for this work are provided in the New Medical School at Sydney University. Methods of collecting urine from ewes by mushroom catheters and cystoscopy for hormone assay are being evolved, the steroids of human and ovine urine have been fractionated. Standard methods for assaying the 17-ketosteroids of ovine urine are hindered by its high pigmentation, and methods of overcoming this difficulty are being sought. Relatively high titres of gonadotrophins (F.S.H.) have been obtained with wether's urine. Examination of sheep's blood for diastatic activity has indicated a diastatic cycle corresponding to the oestrus cycles. This may provide a useful and relatively simple indirect measure of oestrogen production.

(vi) *Wool Biology.*—(*a*) *Progeny testing.*—A full report of all data from progeny-testing trials at "Noondoo" from 1941-45 has been prepared and will be used as the basis for a series of publications. This work makes it possible to lay down a system for progeny-testing Merino sheep which is appropriate under Australian conditions. In general, some 75 ewes should be allotted to each ram under test, so as to obtain at least fifteen progeny of each sex on which his worth as a sire may be gauged. The comparison of rams which are of somewhat similar merit is complicated by the fact that some beget better male than female progeny and vice versa, and that when several characters are involved the rams tend to rank differently in regard to each of them. Emphasis must therefore be placed on a relatively few characters of undoubted significance in regard to wool production. Before sheep breeders can derive full benefit from progeny-testing a service must be provided from which at least clean scoured yields of fleece samples can be obtained.

(*b*) *Specifications of sheep types for wool production.*—An experiment in progress throughout the year and now nearing completion, is providing comparisons between fine woolled sheep (Camden Park Merinos) and strong woolled sheep (Corriedales) when subjected to different planes of nutrition. Three groups of each type are being subjected to a uniform plane of nutrition, a reversal from high to a low plane, and reversal from low to high plane. The response of the two types to these changes in nutrition are being observed as regards live weight, body dimensions, skin area, wax and suint production, fibre thickness, follicle population, respiration rate, rectal and fleece temperatures, water consumption, and composition of the blood. From the results of these very detailed trials it is hoped to define conditions necessary for testing critically the individual performance of sheep in certain types of genetic studies.

(*c*) *Sampling studies of the fleece.*—Work is continuing on the problems involved in sampling fleeces appropriately for accurate estimation of fleece constituents per unit area of skin, fibre population density, and fibre fineness.

(*d*) *Histological studies of the sheep's skin.*—An extensive comparative study has been planned concerning breed and strain differences in the structure of the skin and particularly of the hair follicle. This will be linked with studies already made or continuing, on the comparative histology of the hair follicle group in other mammals. It is believed that the hair follicle group may provide one of the most useful criteria for studying the mode of inheritance of many important skin and fleece characters of sheep.

(vii) *Studies on Fertility in Rams.*—An officer of the University Veterinary School is continuing his studies on the relation of nutritional plane and the

carotene content of diets to spermatogenesis in rams. The costs of this work, including salary, are now borne by the Council for Scientific and Industrial Research and facilities have been provided at the McMaster Laboratory. The current experimental work involves a total of 33 two-tooth rams on high and low planes of nutrition and at high, marginal, and deficient levels of carotene intake. Blood vitamin A estimation and examinations of semen as to quantity, longevity, and morphology are made at frequent intervals.

4. *The F. D. McMaster Field Station.*—(i) *General.*—Approximately twenty inches of rain were recorded during the year—twelve inches fell in February, March, and April. The nine-year average at the station is 22.73 inches. The winter was dry and conditions were more favourable for summer crops and pastures than for cereals. This season, 77 acres of oats, 14 of wheat, and 18 of *Phalaris* and subterranean clover pasture have been sown.

Sheep at the station consist of 130 rams, 136 wethers and 679 ewes—total 945. Lambs raised during 1945-46 totalled 262 from 404 ewes (64.8 per cent); 458 ewes have been mated for 1946-47 lambing. Cattle numbers have increased to sixteen head, of which five are Red Polls, six are grade Jerseys, and five are cross-bred Zebus.

(ii) *Inheritance of Skin Wrinkles in Sheep.*—Populations have been developed to the following sizes: F_1 199; F_2 111; F_3 14; back-cross 139—total 463. Current matings are to provide additional F_2 and F_3 progeny, and to confirm results from the previous back-cross. All observations support the provisional hypothesis that "wrinkling" and "plain-body" are paired characters, the inheritance of which is mendelian and multi-factor. Plain body is dominant to wrinkling. Characterization of lambs born in the back-cross of 1945-46 was particularly interesting. As reported previously, F_1 and F_2 ewes were randomized into five sub-groups, each of which was mated with an individual Merino ram. Each of the rams was phenotypically classified and selected to make a series having ascending scores for wrinkling. The scores of the five rams were 2, 10, 15, 21, and 25. Objective of the mating was to determine to what extent wrinkling of progeny from comparable mates was influenced by different degrees of wrinkling in the sires. A preliminary classification made when the lambs were only three to four months of age disclosed no significant difference between degrees of wrinkling among these similarly maintained progeny by the rams with phenotypes ranging from 10 to 25 points for their wrinkling scores. The results may be modified somewhat in classifications made when the age of the subjects increases.

The average score of progeny by the Merino ram B.387, who himself had the very low score of two, was significantly less than those of progeny by the above four rams. Special interest in this obervation arises from the fact that, whereas the other four rams were drawn, as having different degrees of characterization, from standard-bred Merino populations, the ram B.387 was "bred for plain-body". He was the son and grandson of a Merino ram which had a zero score and was outstandingly prepotent in begetting "plain-bodied" progeny, even from "well-developed" ewes.

The observation suggests something akin to the "building up of dominance". It is being considered in this respect in relation to similar observations in others of the genetical investigations and in relation to another back-cross mating on a similar plan but with different Merino rams.

(iii) *Inbred Flocks of Australian Merinos.*—Inbreeding is a method whereby the heredity of animals can be investigated. It is particularly useful to reveal recessive conditions. With this objective the process has been applied to three groups of Merino sheep.

(*a*) A Merino ram, M3, was mated with a group of stud ewes of the same breeding and subsequently with his descendants from the matings. The flock consists of 25 female descendants with 20 per cent. as its average coefficient of inbreeding. Expectation of the average of the whole drop from this year's mating is 23.7 per cent.

(*b*) A group of 100 stud-bred Merino ewes and one ram was used to establish a second inbred flock; 87 ewes in this group have been mated this year with the expectation of the drop having 20 per cent. for their average coefficient of inbreeding. The flock contains 96 females of which 27 are already inbred with an average of 17.1 per cent. and a range of from 6.25 to 25 per cent.

(*c*) A third inbred group is being established with sheep from the same "blood" as the second but from a different source. Progeny of sheep in this group are only now undergoing consanguineous matings. Expectation of this year's drop is an average of 25 per cent. for 43 lambs and 15 lambs from ewes with no inbreeding as controls.

These three groups of sheep are now approaching degrees of inbreeding which, at 20 per cent., are nearing thresholds for discovery of disabilities. Observations will now be considerably refined and intensified. Wool sampling and its measurement, when it becomes available, will play an important part in the intensification.

(iv) *Faults and Specific Breeding Groups.*—(*a*) *Polledness in sheep.*—Since 1939 a flock of Merino sheep has been maintained to investigate the inheritance of polledness. It was begun with a ram A.992, which had scurrs three inches long. Two of his sons, B.308 and B.320, and other progeny were selected as most nearly having a "depression" at the horn site. In 1943, an unrelated ram, C.294, with a scurr about half an inch long, much smaller than had been previously observed, and one depression, was introduced. At the time the ewes were severely culled until only those with full "depressions" remained. This intensive selection toward polledness in parents has given rise to three 2-tooth depression-rams and to several ram lambs that will, apparently, be of that nature as adults. One of these is being mated in the main polled flock whilst the other two rams are being tested for heterozygosity by mating them with "knobbed" and horned Merino ewes.

This accumulation of completely polled characterization is being associated with the conception of "building up of dominance" that was apparent in the wrinkling investigation.

(*b*) *Hollow back.*—The group totals 30 parents and offspring mated to give an F_1, being hollow-backed ram x straight-backed ewes, and this year to give an inbred back-cross, by the hollow-backed Merino ram x F_1 ewes by the same ram. This back-cross is expected to disclose whether the condition is a hereditary recessive. If it were, some of the inbred progeny should show the condition.

The evidence so far obtained, which is incomplete, does not indicate "hollow-back" to be a "dominant" condition. A probable hypothesis would appear to be that the condition is an extreme instance in a normal range of characterization. The investigation is proceeding to increase numbers of progeny and to develop the inbred back-cross to test recessive possibilities.

(*c*) *Hairiness (synonym "fluffy-tip").*—The mating of a "hairy" ram and ewes with and without apparent hair is proceeding. Earliest progeny are now ready for classification. A series of 300 wool samples, taken periodically since December, 1942, from known skin areas on Merino lambs which were classified in

groups as having birth-coats with many, few, and an intermediate number of "halo-hairs", has been passed to the wool-measuring unit for examination and report.

(*d*) *Parrot mouth.*—The M3 inbred group is being used for these observations. No more cases have arisen. A recent publication from Dubois, U.S.A., on this problem quotes our provisional hypothesis for a recessive condition and considers it to be only one phase of the heredity of parrot-mouth. It is being investigated at Dubois with many more animals than are available on the Field Station.

(v) *Zebu Hybridization.*—(*a*) *Beef cattle.*—Owners of the co-opted experimental herds have been asked to state other centres to which cross-bred cattle have gone for breeding purposes. Arrangements are being made to visit all herds to determine expansion or contraction of the project during the five-year period (1941-46) which has elapsed since the last visit and report.

(*b*) *Dairy cattle.*—A cross-bred herd is being developed at this station and facilities for observations are being built up. A milking shed with appropriate machinery has been erected. Three Jersey cows are in milk and under test. Five pure-bred Red Poll heifers have been acquired, making a total of sixteen head of cattle now in the project. Six are high quality grade Jerseys, five are pure-bred Red Polls, two heifer calves are one-quarter Zebu x Jersey, one heifer calf is three-eighths Zebu x Jersey, and two bulls are half Zebu x Jersey. Cross-breds will not commence lactation until 1947 but the Jersey and Red Poll heifers will commence before that time.

5. *National Field Station, "Gilruth Plains", Queensland.*—(i) *General.*—1945-46 has proved to be the third dry year in succession. Some useful rain fell in July, 1945, following that of the previous month. Some storms were experienced in October and November, 1945, and in January, 1946, but there was insufficient rain to cause the growth of a big body of grass. Light stocking enabled the stock to maintain their condition fairly well. On account of the dry conditions, joining of the rams was postponed from April, 1945, until after the rains in June and July. A 70 per cent. marking resulted in February.

The seasonal outlook at this mid-year is far from good and it may be necessary to reduce stock numbers further by the disposal of some of the older breeders. Consideration may also be given to supplementary feeding which can be performed as a research project.

(ii) *Observations on the Control of Crutch Strike.*—As in the previous year, the continuation of relatively dry conditions interfered with blowfly activity and hindered this work. The efficiency of the Mules operation performed at marking was compared with that performed at about eight months of age, by measuring the size of the bare area ultimately produced. It indicated that treatment as lambs, while relatively effective, was probably not quite as efficiently performed as at the later age.

(iii) *Observations on Sheep Classing.*—In this experiment additional data obtained at the 1945 shearing indicate that the advantage in favour of classing at about eighteen months of age shown in the 1944 figures is not as great as at first appeared and is, indeed, very slight. Further data will be obtained at the 1946 shearing.

(iv) *Miscellaneous Investigations.*—In the experiment designed to compare the relative production of rams and wethers it was found that, under the pasture conditions obtaining during the course of the experiment, there was no difference in wool cut per head between rams and wethers at their first shearing. The mean bodyweight of rams and wethers was practically the same until they were approximately eight months of age; thereafter the rams made greater gains. At eighteen months, the mean weight of the rams was approximately 26½ lb. greater than the mean of the wethers. The wethers castrated at five months of age have not, so far, shown any difference in mean bodyweight or mean wool cut per head from those castrated at marking.

In the experiment on dehorning of lambs which was commenced at lambmarking 1944, only partial success was obtained and a certain amount of trouble with deformed horns has been experienced.

6. *Other Activities.*—(i) *Fleece Analysis Laboratory.*—To provide a service for measurement and analysis of samples from the many investigations dealing with wool production, a Fleece Analysis Laboratory was established in March, 1946. For the time being, the laboratory is located in a building at the former Munitions Factory, Villawood. During the period to the end of the year the main activities were the assembling of the necessary equipment and recruitment and training of the staff.

(ii) *Survey of Wool Production.*—A restricted survey of wool production has been commenced to determine and compare effects of dissimilar environments on sheep having similar heredity. This will entail a careful examination of characters and productivity of representatives of the main strains of wool-producing sheep in the major climatic environments of Australia. As a preliminary to field work, techniques for the measurement of size and shape of sheep and for adequately sampling their fleeces are being developed. Contact has been made with stud breeders to determine locations of representative blocks of the major strains of wool-producing sheep.

(iii) *Investigation of Beef Production in Australia.*—This investigation was commenced following the appointment of a Senior Research Officer towards the end of the year. The objectives of the investigation are (*a*) to plan and carry out a survey of beef production in Australia with particular reference to Queensland; (*b*) to define the major problems so revealed; (*c*) to specify, by measurement and analysis, the standard trade-grades of carcasses and their associations with factors such as age and environment; (*d*) to investigate the status of the various breeds and strains of cattle and methods of breeding and maintenance; (*e*) to discover areas where crop or other special fattening methods are being practised and, later, to conduct co-operative investigations on these matters.

(iv) *Poultry Breeding Investigations.*—A Research Officer has been appointed for this work and plans are in the course of preparation for the establishment of a poultry breeding unit at the Werribee Field Station. Contact has already been made with specialist officers of the Departments of Agriculture and with commercial producers in various States.

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

Austin, C. R. (1946).—Endocrinology and animal production. *Aust. Vet. J.* 22: 48-54.

Beck, A. B. (1945).—The quantitative extraction of cobalt and iron from ashed biological material. *Aust. J. Exp. Biol. Med. Sci.* 23: 311-6.

Bolliger, A.,* and Hardy, Margaret, H. (1945). The presence of large amounts of uric acid in the integument of mammals. *Aust. J. Exp. Biol. Med. Sci.* 23: 99-102.

Campbell, A. D., and Rodwell, A. W. (1945).—The relationship of dosage and site of inoculation to the agglutinin response to *Brucella abortus* strain 19 vaccine: a comparison of the subcutaneous, intracutaneous, and intracaudal routes. *J. Comp. Path.* 55: 277.

Campbell, A. D., and others (1946).—Pleuropneumonia-like organisms in cases of non-gonococcal urethritis in man and in normal female genitalia. *Aust. Med. J.* 1946 (1): 179.

* Gordon Craig Research Laboratory, University of Sydney.

Carter, H. B., Franklin, M. C., and Gordon, H. McL. (1946).—The effect on wool production of a mild infestation with *Trichostrongylus colubriformis* in sheep. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 61-4.

Dick, A. T., and Bull, L. B. (1945).—Some preliminary observations on the effect of molybdenum on copper metabolism in herbivorous animals. *Aust. Vet. J.* 21: 70.

Franklin, M. C. (1946).—Experimental observations on the efficiency and economics of rations for drought feeding of sheep. *Aust. Vet. J.* 22: 78.

Franklin, M. C., Gordon, H. McL., and Macgregor, Catherine H. (1946).—A study of nutritional and biochemical effects in sheep of infestation with *Trichostrongylus colubriformis*. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 46-60.

Gill, D. A., and Parrish, E. (1945).—Microphotography as an aid to the identification of trombiculine larvae. Ibid. 18: 298-300.

Gordon, H. McL. (1945).—Phenothiazine as an anthelmintic. *Aust. Vet. J.* 21: 90-5.

Hill, J. L. (1945).—Further observations on the stability of lime-sulphur during dipping or spraying of sheep. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 201-8.

Murnane, D. (1945).—Preliminary report on the treatment of clinical and subclinical streptococcal and staphylococcal infections of the bovine udder with penicillin. *Aust. Vet. J.* 21: 82.

——(1946).—Second report on the treatment of clinical streptococcal and staphylococcal infections of the bovine udder with penicillin. Ibid. 22: 35.

Munch-Petersen, E., and others (1945).—Further notes on a lytic phenomenon shown by Group B streptococci. *Aust. J. Exp. Biol. Med. Sci.* 23: 193.

Rodwell, A. W. (1946).—The detoxication of *Cl. welchii* type D toxin by formaldehyde. Ibid. 24: 63.

V. BIOCHEMISTRY AND GENERAL NUTRITION.

1. *General.*—While there was no actual break in the sequence of the long-term research projects during the war, the activity in some which were concerned with the nutritional physiology of ruminants had of necessity to be decreased. The study of these problems which are of fundamental importance to the understanding of the nutrition of the wool sheep has again been undertaken. Broadly, these projects aim to extend existing knowledge of the chemical, microbiological, and physiological mechanisms involved in the process of rumination and in the production of wool fleece. Incidentally, they will provide essential quantitative data on the nutritional requirements for normal health of the sheep and for the production of wool. Lack of information of this sort renders it impossible to solve by direct logical approach the many problems which are encountered in the wool producing industry, and so extension of knowledge along these lines may be considered essential to further extension of scientific research to practical application.

In order to provide the accommodation necessary for the new activities, additional laboratory space has been designed, and the new building is now being constructed immediately adjacent to the existing Council for Scientific and Industrial Research Nutrition Laboratory and its annexes in the grounds of the University of Adelaide.

Recently, arrangements were made for the acquisition of the Remount Depot at O'Halloran Hill which is being relinquished by the Army. This property of approximately 600 acres is situated 10 miles from the central laboratories of the Division. It is an ideal site on which to produce the special foodstuffs for nutritional studies and on which to support the experimental flocks of various strains of Merino sheep for the conduct of the research programme envisaged. While some at least of the experimental work which involves the study of individual sheep in pens will continue to be conducted at the Division's pen-feeding block in the grounds of the Waite Institute, any further extension of these activities will be made at O'Halloran Hill.

2. *Nutrition and Wool Production.*—The amino acid constitution of wool keratin has been studied further with the use of modern tools of research, and at this juncture a very complete and reasonably exact knowledge of the composition of this protein is available.

The analytical studies of the distribution of amino acids in plant proteins which have been conducted in this laboratory for several years indicate that the proteins in the leaves of the higher plants are of very similar, if not identical, composition. The assemblage of amino acids derived from the pastures by grazing sheep is thus of such regular composition as to simplify materially the understanding of the relationships between protein intake and wool production, for nutritional transactions in grazing herbivora are not complicated as they are in mixed feeders by considerable variation in the biological values and supplementary relationships of the proteins in the diet.

The amino acid constitution of wool keratin and of the protein from which it is elaborated by grazing sheep indicates that, for wool production, the biological value of pasture proteins would never exceed the 35 per cent. it would attain under ideal conditions, if the whole of the sulphur of the methionine and cystine, which are the limiting amino acids, were transferred to wool keratin. Investigations which have involved the determination of the nitrogen and energy balances and the direct estimation of the wool grown by a number of sheep when subjected to varying conditions, indicate that the proportion of the available protein (that which is digested and absorbed) which is transformed to wool is very much smaller than this: the efficiency of protein utilization, primarily a characteristic of the individual, rarely exceeds 8 per cent. under nutritional feeding conditions. The necessity for the provision of relatively large quantities of protein in the fodder, if sheep are to approach their full hereditary propensity for wool production, is emphasized by this, and the implications which bear directly on the broad subject of wool production are obvious.

The detailed study of the influence of protein intake on wool production has advanced to a stage where several broad principles become apparent.

The fact that the quantity of wool produced by a sheep depends primarily on the amounts of the raw materials which are available for the elaboration of keratin after its other needs have been fulfilled, has been discussed in previous reports. Intensive study of the effects of the nutritional level on the type and quality of wool produced has revealed that changes, both in the diameter and in the length of the fibres, contribute to the alteration in the rate of wool production. The relationships between these variables are individual characteristics, as is also the range over which each can extend. In all, these factors designate the wool producing capacity of the individual. They are determined not only by the genetical propensity of the sheep but also by its nutritional history, for it is obvious that an animal which has been stunted by early malnutrition can never express its full hereditary capacity for wool production. The results of a comprehensive quantitative study of the effects which

supervene when the food intake is limited during the period when the animal is developing have been mentioned in previous reports.

Study of the distributions of the cross-sectional areas of wool fibres taken from marked areas on individual experimental animals reveals that these are modified by changes in the nutritional level at which the animal is supported: the finer classes apparently vary over a more restricted range than the stronger classes and each fibre seems to be influenced directly in proportion to its cross-sectional area. The attempt by animal breeders to classify sheep by the nature of their wool fibre distribution curves is thus a dubious procedure. Irrespective of the variations in the diameter along each fibre which reflect the ever-changing nutritional environment of the grazing sheep, the relative degree of modification of individual fibre diameters is by no means constant, and so the nature of the distribution at any one level may be quite different at another level of feeding.

Arrangements are being made to carry out the comprehensive study of the reaction of various Merino strains to different environments in Australia to which reference was made in the preceding report.

3. *Metabolic Studies.*—(i) *The Processes of Rumination.*—(*a*) *Utilization of urea.*—During the year the study of factors that determine the efficiency with which the microflora of the rumen can synthesize protein from urea has been continued. The results do not yet allow any final recommendation to be made; it is clear that further intensive study of the nutritional requirements of the micro-organisms concerned is necessary before ideal conditions may be understood. The work is being continued.

(*b*) *Cellulose digestion.*—Investigations concerned with cellulose digestion and the physiological and biochemical study of the intermediary metabolism of the products which arise from the bacterial degradation of cellulose have been extended and work along these lines is continuing.

In vitro fermentations of pure cellulose and of chaffed wheaten hay indicate that much larger amounts of propionic acid are formed during rumen fermentation than is indicated by direct examination of the rumen content.

(*c*) *Absorption from the rumen.*—A study of the relative rates of absorption of the fatty acids from the rumen was undertaken. Analysis of the relative rates of absorption of acetic, propionic, and butyric acids from solutions introduced through a fistula into the emptied washed rumen proved that propionic acid was absorbed more rapidly than either acetic or butyric acid. Further investigation revealed that the relative rates of absorption are influenced by the reaction of the solution of mixed acids. The investigation is being continued.

(*d*) *Intermediary metabolism of fatty acids.*—The fact that the end-products of rumen digestion are fatty acids strongly suggests that the intermediary metabolism of the ruminant is different in certain important respects from that of the mixed feeders which has been more completely studied. Further knowledge of the course of degradation and utilization of the simpler fatty acids as sources of energy for the physiological transactions involved in the process of living is thus fundamental to the understanding of the nutrition of the sheep. This aspect of ruminant physiology is being actively investigated.

A study of the carbohydrate and fat metabolism has been undertaken and for this it was desirable to produce diabetic sheep. This was accomplished by poisoning the islet tissue of the pancreas with alloxan. The glycosuria and ketonuria typical of diabetes supervened on the administration of a single intravenous injection of alloxan. Sheep in this condition are being employed together with phlorizinized sheep for the study of the transfer of fatty acids to carbohydrate and especially for the investigation of the metabolism of acetic and propionic acids by the ruminant.

(ii) *Energy Metabolism.*—During the period under discussion the calorimeters were used more especially for experiments concerned directly with the utilization of various products which arise from bacterial fermentation in the rumen. A comprehensive experiment to determine the energy relationships of high protein diets is planned and will be undertaken as soon as the requisite foodstuffs are available.

(iii) *Vitamin A Requirements of the Sheep.*—The investigation of those nutritional aspects of vitamin A which may come into play under natural grazing conditions in Australia is proceeding. The effects which supervene when sheep are forced to subsist on rations that are adequate in all respects other than in their ability to provide vitamin A have been studied intensively by the use of sheep confined in pens.

In order to correlate the findings with conditions which obtain under natural grazing conditions, a survey has been made of the seasonal variations in the vitamin A concentrations in the blood of sheep from flocks in areas where vitamin A deficiency might most likely occur. Changes in the levels of carotene and of vitamin A in the blood and livers of lambs of various ages have been determined in order to provide further basic information of the normal site of storage of this vitamin.

The experiment designed to determine the effect of vitamin A deficiency on the capacity of ewes to reproduce has now been in progress for approximately two years. The experimental ewes were divided into four groups of six, and after a period of fifteen months which was required to deplete them of vitamin A they were given suitable supplements to provide each day 50, 100, 150, and 200 γ carotene per kg. body weight. They were then mated. Lambing was satisfactory in all groups: there was no abnormality which could be attributed to vitamin A deprival even at the very low levels of intake. This is contrary to the findings with cattle; a daily intake of 150 γ of carotene per kg. body weight is necessary for normal reproduction in the cow. The observations are being continued through another cycle of gestation during which the intake of carotene will be further reduced.

(iv) *Plant Proteins.*—An alternative method used to check the estimation of the arginine, histidine, and lysine contents of the large-scale preparations of protein separated from the leaves of *Phalaris tuberosa, Hordeum murinum, Medicago sativa,* and *Medicago denticulata* provided convincing evidence that the histidine estimations were not reliable.

Accordingly a new series of histidine estimations by Block's modification of Kapeller-Adler's method, which appears to have been employed satisfactorily by some workers with proteins of animal and plant origin, was carried out. This method too was found to be unsatisfactory, more so in fact than the methods formerly used.

Late in 1945 the gravimetric method of Vickery and Winternitz was applied, and it now seems reasonably certain that this will provide a satisfactory estimation of the histidine contents. The experimental work with these preparations has been completed.

(v) *Physiological and Tissue Metabolism Studies.*—(*a*) *Tissue respiration.*—The study of oxygen transfer in tissues of normal animals and of animals which have been rendered deficient in certain of the essential minor elements has been continued.

The methods which were perfected previously for the determination of cytochrome c oxidase concentration in tissues have been applied to the investigation of the mechanism of cyanide poisoning. Sub-lethal doses of cyanide administered over long periods bring about changes in the nervous system which are similar to

those encountered in lambs born of copper-deficient ewes. Little if anything is known of the physiological processes involved when myelin is laid down in the central nervous system, and problems associated with this function are of widespread importance.

The effect of cyanide upon the cytochrome system was investigated both *in vivo* and *in vitro*. Complete systems that had been poisoned with cyanide were subjected to dialysis. The recovery of activity after further addition of cytochrome c revealed that cyanide has more affinity for the oxygen carrier, cytochrome c, than for the enzyme, cytochrome c oxidase. From preliminary experiments on rats which had been treated over long periods with sublethal doses of cyanide, evidence was obtained which indicated that the cytochrome oxidase acivity of the cerebral cortex is reduced under such circumstances, although no symptoms suggestive of demyelination have yet been observed in the experimental animals.

(*b*) *Physiology of rumination, &c.*—Means for administering relatively large quantities of metabolites directly into the blood stream of sheep have been worked out, and this technique is to be employed for the study of the intermediary metabolism of fatty acids, *vide supra*.

Techniques for the establishment of permanent fistulae in the rumen and for the introduction of various instruments for recording changes in reaction, temperature, &c., in this organ have been perfected and are being used in the experimental study of rumination.

4. *Chronic Fluorosis.*—The necessity for further detailed knowledge of the effects which follow when small amounts of fluorine are ingested each day over very long periods was outlined in the previous report. An experiment was designed to provide information on the effects which supervene when young sheep are provided with water containing fluorine in such concentrations as are frequently encountered in the natural waters from artesian bores. Five groups, each of six sheep, which were six months old when the treatment was begun, have been supplied with water containing 0, 2.5, 5, 10, and 20 parts per million of fluorine. No lesions characteristic of chronic fluorosis have been observed during the first year of treatment in any way. The first permanent incisors were normal when erupted, presumably because the enamel of these had been laid down before the fluorine was administered. Changes, if any, may be expected in the second incisors which are now beginning to erupt. The observations will be continued for some years, as the long-term effects are those that are of especial importance.

5. *Minor Elements.*—(i) *General.*—The development of the researches concerned with minor element deficiencies has been discussed briefly in the reports submitted over the past ten years. The investigations have been conducted along two main lines. Semi-intensive study of the effects of cobalt and of copper deficiency at the Division's field station at Robe, and intensive experiments conducted at the laboratory have provided the information about the physiological mechanisms which are affected when the fodder fails to provide sufficient of these essential factors for normal function. These findings have been applied for the elucidation of the aetiology of the many ailments of grazing sheep which now, from the information gained in the former investigations, we know are the result of dietary deficiencies of this nature. In the course of these studies the efficiency of wool production of sheep depastured on very extensive areas in Australia has been proven to be limited by dietary factors of this sort.

During the past year a survey of central and western Queensland amply confirmed previous suspicions that the untoward effects of copper deficiency are widespread in that State, as they seem to be in other parts of Australia. Under natural conditions the degree of these deficiencies is known to vary from the acute forms which are fatal, to more subtle and incipient forms which are not at all simple to recognize but which may still very materially affect the health of grazing stock and seriously limit their capacity to produce. Means for ready diagnosis of any order of copper deficiency have now been perfected and are being applied to similar surveys which will cover suspect areas in other States.

In some of the affected areas, field experiments will be necessary to determine how best to supplement the flocks. From experience in southern Australia there is reason to expect that simple, effective, and inexpensive means will be found to combat these disabilities, and that very material increase in the efficiency of wool production will result.

The experiments especially designed to provide further knowledge of the specific effects that varying degrees of copper deficiency exert on wool production have already yielded valuable information. These are discussed under the appropriate heading in this section.

During the year the structural lesions in the wool which is grown by copper-deficient sheep have been studied. The results already have provided an explanation of the nature and origin of these changes which are brought about in the fibres and which cause the wool to perform abnormally during the manufacturing processes. The lack of crimp in the copper-deficient wool is directly correlated with the abnormal manufacturing performance. It is easily recognized and so leads the appraiser to heavily discount the value of copper-deficient wool. The absence of crimp, *per se*, obviously does not explain the abnormal manufacturing performance of the straight steely wools from copper-deficient sheep. This is due to profound changes in physic-chemical constitution of the fibres.

(ii) *Robe.*—(*a*) *The effect of various degrees of copper deficiency on wool production by Merino sheep.*—Reference was made to this experiment in the previous report. It is the first of a series designed specifically to study the effects of copper deficiency on wool growth. Although our previous experiments had thrown considerable light on this aspect the animals had been chosen for characteristics other than evenness in wool-producing capacity, and so it was not possible to base significant quantitative conclusions on the observed differences in the fleece weights.

Eight groups each of ten young Merino ewes which were chosen from a very even flock of strong-woolled sheep that were noted both for the quality and quantity of the wool they produced, were employed. These were provided with supplements containing the equivalent of 0, 1, 2.5, 5, 7.5, 10, 15, and 20 mg. copper per day, and all were run together as a flock on the seriously copper-deficient terrain. Wool production data for 1945 showed clearly that a significant increase in weight of fleece resulted with each increase in the copper supplement until a level of 7.5 mg. copper per day was reached; greater supplements produced no further increase that was statistically significant. The unsupplemented group of ewes produced an average of 4.3 lb. of clean-scoured wool during twelve months; the group which received 7.5 mg. copper per day produced an average of 6.0 lb. during the same period. The value at appraisal was 25 pence per lb. for the former and 27½ pence per lb. for the latter. The average total return per sheep was thus 106 pence and 161 pence, respectively.

The observed gradation of the effects which supervened on increasing the supplements confirmed our previous findings and allowed a number of conclusions to be drawn. It again became obvious that the copper requirements for normal health of the sheep are met by an intake of copper which is far below the level essential for the complete and normal keratinization of its wool. The quantities of copper necessary for each may

now be precisely assessed, and the symptoms of varying degrees of deficiency may be appraised with confidence. The application of the findings is obvious. The experiment is being continued; after the collection of the fleeces of the second year the ewes will be mated so that a study may be made of the capacity to reproduce while in a state of copper deficiency which varies from the acute degree suffered by unsupplemented animals to the incipient degrees suffered by those which receive supplements which are not quite sufficient to provide the full quota necessary for normal health.

(*b*) *Effects of copper dressing of pastures on the* copper status of grazing sheep.—Five years ago an experiment was begun at Robe to determine whether top dressings of copper sulphate applied to the acutely copper-deficient soils in this area would enable natural pastures to assimilate sufficient copper to fulfil the requirements of grazing sheep. A manurial dressing of 14 lb. copper sulphate plus 98 lb. superphosphate per acre was applied to an area in May, 1940, and in 1941 a group of ewes which had been rendered very copper-deficient—each had produced an ataxic lamb the previous year—was confined to this area. All of the ewes were supplemented with cobalt, and half of them received in addition an extra 5 mg. of copper per day. The ewes were mated and all produced normal offspring. Since then, three successive generations have been bred in this area without any sign of impairment of general health or trouble with lambing. It is evident that even in these calcareous soils the pastures are able to absorb sufficient copper to provide the amount necessary to maintain good general health and ensure normal reproduction of sheep. The amount of copper assimilated by the sheep under such circumstances, however, is not quite sufficient to provide for normal wool production: some of the ewes in the group which have not received additional copper now tend to produce steely wool. The extra 5 mg. copper per day has proved sufficient to overcome this tendency, as those which have received it are still producing boldly crimped wool. This difference is not marked, however. The groups produced the same average weight of fleece and its appraisal value differed by only a farthing per lb. in favour of those which received the copper supplement.

(*c*) *The effects of cobalt dressing of pastures on the cobalt status of grazing sheep.*—Similar experimental trials have been undertaken to determine whether top dressing acutely deficient terrain with cobalt sulphate will enable the pastures to assimilate sufficient cobalt to provide for full requirements of grazing sheep. Experimental work conducted elsewhere to provide information on this point is not convincing. Such trials have been of comparatively short duration and the sheep have been allowed to graze, and analyses have been made, too soon after the dressing had been applied. Under such circumstances the quantity of cobalt adhering to the pastures has been more than sufficient to provide the very minute amounts necessary for the grazing sheep. A dressing of 5 lb. cobalt sulphate per acre was applied twelve months before the experimental animals were placed there. After one year no difference is evident between the unsupplemented controls and those which received an additional 1 mg. cobalt per day while in the cobalt-dressed area. The controls of the immediately adjacent paddocks to which no cobalt had been applied all become seriously ill and were withdrawn when *in extremis*.

(iii) *Cobalt Deficiency.*—A number of experiments are being conducted in the field and in the laboratory to determine the physiological function of cobalt. Our experiments proved some years ago that cobalt has to be taken *per os* if it is to be effective, either as a prophylactic to prevent the onset of untoward symptoms of cobalt deficiency in sheep when they are grazed on the deficient pastures, or as a cure when the animals have been allowed to develop cobalt deficiency. Massive doses of cobalt injected intravenously were found to be without effect. This implies that cobalt is essential for the nutrition of the symbiotic micro-organisms of the rumen upon which the ruminant depends not only for the digestion of the major bulk of its foodstuffs but also for a considerable quantity of the accessory food factors necessary for its well-being. The fact that only ruminants suffer the nutritional disability of cobalt deficiency when grazed on the deficient terrain adds some weight to this hypothesis. There is as yet, however, no unequivocal proof of it. This and other aspects are being investigated. Incidentally, it has been conclusively proved that the onset of the anaemia associated with cobalt deficiency is not prevented by massive doses of liver or by depot therapy with iron and liver, nor do massive doses of zinc or of iron, or of nickel, either alone or in combination, exert any beneficial effect. The quantity of cobalt that it is necessary for a sheep to ingest for normal health is very small. It is certainly under 0.2 mg. per day.

(iv) *Field Stations Concerned with Cobalt and Copper Deficiency.*—(*a*) *Keith.*—In previous reports the trial to determine the effects of copper dressings on the health and wool production of sheep was described. During 1945, the provision of copper supplements did not result in extra wool production by the sheep on the copper-dressed pastures. Steely wool was grown only by the controls on the adjacent areas which had not been treated. The observations are being continued.

(*b*) *Borrika.*—Adverse seasonal conditions rendered the observations in this area equivocal. The experiment is being continued.

(*c*) *Glenroy.*—A trial to test whether the application of cobalt to the soil of this area will prevent the effects of cobalt deficiency which have previously proved to affect the flocks has been initiated.

(*d*) *Kybybolite.*—The trial which is being conducted in conjunction with the South Australian Department of Agriculture at the experimental farm, Kybybolite, has as yet provided no evidence of copper deficiency in that area.

(*e*) *Other field stations.*—The results of the experimental trials at Elliston, Tintinara, Pillana, Glenroy, Keith, and Borrika have been discussed previously. They are now being prepared for publication.

(*f*) *Epidemiological surveys of intestinal parasites.*—Assistance is being given to our colleagues in the McMaster Laboratory in the conduct of epidemiological surveys at Pillana, on Eyre's Peninsula, at Clare, in the middle north of South Australia, and at Kybybolite, in the south-east of South Australia.

(v) *Queensland.*—A preliminary survey of some of the main pastoral areas in Queensland has been made in co-operation with the officers of the Queensland Department of Agriculture and Stock. The results indicate that copper deficiency is prevalent there. Experimental studies are being planned to determine how the deficiency may best be corrected in the affected areas.

(vi) *Steely Wool for Extension and Education Purposes.*—Sets of the fleeces from the ewes of the groups which received the graded supplements of copper have been distributed to the State Departments of South Australia, New South Wales, and Queensland. These will be used by extension officers to demonstrate the effects on wool production which follow copper deficiency in its various degrees of severity. These effects are sufficiently dramatic to render the sets of fleeces valuable material for extension and educational purposes.

(vii) *The Effects of Copper Deficiency on the Structure of Wool Fibre.*—The chemical and physical nature of the lesion in the wool which supervenes on copper deficiency has been the object of a series of

studies during the past year. Fleeces were produced especially for this work by allowing sheep to become depleted of copper, and then, after six months' copper-deficient wool had been grown, providing them with a supplement containing sufficient copper to reinstate normal keratinization. The properties of the normal and copper-deficient parts of the fibres were contrasted. Chemically, there is ample evidence of abnormal keratinization. The deficient end of the staple was found to contain approximately 10 per cent. less sulphur, and this proved to be due entirely to a lessened cystine content—the methionine content was unchanged. The acid-combining capacity of the deficient wool was altered. The serine content was found to be identical in both ends of the staple.

The physical properties of copper-deficient wool are manifestly different from those of normal wool. Straight steely fibre stretches more easily when stress is applied and recovers less readily when released.

A study of the histochemical changes which occur during the keratinization process of the fibres when they are being formed in the lower portion of the follicles revealed that the closure of the thiol groups to the disulphide groups of normal keratin is very much delayed in copper-deficient sheep. Evidence was found to support the hypothesis that this reaction is catalysed by copper-containing enzymes. The work is proceeding.

6. *Agrostology and Plant Nutrition.*—(i) *Robe.*—The long-term pasture trials concerned with the use of different quantities of copper sulphate in association with other elements have been continued at Robe. Several of the sward trials which have been under observation for five years or more have been discontinued. The results are being prepared for publication.

(ii) *Ninety-Mile Desert.*—Investigations concerned with the mineral nutrition of plants grown on the heath sands of the Ninety-Mile Desert in the upper South East of South Australia have been continued. Copper and zinc applied to subterranean clover at seeding on new land very markedly enhanced both the persistence and the development of that species in the second year. This treatment alone, however, did not prevent the very rapid decline in the density and vigour of the plants during the third year. Subterranean clover sown on land that had previously been cropped was found to lack vigour even in the first year, and under such circumstances there was little if any response to copper or to zinc. Lucerne, which proved to be a more persistent species, responded to the application of copper.

Field experiments are being conducted in three localities. More intensive study by means of pot-culture technique has yielded information which illuminates the problem of minor element deficiency in these areas.

7. *Accessory Food Factors and Food Composition.*—An experimental survey was made of the capacity of various chemical methods to provide critical assays of thiamine and riboflavin in flour and bread. The methods evolved are being applied to a survey of the vitamin B_1 and vitamin B_2 content of some of the foods commonly employed in the habitual dietary of Australians. The work is being conducted in collaboration with the Animal Products Research Foundation of the University of Adelaide.

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

Dawbarn, M. C. (1945).—The determination of vitamin C by the growth of guinea pigs. *Aust. J. Exp. Biol. Med. Sci.* 23: 281.

——(1945).—The vitamin C content of dried lucerne (*Medicago sativa*); chemical and biological assays. Ibid. 23: 289.

Jarrett, I. G. (1946).—Alloxan diabetes in the sheep. Ibid 24: 95.

Lugg, J. W. H. (1945).—The chemistry and metabolism of the compounds of sulphur. *Ann. Rev. Biochem.* 14: 263.

——(1946).—Plant proteins. *Aust. Chem. Inst. J. Proc.* 13: 88.

Peirce, A. W. (1945).—The effect of intake of carotene on the general health and on the concentration of carotene and of vitamin A in the blood and liver of sheep. *Aust. J. Exp. Biol. Med. Sci.* 23: 295.

VI. SOILS INVESTIGATIONS.

1. *General.*—The major portion of the field activities of the Division of Soils during the past year has been directed towards problems in land settlement connected with post-war schemes. Surveys of various types have proceeded actively in five States. As a new development, considerable attention has been given to the place of soil investigations in research on building problems with particular reference to foundations.

The main restricting feature in advancing these urgent investigations has been the lack of qualified research staff. There have been small increases in the number of personnel, but it is not yet possible to meet in any way adequately the more pressing demands from State and Commonwealth authorities. It may be pointed out that only two of the States have any soil investigating unit capable of undertaking the type of work carried out by the Division of Soils, and the co-operation of the Council is therefore necessary in the post-war period of settlement planning.

Decentralization has proceeded further in field operations. Three regional centres are now in existence, namely Hobart, Perth, and, from the present year, Deniliquin. The officer in charge of the latter has his head-quarters at the Council's new research station at Deniliquin, and his zone of operation is the potential or actual irrigation country from the Lachlan to the Murray in New South Wales, and the north central plains of Victoria. A fourth unit is to be set up at Canberra within the forthcoming year. Each region is to be staffed with a nucleus of officers for an extended period reducing the numbers of those who in the past have worked under mobile conditions. For some years yet, all analytical work on survey samples will probably be carried on in Adelaide at head-quarters with the staff of analysts which has been built up for the purpose.

The Division has its head-quarters at the Waite Agricultural Research Institute of the University of Adelaide and the staff of both bodies are closely associated in research. Co-operation with State Departments of Agriculture, Lands, Forestry, Irrigation, and the Reconstruction authority set up more recently, has proceeded smoothly. In the Commonwealth sphere, the Division has provided technical advisory service to the Departments of Post-War Reconstruction, Commerce and Agriculture, and the Interior.

In August, 1945, a very successful school in Soil Science was held at the Waite Institute under the joint sponsorship of the Council for Scientific and Industrial Research and the University of Adelaide. This followed the precedent of a similar meeting in 1939, and in both cases a representative gathering of virtually all bodies concerned directly or indirectly with soil investigations resulted. The conference covered a period of ten days of lectures and discussions. The attendance varied between 100 and 130 for individual sessions.

The keynote of the field investigations has been the relation of the soil type to land use in the broadest sense. This concerns not only the classification of the soils but such features as their individual relationship to fertility problems, erosion damage or hazard, suitability for specific crops, relation to pasture, and quality or health of stock grazing on them. Problems

in ecology are frequently presented, and there is also the basic study of pedology and morphology of soils. During the past year, chemical research has turned towards soil fertility and stock disease problems; physical research has tackled the engineering properties of soils and their water-absorbing capacities, and the relationship of structure and physical condition. Each research has its fundamental and applied aspects, and the community is becoming increasingly aware of the value and significance of soils investigations.

2. *Soil Survey Section.*—Surveys have continued in five States in varying degrees of detail. The methods for field study of soils have been under review for better means of attacking land utilization studies. The detail and requisite accuracy for work under varying conditions involves techniques which are still being perfected. In several regions, broad-scale reconnaissances have been made to sum up the relative values of portions for development. Other reconnaissances in the nature of inspections have been made of estates and areas of Crown Land proposed for settlement of servicemen.

(i) *Western Australia.*—Following the completion of the surveys of the Margaret River and Blackwood River districts in 1945, a further area of somewhat similar country near the drier margin of the jarrah forest zone was classified and mapped. This area of 45,000 acres known as Rocky Gully is located about midway between Mt. Barker and Manjimup in uncleared heath scrub typical of the district. It is very sparsely settled and is in an isolated region removed from towns. The rainfall of about 28 inches falls off to the north where jarrah is partially replaced by wandoo in the forest. The object of the survey was to assist in determining whether the area was suitable, or could be made so, for land settlement mainly as a pasture proposition for dairying or sheep. The field work with maps is now complete and the analytical work and report are in preparation. In general, because of poor soil types and heavy costs of clearing, it seems the area is submarginal for economic settlement. A feature of the soils of pedological interest was the discovery of a solonetz formation which in view of the present humid environment is probably related to past climatic conditions.

(ii) *South Australia.*—During 1945 a soil survey was commenced on Kangaroo Island on an area of virgin heath and low scrub selected for possible post-war settlement by the South Australian Land Settlement Executive. The area of 120,000 acres in the Hundreds of Seddon and McGillivray has now been completed. Analytical work and other investigations are now proceeding to allow publication of a bulletin. In addition three partially developed properties aggregating about 4,000 acres in the Hundreds of Cassini and Duncan were studied for comparison with the virgin area. One of these properties has suffered lamb and sheep losses through the occurrence of dystokia, and an attempt was made without significant success to correlate the disease with soil type and vegetation. It was, however, clearly shown that the developed soils of the Estates differed materially in type from the area suggested for settlement and that results and methods cannot necessarily be applied from these established areas to the new virgin conditions. Preliminary data have been supplied to the Parliamentary Land Settlement Committee of South Australia.

Soil erosion studies have been carried out from time to time at the request of conservation authorities of South Australia and Victoria. The South Australian Conservator has invited collaboration in an examination of the northern marginal lands, and recently a reconnaissance was run over an area of 2,500 square miles between Peterborough and Hawker. The immediate objective was the assessment of the general erosion position, setting up an appropriate classification scheme for defining damage, and finally the selection of certain units for detailed survey next year. It was clear that current land usage was faulty, particularly in the continued use of the dominant desert loam type of soil for wheat cropping and probably in not taking advantage of lucerne growing on the flooded country. Over large areas as much as six inches of soil have been removed by sheet erosion. Two areas were selected for further study which, it is hoped, will be carried through next year and will afford a basis for experimental and demonstration work by the State body. Research and survey on these areas are the responsibility of the Division of Soils. Use was made of aerial photographs in the reconnaissance and, in part, use was made of oblique photographs in a satisfactory manner.

Three small surveys were made in detail at Renmark. An area of 1,200 acres at present unplanted in the Chaffey Irrigation Area was examined for horticultural value on behalf of the Lands Department. The conclusion was that the soil types and general character were unfavourable for settlement by small farmers of limited capital. An area of 2,000 acres adjoining the Settlement on the west side was surveyed for the Renmark Irrigation Trust as a potential extension. The flat is of doubtful value except in limited portions which were defined, and all pose problems in management as to drainage, salinity, and intractability. A second portion of 700 acres adjoining the Settlement on the north side and involving an additional pumping lift proved to be of good quality, and from the soil angle considered of value, provided adequate care is taken in irrigation and control of seepage.

An examination of the site of the proposed new Adelaide airport was made on behalf of the Department of Interior prior to negotiation for securing the land which is partially developed. The soils are diverse and present problems in drainage, salinity, and fertility.

(iii) *Tasmania.*—During the spring of 1945 a survey was commenced in the Hagley-Westbury district adjoining the Cressy area, a study of which was published in 1942. The main purpose of the extension was to locate further occurrences of certain soils, particularly Cressy shaley clay loam, which experimental and field work has shown to respond markedly to small dressings of molybdenum. Aerial photographs were procured and have assisted greatly in the field work owing to the lack of accurate land survey plans. Pressure of land settlement requirements forced the suspension of the survey before completion.

In the summer months, a third attempt was made to do a significant survey on the Montagu Swamp in the extreme north-west of the State. This survey can only be carried on in a very limited portion of the year dependent on drainage conditions in the swamp which are quickly affected by storm rains. Unfortunately, early unexpected rains caused an early rise of water in the swamp and traversing could not be completed, nor were any samples obtained for analysis. The effective examination of the swamp lands can only be properly attempted when some form of drainage channel is cut for relief of summer rains. A reasonable assessment of the soils of the swamp still remains a matter of some doubt, and is now rendered still more difficult by the discovery, from a survey this year, that the soils of the nearby Mowbray Swamp which has been developed for some time are different to those of the Montagu Swamp.

A reconnaissance of the soils of a coastal heath formation in the Smithton district has also been done as a preliminary to assessing the possibilities for pasture establishment. There still remains a great deal of work on the virgin lands of the north-west corner on both the heath and swamp formations which can only be carried out on a long-term programme.

(iv) *Victoria.*—The field work of the soil and erosion survey in the Dookie-Euroa district mentioned in last report has now been finished. It included additional field investigations on the tunnel type of erosion. The survey presents a clear picture of the soil types and their distribution and liability to erosion. The pattern of erosion has been mapped over 200 square miles of grazing and wheat country with observations on the trend and control of damage.

In 1940 the survey of the Murray Valley Irrigation Area was suspended pending the extension of irrigation facilities westward. Post-war settlement schemes involving large resumptions for resubdivision have made necessary the examination of an additional 18,000 acres in the Nathalia district. The Victorian Department of Agriculture collaborated by undertaking laboratory analysis of soil samples. A report has been submitted on the comparative irrigibility and problems of development of the various soil types classified.

(v) *New South Wales.*—Soil survey activities in the State have in the main been of a detailed character on potential or existing irrigation areas. An area of aproximately 30,000 acres known as the Abermusden Area in the Upper Hunter Valley has been closely mapped. The valley which is an average of two miles wide has a considerable expanse of alluvial flats reported to be of high fertility. The proposed construction of two dams on the upper reaches of the Hunter and Page Rivers will ensure a supply of irrigation water to them, and the survey was designed to assess the value of the soils under irrigation. So far the work has been confined to the valley floor, but it is intended to carry it on to the adjacent eroded hills where significant damage has occurred.

In the Riverina detailed surveys have been confined to estates projected for soldier settlement. One of the Pine Lodge Estates of 11,000 acres has now been mapped, defining those soils and portions of greater value for irrigation so that subdivision into small units may be made to good advantage. This is also of individual significance, as each farm has a limited water right to be used on the most suitable soils.

A rapid examination was made of 8,000 acres of land adjoining the present Coomealla Irrigation Area near Wentworth. This is a new scheme involving an extensive installation of channels and it was desired to obtain an estimation of the irrigation characteristics of the soils. The soils have a significant proportion of sound types including some excellent citrus land, and the general summary was favourable as far as justifying a detailed survey.

The scheme for the diversion of the Snowy River into the Murrumbidgee River would provide a large volume of additional water for irrigation development on the plains below Narrandera. A general inspection was made of the region as far downstream as Balranald, with a view to determining the needs of survey and pattern of soil occurrences and thereby endeavouring to define the more suitable land for detailed examination. This better area appears to lie south of the river between Yanco Weir and Hay and north of the river adjoining the western side of the Mirrool Irrigation Area.

The reconnaissance inspection of the soils and their related problems in the Macquarie Region was begun at the request of the Reconstruction and Development Division of the Premier's Department. A preliminary report was submitted indicating the needs of a full survey to clear up the soil and potential land use development in the region which includes a wide range of rainfall conditions including some practicable irrigation. The fuller survey has been postponed because of difficulties of available staff and transport.

At the request of the Department of the Interior, a close survey was made of the soils of portion of Canberra City area which is to be completely mapped in the future. The information is being sought for developmental schemes concerning improvements in parks and gardens in the city, the soils of which are diverse and in a complex pattern.

(vi) *Queensland.*—A report on the inspection made in south-eastern Queensland last year has been submitted to land settlement and reconstruction bodies. The suitability for development of the black soils from Dalby to Taroom and the problems facing more intensive use of certain included types of country was pointed out. A second report dealt with the erosion position in the sugar cane country of the north coast in which the danger of soil deterioration is growing.

(vii) *North Australia.*—The North Australia Development Committee sought the inauguration of a scientific reconnaissance of North Australia to determine more definitely the areas of great potential value for development and to set down the kind of problems requiring research. The Division of Soils is participating in these exploratory traverses which were recently begun and which it is hoped will be continued on a long term programme. The Division made available a soil surveyor to be responsible for soil observations and to assist in the general assessment of the region. The area selected for the first year's work is that portion of the Northern Territory between the coast on the west and a line running south from Alligator River to Katherine and thence west to the Fitzmaurice River.

(viii) *Housing Surveys.*—The Section of Soil Physics and Mechanics of the Division has undertaken the study of soils of certain areas in the capital cities proposed for large housing schemes, and as a first step soil surveys were put in hand.

In Melbourne the main work has been the suburbs of Heidelberg, 1,200 acres, Maidstone, 600 acres, and Ashburton, 50 acres. In Sydney close surveys have been made at Villawood, 400 acres, and at the Building Research Station at Ryde, 40 acres. In Adelaide, apart from general inspections, a unit of 70 acres at Glenelg with very mixed and problem soils is at present under investigation. The surveys form the basis for testing and research on the various soil types in respect to type and stability of building foundations.

(ix) *Aerial Photography.*—The policy of making use of all available aerial photographs for survey has been continued. For this purpose prints have been obtained through the Royal Australian Air Force of areas in Western Australia, South Australia, and Victoria, and a new small unit of 250 square miles in the Hunter Valley, New South Wales, was flown for the Division by a commercial company. Unfortunately, with many of the available photographs in the Royal Australian Air Force collection, the scale is too small for the needs of soil surveys. Recently, survey on broad lines on oblique photographs was attempted with some success, and as much of the thinly occupied area of Australia has been photographed only with tri-lens camera it will be necessary to work out a sound system for using these oblique views.

3. *Soil Chemistry Section.*—During the year routine analyses required by the Soil Survey Section have been carried out and an increased number of samples examined. Attention continues to be focused on improvements in methods of analysis designed to reduce the time required or to improve the accuracy and reproducibility of the results. In addition to these analyses from soil surveys in progress, a number of soils have been examined for their nitrogen content in connexion with cultivation and structure studies carried out by the Soil Physics Section. Three further large series of soils from field experiments carried out by the Wakool District Irrigation Research Committee have been examined for soluble salts.

A pot experiment designed to compare the yields and relative copper status of various herbage plants grown on Barooga (New South Wales) and Waite Institute (South Australia) soils has been carried out to assist the Division of Animal Health and Production in its study of enzootic (toxaemic) jaundice of sheep. Toxaemic jaundice is associated with excessive storage of copper in the livers of animals subject to the disease, hence arises the importance of securing comparative information on the copper status of herbage plants from areas liable to the trouble and from normal areas. Three plant species were used, namely *Erodium cygnorum, Medicago denticulata,* and *Hordeum leporinum.* On Waite Institute soil the application of a fertilizer supplying soluble nitrogen, phosphorus, and potassium led to very considerable increases in the yields of dry matter of all the plants tested. The same application of fertilizer to Barooga soil gave increases of a very much lower order. The Waite Institute soil used was known to be very deficient in readily available phosphate.

Examination of the plants for their copper status discloses that, in general, the proportion of copper in the dry matter was decreased when the yield was increased by the application of fertilizer. Only in the case of *Hordeum leporinum* were the plants grown in the pots of Barooga soil significantly richer in copper than the corresponding plants grown on Waite Institute soil. The small increase (about 1 mg. of copper per kg. of dry matter) in the amount of copper in *Hordeum leporinum* growing on Barooga soil could not be considered sufficient to account for the enormously increased copper storage of animals grazing on such areas. Examination of the fresh plant material for the proportion of readily soluble copper also failed to demonstrate any significant differences between the plants from the two soil types. This investigation is being continued, and a pot experiment designed to evaluate some of the factors controlling the availability of both copper and molybdenum in these soils is at present in progress.

Spectrochemical studies have continued to receive attention. A qualitative survey of the trace elements present in a range of phosphate rocks from a wide variety of sources, and the superphosphates made from these rocks, has been completed. Considerable variations were noted in the amounts of some of the trace elements present, particularly in the lower grade rock phosphates used during the war. The quantitative estimation of the more important elements is in progress.

A wide range of miscellaneous samples has been examined spectrochemically to assist in trace element investigations being conducted by other organizations. These have included molybdenum determinations in subterranean clover from pot experiments with soils of varying reaction, soil and plant samples in connexion with dystokia in Western Australia and Kangaroo Island, and miscellaneous samples from the State Department of Agriculture.

Attention continues to be devoted to spectrochemical technique. A statistical study of results obtained by the flame method of excitation enabled the separate evaluation of the errors due to the method of excitation, the microphotometer, and the photographic plate. Irregularities in the emulsion of the photographic plate accounted for the largest proportion of the total error. An appreciation of the nature of this error enabled the proper replication and placement of the spectra on the plate to keep the overall error within pre-determined limits. Optimal conditions for arcing soil and plant samples have been further studied and a start made with the study of the background correction.

4. *Soil Physics and Mechanics.*—The main lines of investigation of the Section have been in the fields of soil-water relations, soil structure, and engineering properties of soils. Work has continued on methods of analysis and the treatment of data.

(i) *Soil-Water Relations.*—A spray infiltrometer has been designed for the study of the infiltration of water applied as a spray to soils. The spray infiltrometer was compared initially with commercial spray systems with regard to critical conditions of water entry into soils. It was found that for given rates of irrigation results for the two systems compared closely. This part of the work was carried out co-operatively with the Departments of Agriculture and Engineering and Water Supply, South Australia. The rate of infiltration of water into soils of the proposed Loxton Irrigation Area, S.A., was then investigated by the same means. The objects were to determine which soil types were suitable for spray irrigation and what rates of application of irrigation water could be safely assumed for design purposes of plant and lay out. Infiltration characteristics of the same soil types were compared in non-irrigated and in irrigated sites to enable a forecast to be made of future trends in the rate of infiltration after an area has been developed for a number of years. The material is being prepared for publication with conclusions on the reaction of specific soil types.

Continuous methods for measuring fluctuations in the water content of soil *in situ* have been reviewed and trials made with tensiometers and electrical conductivity (gypsum block) methods. Details of methods which have been developed for constructing tensiometers have been published in view of the wide interest of other investigators. Records of measurements with tensiometers supplied by the Division and installed at Waikerie, S.A., by the Department of Agriculture, have been analysed to determine the pressure potential of soil water at field capacity in a typical sandy soil. The value obtained of approximately minus 70 ergs per gram has since been confirmed by experiments on a similar type of soil at Loxton. Tensiometers have been used also to determine the pressure potential of water passing through a uniform sandy soil under two conditions of application—flooded surface and sprayed—with three rates of spray application. A slight negative potential was maintained during transmission indicating that the water was moving downward sufficiently fast to prevent complete saturation of the soil.

The work begun on physical characteristics of the Ord River soils last year in association with the Western Australian Department of Agriculture was completed by the determination of wilting percentages. A comparison of the direct and the indirect (freezing point depression) methods was made showing that a reasonable comparison is possible, particularly if a correction for heat capacity of the soil and apparatus is used.

(ii) *Soil Structure and Texture.*—The work on soil structure begun earlier at Griffith on the Murrumbidgee Irrigation Area has been extended in collaboration with the Commonwealth Research Station there to include a study of soil changes in an experiment for reconditioning a soil of poor structure. The initial structural condition has been closely measured as a background to subsequent improvement. Measurements have also been made of the water-stable structure of the soil aggregates in an experiment at the Griffith Station on the growth of lucerne between rows of orange trees. It was found there was a marked difference in the soil of the clean cultivated and lucerne land, the latter having significantly more stable aggregates than the former.

Statistical methods have been applied to the examination of data from Griffith and the Waite Institute on measurement of structure for soils of variable

texture. Corrections for texture variations have been made by means of linear and multiple regression equations relating structure with mechanical composition.

The diagrammatic representations of texture on a triangular chart according to mechanical analyses and the classification used in field work has been reviewed following a similar move in the United States. Correlations between the definitions of texture classes for Australia and America have been worked out. There has been some drift in the relation of texture and mechanical composition since the original diagram for Australian practice was produced in 1934 by the Division.

(iii) *Soils and Foundations.*—As a result of discussions between State Housing authorities, the Building Materials Research Section of Council for Scientific and Industrial Research and the Building Research Experiment Station of the Department of Labour and National Service, work has been begun involving field and laboratory studies on the qualities of soils in relation to foundations. The first step has been the carrying out of soil surveys, mostly in detail, of selected areas in Sydney, Melbourne, and Adelaide (see above under Soil Surveys). The physical work now beginning concerns seasonal moisture fluctuations beneath foundations which affect soil movement by causing shrinkage and expansion, and the bearing properties of soils. Apparatus has been designed and is in part assembled for such research.

(iv) *Analytical Methods.*—A rotary sieve has been designed and constructed for the gentle sieving of soils of field samples without undue breakage of structural aggregates. Rapid methods for mechanical analyses of soils have been further examined with respect to new hydrometer designs and the type of dispersing agents for use with calcareous soils. The calculation of settling depth applied to the usual type soil hydrometer has been checked.

5. *Soil Bacteriology.*—Work carried out during the past year has continued to centre on the influence of molybdenum on symbiotic nitrogen fixation. Experiments have included a wider range of molybdenum-deficient soils.

The pattern of nodulation throughout the life of the plant in the presence of molybdenum and an adequate dressing of combined nitrogen has been determined by counts of nodules, their distribution, and the nitrogen content of leaves and stems. Changes in the nitrogen status of the plant are reflected in the nodulation.

An experiment has been conducted with *Phaseolus lathyroides* during the summer months, where the plants received dressings of phosphate, molybdenum, and nitrogen in all combinations, one series being inoculated with an effective strain of *Rhizobium* spp. and the other being kept uninoculated for the duration of the experiment. Plants responded to all three elements in the inoculated series, but there was little response by uninoculated plants.

With a view to ascertaining the growth of the anaerobic nitrogen-fixing organism, *Clostridium butyricum,* at varying levels of added molybdenum, strains of the organism have been isolated from a wide range of soils. These organisms were absent from known molybdenum-deficient soils.

Cultures for inoculation of legume seeds have been supplied to farmers during the past year, all strains being tested under controlled conditions in the glasshouse before distribution.

6. *Publications.*—During the year, 22 Divisional reports dealing with small units of work or work not in complete form or of a confidential nature were prepared and circulated to interested bodies, and the following papers were published:—

Anderson, A. J., and Thomas, M. P. (1946).—Plant responses to molybdenum as a fertilizer. 1. Molybdenum and symbiotic nitrogen fixation. Coun. Sci. Ind. Res. (Aust.), Bull. 198.

Anderson, A. J., and Oertel, A. C. (1946).—Plant responses to molybdenum as a fertilizer. 2. Factors affecting the response of plants to molybdenum. Coun. Sci. Ind. Res. (Aust.), Bull. 198.

Crocker, R. L. (1946).—Post-Miocene climatic and geologic history and its significance in relation to the genesis of major soil types of South Australia. Coun. Sci. Ind. Res. (Aust.), Bull. 193.

Marshall, T. J. (1945).—Tension of water in a sandy soil at field capacity. *J. Aust. Inst. Agric. Sci.* 11 : 192-4.

——(1946).—Ceramic instruments for use in investigations of water in soils. *J. Coun. Sci. Ind. Res.* (Aust.) 19 : 166-71.

Smith, R. (1945).—Soils of the Berriquin Irrigation District. Coun. Sci. Ind. Res. (Aust.), Bull. 189.

Stephens, C. G., *et. al.* (1945).—A soil, land use, and erosion survey of County Victoria, S.A. Coun. Sci. Ind. Res. (Aust.), Bull. 188.

VII. IRRIGATION SETTLEMENT INVESTIGATIONS.

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

1. *General.*—During the past year, the staff has been increased by the appointment of two Research Officers and one Assistant Research Officer to work on irrigation and drainage problems, the soil moisture problems of irrigated lands, and soil deterioration resulting from irrigation.

The outstanding events in dried fruits production have been the abnormally high sprouting percentage last spring after the period of drought. This was followed by slow development and maturation, damage by tropical rains, and the poorest drying season for many years. During February and part of March the position was aggravated by the shortage of potash. The resulting losses of currants have been heavy, possibly 35–40 per cent. With sultanas and lexias, quality was very seriously affected, and final yields, though satisfactory in the Mildura district, were much reduced in other dried fruit areas in which the rainfall was greater.

Most of the citrus trees in Mildura district received a severe gruelling during the drought years, by the destruction of growing shoots and damage to leaves which caused them to fall prematurely. The crop was reduced in the 1946 harvest, but, with the end of the drought, trees are now recovering rapidly and the fruiting surface is being restored.

The Advisory Committee of the Station met during the first half of the year and made a strong plea for a concentration on land reclamation investigations which had almost lapsed during the war. In the northern Victorian districts, investigations have commenced in co-operation with the Department of Agriculture, Victoria. In the western Riverina, preliminary investigations on the salt status of land being brought under irrigation were carried out in co-operation with the Division of Soils.

Entomological work covering the use of additional spray specifics was continued, but results were negative because of the freedom from insect pests during the drought.

Vegetable work, in which the Station is a unit in comprehensive investigations being carried out by the Division of Plant Industry, is being continued. The work at Merbein included variety trials of different varieties of tomatoes, potatoes, beans, and rock melons, and the further selection from crosses and hybrids developed at Canberra. An interesting phase of the examination is the determination of vitamin C in tomatoes, for variety comparison and also for comparison with other districts.

2. *Viticulture.*—The nutrition of the vine is studied by means of fertilizer trials embracing the principal fertilizers and applications of solutions of minor elements. The treatments in the various fertilizer field trials have been continued with a view to measuring long term effects, the yields being measured and recorded periodically. A special trial for a study of factors affecting the growth of the gordo grape was also commenced.

Swabbing trials at the Research Station on sultanas and currants, in which all pruning cuts were swabbed at pruning time with a strong solution of one of the "minor" elements, boron, iron, manganese, molybdenum, and zinc, were interfered with by rain to some extent, but no increases in yield with any of these treatments have yet been obtained. Increases in yield have been obtained, however, on gordo vines at Red Cliffs by swabbing pruning cuts with zinc sulphate solution. Some improvement in the quality of the fruit may also result.

Iron chlorosis investigations have been continued and it has been found that chlorotic currant vines can usually be cured or considerably improved by swabbing all pruning cuts and later all cincturing cuts with a 20 per cent. ferrous sulphate solution. The advisability of the shallow working of the soil where this condition occurs, is also being investigated.

The work on bud fertility has been continued and extended. The results obtained during May indicate prospects for a normal sultana crop next season.

A record of the growth and maturation of sultana grapes was taken and showed departure from normal as a lag in both size and development of sugar, probably associated with an abnormally heavy crop and a season of low temperatures.

3. *Fruit Processing.*—Potassium carbonate was again in short supply during the earlier part of the drying season, and growers were in many cases obliged to use reduced quantities in their dips, or to use substitute dipping mixtures during the first few weeks. Trials carried out confirmed the results obtained previously that, during poor drying weather, mixtures of caustic soda and potassium carbonate are less satisfactory in the cold dip for sultanas than the standard dip containing only potassium carbonate. Suitable mixtures of potassium hydroxide and potassium carbonate, however, gave satisfactory results. As an aid to the removal of "green tinge" in sultanas, the use of caustic potash in the cold dip mixture is therefore preferable to that of caustic soda.

Promising results in drying sultanas have been obtained with the use of a new sulphonated oil preparation derived from neatsfoot oil. When used in the cold dip mixture, it improved wetting and gave faster drying. Interesting results were also obtained in spraying trials carried out on sultanas during poor drying weather in March, April, and May. A comparison was made between the established spray (carbonate of potash), and caustic potash, plus oil emulsion in both cases. Under the conditions prevailing caustic potash was very much more effective than the carbonate in hastening drying.

The possibility of using infra-red heating in quickly removing small amounts of moisture from dried vine fruits is being investigated. Trials carried out by one of the packing houses in the district suggest that it may be possible to complete the drying of some lines of fruit by this means.

Further work has been carried out on the control of mould growth on grapes during drying. A practicable method of enclosing and sulphuring racks of fruit with the fumes of burning sulphur has been devised. Work on various harmless fungicides has been continued.

A limited amount of work was carried out on the losses involved in the seeding of lexias. The preparation of emulsions used for dips was supervised for the Mildura Packers' Association.

4. *Irrigation.*—A survey of the usage of irrigation water on a representative portion of the Red Cliffs settlement has been carried out. Examination of water distribution figures discloses an alarming increase in the water distributed annually. For many years, the average applications were under 36 acre inches per year, but in recent years applications have approached 48 acre inches. A similar trend is noted in other large irrigation settlements used for horticulture. The individual applications also vary, some settlers using twice as much water as others. Small scale trials indicate that it is practicable to increase irrigation efficiency considerably under existing conditions, but structural alterations to the distributing channels of the holdings are necessary in many cases.

The survey also disclosed that the design of many holdings, particularly the relation between water supply, gradient, and length of irrigation run, is so faulty that a high irrigation efficiency is not possible.

Following the surveys, methods of measuring irrigation water are being examined, and models of devices which may possibly be suitable have been prepared for trial. Arrangements have been made for the co-operation of the State Rivers and Water Supply Commission, Victoria, and the Water Conservation and Irrigation Commission, New South Wales, in additional surveys designed to measure present irrigation efficiency in portions of major settlements, and to define procedure by which irrigation efficiency can be increased.

5. *Reclamation.*—An examination of soil wastage under irrigation has been made in the districts of Mildura, Swan Hill, and Cohuna (Victoria); Curlwaa and Goodnight (New South Wales); and Renmark (South Australia). In Swan Hill and Cohuna, investigations have been commenced in co-operation with the Victorian Department of Agriculture. These have taken the form of examination of the free water status; the analyses of the soils for injurious salts; and an alteration of the irrigation and land-use procedure contributing to wastage. In the Curlwaa Irrigation District, a shaft extending into waterlogged sands has been sunk, and pumping equipment is being installed in order to test the range and efficiency of this method of removing subsoil water. In the Goodnight and Renmark settlement, the response to agricultural drainage of wasted lands is being examined.

6. *Land Use.*—The Station has co-operated with the land settlement authorities of the Commonwealth, New South Wales, and Victoria in the preliminary selection of lands for soil survey on which the suitability for post-war land settlement will ultimately be based. The results of irrigation investigations of the Merbein and Griffith Stations have been re-examined, with a view to utilizing established principles in the design of new irrigation areas selected for soldier settlement. The experiences of established irrigation areas, in the important work of correctly fitting horticultural plants to the available soil types, is being closely examined, with a view to avoiding costly errors in plantings which have characterized irrigation settlements in the initial stages of development. The selection of areas for

settlement is also based on the required volume of varied kinds of produce, as determined by marketing authorities.

7. *Vegetables.*—The work carried out at the Merbein Station is portion of a comprehensive programme undertaken in various parts of Australia, on an investigational design planned by the Vegetable Problems Committee, and with the co-operation and direction of the Division of Plant Industry. Many useful varieties of vegetables have been introduced, others are being developed by crossing and selection, and all promising varieties and strains are being tested and examined under field conditions.

The vegetable work of the Merbein Station is carried out on an area in Red Cliffs on which irrigation is continuously available from the urban supply. The plants grown include various varieties of tomatoes, and also crosses and hybrids developed by the Division of Plant Industry. The records include detailed growth studies, flowering and setting characteristics, yield and quality, reactions to disease, and determination of vitamin C. The disease survey was mainly directed towards the occurrence of Fusarium wilt.

Of the potatoes tried, three varieties, Katahdin, Sebago, and Up-to-Date 265 proved satisfactory, producing little second growth, and in general a satisfactory quality which held condition for several months. The varieties of potatoes gave much better results, particularly in the absence of second growth, at the autumn as compared with the spring crop. A virus trial was carried out to note the reaction when varieties of potatoes were infected with virus X prior to planting.

Of other vegetables tried, introduced varieties of beans failed because the flowers did not set. Of 51 varieties of rock melons which were grown, about ten gave a very attractive product. Attempts at self-pollination for purity of seed were unsuccessful, as all flowers perished when enclosed in cloth or paper bags, a method of isolation which is successful in cooler and less variable climates.

A most interesting result was obtained from a tomato trial on which the periodicity of irrigation was varied. The plants irrigated at weekly intervals were consistently inferior to those irrigated at intervals of three weeks. Weekly watering was associated with leaf folding, drooping, less growth and crop, and a root system closer to the surface of the soil.

8. *Maturity Records.*—The maturation of the sultana and gordo grapes and of navel oranges was recorded during the ripening periods. The work on oranges was to examine properties of the fruit as possibly affected by root stocks, and also to compare a locally developed sport with standard navels. The maturation of the sultana is recorded each year in order to fit routine operations, including irrigation and harvest, with the ripening of the fruit.

9. *Finance.*—Two valuable contributions were again made available for the work of the Station, £1,000 from the Mildura Packers' Association, and £1,000 from the Australian Dried Fruits Control Board. Other subsidies have been obtained from the State Rivers and Water Supply Commission, Victoria, the Water Conservation and Irrigation Commission, New South Wales; the Rural Bank of New South Wales; and from local producers' organizations for examination of special problems affecting particular districts. Portions of the major subsidies are unexpended, owing to staff shortage during the year.

10. *Publications.*—The following papers were pubpublished during the year:—

Lyon, A. V., and Pennefather, R. R. (1946).—Furrow irrigation of community settlements. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 38-45.

Orton, E. C. (1946).—Investigations on the use of sulphite dips in the drying of peeled pears and peaches. Ibid. 19: 128-39.

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 to orchard trees, and it is provided with good laboratory facilities.

2. *Field Experiments with Fruit Trees.*—Permanent field experiments with orange trees cover investigations of the following: methods of irrigation and water requirements of the trees, including frequency of irrigation; fertilizer requirements, including both major and minor elements; cultural treatments, and other studies.

Besides these experimental fields on the Station's property, there are experimental plots on settlers' farms. These plots have given much information concerning the appropriate methods of irrigation for different soil types and the effect of different cultural treatments on the health and yield of the trees.

3. *Irrigation Investigations.*—The aim of this work is to determine the best methods of irrigating fruit trees and vegetables. Work reported in previous years has shown the effect of slope, soil type, and flow of water entering the furrow on the amount and uniformity of the irrigation.

A particular problem in irrigating vegetable crops on a field scale is to soak the top of the ridges where the seeds are placed without giving excessively heavy irrigations. The effect of the depth of water in the furrow on the time of soakage necessary to wet the tops of the beds and the total amount of water applied in an irrigation has been studied.

The amount of water that is applied to a soil during an irrigation is largely dependent on the soakage rate of the soil. It is therefore important to know the changes that occur in the soakage rate from year to year and from season to season, both from the point of view of managing existing areas and of surveying new areas.

It has been found that there is a seasonal variation in the soakage rate even of virgin soils; the causes are being investigated. Other things being studied are:—(*a*) the effect of the initial soil moisture on the soakage rate, (*b*) the effect of cultural treatments, and (*c*) the cause of the decline in soakage rates of orchards during the irrigation season.

4. *Rice Fields Investigations.*—The excessive use of water by rice farmers on certain soil types has recently been condemned as being uneconomic and even dangerous to certain sections of the horticultural community. Following a recommendation by a special scientific committee appointed by the Premier of New South Wales, the Research Station is carrying out investigations to determine the water requirements of rice and to show the extent to which rice farms may be a contributing factor to the rising water tables of some areas.

5. *Drainage Investigations.*—Waterlogging and salting are now widespread on the Murrumbidgee Irrigation Area as a result of past irrigation practices and wet winters. The commercial life of many farms is thus being threatened.

A tile drainage experiment installed on a commercial farm in the winter of 1942 has yielded valuable information. The value of lucerne in reclamation has been demonstrated, and the health and yields of orange trees have improved. Drainability studies to determine optimum depths and spacings of tile drains on the main soil types of the Murrumbidgee Irrigation Area have been continued. These studies have also been conducted on virgin land being considered for settlement. Information from investigations to date is being used in two farm-size tile-drainage trials on two major soil types. The effects of drainage on the plant and upon the soil-salt status will be watched. The place of mole drainage in the reclamation programme is

being considered. Methods of establishing and maintaining pastures for dairying purposes on salted horticultural land are being worked out. This work includes studies of such factors as width of bay, length of run, and pasture mixtures.

6. *Soil Reconditioning Investigations.*—The average life of orchards is about twenty years, and as most of the plantings on the Murrumbidgee Irrigation Area are now 20 to 30 years old, the district has passed through the first cycle of its development, and the use of old orchard lands presents some problems.

The effect of constant tillage and working the land results in the loss of crumb structure and the formation of a plough-sole; these cause a decline in the fertility of the soil. Investigations are proceeding to determine the exact nature of these soil-structural changes, how they can be prevented, and how the structure of soils so affected can be improved.

7. *Vegetable Investigations.*—(i) *Agronomy.*—The first four years of research into problems of vegetable growing on the Murrumbidgee Irrigation Area have yielded may valuable leads, and during the past season the more important of these have been investigated further.

The value of a cultivated and irrigated spring fallow in supplying the nitrogen required by vegetable crops has again been demonstrated. It seems that autumn crops, even heavy nitrogen feeders such as cabbages, may have their nitrogen requirements satisfied by a fallowed soil. For spring crops, the period of effective fallowing may not be long enough to obviate the need for nitrogenous fertilizers.

Several factorial field experiments were carried out to investigate the influence of soil structure on vegetables. On heavy soils, depth and time of ploughing have been shown to be important for carrots. An application of rice hulls to a heavy soil has benefited the growth and yield of both peas and tomatoes. Gypsum also proved to be a useful supplement for tomatoes.

Evidence suggests that relatively heavy dressings of superphosphate over a number of years may build up the available phosphoric acid in the soil to such a level that crops fail to respond to phosphatic fertilizers. The interplanting at close spacing of early and late tomato varieties has increased the yield of tomatoes per acre as compared with standard practice.

(ii) *Plant Physiology.*—The interpretation of the effects of nutrient and cultural treatments on vegetable crops calls for detailed studies of the growth of these crops in the field. Studies of this type were begun during the year. The initial project is concerned with the problem of soil structure in relation to organic manures and as revealed in terms of plant response.

8. *Soils and Irrigation Extension Service.*—By arrangement with the New South Wales Department of Agriculture, the Council has undertaken a programme of education and extension work to bring the results of investigations of soil-water relationships and irrigation methods to the irrigation farmers. The work was inaugurated in 1943, initially for a period of three years, after which the agreement with the Department was to be reviewed. The policy of the Service is directed by the Advisory Committee of the Research Station, representing local farmer interests and State and Federal organizations concerned with agriculture on the Murrumbidgee Irrigation Areas. Details of the work are given in two mimeographed progress reports available from the Research Station.

The Service has concentrated on more urgent district problems—chiefly, controlled irrigation to prevent salting, reclamation of salted land, and cultural practices to maintain soil fertility. The aim of extension work must be to contact every member of the farming community to see that research and other information is applied on every farm. A proved requirement for effective extension work is the full participation of local farmers in its planning and conduct, and the Soils and Irrigation Extension Service has co-operated with the New South Wales Department of Agriculture in assisting farmers to form eight district extension groups, which are now organized on a regional basis.

In addition to farm visits, the methods used have included the holding of field days, farmers' extension schools, lectures at meetings of extension groups and at general farmers' meetings, weekly press articles and broadcasts, and the periodical publication of a Farmers' Newsletter. Visual education methods, including the use of an epidiascope and a sound-film projector, have greatly increased the effectiveness of the work. In April, 1946, a five-weeks course on "Soils and Irrigation" was attended by officers of the South Australian Department of Lands, the New South Wales Water Conservation and Irrigation Commission, and the Rural Bank of New South Wales. Special courses for Junior Farmers are conducted throughout the year.

By arrangement with the New South Wales Department of Agriculture, the service is being continued in 1946-47. Experience has shown the need for extension and research to be intimately linked for their mutual benefit, and during 1946-47 the Research Station Advisory Committee is to draw up a scheme for the co-operative conduct of research and extension on a regional basis, covering the Murrumbidgee Irrigation Area and adjacent irrigation districts.

9. *Publications.*—In addition to the Soils and Irrigation Extension Service Farmers' Newsletter, Nos. 6 to 9, the following paper was published during the year:—

Lyon, A. V., and Pennefather, R. R. (1946).—Furrow irrigation of community settlements. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 38-45.

VIII. FOREST PRODUCTS INVESTIGATIONS.

1. *General.*—The year under review has seen a rapid transition from research on war-time problems to research into post-war problems. Very pressing demands have been received from industry for assistance, particularly in connexion with housing. These demands have fallen heavily on the Division because little time was allowed for readjustment before they had to be met. The position was further complicated by the loss of research staff to other Divisions and Sections of the Council and to industry. While under normal conditions this would have been a severe enough blow, at the present time it is particularly unfortunate because of the difficulties in obtaining replacements and, even when such replacements have been obtained, the difficulties of training them. It has meant, therefore, that the senior officers of the Division have had far too little time for more fundamental investigations of which there are many calling for attention.

One outstanding development during the year was the calling of the first Forest Products Conference to which representatives from all the State Forest Services and from the Forestry and Timber Bureau (Commonwealth Department of Interior) and the Forest Department of New Guinea and Papua Administration, were invited. One major purpose of the Conference was to discuss programmes of work with particular reference to those of the Division of Wood Technology (N.S.W. Forestry Commission), the Queensland Sub-Department of Forestry, and this Division. It is hoped that this Conference will be an annual affair. The Chief of the Division was an official guest at the annual Eastern States Timber Industry Stabilization Conference held in Melbourne during the year. The Seventh Annual Pulp and Paper Co-operative Research Conference, which was held at Boyer,

Tasmania, during February, was attended by groups of technical representatives from the three companies and by five members of the Division.

During the year the Forest Products *News Letter* was re-issued. This was first published in February, 1932, and, up till April, 1945, 138 issues had been distributed. It was decided to resume publication early in 1946 and, in order that the material prepared for the *News Letter* should have as wide a circulation as possible, arrangements were made for it to be printed. To date three issues of the new series have been prepared. It is proposed to use the *News Letter* for the dissemination of the results of certain experimental work and of information regarding forest products in general.

Two senior officers of the Division were appointed members of the Australian Scientific Mission in Japan, and reached Tokyo in April, 1946. One is paying particular attention to aspects of pulp and paper and rayon research, while the other is investigating the plywood industry as well as forest products developments in general. The Officer-in-Charge of the Utilization Section returned to duty with the Division after 4½ years with the Ministry of Munitions as Assistant-Controller of Timber.

It has become evident during the year that the staff of certain sections of the Division needs strengthening to cope with the many varied problems received. This is particularly the case in such Sections as Timber Preservation and Utilization where the enquiries for assistance from Commonwealth and State Departments, and industry in general have been heavy. It is realized that concentrated effort is needed on problems related to the utilization of waste material and to the more efficient functioning of sawmills at present in operation, in order to give the greatest return from the forests. For this reason the Division has assisted several of the State Forest Services in planning and carrying out sawmill studies. Further, the Division has been investigating fields of usefulness for waste sawdust and has paid attention to the development of sawdust cements. The increased demand for timber for various purposes, e.g. railway sleepers, has brought again into prominence the need for the development and use of methods of timber preservation and, in this field of work, the Division's officers have been particularly active.

Special reference should be made to the library facilities of the Division where the number of publications received has greatly increased, both to the benefit of the officers of the Division and industry in general. Several comprehensive bibliographies have been compiled on request during the year, including "The Bibliography of Australian Timbers and other Forest Products," and its first supplement. In this, the post-war year, the officers of the Division have been called upon to a large extent for lectures on forest products for various rehabilitation classes. In addition, a series of lectures on seasoning and preservation has been given to forestry students from the Australian Forestry School and another series has commenced for forestry students of the University of Melbourne.

2. *Wood Structure.*—(i) *General.*—With the cessation of hostilities and the gradual withdrawal of troops from bases in the South-West Pacific area, the urgency regarding information on the timbers of this region diminished greatly. Some realignment of the work of the Section therefore was necessary, and, although study of the timbers of the New Guinea region has been continued, especially from the aspect of their post-war utilization, attention has been gradually directed to the more basic investigations such as those related to the structure of the individual fibre, reaction wood, structure in relation to properties, growth problems, and the general examination of Australian timbers. Keen interest in the last project has been expressed generally, because of the plan to develop a simple card-sorting key for the identification of the commercial Australian timbers. The staff of the section has been gradually strengthened to cope with expanding fundamental problems.

(ii) *Timbers of the South-West Pacific Area.*—(*a*) *New Guinea.*—It has been found necessary because of the demand from firms and individuals returning to the New Guinea region, to revise and expand the card-sorting key developed for New Guinea timbers. This has involved the amendment of many of the cards in the original war-time sets and the addition of new cards which represent species new to the key. Such additions and amendments have been made on the basis of completed botanical determinations. Other work on New Guinea timbers has been connected with the microscopic examination and description of the wood anatomy of all species where definite botanical identification has been obtained.

(*b*) *British Solomon Islands Protectorate.*—Assistance on timber identification problems has been rendered to Major F. S. Walker who has been carrying out a timber survey in the British Solomon Islands for the High Commissioner of the Western Pacific. Timber specimens received have been identified as far as possible and the identifications together with notes on wood structure forwarded to Major Walker. It is of particular value at the present juncture to have this opportunity of comparing the New Guinea timbers with those from the Solomon Islands.

(iii) *Wood Anatomical Investigations.*—During the year, these studies have covered certain particular groups where information was needed in the course of other investigations. In connexion with the work on New Guinea species, it was essential to investigate the anatomy of a number of genera of the Flacourtiaceae and the Euphorbiaceae. Available material of the Elaeocarpaceae has also been investigated in order to clarify the distinctions between timbers of the genera *Sloanea* and *Elaeocarpus*. This again arose from work on New Guinea species. Recent botanical evidence has indicated that numerous Australian and New Guinea species previously classified in the genus *Eugenia* are not rightly placed in this genus. The examination of the available wood specimens and reference to descriptions of the wood anatomy of species of the genus *Eugenia* occurring in the New World showed that there was ample anatomical evidence in support of Merrill's separation of *Cleistocalyx, Syzygium,* and *Acmena,* from the genus *Eugenia.* Revision of the earlier work on the structure and methods of identification of the coloured woods of the genus *Eucalyptus* has been undertaken and a revised edition of Bulletin 67 will be published.

(iv) *Development of the Card-sorting Key for Australian Commercial Timbers.*—The work on this key which has macroscopic features only as its basis, has been advanced considerably during the year, and the first set, containing 158 key cards and covering various Australian timbers selected for inclusion, has been completed. Photographs have been taken at three magnifications of the cross-section of each of the species included. The efficacy of this set for identification purposes has been tested thoroughly, using numerous trained and untrained operators. The work of preparing some 500 sets of the key is now in hand, but it is not expected that they will be ready for distribution until early 1947. At the request of the recent Forest Products Conference, to which reference has been made earlier, arrangements will be made to include on the cards for each species botanical notes and line drawings of leaves, flowers, and fruits.

(v) *Identifications.*—Over 600 timber identifications were completed during the year. These were received from various sources including Commonwealth and State Departments, manufacturing firms, and private

individuals. Other identifications carried out by the Section have covered fibres, glue lines, wood flour, paper, &c. Numerous sets of the card-sorting keys for New Guinea timbers, for Philippine timbers, for the timbers of the Dutch East Indies, and for timbers used in Australia for sleepers, have been distributed during the year, both locally and overseas.

(vi) *Cell Wall Studies.*—From earlier work the conclusion had been reached that intercellular adhesion in delignified tissue could be attributed to the existence of a non-lignin bonding material which was soluble in dilute alkali. Further investigations have now indicated that any tendency to maceration (cell for cell separation) of a delignified section on treatment with dilute alkali should be attributed to the swelling of the cell wall. In addition, however, the alkali does take into solution part of the cambial wall. The previous conception of a non-lignin bonding material soluble in dilute alkali must therefore be rejected. The extension of this work showed that the intercellular adhesion in delignified tissue might well be attributed to mechanical adhesion between the cells, since delignified cross-sections of wood can be degraded to a composition equivalent to that of Cross and Bevan cellulose and even alpha-cellulose without complete maceration taking place unless mechanical means are employed.

(vii) *Fibre Studies.*—The study of slip planes and minute compression failures in wood and isolated fibres has been continued. The relation of these features to the cell wall deformations (dislocation marks) of certain textile fibres has been considered. Examinations have been carried out from the following standpoints:—(*a*) optical properties, (*b*) susceptibility to chemical attack, (*c*) staining reactions, and (*d*) distribution in the growing tree. It is suggested that these structures represent regions of micellar distortion which account for their observed anisotropy in polarized light. It is further suggested that, because of micellar distortion, there is a local increase in the micellar surface of the fibre. For this reason there is a greater increase in the absorption of stains, thus accounting for the preferential staining reactions. The development of broken fibres by acid hydrolysis from fibres isolated from brittle heart material proceeds most readily in the region of minute compression failures. Breaks similarly occur in textile phloem fibres in the region of dislocation marks. It has been shown that chemical constitution in the region of a compression failure or dislocation mark is not the dominant factor governing the preferential hydrolysis in these regions. Acetylation also proceeds most rapidly at the cell wall deformations. It is suggested that this susceptibility to chemical attack is governed by micellar arrangement and can be attributed to (*a*) the greater ease of penetration of the reactive molecules because of the increased intermicellar spaces and (*b*) increased reaction rate because of the locally increased micellar surfaces. As a result of this work it has been concluded that slip planes are in the form of a crinkle, while minute compression failures are in the form of a double crinkle or fold in the cell wall.

(viii) *Tension Wood.*—Investigations into the development of tension wood in young trees have been carried out in co-operation with the Commonwealth Forestry and Timber Bureau. Young saplings of *E. gigantea* have been deliberately pulled from the vertical. Selected saplings that have been deformed in this manner have been cut at prescribed intervals and the wood laid down after the deformation examined. It was found that in all cases tension wood had been formed very soon after the tree had been bent. It was found, further, that numerous slip planes and minute compression failures were present in the tension wood areas. Tension wood fibres from eucalypts have been examined, and the present evidence would indicate that such fibres are composed of an outer flat micellar spiral and a thick inner unlignified layer where the micellar alignment is almost parallel to the longitudinal axis. In terms of this structure it is considered possible to explain the abnormal shrinkage of tension wood.

(ix) *Growth Studies.*—These investigations have been continued during the year in co-operation with the Commonwealth Forestry and Timber Bureau. Specimens from selected trees of *Pinus radiata* have been examined and comparisons made between corresponding growth rings in each tree. It has been observed that, in general, the relative width of the growth rings, the percentage latewood, and the number of false rings present are comparable in the different trees and may be correlated with growth conditions. Variations in tracheid length from pith to sap and variations in the micellar angle in individual fibres from pith to sap have been studied. It has been shown that latewood formation occurred in alpine ash (*E. gigantea*) during the months of August and September. Fresh spring growth had commenced in October while the specimens cut in November revealed that the first earlywood had been formed and the growth of the pored zone was well under way. Specimens of *E. dalrympleana, E. fastigata, E. melliodora, E. macrorrhyncha,* and *E. blakelyi* are also being examined to determine the type of wood growth laid down by these species.

(x) *Miscellaneous.*—(*a*) *Investigations of glue line failures.*—Experiments have been carried out in an attempt to develop some staining technique whereby the presence of the wood failure in glue shear specimens may be accentuated, thus enabling the determination of percentage wood failure with a greater degree of accuracy.

(*b*) *Sapwood-truewood transformation.*—The anatomical changes which take place when sapwood changes into truewood have been investigated in specimens of *Pinus radiata,* cypress pine, and karri (*E. diversicolor*).

(xi) *Photography.*—(*a*) Experiments have been carried out using a high speed movie camera for revealing the action taking place during the mechanical testing of timber and the tearing of a piece of paper.

(*b*) The extent of the photographic work during the year can be gauged from the fact that some 56,000 enlargements and 20,000 prints have been handled.

3. *Wood Chemistry.*—(i) *General.*—Co-operation with the pulp and paper industry has been continued throughout the year. At the Seventh Annual Pulp and Paper Co-operative Research Conference, reports of work on fibre studies, wood lignin, wood carbohydrates, methods of wood and pulp analysis, pulp evaluation studies, and paper testing studies which had been carried on by the Division, were discussed, together with contributions made by the various companies. The conference expressed appreciation that the reports of the research work presented at previous conferences had attracted considerable interest overseas. It was decided that New Zealand Forest Products Limited, who had requested admission to the conference, should be invited to attend future conferences in an observer capacity.

(ii) *Wood Sampling Investigations.*—The sampling of wood is a difficult problem because the cellulose determinations require a sample of certain standard mesh and uniform particle size. An investigation was carried out to ascertain whether it was necessary to take for analysis the total wood sample, ground to pass 60-mesh screen, with the inclusion of the fine material or whether the material passing the 60-mesh screen but retained on the 80-mesh screen and consequently of uniform particle size, could be used. Several eucalypts were examined, and it was found that small differences in composition did exist between

the 60-80 mesh sample and the total 60 minus mesh sample. This was particularly marked when the samples contained large amounts of resinous materials. When the 60-80 mesh sample was reground to resemble a 60 minus mesh sample, it was found that the solubility in hot water of the reground sample had increased. It was evident that if accurate results were to be obtained, it was necessary to take the total sample passing the 60-mesh screen and that the grinding procedure had to be standardized to ensure that the amount of fine material was reduced to a minimum.

(iii) *Lignin.*—(*a*) *Reactions of methanol lignin.*—It was established last year that lignin isolated from wood by heating with methanol at high temperatures had undergone methylation during the extraction. The methoxyl content of methanol lignin from *E. regnans* has been determined to be higher than that of any isolated lignin yet recorded. In spite of this, it has been found that methanol lignin reacts with bisulphite and gives colour reactions in the same way as lignin in the wood. In this, it is distinct from other isolated lignins. This is strong justification for the use of methanol lignin as a material for the chemical study of lignin.

(*b*) *Extraction of softwood lignin with methanol.*—The work on the extraction of lignin with methanol has been extended to a softwood, *Pinus radiata*. The results are substantially the same as for *E. regnans*, in that only part of the lignin was removed and there was accompanying degradation of the carbohydrates. The yield of isolated lignin and the extent of breakdown of the carbohydrates were both less for the softwood than for the hardwood. However, a larger fraction of the xylan was lost from the softwood. The isolated *P. radiata* lignin gave colour reactions with phloroglucinol and aniline, but not the chlorine-sodium sulphite reaction. Under suitable conditions, it was soluble in bisulphite solutions. Thus the reactions of the isolated lignin were the same as those of the lignin in the wood. Treatment of the isolated lignin with methanol and dry hydrochloric acid caused disappearance of the colour reactions and loss of sulphite solubility.

(*c*) *The lignin determination.*—A detailed study of the variables of the lignin determination has been made for a number of woods and a number of pulps. It was found that the critical factor was the concentration of the hydrolysing acid, time of hydrolysis with the concentrated acid and time of boiling with dilute acid could be varied within fairly wide limits without affecting the result.

(iv) *Carbohydrates.*—(*a*) *Carboxyl group.*—The possibly fundamental role played by the cellulosic carboxyl group in determining certain properties of pulps and papers, has stimulated the search for a reliable and rapid method of determination of this group. The calcium acetate method having proved unsatisfactory, considerable attention was devoted to the silver-o-nitrophenolate method. More encouraging results were obtained, the chief complicating factor when this procedure is applied to pulps appeared to be the acidic nature of the lignin phenolic hydroxyl group, which leads to prolongation of the reaction and high results. Other, more rapid, methods are in process of examination.

(*b*) *Fractionation according to molecular weight distribution.*—The phosphoric acid method of Ekenstam, by which a fractionation of wood carbohydrates according to molecular chain length may be achieved, has been further utilized in the study of pulps and *E. regnans* holocellulose. The application of the method to residues left after treatment of holocellulose with alkaline solutions of various strengths has revealed a marked decrease in the degree of polymerization, concurrent with the removal of a large proportion of the xylan. Similar results are obtained when the alkali treatment is carried out under nitrogen. These results appear to indicate the presence in the carbohydrates fraction of *E. regnans* of long mixed chains containing xylose as well as glucose units.

(*c*) *Wood hydrolysis.*—The limited amount of information available on the behavior of Australian woods under conditions of acid hydrolysis, has led to the initiation of work in this field. Various preliminary tasks have been undertaken and are in progress.

(v) *Pulp Evaluation Studies.*—(*a*) *Influence of dissolved salts on pulp and paper properties.*—Further investigations carried out under this project have shown that a large number of pulps are influenced in their strength properties by the presence of small amounts of salts in the water supply. Two main lines have been followed in this investigation. The first has been directed towards methods of overcoming the differences introduced by the varying mineral content of the water supplies at the various pulp testing laboratories, the second has been devoted to attempts to ascertain why a concentration of a few p.p.m. of a salt in a water supply should have such a marked influence on the pulp and paper properties. It has been demonstrated that the variations in the mineral content of various water supplies are sufficient to introduce marked differences in the strength properties of test sheets made from matched samples of pulp, but using different water supplies. This effect was most marked if the water contained divalent or trivalent metallic ions. A number of commercial pulps (both eucalypt and long-fibred imported pulps) have been examined; it has been found that they are all influenced by traces of salts. These pulps were evaluated in distilled water and then in distilled water containing known amounts of chlorides of mono-, di-, and tri-valent metals. Even when the results obtained with mono- and di-valent metal salts did not differ significantly from those obtained with distilled water, concentrations of the trivalent metal salt (cerium chloride) of only 50 p.p.m. influenced the sheet properties. Attempts have been made to overcome the differences due to the variations in the mineral contents of the various water supplies by adding aluminium sulphate in sufficiently large amounts to swamp these differences. Further work will be necessary before any definite statement can be made on the usefulness, or otherwise, of this method.

Apart from the more immediate problem of obtaining strictly comparable results between laboratories using different water supplies, it is hoped that further knowledge of the influence of salts on sheet properties will throw some light on the chemical factors involved in the formation of a sheet of paper.

(*b*) *Tear testing and stock dividers.*—Studies have been carried out with both these instruments, in order to obtain further data concerning their operation and efficiency. Considerable interest has been shown overseas in these instruments, which have been developed largely within the Division, and enquiries have been received regarding their construction and performance. At the present time, two overseas organizations are contemplating the purchase of locally made tear testers.

(vi) *Coalification of Wood.*—During the excavation for the Captain Cook Graving Dock in Sydney, a tree in a relatively good state of preservation was uncovered in a stratum belonging to the Pleistocene period (estimated to be 15,000-20,000 years old). The wood from this tree was identified as belonging to the bloodwood group of eucalypts. This wood has been studied in collaboration with the Geology Department of the University of Sydney and compared with contemporary members of the bloodwood group to ascertain what changes have taken place in the wood during the 15,000 years it has been buried. Chemical analysis failed to show any marked changes in the chemical

composition of the Pleistocene wood, although some of the lignin and the carbohydrate had been modified. In the absence of any marked changes, it was difficult to say whether the wood would have ultimately become coalified, petrified, or converted to some other form of fossilized wood.

4. *Timber Physics.*—(i) *General.*—The continuity of the work of this Section has been greatly handicapped by the fact that there has been a complete change of staff during the year. A certain re-arrangement of work was affected in the early part of the year and the fundamental creep investigations and strain measurement studies, which had previously been carried out in the Timber Mechanics Section, were transferred to the Section.

(ii) *Wood-Water Relations.*—Although this work has been badly hampered by staff vacancies, a survey of the literature on this subject has been completed during the year. One factor which is of great importance is the question of capillary structure on which a considerable amount of work has been done with softwoods, but very little with hardwoods. It is felt that this gap should be filled, as interest in this project is mainly in relation to hardwoods. The initial planning of the work is now in progress and equipment is being obtained. In connexion with other work in progress in the Division, it has become necessary to know the exact shape of the sorption isothermals at high humidities for certain Australian hardwoods. Apparatus, generally similar to that used by the Princes Risborough Forest Products Laboratory in England, is now being constructed. Work has also been planned and preliminary trials carried out on the sorption and capillary properties of building boards of wood or other vegetable fibre.

(iii) *Physical Properties of Wood.*—Density and shrinkage studies on the wood from coconut logs were completed. Although the density increase from the centre to the outside was very regular, the shrinkage proved variable, and apart from the incidence of collapse near the centre was relatively low and approximately equal in the radial and tangential directions. Work has also been carried out on a number of New Guinea species, and a survey of Australian species has been made with a view to filling in gaps in the available information. Work on discs from a number of logs of silvertop ash is in progress. Methods of improving the properties of wood by means of compression have been further investigated. The properties of one species so treated have been studied. Work so far planned on the effect of temperature on the properties of wood has now been completed and all except one of the reports prepared. A bulletin is being prepared for publication by the Australian Council for Aeronautics. Preliminary measurements have been made of the thermal conductivity of wood using a dynamic method. The method is now being studied with the object of decreasing variability. It has the advantage of speed and small temperature change, and hence there is little movement of moisture during test in contrast with the static hot plate and guard ring method which thus appears less suitable for timber. The method adopted is, in many ways, more suitable for materials of low thermal conductivity. Initial tests have also been carried out on the physical properties of certain building boards.

(iv) *Creep Studies.*—The manufacture of equipment for tests on wood subjected to long-time loading in tension and compression has continued. The air-conditioned cabinets, loading gear, and extensometers for the first two replications are now nearing completion and a building to house them has been erected. One reading instrument is also complete. Further replications of the creep tests on wooden beams are in progress. The arrangement of these tests is such that the variability of wood from tree to tree has shown up very markedly, and it has been made clear that a considerable number of replications are necessary. These beams are not as large as the average size used in structural work, and it appears advisable that tests on a smaller size again should be carried out to investigate the magnitude of scale factor. If necessary, a few large beams will be tested. Material matched with the beams now under test has been reserved for the small scale tests.

(v) *Temperature and Moisture Content of Aircraft Wings.*—This work has now been completed and all reports, except one, issued. A bulletin has been prepared for publication by the Australian Council for Aeronautics. The remaining report will be based on work carried out in Melbourne and Cloncurry to compare the infra-red reflectances of various aircraft finishes.

(vi) *Electrical Strain Gauges.*—Panel shear tests were carried out on plywood, and it became apparent that smaller gauges were needed to form a rosette sufficiently small to give consistent results. A wire resistance strain gauge $\frac{1}{4}$-inch long has been developed for this purpose. For one inch gauge length a single strand of wire has been found sufficiently sensitive and has the advantage of lack of sensitivity to lateral stress fields. A working plan has been prepared for quality control in gauge manufacture by the Section of Mathematical Statistics. Some difficulty has been met when the resistance measuring equipment is located near a mass of metal such as a testing machine and means of overcoming this are being investigated.

(vii) *Dielectric Heating.*—The existing 400-watt equipment has been modified, a new 5-kilowatt unit planned, and material obtained for its construction. This will enable pilot plant tests to be undertaken. The main tests carried out included the use of dielectric heating for edge-gluing of solid timber and the variation of heat distribution in solid timber during drying. It became apparent during the latter tests that automatic current and frequency control were desirable. Mechanical equipment is at present being constructed by a State Forest Service to carry out pilot plant tests on the gluing of case ends, using selective heating so that as little heat as possible is lost in heating the wood.

(viii) *Battery Separators.*—An officer of the Section recently visited the larger Australian separator and battery manufacturers. It was found that the supply position was very bad, especially with regard to local timbers, while even in the case of overseas timbers, substitute material was being accepted. It was apparent that new timbers would have to be found for separators, and a survey of possible Australian and New Guinea timbers is now being undertaken to this end. Softwoods generally prove more suitable for this purpose than hardwoods, and specimens of klinki pine from New Guinea are being obtained for investigation. At present work is being carried out on antarctic beech and *Pinus radiata*. The former is a hardwood, but is being investigated because its properties seem quite satisfactory for the purpose and the criterion will probably be its ability to withstand the softening influence of sulphuric acid.

5. *Timber Mechanics.*—(i) *General.*—This Section, in keeping with other Sections of the Division, has suffered considerably because of staff difficulties. At the beginning of the year under review the Section was working two shifts and concentrating mainly on the specification testing of aircraft timber. However, with the cessation of hostilities one shift only was necessary and work was commenced on pre-war problems, that had of necessity been dropped during the war, and new urgent problems related to housing.

(ii) *Design of Containers.*—Work done for the Services included the testing of mortar bomb containers, design of munition boxes and fittings, and the construction of twenty collapsible boxes of various designs.

Comparative tests have been made of mountain ash cases used for the transport of glass bottles. These showed clearly the superiority of the dumpy, cubical case over those of a flatter shape and also the better performance to be expected when a case is wired tightly rather than loosely.

(iii) *Standard Tests.*—The tabulation of the results of physical and mechanical tests carried out on Australian species has been completed in draft. From this a table is in preparation which will list the species in order of hardness so far as this is known. When a toughness list is also available, it is proposed to undertake minor investigations wherever information is lacking for important species. Before the war, standard tests had been carried out on several species which were reported only in part, or not at all, at that time. This work is now being resumed and reports are being prepared on red tulip oak and jarrah. Because of the opening of new forest areas in Victoria to milling operations, certain species will become increasingly important. As little information is available on the mechanical properties of these species, standard tests are being carried out on silvertop ash (*E. sieberiana*), perhaps the most important of them. Material from one district is being tested, but later other districts will be sampled, including areas in New South Wales and Tasmania if their probable productions warrant it. Several further lots of flitches of New Guinea timbers were received and tested. Dry material from the coconut logs which were tested green last year has also been tested.

(iv) *Silvicultural Treatment and Strength.*—Work planned on the investigation of the effect of silvicultural treatment on the properties of timber was greatly upset by the war. Some results had been obtained in one project where the properties of immature trees had been investigated. The results are now being analysed; one conclusion seems to be that, while the strength of immature mountain ash is less than that of timber from mature trees, the strength-weight ratio is not much different. Another project, which had as its objects the investigation of the effect of rapid growth, the determination of the properties of thinnings of merchantable size, and the investigation of the effect of age on the properties of wood laid down in the early life of the tree, will need to be virtually restarted. It is proposed to examine the working plan and to amend and extend it in co-operation with all interested State Forestry Services. As a preliminary to this, the work which was done is being examined and a report will be prepared on the tests on 85 logs of blackbutt which were received from Queensland. Other material from Queensland (hoop, loblolly, and cypress pines) met with varying fates, some did not arrive, some which was to be tested green, dried out, and some has been badly attacked by borers during the war years. As far as possible, however, the material is now being tested. It is intended to press on with this work, as it will become increasingly important with the increase in acreage of plantations.

(v) *Fundamental Studies of Properties of Wood.*—Several investigations have been made on various properties of wood and some of them are being continued. The effect of moisture content on the impact strength of celery-top pine and sitka spruce was found to be similar to that of other species which have been investigated. The effect of rate of loading on the compression strength of spruce was studied and the result related to figures obtained elsewhere. The effect of moisture content on the strength of mountain ash in compression parallel to the grain is being studied. It is well known that many overseas species have very different impact values when tested in the radial and tangential directions, the tangential value of sitka spruce, for example, being about 50 per cent. higher than the radial value. Using the Izod test the effect of direction of blow has now been investigated for ten Australian species, six of which showed the same sort of variation as spruce, the greatest variation being about 60 per cent. in the case of King William pine. Two species showed no variation and two gave the tangential value about 10 per cent. less than the radial. This investigation will be continued and an attempt made to explain the test results in terms of the wood structure.

(vi) *Investigation of Tests.*—Further work has been carried out on the shape of the specimen in the Izod test, the effect of pendulum velocity and the effect of the presence of brittle heart have also been investigated. The investigation is being extended to the effect of size of specimen in the toughness test. When beams are used which differ in shape from the square specimen of the standard bending test, "form factors" have to be used to correct the moduli of rupture. These factors are well established for overseas species but have not been checked on Australian species, some work is therefore being undertaken to investigate the effect of variation of both size and shape in beams.

(vii) *Aircraft Timbers.*—The urgency of this project has passed away, but the testing of the species planned has been continued and is now almost complete. The reporting of the work will be continued and reports on hoop pine, mountain and alpine ash, northern silver ash, Queensland kauri, white birch, and Queensland maple are in various stages of preparation.

(viii) *Specification Testing.*—The routine specification testing of aircraft timber was finished early in the year, thus bringing to a close this important part of the Division's war-time work. A report dealing in detail with this work is being prepared.

(ix) *Long Time Loading.*—(*a*) *Connectors.*—Early in the year the remainder of the preliminary tests were dismantled to make way for the main series. This consists of 300 separate tests, three species, yellow stringybark, mountain ash, and Douglas fir, being included. Various end treatments, end distances, and member sizes are used and both split rings and shear plates are being tested. The loads vary from one half to twice the nominal design load, and a compression spring is used so that the load does not fluctuate greatly even when the joint moves appreciably. About 40 specimens, mostly mountain ash, have failed. This was the first species put under load, but so far there is no significant trend discernible in the results.

(*b*) *Columns.*—Two Douglas fir model columns, 2 in. by 1½ in. by 45 in. long have been standing under loads of 3,000 lb. and 2,500 lb. for 21 months and 14 months respectively. The central deflection of the former is almost 1 in. and of the latter almost ½ in. These tests were set up as a preliminary to planning a larger experiment with similar equipment, but using various species, lengths, eccentricities, and loads. Some tests have been made on the knife edges through which the load will be applied and a satisfactory technique developed. Equipment sufficient to set up 100 tests has been ordered.

(x) *Flooring.*—Considerable progress has been made with the investigation of the strength and deflection of floors. A flat-ended loading tool has been developed which has a diameter of 0.8 in. with an edge rounded to a radius of 1/32 in. as it is considered that high loads may be applied to small areas on domestic floors. This tool was suggested by the Director of the Commonwealth Experimental Building Station, with whom close contact has been maintained regarding these tests. When a floor is under test, deflection contours in two directions, and the indentation made by the loading tool are measured as well as the applied load.

Tests have been carried out on jarrah, mountain ash, and radiata pine tongued and grooved flooring. Jarrah and mountain ash end-matched have also been

tested. On the average the strength of end-matched jarrah was less than half the strength of jarrah tongued and grooved flooring but it would, however, just satisfy the proposed specification of the Experimental Building Station. Plywood floors, $\frac{5}{8}$-in. thick, with noggings at 18 and 36 in. centres, and without noggings have also been tested. Wherever it appears that a substantial saving would result from the use of thinner material than that now standard, the experiment will be extended to investigate it. This has already been done with jarrah and mountain ash where 9/16-in. thick material has been tested. The investigation is being continued.

(xi) *Fibre Building Boards.*—It was decided to make a comprehensive investigation of the properties of the two boards, caneite and masonite. The plants have been visited and, from information supplied by the managements, the variabilities of the products have been investigated and an estimate made of the quantity of material required for test. A working plan is being prepared.

(xii) *Building Units.*—A number of wall sections have been tested in co-operation with Building Materials Research. One type consisted of pressed steel studs with steel sheeting, and another of a hardwood grid with face sheets of plywood or asbestos cement. This co-operation will be continued. Some tests were made on a certain type of nail joint for the Commonwealth Experimental Building Station to determine the reduction in stiffness on drying due to the timber checking around the nails.

6. *Timber Seasoning.*—(i) *Trade Contact and Extension Work.*—No doubt accelerated by the demand for stocks of seasoned flooring, lining, mouldings, and general joinery and furniture timbers for post-war building and rehabilitation requirements in Australia, numerous inquiries were received for assistance in the planning and integration of air- and kiln-seasoning plants throughout the Commonwealth; in this connexion, officers of the Section visited Queensland, New South Wales, Tasmania, and South Australia to provide appropriate advice. The importance of maintaining general extension work of this nature was clearly shown in an examination of some 12 kiln installations, comprising 50 timber seasoning kilns. It was found that from 15 per cent. to 20 per cent. of the output of individual plants was being lost from lack of an appreciation of proper kiln seasoning technique; in the aggregate, this loss was equivalent to 5,000,000 super feet of seasoned timber per annum—enough to supply the seasoned timber requirements for the construction of an additional 2,000 homes annually.

Additional work of a major nature carried out at the request of trade contacts, included (*a*) an examination of the seasoning technique used at a plywood plant, and the preparation of detailed recommendations for modification and improvement; (*b*) an examination of the artificial drying of the seed cones of conifers, and the preparation of appropriate design data to cover the construction of a suitable drier, (*c*) the testing of an aircraft-fuselage portable conditioning chamber, and the preparation of recommendations covering modifications necessary to the existing design to give satisfactory performance, (*d*) the preparation of designs for a new type of large scale sawdust incinerator for sawmill waste disposal, (*e*) the preparation of a comprehensive layout plan to cover the setting up of a sawmill and associated case factory to handle from 40,000 to 50,000 super feet of sawn timber per week. A considerable number of minor miscellaneous inquiries to answer some of which some minor experimental work was necessary, were received during the year. The practical training of plant personnel from industry, in the principles of proper seasoning technique, was continued at the laboratory.

(ii) *Kiln Drying.*—Work on the development of commercial kiln-drying schedules for brush box and satinay was commenced, and schedules for celery-top pine and mountain ash were determined. The planning of work on a number of timbers previously regarded as only of secondary importance, but which now are being increasingly milled as general utility timbers, has been completed and some of the material has been received. Preliminary work to determine drying methods for veneers from some of the more refractory hardwoods (such as mountain ash and alpine ash) which are now being commercially peeled, but for which no fully satisfactory method of kiln drying has been developed, was commenced. The critical factors affecting the drying of these hardwood species appear to be (*a*) the extent of peeling cracks (as distinct from drying cracks) formed during conversion, (*b*) the extent of certain changes in the physical properties of the veneer which may occur during peeling, and (*c*) the degree of collapse which develops during drying.

(iii) *Kiln Design and Aerodynamics.*—The demand for plans to cover the construction of kiln installations, drying rooms, conditioning rooms and cabinets, and veneer and plywood driers, remained fairly heavy throughout the year; some 350 drawings were issued on request. Modification was made to the earlier design of the cross-shaft kiln, enabling more rapid and economic construction without impairing performance. Complete performance tests were carried out at the request of the appropriate trade interests on a considerable number of commercial kilns; where necessary, recommendations to cover the elimination of faults observed were made. This type of service, of great importance to industry, is not as yet available from commercial sources. Plans to cover the conversion of outmoded and inefficient seasoning kilns to more satisfactory types were also prepared, and advice was given on methods of overcoming difficulties in handling in an area of ground of extremely low bearing capacity in which excessive subsidence of kiln foundations occurred. Close co-operation is maintained with the timber industry in this field. Ample evidence of the necessity for keeping an interest in kiln constructional and operational standards is continuously being obtained.

(iv) *The Development of Building Materials from Wood Products and other Organic Substances.*—Work designed to test the suitability of combinations of low-priced, or freely available organic materials, with binders or cements to form building materials, was continued throughout the year. Typical organic materials considered worthy of consideration in this regard include sawdust, woodwool, flax tow, straw, wood chips, &c., and possible cements or binders include Portland cement, magnesite, gypsum, bituminous preparations, synthetic resins, &c. A considerable amount of work has now been completed on sawdust and cement, both these materials being chosen initially because of the normal ready availability and cheapness of the materials; to date Portland cement has been used as the binder, both with and without sand as a fine aggregate. Variables which have been investigated include (*a*) the effect of sawdust species (the sawdusts of seven species, comprising mountain ash, radiata pine, satinay, hoop pine, brush box, Queensland maple, and silky oak, have now been studied), (*b*) the effect of particle size, (*c*) the effect of sawdust-cement ratio, (*d*) the effect of accelerating and neutralizing agents. Particular factors being investigated are compressive strength, wear resistance, workability, surface finishing, hardness, and other physical properties (density, shrinkage, &c.). Test floor slabs, of a range of mixes from 1 : 1 : 1 (cement : sand : sawdust, by volume) to 1 : 0 : 3 and 1 : 1 : 3 in which both softwood and hardwood sawdusts in two grades were used, were laid over an aggregate area of 135 square yards.

Experimental work was also commenced on wood-wool—cement building boards, and numerous boards were manufactured for test purposes. Methods of accelerated setting and drying are being investigated, and the value of cement dispersing agents is to be examined. A number of commercial pre-fabricated building and wall sections were tested, in collaboration with the Timber Mechanics Section, on behalf of housing authorities. Principal tests include (*a*) water absorption, (*b*) shrinkage, (*c*) equilibrium moisture content condition, (*d*) water permeability, (*e*) modulus of rupture, and (*f*) impact strength.

At the request of fibrous plasterboard manufacturers, laboratory work to determine suitable drying conditions for this product was completed. The major object of this work is to provide designs for a drier so that plant output will not be limited by the frequently poor and uncontrollable drying conditions prevailing under present methods of air-drying. As a result of this work a commercial drier is in course of erection.

(v) *Sawmill Studies.*—In co-operation with the Queensland Sub-Department of Forestry, and the Queensland Timber Stabilization Board, a comprehensive mill study was made of four typical sawmills in the cypress pine areas of Queensland. A close examination was made of conversion methods, mill production, the general mill design, and equipment used, and a time study of the log yard and production bench operations was made. The first report on the study has been completed, and a detailed appreciation of the mill performance obtained. Amongst other data, the relation between girth class, mill percentage recovery, mill output per hour, log value and manufacturing margin, relative proportions of sizes sawn, frequency of lengths, extent of log degrade, and the extent of lost or wasted time and causes, were obtained. At the request of, and in co-operation with, the Victorian Sawmillers' Association, a mill study to determine the relation between class of sawing and mill production and recovery, has been commenced on eight mills sawing "ash" type eucalypts. One subject of this study is to obtain basic information so that serious anomalies in the wholesale and retail price structure which at present operate to the detriment of home construction, can be equitably adjusted.

(vi) *Miscellaneous Seasoning Investigations.*—(*a*) *Prefabrication for bus construction.*—Difficulties being experienced from dimensional changes in pre-assembled sections of bus bodies, which resulted in distortion in the bus body framework assembly, were investigated. It was found that the trouble experienced was due to poor moisture content control, first by the use of incorrectly seasoned timber, and secondly because the sub-assemblies were fitted without adequate conditioning after gluing.

(*b*) *Equilibrium moisture content.*—Relatively little information is available on the equilibrium moisture content attained by many Australian timbers when exposed to specific conditions of temperature and humidity, and virtually no information is held on the effect of thickness, grain direction, or initial drying conditions, on the rate of change of E.M.C. when exposed to varying conditions of temperature and humidity. Work planned to obtain information on these points was commenced using six species namely jarrah, radiata pine, mountain ash, hoop pine, silky oak, and Queensland maple, with a range of thicknesses of $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, 1, and 2 inches.

(*c*) *Checking in laminated spruce spars.*—In the factory-fabrication of laminated aircraft spars, considerable trouble had been experienced from the development of pronounced checking and splitting adjacent to and along the glue lines. Normal protective coatings and proprietary sealers did not appear to be of value in reducing degrade. It was found that the use of excessively dry laminations (i.e. at a moisture content of 5 to 6 per cent.) was the main cause of the trouble experienced, the effect being to throw the fabricated spars into a pronounced tension-stressed condition along the glue lines when normal E.M.C. conditions, at about 12 per cent., were reached.

(*d*) *Insulation.*—Rates of heat loss from special incubating cabinets maintained at internal temperatures of 100°F. and 160°F. respectively, were determined.

(vii) *Correspondence Courses in Timber Seasoning.*—Active interest in the correspondence courses conducted by the Division was shown throughout the year. An additional 35 students were enrolled.

7. *Timber Preservation.*—(i) *General.*—This Section, depleted of staff during the war, has not yet been restored to normal level and has faced a difficult year with insufficient trained staff to deal adequately with the heavy programme of work which has, of necessity, been undertaken to meet the urgent demands of industry, and of Government timber-using departments. In addition to new lines of investigation largely of a fundamental type, many old projects of a long-term nature, interrupted by the war have required immediate attention to avoid loss of valuable data. Close contact with the Services was maintained during the first half of the year and officers of the Section acted in an advisory capacity on interservice committees dealing with the preservation of timber and organic materials in service equipment and with the underwater protection of wooden craft and harbour installations. Other work of similar origin involved the preparation of data on the inspection, maintenance, and repair of wooden ship hulls, the investigation of mould resistance of packaging materials, and the delivery of lectures on tropicproofing to service personnel. Technical assistance rendered during the war on problems of marine borer attack has resulted in a request that this work be considered of national importance and continued as a peace-time project.

Contact with industry has been renewed on a wide scale and technical assistance given on many aspects of wood preservation. The volume of inquiries relating to problems of Lyctus borer attack prompted the calling of conferences in Sydney and Melbourne between officers of the Queensland, New South Wales, Victorian, and New Guinea Forest Services.

(ii) *Field Tests.*—Long term field and service tests to evaluate the efficiency of various preservatives and methods of application and to compare the relative durability of untreated timbers still occupy the status of a major project. Since the inception of these tests in 1929, approximately 12,000 test pieces, variously treated and individually numbered, have been installed in all States except the Northern Territory as posts, poles, rail and tram sleepers, and as small specimens. Many of these field tests are still current and their detailed inspection, which of necessity was neglected during the war, has entailed considerable work during the present year. As many of these tests have reached the stage where the final result is apparent or can be anticipated with reasonable certainty, they now provide a reliable guide to the performance of wood preservatives in Australia and their basic importance cannot be over-estimated. Extension of these tests has been planned and details of a co-operative service test of rail sleepers in Western Australia is now being completed with the Western Australian Forests Department. Collection of material is also proceeding for field tests designed to compare the natural durability of a number of eucalypt timbers against decay and termite attack.

(iii) *The Preservative Treatment of Rail Sleepers.*—During the year this investigation has developed rapidly to a major project, as the large-scale use of lower durability eucalypts is becoming increasingly

necessary and must reach even greater proportions if unification of gauge is proceeded with. The investigation has been given urgent status as the local supply of naturally durable sleeper timbers is already far below the requirements for normal maintenance. Unfortunately, satisfactory preservative treatment of eucalypt truewood is a difficult problem as the timber is extremely refractory to normal pressure penetration while diffusion treatments so far tested have not proved generally satisfactory. During the year the investigation has been developed along three main lines:—

(*a*) *Statistical surveys to determine the principal causes of service failure of rail sleepers in Australia and the effect of climatic and service conditions on type and rate of failure.*—The Victorian survey which has been completed covered a total of 67 localities on the suburban and country systems representative of the whole of the State. The results have proved of great value and have demonstrated the importance of mechanical failure due to splitting, "spike kill", rail cut, and surface breakdown. It is now clearly apparent that the problem of preservative treatment is complicated by the dual necessity of retarding mechanical failure as well as conferring lasting protection against decay.

(*b*) *Fundamental factors affecting pressure penetration of preservatives.*—As normal methods for the pressure treatment of timbers do not give satisfactory penetration of eucalypt truewood, investigations were commenced to study the factors affecting pressure penetration of fluids into wood. Preliminary tests to determine the effect of pressure, temperature, viscosity, and polarity of preservative, early established the important result that at pressures in the vicinity of 1,000 lb./sq. inch satisfactory penetration could be obtained in many eucalypt timbers untreatable by standard schedules used abroad. The employment of high-pressure penetration is apparently a new development and, if applicable in commercial practice, may prove of considerable importance in Australian wood preservation. While investigation of basic factors affecting penetration is being continued with the object of reducing the pressures necessary, a pilot plant has been erected to determine the practicability of high pressure treatment for preservation of rail sleepers. Reconnaissance tests have been made of 31 eucalypt and sixteen non-eucalypt species at pressures of 200 and 1,000 lb./sq. inch.

(*c*) *Factors affecting the rate and depth of penetration of water-soluble preservatives into green timber by diffusion.*—The object of this work is to develop the best possible diffusion treatment as an alternative to pressure methods. Owing to lack of information on the factors affecting the diffusion of chemicals into green timber, the investigation has so far been confined largely to a theoretical study rather than to the development of practical schedules. The method described in the previous annual summary is a considerable advance on previous techniques and has been used to study the effects of temperature, solution concentration, type of chemical, hydrogen ion concentration, &c., on rate of diffusion into green eucalypt truewood. From the results obtained a mathematical theory has been developed to characterize diffusion into green timber. This work has also been applied and extended to an examination of the boric acid diffusion process for the treatment of timber against the Lyctus borer. In this case the object of the work is to provide a mathematical basis for the calculation of treatment schedules which are at present being developed by the New South Wales and Queensland Forest Services by the laborious method of pilot plant treatment of each timber species followed by detailed chemical analysis of the treated timber.

(iv) *Lyctus Investigations.*—The two conferences at which the subject was discussed with the State Forest Services resulted in the Section undertaking to assist the States in the more basic problems relating to the treatment of the Lyctus-susceptible non-eucalypt timbers. Investigations now current include a re-examination of the methods of treatment of green veneer, tests to determine whether Lyctus attack in plywood can be prevented by addition of toxic chemicals to the glue, and tests to compare the diffusion rates of boric acid and sodium fluoride in the radial and tangential grain directions for a range of timbers. Work has also been commenced to determine the susceptibility of New Guinea timbers to Lyctus attack. From the two investigations connected with the prevention of Lyctus attack in veneer and plywood it is hoped to introduce a simpler process than the original method developed earlier by the Division which is now in commercial use. As extensive biological testing of the treated material is necesary, the breeding and handling of 20,000 Lyctus beetles is no small part of the work.

(v) *General Survey Work.*—In addition to the previously mentioned survey dealing with causes of failure of rail sleepers, two other surveys have been commenced—one with the object of assessing the extent and economic importance of marine borer attack in Australian waters and the second dealing with the causes of service failure of pole cross-arms in various States. In connexion with marine borer attack in harbour installations, questionnaires have been forwarded to approximately 35 Australian ports and personal contacts made with harbour engineers in four States. The cross-arm survey is being conducted at the request and with the co-operation of the Postmaster-General's Department with the object of determining the principal types of failure for each species and the most suitable preservative treatments.

(vi) *Timber Pathology.*—Investigations which were discontinued during the war years have now been restarted. The collection of standard cultures of wood-destroying fungi has been expanded and a series of investigations commenced with the object of determining comparative natural durability to decay of Australian commercial timbers by accelerated laboratory tests. As a preliminary, various methods of accelerated test are being investigated to develop a standard technique. In addition, the method in which the test wood block is embedded in moist soil, sterilized, and inoculated is being investigated to determine the effect of soil type and soil moisture content on rate of decay. Soils have been collected from ten widely separated localities in Victoria representing a variety of soil types and a comprehensive series of tests commenced.

(vii) *Wood Pipe.*—An inspection was made of approximately 40 miles of 24-in and 30-in. diameter karri woodstave pipe which is part of the main conduit on the Western Australian goldfield's water supply between Mundaring and Kalgoorlie. The object of this inspection was to advise on a suitable protective coating for this pipe which is exposed above ground to severe inland climatic conditions and is beginning to deteriorate. Following the inspection, work is now proceeding on the development of suitable coatings.

8. *Veneer and Gluing.*—(i) *General.*—With the transition from war to peace emphasis has been removed from problems of a strictly military nature, and transferred to those of reconstruction, in addition projects of a more fundamental, or long-range character are now receiving some attention. The work of the Section has included close contacts with industry, and State departments and has taken the form of: (*a*) answering requests for information and providing a general consultative service, (*b*) carrying out routine tests, (*c*) providing laboratory and staff facilities for the solution of immediate problems in industrial

practice, (*d*) disseminating information through the publications of the Division or in special reports, (*e*) delivering lectures and participating in exhibitions of work, and (*f*) visiting producing plants. Close contact has been maintained also with the Australian Standards Association.

(ii) *Veneer Production.*—The acute shortage of plywood in Australia has necessitated the carrying out of experiments on several species formerly considered unsuitable for veneer, including some eucalypts, with a view to determining under what conditions, if any, they could be utilized. The following species were peeled during the year: coachwood, karri, manna gum, narrow-leaved peppermint, southern blue gum, jarrah, shining gum, hoop pine, black bean, garawa, silvertop ash, and alpine ash. Some of these were peeled or half- or quarter-rotary sliced for special investigations. In all cases, parallel investigations were carried out to determine the best kiln-drying conditions for these veneers. Of particular interest, perhaps, have been the promising results obtained in experiments on the production of plywood with jarrah from Western Australia and garawa (*Anisoptera polyandra*) from New Guinea.

(iii) *Gluing Investigations.*—The gluing characteristics of a number of species were investigated using, in the main, typical representatives of the principal types of adhesives in industrial use, such as casein, and the urea-formaldehyde and phenol-formaldehyde resins. The experiments were extended to materials other than wood including asbestos-cement, Masonite, metals, and ceramics. Some of this work was in connexion with pre-fabrication for building purposes. The effects of various gluing factors upon the strength and other properties of the glued joint were also examined. The factors investigated included: conditioning time (for the cold-setting urea-formaldehyde adhesives) and faults in glue-mixing, assembly conditions, the presence of chalk in the glue line, the working life and closed assembly times at various temperatures, the presence of lacquer on the gluing surface, the addition of size, and unsatisfactory gluing surfaces (for a casein aircraft cement).

(iv) *Development and Testing of Adhesives.*—Soya-bean flour and peanut flour were examined as adhesives for use in the manufacture of karri plywood. Reasonably satisfactory results were obtained, but distinct improvement in the strength of the bonds took place when these flours were blended with lactic casein. Experiments are in progress to determine the suitability as wood adhesives of (*a*) lignin and (*b*) Australian-produced potato flour. Lignin, which is a by-product of the pulp and paper industry, is being tested as an extender of synthetic resin adhesives. Potato flour is a recognized plywood adhesive overseas, but its use has not been wide in Australia owing to the lack of a suitable source of supply. However, a plant has recently been established and there are indications that favorable results from these experiments may open a market for the product in this and adjacent countries. In an investigation of the relative durability of casein, and cold-setting and hot-setting urea-formaldehyde glue lines, panels were exposed to three contrasted types of Australian climate for a period of one year. It was found that urea-formaldehyde glue lines were more durable than casein, and that moist tropical conditions caused most rapid deterioration, while joint strength was best maintained under dry continental conditions. The effect of heating cycles upon laminated blocks bonded with these adhesives was also determined.

Routine tests to various specifications were carried out on a number of proprietary adhesives. A hot-setting urea-formaldehyde glue was tested with rye flour as an extender; although dry shear strengths were satisfactory, more than 50 per cent. of rye flour caused serious decline in water resistance.

(v) *Face-Checking of Plywood.*—Plywood panels were made up, under a wide range of conditions, for exposure to the weather in order to determine the effect of the various factors in manufacture upon the degree of face-checking. This project is continuing. The relative effect of different proprietary paint coatings in arresting checking was also examined. Some experiments were carried out on plastic overlays for plywood. Pulp sheets filled with lignin were pressed on to the plywood face at elevated temperatures, and although the process had several disadvantages, there were indications that most of these could be eliminated by using the lignin in conjunction with a small amount of phenolic resin. The properties of the laminate were found to be dependent upon the lignin content of the overlay sheet, the moisture content of the base panel, and the laminating conditions. Incidental measurements of the decrease in thickness of panels during pressing suggested a critical temperature range in the plasticity of wood, according to the melting range of dry lignin.

(vi) *Testing Methods.*—Several experiments were carried out with the object of improving existing methods of testing veneers, glues, or plywood, or of developing new methods. They included: (*a*) a method of evaluating quantitatively the "tightness" of veneer by determination of certain mechanical properties, (*b*) an investigation of the effect of thickness, species, and the geometry of glue shear test specimens upon the failing load, (*c*) a method of testing the tensile strength of glued lap joints, (*d*) experiments designed to reduce the subjective factor in estimating percentage wood failure of tested specimens (in co-operation with the Wood Structure Section), (*e*) determination of the effect of inter-log variations in karri, and of the distance from the centre of the log, upon glue shear strength, with a view to using this species as the standard material for testing adhesives.

(vii) *Improved Wood Investigations.*—The gluing of improved wood has been a major project during the year (in co-operation with the Division of Industrial Chemistry) and, as a result of extensive tests various cool-setting resin adhesives of the cast phenolic type have been developed for bonding improved wood, Tego-bonded high-density plywood, and laminated plastics.

A locally manufactured methylolurea resin has been impregnated into various Australian timbers and the results indicate that most Australian timbers, especially hardwoods, are not easily treated with methylolurea resin. Penetration to any significant depth in the truewood is very difficult and even when good penetration is obtained the resultant increase in hardness is usually small. Methylolurea resin appears to be more promising as an impregnant for decorative veneer overlays, but is inferior to the phenol formaldehyde resins for this purpose.

Among other factors, the effect of pressing temperature on the mechanical and physical properties of high-density Tego-bonded plywood has also been investigated and, in general, mechanical strength appears to increase with pressing temperatures up to 320° F.

(viii) *Miscellaneous.*—Some of the more important miscellaneous investigations were—

(*a*) *Aircraft project.*—During the war much attention was devoted to problems connected with the "Mosquito" aircraft. A destructive technical examination was also made of selected parts of a "Mosquito" which had completed a tour of tropical operations.

(*b*) *Fire hazard.*—A simple apparatus was devised to assess the degree of bush fire hazard due to changes in moisture content of inflammable material.

(*c*) *High-frequency heating.*—In co-operation with the Section of Timber Physics work was carried out on the high-frequency heating of glue lines.

(*d*) *Lyctus control.*—Tests were made on the compatibility of various glues and insecticides, as a preliminary to an experiment (in co-operation with the Preservation Section) to determine the effect, in controlling Lyctus attack in plywood, of adding chemicals to the glue.

(*e*) *Utilization.*—Problems of utilizing plywood or laminated materials covered a wide range and were related to such diverse commodities as tea chests, golf clubs, boot lasts, and furniture panels.

9. *Utilization.*—(i) *General.*—The volume of enquiries reaching the Utilization Section increased considerably with the cessation of hostilities, and advisory services were therefore expanded considerably. The problems associated with the needs of the Services and essential war-time industry gave place to those of the reconstruction authorities and of firms and individuals desiring to meet the demands for forest products in the post-war period.

(ii) *Liaison.*—Contacts were maintained with the Commonwealth Departments of Navy, Army, Air, Aircraft Production, Munitions, Supply and Shipping, Commerce and Agriculture, Post-War Reconstruction, Works and Housing, and with the Royal Navy and the respective State Forest Services. Officers attended conferences on the standardization of timber for use in building construction; supply, utilization, and grading of timber for house construction; and planning in various fields of wood manufacturing.

(iii) *Timber Uses.*—Advice was given to enquirers seeking information on timbers for artificial limbs, boats, bobbins, building, cases, casks, churns, coin boxes, concrete formwork, doors, drawing boards, fishing rods, flooring, handles, hat blocks, mining timber, mining machinery, motor bodies, pegs, shovels, shuttles, sieves, smokers' pipes, sporting goods, textile rollers and carders, toys, vats, wood flour, and wood wool. Trials of new designs were inaugurated to test Australian materials or new techniques that might allow replacement of imported timbers. The possibility of promoting greater utilization of Victorian foothill timbers is being taken up with the Forests Commission of Victoria. All information available on twelve species embraced in this class has been assembled to indicate the gaps that need to be filled if all properties are to be established. Timber has been procured for standard tests on the species of first importance and for scout tests on a further two.

(iv) *Cases.*—A co-operative project with the Woods and Forests Department, South Australia, was initiated to test the suitability of radiata pine for butter boxes. Immature and mature radiata has been made up into boxes, some of which have been sprayed using the casein-formalin anti-taint treatment and others lined with selected wrapping materials. The boxes have been packed with butter and placed in store and will be re-examined at the expiry of the customary storage period. At the request of the Australian Apple and Pear Board examination is being made of current designs of apple cases with a view to improving their serviceability or reducing their cost. Field surveys of the condition of the later designs of ammunition boxes in service in New South Wales, and South Australia, were conducted. These are of the glued, cleated plywood construction and have given much superior service to the old solid box. In co-operation with the Victorian Railways the damage to rail goods in transit is being investigated. The design and construction of wine casks and the selection of suitable Australian species are being examined.

(v) *Standards.*—The secretarial duties of the Timber Sectional Committee of the Standards Association of Australia were carried out. The first meeting of the Committee for some years was held in Sydney in December, 1945, and paved the way for the revival of activities of sub-committees in all States. Revision and extension of standards is of particular importance in view of the leading part that timber plays in the housing programme. The series of 22 specifications for Western Australian timbers covering the range of grades for milled products, joinery, boards, scantling, structural timbers, and sleepers have been revised in collaboration with the Western Australian Forests Department and the State's timber industry. In the course of this review detailed examination was made of the influence of various defects on the strength of timber and limits for sloping grain, knots, curvature, and minor defects have been adjusted to conform with the requirements of select and standard quality for Australian structural timbers. Some progress has also been made with the revision of specifications for milled flooring of the ash eucalypts in eastern States.

(vi) *Manufacturing Processes.*—Advice on sawmill design, saw speeds, and performance of woodworking machinery has been given to callers and correspondents. Details of mill studies carried out at cypress pine mills in Queensland and in ash eucalypt mills in Victoria have been reported on by the Seasoning Section. Interest in wood flour was particularly active during the year and many enquiries were dealt with and advice given on species suitable for manufacture, equipment required, probable output and cost, uses of wood flour, and special requirements in respective fields of use. A revival of interest in fibre boards was also evident and information and advice was given to a number of enquirers regarding their manufacture and use.

A manufacturer of shovels unable to procure prebent handles free of bending defects was advised to attempt insertion of straight handles, pre-heated in oil and thus to rely on the curvature of the throat of the shovel to bend the handle as required. His adoption of this method resulted in a reduction of losses. A range of minor problems was dealt with including the dyeing of timber, the finishing of manufactured articles by rumbling, the manufacture of handles and of wood wool, and boat building.

(vii) *Waste Utilization.*—The lines of work that the Division may undertake to explore possible uses of sawdust have been reviewed. A survey of the present uses of sawdust and the surplus quantities produced in various parts of the Commonwealth is proceeding. Investigations covering sawdust cement mixtures are in hand and have been reported on by the Seasoning Section. Information on successful utilization of sawdust overseas is being assembled prior to the development of further projects within the Division.

(viii) *Publicity and Educational Work.*—A display for the "Save the Forests" Exhibition in the Melbourne Town Hall in November, 1945, was prepared to assist the campaign for forest conservation. Further displays for the "History of the Bee in Australia" Exhibition were assembled in the Velasquez Gallery, Melbourne, in October, 1945, and a third for a "Save the Forests" display at the Royal Horticultural Show, Wirths Park, Melbourne, in April, 1946. Further material is being assembled for exhibition by the Queensland Sub-Department of Forestry and consideration has been given to material that might be made available to the Western Australian Forests Department for a permanent exhibit on forest products in Perth.

(ix) *Miscellaneous.*—The Section has been responsible for the procurement of timber for test by other Sections of the Division including *E. regnans* from Gladysdale and Turtons Gap and *E. sieberiana* from Erica. The breaking down of logs at co-operating sawmills and conversion of flitches of *E. capitellata*, *E. eugenioides*, *E. regnans*, *E. sieberiana*, *Pseudotsuga taxifolia*, and *Tristania conferta* were supervised in the Divison's sawmill and material handed over for testing in other Sections.

10. *Publications.*—In addition to the Forest Products News Letter, Nos. 139-141, the following papers were published during the year:—

Christensen, G. N. (1945).—Note on a method for the study of diffusion of salts through green timber. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 407-11.

Dadswell, H. E. (1945).—Timbers of the New Guinea Region. *Trop. Woods* No. 83: 1-14.

Sulzberger, P. H. (1945).—Radio frequency heating of dielectric materials: method of power generation; resin-bonding of wood; plastic moulding; cost and efficiency. *Elec. Eng. Merchand.* 21 (7): 197-200.

Tamblyn, N. (1945).—Service tests of fluarized karri rail sleepers in Western Australia. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 254-62. (D.F.P. Reprint No. 89.)

Tamblyn, N. (1945).—Field tests of wood preservatives; creosote-oil mixture proved valuable for fence posts, poles and rail sleepers. *C'wealth Eng.* 33 (4): 129-33.

IX. FOOD PRESERVATION INVESTIGATIONS.

1. *General.*—Some re-organization of the Division's work has taken place during the year. It has not been possible, however, to resume all the investigations dropped early in the war. This has been due partly to shortage of laboratory space and staff and partly to the need for completing several long-term "war" projects. The following important changes have taken place.

(*a*) All short-term investigations aimed at maintaining or increasing the commercial output of canned foods have been terminated and the investigations have been able, thereby, to concentrate on several long-term projects, such as the effects of maturity and variety on the quality of certain processed fruits and vegetables.

(*b*) Investigations on the storage of egg powder have been terminated. While work on the processing and storage of dehydrated vegetables has been continued, its scope has been reduced.

(*c*) Studies on preventive measures for bacterial rotting in shell eggs have been resumed on a considerable scale, aided by a generous grant of money from the Egg Producers' Council.

(*d*) The investigations concerned with the cold storage of foodstuffs suffered severely when it was necessary to transfer investigators to urgent war-time projects. Certain aspects of this work are now being resumed as staff and facilities become available. For instance, a small team of investigators has recently been formed to resume some fundamental studies on the metabolism of fruit in cold storage, and the Physics Section of the Division has been able to give increased attention to certain problems of heat transfer and evaporation during the cooling of meat in refrigerated chambers.

In January, 1946, a conference was held in Sydney between all Australian research workers in the field of fruit and vegetable storage. Since most of this work has been suspended during the war, it was opportune to review the present status of the investigations and to indicate the major problems which might be studied by the Council and the several Departments of Agriculture.

With the help of Commonwealth Food Control, in February the Division of Food Preservation convened a conference of operators of vegetable dehydration plants. Technical aspects of dehydration were reviewed, and there was some discussion of the future of the industry.

The building of a small extension of the Homebush laboratory was completed in August, 1945. Accommodation was thereby provided for the growing needs of the library and for investigations on the quick-freezing of fruits and vegetables to be carried out in co-operation with the New South Wales Department of Agriculture.

The Division is indebted to the Leeton Co-operative Cannery for generous gifts of fruit used in connexion with several canning and dehydration experiments, and also for placing processing equipment and labour at the disposal of the fruit dehydration investigators.

2. *Physical Investigations.*—(i) *General.*—As in previous years a large part of the time of the Physics Section has been devoted to the maintenance and running of mechanical equipment, the design and construction of new equipment, statistical analyses of data, to collaboration with other Sections on various problems, and general advisory work.

(ii) *Substitute Containers.*—Storage trials with jam referred to last year have been completed and a summary of the results published. A storage trial at 68° F., and 80 per cent. relative humidity with baking powders of various compositions packed in containers of known characteristics (roughly equivalent to the best, standard, Australian types) has been completed and a trial of 68° F., 70 per cent. relative humidity is in progress.

(iii) *Fruit Cake.*—Experiments referred to last year, on the prevention of mould attack on fruit cake in storage by controlling the composition to ensure an equilibrium humidity below about 73 per cent., have been completed.

(iv) *Vapour Pressure of Dried Foods.*—The relation between the vapour pressure and water content of dried egg has been studied in some detail at a series of temperatures. Measurements have also been made with dried onion.

(v) *Cooling of a Wet Body.*—Work aimed at fairly exact calculation of the temperatures and rates of evaporation during the cooling of wet bodies of simple shapes was begun some years ago but it had to be abandoned during the war. The study was undertaken because of its immediate application to some outstanding problems in the chilling of beef.

A series of calculations is now in progress. It is designed—

(1) To test the suitability of various approximation methods for integrating the equations.

(2) To estimate the magnitudes of the effects on total weight loss, rate of evaporation at certain stages, and rate of cooling, of (*a*) rate of air flow, (*b*) heat transfer by radiation, (*c*) relative humidity of the air, and (*d*) ratio of maximum refrigeration capacity to the quantity of material being cooled.

(3) To estimate the effects of the uncertainties of heat transfer and evaporation data in the literature on the important calculated figures.

(vi) *Design of Equipment.*—Consideration has been given to the design of a number of pieces of laboratory equipment including (*a*) a quick freezing tunnel, (*b*) a meat dehydrator with a special weighing device to measure water loss continuously, (*c*) a meat extract concentrator, and (*d*) fruit juice concentrators.

(vii) *Temperature Distribution in Retorts.*—Measurements have been made in a small experimental unit and a series of measurements in commercial types is being started.

(viii) *Food Processing Machinery.*—A study of existing types of food processing equipment has been begun. Data are being collected and analysed so that the Division shall be in a better position to advise on the selection, design and development of equipment, and to plan future investigations in this field.

3. *General Chemistry.*—A considerable variety of work has been carried out, including the determination of metals, dissolved oxygen, and curing ingredients in meat; and investigations on pectin, the liquid coating of apples, and ascorbic acid.

(i) *Metals in Foods.*—A large number of determinations of tin, iron, and copper have been made in relation to flavour deterioration, oxidation of ascorbic acid, and the staining and corrosion of tinplate containers.

Studies on the accumulation of tin and iron in silver beet in plain cans were completed. The rate of accumulation of tin increased significantly with increasing temperature. Less than half the tin occurred in a soluble form. Iron only appeared when practically all the tin was removed from the tinplate.

Investigations on increasing the accuracy of various analytical methods are still proceeding. A more precise method of determining iron in canned foods, using o-phenanthroline, has been developed. Work on the electrometric determination of tin, copper and mercury is being initiated.

(ii) *Tin Coating on Tinplate.*—Many routine determinations of tin coating weight on tinplate have been made in connexion with canning investigations. Various tests for porosity of the tin coating are being critically examined. The Division is co-operating with the Munitions Supply Laboratories in a microscopic examination of the alloy layer in tinplate sections.

(iii) *Dissolved Oxygen in Fruit Juices.*—A polarographic procedure for the determination of dissolved oxygen in citrus juices has been developed. This method gives practically instantaneous readings which can be used for control during processing. The procedure involves a correction for the sugar in the citrus juice, which reduces the diffusion current.

(iv) *Curing Ingredients of Meat.*—A number of determinations of curing ingredients—chloride, nitrate, nitrite, and sugar—in canned bacon were carried out as part of a co-operative investigation. Investigations on the determination of "fermentable sugar" in pork and bacon were completed, and a paper was prepared for publication. The use of dried yeast for fermentation was found extremely convenient for this analytical procedure.

(v) *Pectin.*—The investigations on the extraction and jellying properties of pectin were completed, and an article on this subject was prepared for publication. Pectin solutions and extracts were found to be more stable to heat than previously reported. One hour at 100°C. gave only slight loss of jellying power. Serious loss occurred at 105°C.

(vi) *Natural Lipoid Coating of Apples.*—Investigations on the natural lipoid coating of Granny Smith apples have shown that the wax fraction remains approximately constant during ripening and storage. The oil fraction, however, tends to increase initially during storage and ripening but decreases after prolonged storage. Similar changes were found in the iodine value of the oil fraction.

No significant relation was found between the oil fraction and the incidence of superficial scald. A delay of four weeks at 18°C. more than doubled the concentration of oil in the skin without appreciable control of scald. No significant difference was found between the oil content of scalded and non-scalded apples.

Preliminary chemical studies have been made on the oil fraction. After saponification, the major fractions have been found to be fatty acids and "unsaponifiable matter". Both fractions exhibit a marked degree of unsaturation. Evidence of the presence of hydroxy acids has been obtained.

Preliminary investigations on the "ursolic acid" fraction of the coating, which is soluble in chloroform but not in petroleum ether, have been carried out. Tests have been made of the physical properties and mutual solubility of constituents of the apple skin. It is hoped to obtain further information on the surface film of apples and its possible relation to the storage life.

(vii) *Ascorbic Acid (Vitamin C).*—Changes in the ascorbic acid content of apples and oranges have been investigated. The ascorbic acid content of apple skin was found to be about twenty times that of the flesh. Both in skin and flesh the ascorbic acid decreased to about half its initial concentration after storage for eight months at 1°C. Washington Navel and Late Valencia oranges were found to reach their maximum concentration of ascorbic acid during August and September, when the fruit was approximately full colour. Ascorbic acid in the skin tended to increase initially and fall subsequently. In the juice it did not change significantly till September, but fell subsequently.

Further studies were made on the influence of ferrous iron in the determination of ascorbic acid, and a paper was prepared for publication. Measurements of the metal-catalysed oxidation of ascorbic acid were made in 0.01M oxalate at pH 0.4-3.0.

Investigations on the ascorbic acid oxidase of cabbage are being carried out. The oxidase was found to be active between pH 4 and 8 with a maximum activity at pH6. In a water suspension of cabbage prepared in the Waring Blendor, the enzyme activity was found to be mainly in the insoluble particles. A considerable increase in solubility was obtained by using various salt solutions. Further investigations are being carried out.

4. *Microbiology.*—(i) *Egg Investigations.*—Large-scale storage experiments were conducted in New South Wales, South Australia, and Western Australia, in addition to laboratory studies in New South Wales. In New South Wales further trials were made with hypochlorites and cationic detergents as disinfectants for use in egg-cleaning machines. Both types of disinfectant gave some measure of control of bacterial rotting, but the results indicated that consistently satisfactory control of wastage was unlikely to be attained when the disinfectants were applied under the conditions obtaining on farms. Laboratory studies of disinfection by cationic detergents are being continued. The immersion of eggs in caustic soda solutions as a means of overcoming bacterial rotting was subjected to critical testing in several experiments carried out in Western Australia. The treatment was found to be inadequate to prevent serious wastage in machine-cleaned eggs.

In New South Wales and South Australia, several large-scale experiments on the hot-water treatment of shell eggs were carried out. Several pasteurizing treatments which caused no detectable coagulation of the egg contents were found very effective in preventing bacterial rotting. The possible effects of the hot-water treatments on other aspects of egg quality have, however, not yet been studied and this will be necessary before recommendations of the most suitable conditions for the commercial application of the method can be made. Owing to the promising results obtained by treatment in hot water, the publication of results obtained during the last seven years has been postponed.

No further experimental work on the bacteriology of egg pulp has been done, but a third paper on the resazurin test for quality in egg pulp was published during the year.

(ii) *Bacteriology of Canned Foods.*—Minor problems associated with spoilage of various canned foods have been investigated, and some work on the bacteriology of canned cured meats has been continued.

(iii) *Clostridium botulinum Investigations.*—Studies of the growth of this organism have been continued and a further paper on the influence of dissolved tin on

the growth of the organism in canned vegetables has been published. Some further work has been done on the destruction of the toxin by heat, but, apart from the influence of pH, the reasons for the differences in lability when toxin is treated in various products is still unexplained.

(iv) *Heat Resistance of Bacterial Spores.*—These experiments have been continued with several species of *Bacillus* and *Clostridium*. Experiments are still concerned mainly with the cultural conditions necessary for the reliable detection of spores surviving heat treatment. A preliminary note on the effects of small quantities of starch in the media has been published, and a further paper on the influence of pH of the cultural medium is being prepared for publication.

5. *Fruit and Vegetable Storage Investigations in Conjunction with the New South Wales Department of Agriculture.*—(i) *General.*—Plans for a reorganization of the work have been completed and include investigations of physiological and biochemical problems which, though basic to storage research, had to be abandoned during the war years.

(ii) *Plant Physiology and Biochemistry.*—These investigations deal with two main problems, which, in addition to being basic to storage, are of considerable fundamental interest in plant physiology and biochemistry:

(*a*) The organization of the plant cell and its relation to cell stability.

(*b*) The respiration of the plant cell, particularly the organic acid metabolism and the nature of the oxidative enzymes.

In both these fields, the investigators are collaborating with workers in the Botany School, University of Sydney, and Botany School, University of Melbourne. For the first of these problems suitable apparatus has now been collected at Homebush, but some experiments have already been carried out at the Botany School. Carrot, beet, and apple tissues have been used; observations on apple tissue indicate that its organization is physically much less stable than that of other plant tissues. Some time has been given to continuing the investigations on the process whereby plant cells achieve and maintain high concentrations of substances in solution.

On the second of these problems, the techniques necessary for the analyses of organic acids in apple tissue have been developed. A quantitative survey of the principal organic acid constituents in (*a*) developing fruit and (*b*) mature fruit in cool storage is being carried out. In addition to the principal constituents (malic, oxalic, and citric acids), analytical techniques for the other organic acids, likely to play a part as catalysts in metabolism, have been developed and are being used to survey the quantity of these constituents; starch, sugar, and nitrogen fractions are being analysed simultaneously.

(iii) *Fresh Fruit Storage.*—(*a*) *Skin coatings for apples.*—Common storage and cool storage experiments with Jonathan, Delicious, and Granny Smith apples treated with various coatings were completed in 1945. The results of these experiments are being prepared for a detailed report.

An experiment commenced in 1946, and at present in progress, is designed to compare the effect on storage of the physiological conditions within the fruit (particularly with regard to internal atmosphere) brought about by skin coating, with the effect of those brought about by gas storage. Granny Smith apples of commercial maturity, treated to give a range of internal gas compositions, are being used.

(*b*) *Orchard variability in relation to storage.*—Variability in storage behaviour between orchards is being tested with Delicious and Granny Smith apples from two orchards in the Orange district. Analytical data are also being collected; some correlations between keeping quality and these data are being sought.

(*c*) *Citrus storage.*—Experiments with Washington Navel oranges and Valencia oranges were designed to test the effectiveness of "Pliofilm" wraps, "stretch wraps", and case liners compared with a standard wax treatment. The stretch wraps showed some promise, but the ordinary pliofilm wrap seemed to have little advantage as compared with the standard wax treatment. Two gauges (120 and 40 gauge) were used in these experiments.

(*d*) *Stone-fruit storage.*—Plums, peaches, and nectarines were stored at one temperature (32°F.) with the two objects of obtaining data on storage and of obtaining specimens of disorders for photographs. These photographs of disorders are to be used for a publication on stone-fruit storage.

6. *Meat Investigations (Brisbane).*—(i) *General.*—Consultation work and requests for assistance covering a wide range of problems continued to make a large demand on the resources of the laboratory. Some general observations have been made on the quality and storage life of beef prepared in small slaughter yards as compared with modern abattoir practice. Evidence by the officer-in-charge was tendered to the Royal Commission on Inland Abattoirs in Queensland.

(ii) *Laboratory Accommodation, Plant, and Equipment.*—The investigations planned are chiefly related to the export of chilled beef to the United Kingdom, and problems relative to the tenderizing or ripening of beef for the domestic market. In this connexion the necessary approvals were obtained for considerable extensions to the laboratory and its equipment, and for the appointment of extra research staff. Since the cessation of hostilities, the structural features of the laboratory and the plant and equipment have undergone extensive alterations and repairs to fit them for the resumption of storage investigations.

(iii) *Collagen-Gelatin Studies.*—Arising out of the work on dehydrated beef, a series of studies related to the fate of collagen when it is subjected to heat treatment in the presence of water has been made. The histological part of this investigation has had to be temporarily suspended owing to staff shortage.

In connexion with this work, the desirability of developing a satisfactory technique for the quantitative estimation of gelatin in the presence of other proteins and organic substances, became immediately apparent. Investigations which have been made embrace most of the suggested methods in connexion with the quantitative estimation of gelatin, covering precipitation by alcohol, magnesium sulphate, tannic acid (including its behaviour as a function of pH) and other methods in which the two amino acids, proline and hydroxyproline, are determined. This comparative, critical study has shown that the results obtained by the various methods for the quantitative estimation of gelatin are not at all consistent with each other and, in part, has shown also in many instances why this is so.

(iv) *Moisture Content of Meat Extract.*—A paper on a quick density method for the determination of the moisture content of meat extract, published in the Council's *Journal* for May, 1945, stressed the influence of the composition of the material from which the extract was derived on the successful operation of the method. At the time of writing the paper, it was definitely known that a second-grade extract, concentrated from a "soup" which had been derived from hearts, "skirts", bones, sinews, &c., as well as boned-out muscle tissue, would not give satisfactory results if readings were interpreted by reference to a curve for an extract derived solely from muscle tissue. Further investigations strongly suggest that when muscle tissue only is employed with otherwise standardized procedures for a first-grade extract, the addition of

mutton to beef in the original material influences the density method of determination of moisture content to such a small degree that, for commercial purposes, a curve for whole beef extract could be employed.

(v) *General Microbiological Work.*—Microbial surveys on chilled beef were conducted at two exporting works which will be actively engaged in this industry. Some of these surveys made very plain the fact that much will have to be done to raise the standard of slaughter-floor hygiene to the conditions required for the preparation of export chilled beef.

7. *Canning and Fruit Products Investigations.*—

(i) *General.*—Outstanding features of the year's work related to modification of procedure for canned citrus juices, the canning of freestone peaches, the steam-flow, hot-lid method of obtaining vacuum in commercial, automatic, can-closing machines, and the maintenance of colour by addition of soluble tin to fruits packed in lacquered cans. Advisory work was well maintained, with a considerable increase in the number of enquiries concerned with the curing, smoking, and canning of fish. The laboratory examination of samples on behalf of the Department of the Navy was continued. A spacious canning laboratory was made available during the year, and the previous space has been retained solely for fruit juice investigation.

(ii) *Vegetable Canning.*—Field work at Windsor on the prediction of the optimum maturity at picking of sweet corn was resumed in November, 1945, and regular weekly visits were made until the season terminated in April, 1946. Selected crops were recorded from planting to harvest, and data were collected on growing conditions and on moisture content and refractive index of the grain. Good correlation was found between moisture content of grain and refractive index, as in the previous season. Information obtained for two seasons was used to predict canning maturity with accuracy ten days prior to picking. Statistical analysis of the data has been completed and results have been presented in graphical form.

Tomatoes were grown for variety trials at Mildura (Victoria), and Griffith (M.I.A.), and these, together with a number from field variety trials, were processed. Field work was organized and supervised by the Council for Scientific and Industrial Research Vegetable Problems Committee. Owing to limited material, maturity tests were eliminated and all fruit was canned in firm, full-ripe condition. Sixteen varieties were canned at Griffith but owing to prevalence of disease, useful data could not be obtained. Eleven varieties were canned and tested at Mildura. Results showed that a number of varieties are suitable for canning when picked at correct maturity, processed with reasonable care, and made firm with calcium chloride.

Three plantings of Chantenay carrots were made at Mildura at three-weekly intervals and the material harvested together to give growth periods of 149, 170, and 191 days. They were canned as whole, "baby" carrots, but further work is required to duplicate the quality of similar material in United States of America.

"Baby" beetroot of the Detroit Red variety was similarly planted to give growth periods of 107, 121, 135, and 164 days. The canned product was of good colour. The two younger groups were superior in quality, and, of these, slight preference was shown for 121 days.

Lima beans and climbing beans of the Blue Lake variety were grown at Griffith and canned at Homebush. Lima beans were canned both in green and dry condition. Further experience in canning technique will be necessary to produce a high-grade product.

The location of taint in carrots sprayed once, twice, and thrice, for weed control was determined. The tainted areas in the singly sprayed carrots are removed by normal canning pre-treatment. When sprayed more than once the taint becomes deep-seated and cannot be eliminated other than by excessive trimming losses. Various blanching treatments proved unsuccessful.

Further work with dry beans, in all ten varieties, from the New South Wales and Victorian Departments of Agriculture, indicated the superiority in flavour of the Pale Dun variety over the usual varieties when used in baked bean packs. Differences between the other varieties were not marked, but preference was shown for Pinto and Canelini. The superiority in flavour of the Pale Dun is handicapped by the colour of the bean which may influence its commercial acceptance.

Work on the calcium chloride blanching of potatoes indicated that drained weights increase with decreasing calcium chloride concentration and that turbidity of brine sometimes noted in commercial packs is directly related to maturity within each variety. New potatoes yield brines comparatively free of suspended material while old potatoes are invariably associated with turbid brines. A comparison of ten potato varieties grown at Canberra, using the normal canning procedure for diced potatoes, demonstrated Snowflake and Bismark as the best varieties when judged by colour, flavour and texture.

Canned white turnips were improved in colour and flavour by pre-treating with a 10-minute soak in 2.6 per cent. calcium chloride.

Silver beet which had been vacuum-injected with calcium chloride solution, and then cold-filled, vacuum-closed and heat-processed, retained three times the amount of vitamin C as compared with the silver beet canned by the normal commercial process.

(iii) *Meat Canning.*—An improvement in palatability of canned, corned meat resulted from the elimination of the standard precook, but it was found necessary to include agar to bind the meat pieces together and to absorb liquid exuded during cooking. The development of discolouration in canned meats is being investigated.

(iv) *Fish Canning.*—Experiments have proved that the undesirable toughness and dryness of canned Australian salmon can be mitigated by pre-soaking previously-frozen fish for several hours in salt solutions of approximately 40° salinometer strength. The effects of this treatment on this, and other, species of fish are being studied.

Fish pastes of satisfactory quality have been prepared from salted pilchards and from heavily smoked fish such as Australian salmon. Surveys have been made of fish processing and canning facilities in Tasmania; similar surveys are to be made in other States of the Commonwealth.

(v) *Fruit Canning.*—Investigations into the practicability of forwarding papaws processed in cans from northern to southern areas for the manufacture of tropical fruit salad and other products confirmed that papaws picked at the optimal maturity can be processed in bulk and satisfactorily reprocessed either as papaw or as a constituent of fruit salad. The optimal maturity was determined as maturity at which the fruit yields slightly to digital pressure. Fruit colour, when taken by itself, is considered to be an unreliable index of maturity.

Apple pulps were prepared from three varieties, Jonathan, Rome Beauty, and Granny Smith, by disintegration of the whole apple. The flavour of Jonathan and Granny Smith was considered superior to the other varieties, while the colour of the Granny Smith was the best of the three. Precooking the apples in steam further improved the colour of the pulp. This work is continuing.

A variety trial embracing thirteen varieties of freestone peaches was undertaken. Eight of these varieties were deficient in one or more of the characteristics

essential to good canning varieties, while the remainder gave good performances, approaching very closely the standards looked for in the best canning clingstone varieties and possessing, in addition, the superiority in flavour characteristic of freestone peaches.

Investigations into the effect of storage upon the canning quality of Golden Queen clingstone peaches were begun. Periodic withdrawals of three maturities of fruit from two temperatures over a period of five weeks were made and the fruit canned. Examination of this series is not yet complete.

Experimental investigation of discolouration of canned peaches, pineapples, and pears packed in lacquered cans was continued. In all cases discolouration was evident when the total internal surface of the can was lacquered. The effect was progressively reduced when increasing areas of the lid were not lacquered, and differences in colour were negligible when the lid was unlacquered as compared with a completely unlacquered can. Likewise, colour was well maintained in fully lacquered cans when 100 parts per million of tin stannous citrate was added. These results are of value firstly because of the enhanced appearance of an internally lacquered can, but chiefly for the reason that shelf-life is greatly increased by the elimination of chemical action resulting in the development of hydrogen "swells". Further work will be necessary to define the method of control with greater precision.

(vi) *Fruit Juices.*—In the 1945 citrus season, investigational work on citrus juice canning was recommenced after a period, during the war years, when the activities of the Section were devoted chiefly to assisting the commercial production of large volumes of canned citrus juices for the Services. About twenty juice canning lines commenced operations using procedures, developed in this laboratory, involving deaeration and flash pasteurization. In the course of this large commercial canning programme, it became evident that unless canned orange juice improved considerably in flavour it would not be accepted readily in the civilian market. In an attempt, therefore, to improve palatability, two aspects of the canning procedure were selected for intensive study.

Firstly, the method of heat treatment of the juice to ensure freedom from microbial spoilage was studied. It has been found that cold-filled juices processed in boiling water in rapidly rotating cans are distinctly superior in fresh flavour to flash-pasteurized juices. Some very palatable Valencia juices which have been prepared have retained their fresh flavour to a high degree over storage periods of six months at cool temperatures (68° F.). Secondly, the significance of the deaeration operation was studied and the performance of the Homebush deaerator was examined under various conditions in terms of efficiency of oxygen removal. The available evidence indicates that deaeration as carried out at present under commercial conditions does not contribute significantly to flavour retention. This study was handicapped by the lack of a reliable method for the determination of oxygen in orange juice. A polarographic method which will give an accurate estimate of the oxygen content of a juice sample in a few seconds has now been developed and calibrated. Using this method, it is planned to carry out a more precise study of the role of oxygen in the deterioration of canned orange juice during the 1946 season.

The problem of bitterness in canned orange juices was also studied, and some interesting observations were made on the incidence of bitterness in Valencia juices. Preliminary results suggest that this bitterness may be associated with the use of copper fungicidal sprays. Some chemical work has been done on the isolation and identification of the bitter principles in Navel and Valencia oranges.

An attempt was made to improve existing methods for the determination of peel oils in citrus juices and a new type of oil separatory trap was designed and constructed.

(vii) *Fruit Spreads.*—In order to trace the loss, during storage, of vitamin C in fruit spreads fortified with synthetic ascorbic acid and rosehip concentrate, a number of prepared samples were held at room temperature (60°-70° F) and also in the incubator at 97° F. The vitamin C content of incubated samples decreased rapidly during storage, 50 per cent. of the original content being destroyed after six weeks in the case of rosehip concentrate and after eleven weeks when synthetic vitamin C was used for fortification. The rate of destruction in room-stored samples was considerably slower, 30 per cent. only of the material being lost after twenty weeks storage.

"Swells" due to the production of carbon dioxide were noted in Army rations of canned fruit spread incubated at high temperatures, and these were shown to be caused by spontaneous chemical reactions within the spread. Further work demonstrated that all foodstuffs tested produced carbon dioxide spontaneously at a slow rate, and that this production is accompanied by darkening of the product. A preliminary study of the reaction concerned has been made and several of the dark reaction products isolated.

(viii) *Can Lacquers.*—As in previous years a number of internal lacquer formulations prepared by commercial organizations have been tested for suitability for various appropriate canned products.

Fourteen sausage can lacquers were tested, including American samples, but only three behaved satisfactorily. Of these, one manufactured locally from an imported resin had an excellent performance.

Two trial lots of processed cheese were packed in cans coated with several different commercial lacquers. Examination after storage indicated the superiority of the abovementioned sausage lacquer for this purpose also.

Several citrus-type lacquers, formulated from substitute materials owing to lack of original raw materials, have been tested and two have proved resistant to citrus juices. One of the successful citrus lacquers has been tested with beetroot packed in acid brine, and examinations so far indicate a satisfactory resistance to this product.

Lacquered blackplate panels packed in papaw cans showed a high degree of resistance after six weeks' incubated storage. Further investigations to establish the performance of commercially lacquered blackplate drums with this product under tropical conditions are now proceeding.

(ix) *Equipment.*—An all-glass climbing-film fruit juice evaporator was installed, tested, and numerous adjustments made. The limiting factor in operation was found to be rate of water vapour removal and a redesigned refrigerated condenser is now under consideration.

A tenderometer for determining maturity in canning peas was designed and constructed. It will be tested during October, 1946, at Bathurst.

Two methods were tested for achievement of vacuum in cans closed in a commercial automatic can closer. Both methods rely upon removal of headspace air from the can immediately before the can lid is applied and double-seamed. Removal of air by the use of explosive gas mixtures produced vacua of the order of eighteen inches of mercury when the headspace was excessive but these were reduced to the 4 to 8-inch range when headspaces ranged from $^5/_{16}$ to $^9/_{16}$ of an inch. The method of air displaced by steam developed in United States of America, and known as the steam-flow closure, gave satisfactory results when can headspaces were held within commercial limits. When combined with the hot-lid technique developed by the Division

several years ago, vacua of eighteen to twenty inches of mercury were consistently maintained. Owing to the unsatisfied demand in recent months for fully automatic vacuum closure, the ability to use existing cannery equipment with little mechanical modification may be of considerable help to the canning industry.

8. *Dehydrated Foods.*—(i) *Vegetable Dehydration.*—An investigation of the suitability of a wide range of onion varieties for dehydration was started last year with the co-operation of the Division of Plant Industry, and has been continued. This work includes a study of the general characteristics of the onion bulbs, investigation of their storage life, dehydration tests, and the determination of the solids, volatile sulphur and sugar contents of the onions. The characteristics required have now been defined and it has been shown that all the varieties studied fall considerably short of the ideal.

The investigation of the suitability of different varieties of potatoes for dehydration has been continued. The material used in this investigation this year was grown by the Departments of Agriculture in Victoria, South Australia, and Tasmania and by the Division of Plant Industry, and the Irrigation Research Station, Merbein. This season's work has not yet been completed, but it appears from the results obtained in this and preceding years that none of the varieties tested is outstanding and that the factors influencing the reaction of potatoes to dehydration have not yet been defined.

A series of factorial processing and storage experiments was started. The vegetables used in these experiments were potatoes, carrots, cabbage, beetroot, and silver beet. The variables being studied are blanching treatment, sulphite level, drying temperature, and drying time. The storage experiments also include a comparison of air- and nitrogen-packing. Most of the processing work required for these investigations has been completed, and the examination of the stored dehydrated samples is in progress.

Some small scale experiments on the dehydration of green peas were carried out using a number of varieties grown at the Griffith Research Station. Some promising results were obtained, and it is proposed to continue this investigation.

One of the main problems in dehydration is to obtain sufficiently low moisture content in the finished product to ensure adequate storage life, particularly under tropical conditions. Preliminary reports have been received from overseas describing the attainment of very low moisture contents by packing a desiccant in the can along with the dehydrated vegetable. Experiments have been carried out in this laboratory, using quicklime as the desiccant, to determine suitable types of package for the lime and the rate of removal of moisture from the product in 4 gal. and 30 oz. cans.

The investigation of the compression of dehydrated vegetables into blocks has been continued. The rate of expansion of blocks after removal from the press has been measured, and some work has been done to determine the restraining pressure required to prevent expansion.

Attempts have been made to find a substance which could be used to coat the tinned, perforated, steel trays used in Australian dehydration plants to prevent the sticking of vegetables to the trays. The problem is difficult because in most plants the vegetables are "blanched" on trays. Nothing has yet been found which is satisfactory under these conditions. A mixture of lithium stearate and stearic acid appeared to be promising for use where the trays are not used for blanching.

(ii) *Fruit Dehydration.*—Experiments on the dehydration of apricots and peaches were carried out both in this laboratory and at the Leeton Co-operative cannery in co-operation with the New South Wales Department of Agriculture.

The variables studied in the experiments with apricots were blanching time and drying temperature. At Leeton a comparison between sun-dried and dehydrated fruit was obtained. In the laboratory, drying curves were determined for large and small, blanched and unblanched fruit for four temperature-schedules.

Experiments with Elberta peaches were carried out in the laboratory using Elbertas from Leeton and Blackburn, Elbertas and Hales from the Bathurst Experiment Farm. Drying experiments were done on peeled and unpeeled peaches, using slices and halves and with and without blanching.

Dehydration experiments were carried out at the Leeton Cannery on three varieties of clingstone peaches. All fruit was peeled and slices and halves were dried, with and without blanching. In the laboratory, clingstone peaches were used for a comparison of sulphuring with dipping in sulphite solutions. Some work was carried out on a laboratory scale to determine the suitability of different timbers for the manufacture of trays for fruit dehydration and also on the use of various waxes to prevent the sticking of slices to wooden trays.

Interim reports on the storage of dried fruits have been prepared for the Council for Scientific and Industrial Research Committee on Processing of Dried Fruit. Experiments on dried pears, apples, peaches, and apricots which were commenced earlier have been continued and some have been completed. These have been directed towards studying the effects of storage temperature, initial sulphur dioxide content, and moisture content on the storage life. When the experiments still in progress have been completed, sufficient data will be available to allow of the publication of an authoritative bulletin on the storage of dried tree fruits.

(iii) *Meat Dehydration.*—At the request of the Department of Commerce and Agriculture plans have been made to extend the investigations on the processing of mutton for dehydration. Owing to lack of space, investigations have previously been concerned more with the storage behavior of dehydrated mutton. Equipment for carrying out processing studies is now being installed in a laboratory at Auburn, and work during the year has been mainly concerned with designing and obtaining this equipment. Some storage experiments commenced last year were completed.

(iv) *Egg Powder.*—A storage experiment started last year and discussed in the previous report was continued and will be completed shortly. A small experiment to study the effect of packing quicklime in the can with dried egg was started. The study of the absorption of carbon dioxide by dried egg was continued.

(v) *Culinary Quality of Potatoes.*—A study of the culinary quality of potato varieties was carried out in conjunction with the study of the suitability of potato varieties for dehydration, mentioned above. The ascorbic acid content of potato varieties was also studied. Results are now available for two seasons' work on material grown at Canberra. There were large seasonal differences, but some consistent varietal effects were observed. Only one season's work has yet been done on material grown in the main producing areas.

(vi) *Biochemical Investigations on Potatoes.*—Four varieties of potatoes were grown at Canberra and there were two plantings in the season. The ascorbic acid and solids contents of tubers were determined at various stages of growth, and a study was made of the distribution of ascorbic acid and solids within tubers.

9. *Publications.*—In addition to the Food Preservation Quarterly, Vol. 5, the following papers were published during the year:—

Empey, W. A., and Allen, R. (1946). Fish-curing and smoking. *Fisheries Newsletter* 5 (1): 18-20.

Empey, W. A., and Allen, R. (1946). Fish-curing. Kiln constructional details. *Ibid.* 5 (2): 18-19.

Gillespie, J. M. (1946). Tests for quality in egg pulp. 3. The influence of bacteria in pure and mixed culture on the resazurin reductase test. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 117-27.

Hicks, E. W., and Garden, Joan (1946). Experiment with substitute containers for jam, with some general comments on the problem. *Aust. Food Manuf.* 15 (7): 12,14,16.

Huelin, F. E. (1946). The estimation of fermentable sugar in pork and bacon. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 96-102.

McKenzie, H. A. (1945). A volumetric method for the determination of tin in foods. *Ibid.* 18: 181-7.

Olsen, A. M., and Scott, W. J. (1946). Influence of starch in media used for the detection of heated bacterial spores. *Nature* 157: 337.

Scott, W. J., and Stewart, D. F. (1945). The influence of dissolved tin on the growth of *Clostridium botulinum* in canned vegetables. II. Further experiments in plain and in lacquered cans. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 173-80.

X. FISHERIES INVESTIGATIONS.

1. *Introductory.*—The past year has been a period of transition, witnessing the gradual resumption and amplification of research activities. Special duties assumed by certain of the Division's officers with reference to the war effort—first of all under the Department of War Organization, and subsequently under the Department of Post-War Reconstruction—were tapered off. Ultimately the temporary *ad hoc* Commonwealth Fisheries Authority was transferred to the Department of Commerce and Agriculture there to form a permanent Commonwealth administrative and developmental authority, providing continuity for those war-time activities which in existing or modified form are requisite in normal times.

During the year the Division's research vessel, M.V. *Warreen* was returned by the Royal Australian Navy, by whom, during the war years, it was employed on valuable hydrographic survey work in forward areas. The vessel is being given a preliminary refit in Fremantle prior to resuming research work. In addition, the Council acquired a second research vessel, the auxiliary wooden ketch *Taipan*, 81 feet in length. This vessel will be refitted for research work, and is especially suitable for the tropics. For local work on the east coast the launch *Tipton* was also acquired.

Since the Division had not at its disposal any major research vessels during the year, further experimental fishing tests were restricted to those which could be carried out by charter or other arrangement. Reference is made below to work carried out with M.V.'s *Isobel* (Western Australia) and *Liawenee* (Tasmania) and by arrangement with fishermen (New South Wales). In Western Australia boat facilities for a number of investigations were provided by the Fisheries Department, the Royal Australian Navy, private owners, and fishermen. A 56-ft. lugger, *Isobel,* was chartered from July-December, 1945, for a fisheries survey between Mandurah and Derby. Mr. G. P. Whitley, Ichthyologist, Royal Australian Museum (seconded for a period to the Division) acted as scientific officer-in-charge. The *Isobel* began her cruise on July 14 at Fremantle and terminated at Geraldton on December 13. The survey covered a distance of 4,000-5,000 miles. Considerable information was accumulated on the distribution and approximate abundance of fishes of commercial importance with biological details of the specimens collected. Plankton samples were also obtained and numerous temperature readings recorded.

In order to devote greatly increased attention to exploratory work in general the Council is establishing an Exploratory Section within the Division.

2. *Developmental Work in South-eastern Australia.*—(i) *Tasmania.*—The routine testing of the new southern trawling grounds with the Danish-seine net from the State Fisheries' vessel *Liawence* was continued over most of the year. There is still no clear sign of a return to the good fishing conditions that prevailed in the autumn of 1944, although no very great amount of work was done at the same season in 1946, owing to the pre-occupation of the vessel with work on pelagic fish. Although this experiment has thus not yet reached a definitive stage after nearly two and a half years, it is intended to issue a brief interim report upon the results, which may be of some value to the trade at the present time.

With regard to pelagic fishing, tests upon the horse-mackerel shoals were again an important feature of the Tasmanian work, and it had been hoped that real success would be obtained on this occasion, with the new 200-fathom purse-seine net which was recently obtained from California. The specifications of this net were those which had been suggested by the experience of a long series of previous attempts to capture these fish with locally-made equipment. Unfortunately, almost the whole period of the work, which covered the three autumn months which in other years (1941-1946 inclusive) constituted the optimum period of the year for shoaling mackerel, was unexpectedly characterized by most disturbed weather conditions, and as a result there were extremely few occasions upon which the surveying vessels (the *Liawenee* and *Mary*) found shoals which were even moderately suitable for attempts at fishing by this means. These few opportunities were mostly used up without success in the preliminary "feeling" stages of the work, and did not recur after the effort had got down to a proper working basis, as a result the value of the purse-seine for mackerel remains undetermined. There was evidence that the fish were in the area as usual, but would not surface because of poor weather conditions; it has been shown in other years that these fish hardly ever rise well except on calm sunny days, of which there are generally a reasonable number in the Tasmanian autumn. This setback was most unexpected, because the records of the five previous seasons in which the Division has been attempting to catch mackerel had indicated that this resource was quite stable from year to year in respect of abundance of surface shoals, and it was in fact specially selected for intensive work partly because it seemed unique in this respect among the pelagic fish stocks investigated in south-eastern Australia. However, the effort will require to be continued in the future, probably employing drift nets (ordered from abroad during 1945) as well as surface seines.

A little work was done upon sprat fishing in the autumn of 1946 by one or two private operators, utilizing netting provided by the Division, and the services of a man who claimed extensive experience of fishing for sardines in Spanish waters. Some fish were caught, but in no larger quantity than has been obtained several times before in the course of the Division's previous six seasons' work (1940-45). The matter will probably receive further attention in future, by private operators at any rate, but it still seems unlikely that large catches will be made sufficiently often for the species to support an independent fishery.

(ii) *New South Wales.*—Some attention was devoted to the activities of a small concern which operated in the south coast waters during the spring and summer

of 1945-46, with the object of capturing tuna and pilchards. Although this venture was led by an American who claimed extensive experience of this sort of fishing in the north-eastern Pacific, it proved under-equipped (even with the maximum of assistance the Division could provide) and generally ill-prepared to cope with the conditions under which pelagic fish generally occur in this area. In the outcome, the results achieved were by no means even up to the standard of those obtained in previous years by the Division's own vessel *Warreen,* and the work was not long continued. Pilchard shoals, at least, were not abundant during this period in the area worked.

Subsequently, in the late summer and autumn, the Division provided eqipment and other assistance for some pilchard fishing-trials, by surface seine methods, by private fishermen operating in the Jervis Bay area. A good deal of painstaking work (designing and building of nets, and testing of different types) has been done, and several catches have been made. While these are still well within the range of those obtained by the *Warreen* in 1940 and 1941, i.e. of the order of hundredweights rather than tons, they are apparently proving sufficient to encourage the operators to further efforts. The importance of any such work, especially in view of the value of pilchards as live-bait for tuna fishing, has been emphasized in earlier reports.

(iii) *General.*—The total result of this work, which, it will be realized, has engaged much of the time, effort, and resources available to the Division in the past year, rather supports the conclusion that was suggested by the results of much earlier work from 1938 onwards; that is, that the development of new fisheries in south-eastern Australia, especially for pelagic species, is not likely to be a simple procedure. One very special difficulty, the importance of which will have been realized from the foregoing and from previous reports, is that of annual fluctuations in abundance and availability (in respect of the gear used) of the fish. These occur in all parts of the world but have proved extremely troublesome in these waters. It is hoped that at least some of these developmental projects will eventually yield satisfactory results, if trials are persisted with and highly skilled personnel and adequate equipment are available.

3. *Biological Investigations.*—(i) *Clupeoid Fish (Pilchards, &c.).*—Although there are still no signs of the early emergence of a major fishery based on any of these species, commercial interest in them is now greater than for some time, a measure of experimental fishing is being done (see above), and it seems possible that some expansion will shortly occur in this field. This seems particularly so in Victoria, where a small fishery exists already, and where the demand (especially from the rising fish paste industry) is apparently growing. Since it has been shown that all the principal species so far investigated are subject to abundance fluctuations, it has been thought desirable to continue the biological work upon some of them with the special object of understanding and perhaps predicting such changes so as to minimize the difficulties which the trade will encounter in any attempts to exploit these stocks. This involves studies on raciation, age, and maturity, and the analysis of such abundance data as are available.

A good deal of such work has already been done, and is continuing, upon the pilchard of New South Wales. Much of the age and maturity work was done (and reported) some time ago, and whilst it is still not available for publication (the recent discovery of some fresh possibilities in the scale-reading work compelled some additions to MSS) it is sufficiently complete for use in interpreting annual changes in abundance, as established from the records of shoals seen by the *Warreen* and other boats, as being due to the passage of year-broods of different numerical strengths through the adult stock. From this work it is now possible to make a rough assessment of the relative strengths of six out of seven successive year-broods of south coast pilchards, viz. 1937 poor, 1938 medium, 1939 good, 1940 medium, 1941 no information (due to war-time interference with the sea work), and 1942 and 1943 medium. The relative abundance in any winter is positively correlated with that in the preceding spring and can be predicted from it, and there seem to be good possibilities of establishing an even more long-range system of forecasts, if such is ever required.

In Victoria, such biological work is at present concentrated upon the anchovy, and is not so far advanced. It has been shown that the main spawning season is about the late summer and early autumn, and that fish hatched at this season attain modal sizes of about 65, 80, 95, and 102 mm. body length, i.e., about 3.1, 3.8, 4.5, and 4.8 inches total length, at their first four annniversaries of birth. Two lines of research on this subject (scale reading and length frequency distributions) agreed well in the results. There are larger fish, up to 5.5 inches total length, whose age is probably about five or six years.

Knowledge of the geographical and seasonal distribution of both the pilchard and anchovy in Victoria has been greatly added to over the past two years. The poor supply of both species in Port Phillip Bay in the warmer months of 1944-45, and of the pilchard also in the following season, caused fishermen to seek and catch these fish in other parts of the State. There was a particularly large and sustained occurrence of both species in the Flinders area in the late winter and early spring of 1945, which might not otherwise have attracted much attention.

Pilchards (Western Australia).—Observations on pilchard occurrences in the south-western area are detailed in the report on aerial reconnaissance. Additional data were obtained from an examination of salmon stomachs at Hopetoun in November, 1945 and February, 1946, from which it appeared that extensive pilchard occurrences persist throughout the summer in this area.

An experimental catch of pilchards by small-meshed beach seine was made in Bunbury harbour in May, 1946, and efforts are being continued to find out whether this fishing can be conducted commercially in this way. It was in this area that large occurrences were located from the air in May, 1943, and, since that date, samples have been collected by Fisheries Department Inspectors each year. In July, 1945, shoals were seen in the area further north, near Fremantle, and samples were collected by the *Isobel.*

(ii) *Whitebait (of Tasmania).*—At the request of various parties interested in this fishery, a biological and general investigation was commenced during 1945. Though virtually unfished prior to 1941, the Tasmanian whitebait stocks yielded a catch of some 150 tons in 1945, i.e., approaching the average annual output in New Zealand, although the principal form there (*Galaxias*) is quite different from the main one in Tasmania (*Lovettia*). While it is thus small, this fishery is rather valuable, since it provides the canneries with a suitable pack at a time of the year (the spring) when other supplies are hard to get, and moreover very little equipment is required, a simple scoop, operated from the river bank, being often all that is necessary to make good catches. The fish run up the rivers from the sea to spawn, which they apparently do but once and then die (so that there is only one year-class in any given season's run), and the young fry are carried downstream. The ova may either drift or attach to logs, stones, &c., and are viable in either condition. The sex ratio, which is easily established on account of a marked sexual dimorphism (this and some other points were observed by other investigators prior to the commencement of the Division's work), is

extremely variable. The fishery began in the Huon River, but declined there (see below) and since 1943 about 90 per cent. of the catch has come from a group of rivers in the Devonport region. Further streams are continually being opened up.

On the main point on which the Division's advice was sought, that of the condition of the fishery and the safe limits of exploitation in the different rivers, there seems to be no cause for concern at this juncture. The general picture is that of a fishery at a healthy developing stage. Catches have declined in two rivers, but for definite reasons which are not connected with any scarcity of fish. For one or two streams there are indications that the catch level might be at or approaching its safe maximum. The problem will receive further attention in the coming season, after which more definite and final conclusions can probably be formulated.

The other problem concerned the dark colour of the fish in certain rivers especially the Huon, where the catch fell off largely because a cannery was dissatisfied with the product. The present work has established that the dark coloured fish are the spent ones, and that therefore a better product can be obtained in the same river further downstream. The centre of the Huon fishery is some distance from the sea, much farther upstream than other more favoured localities, and this naturally means that a higher proportion of the available fish are already spent when they arrive there. It remains to be shown, of course, that fishing conditions are suitable at these downstream localities, but this is definitely a line along which a solution should be sought.

It is hoped shortly to distribute an interim report, covering these findings, to the principal whitebait buyers and other interested parties.

(iii) *Southern Bluefin Tuna.*—(*a*) *Western Australia.*—Further new data regarding the distribution of the species in Western Australian waters were obtained during the *Isobel* survey, when a specimen was taken between Fremantle and Geraldton in August. The specimen was of the next older year group from those taken in the same area by a naval vessel the previous January. The evidence to date suggests that the equivalent tuna areas, as compared with south-eastern Australia, have a more northerly extension in Western Australia. This applies to the pilchard situation and also to some of the sea-birds intimately associated with pelagic fish occurrences (cf. the gannet, *Sula serrator*). A handicap, however, has been the lack of systematic observations on this coast, compared with what was accomplished in eastern Australia by the *Warreen* in the period 1938-42. Thus it is not yet possible to interpret as fully the southern bluefin movements on this coast. Fishermen, however, report that the small size group which was taken by the naval vessel between Fremantle and Geraldton in January, 1945, is abundant in Geographe Bay and northwards during the summer months.

The large adult (spawning) bluefin were again plentiful on the south coast during the summer, and an unusual phenomenon was the number stranded or caught in shallow water, as far north as Geographe Bay (cf. Tasmanian and Clyde River, New South Wales, captures.)

(*b*) *South Australia.*—Fewer reports were received from South Australian collaborators than in previous years, but these suggested the species was plentiful during the summer (1945-46) in South Australian waters, with large fish, bigger than ordinarily obtained in New South Wales and Tasmania, particularly abundant.

(*c*) *Eastern Australia.*—It appears from various reports that the season was a good one, and, in New South Wales, quantities were taken commercially for the Narooma cannery (apparently for the first time since 1941), but the season appeared to end earlier than normally. As last year, no contact appears to have been made with the second year group (the smallest size found in the coastal runs in the east). However, systematic sampling on the scale made in 1938-41 was not yet renewed.

In Tasmania, a southern bluefin weighing 125 lb. was taken at Cape Pillar in April. Such a large specimen has not been reported from this area for many years. The only other large one received from Tasmania was a specimen taken in the spring of 1869 at Spring Bay, and the most recent record for eastern Australia, as a whole, was taken in May, 1937 (238 lb. at Bermagui, New South Wales). However, just at the time (June, 1946) that this report was being submitted, notification was received that a southern bluefin tuna, of 153 lb., had just been captured in Clyde River, Bateman's Bay. The location and movements of the large adult bluefin in the south-east remain at present unsolved problems.

(iv) *Other Tuna Species.—Striped tuna* in the south-eastern Australian region again appeared to repeat the 1945 situation—no shoals were observed from the air or contacted by boats in the Bass Strait area during the autumn season. Odd fish were captured in Tasmania, but the only shoal formations were observed along the New South Wales coast.

Extensive observations on the *northern bluefin* were made by the *Isobel* expedition in north-west Australia, where it appears to be the predominant tuna.

(v) *Salmon Investigations.*—General references to the distribution of salmon shoals, as seen from the air, are made in the section of this report devoted to aerial reconnaissance. General biological studies were also continued. In order to obtain comprehensive data for the continuous study of fluctuation in occurrence of the various size (and therefore age) groups, large numbers of measurements were made at the Narooma (New South Wales) cannery and in the Melbourne fish market. The whole series of measurements awaits analysis at a future date, when it is suitably complete. It is anticipated that it will yield valuable information on the growth rate of the species and on the relative productivity of successive years of spawning. Other phases of the biology being studied are the delimitation of the spawning grounds and the elucidation of the early life history, from egg to post-larva.

In Western Australia canning operations were commenced at the instance of the Division and of the Chief Inspector of Fisheries. Results so far have exceeded anticipations. The fish are packed in the "relish" or "fish-loaf" form. With the exploitation of the salmon fishing at the Twelve-mile Beach, Hopetoun, a more effective sampling of the salmon has been possible, and a tagging programme has been instituted.

(vi) *Barracouta Investigations.*—As do salmon, barracouta present difficulties in the making of age determination, because the normal means of ascertaining age in fish (from annual rings on otoliths or scales) are not applicable. Aid is obtainable, however, from copious length measurements likely to show gradation in length from year to year, and such measurements are being steadily accumulated, especially at the Melbourne Fish Market.

Barracouta were extraordinarily plentiful in 1944-45 in Bass Strait, Tasmania, and southern New South Wales waters. This occurrence probably represented the peak of a favorable natural fluctuation. It was anticipated that the plentiful occurrences would continue during the 1945-46 season, and this has occurred, although there is some indication of the passing of the peak. Again during the latter year the production of barracouta was limited chiefly by economic factors. It is evident that a close relationship exists between this exceptional occurrence of barracouta

and hydrological conditions and other observed biological events, and an attempt at collation of the whole is being made.

(vii) *Tiger Flathead Investigations.*—Early in the year it was evident that the Tasmanian State Government was having little success with its vessel *Liawenee* in catching flathead, and it became necessary to carry on a restricted research programme on the New South Wales stocks of the species. The long-term aim of this work is to determine the optimum average catch figure for the eastern Australian flathead fishery; the short-term aim is to have a useful body of data available when the expected complaints of overfishing are voiced by the trade, and advice is requested.

A system for sampling the commercial catch brought in to the Sydney markets has been established. With the decrease in black market sales, this system should efficiently sample the total actual catch, since inland sales from the fishing ports are usually small. (A quantity of fish is also sent to the Melbourne market, and this too is being sampled). Future changes in the New South Wales fish-marketing practices may enforce alterations to this system.

Laboratory work has concentrated on developing a method for determining the percentage age composition of samples of flathead, by means of the otolith. This has now reached a stage when it is felt possible to go ahead and, as soon as adequate samples are to hand, determine the annual mortality in the chief age-groups in the fish stock. A reliable estimate of this over two or three years is perhaps the most important basis from which to start control of a commercial fishery. Already it may be said that the flathead fishery is based on individuals of three, four, and (to a less extent) five years of age, with occasional catches of numerous two-year-old fish.

During the coming year it will be possible to devote more time to the flathead work.

(viii) *Shark Investigations.*—(*a*) *Snapper shark* (*Notogaleus rhinophanes*).—An investigation into the biology of this shark, the liver of which yields a relatively high vitamin A oil, was commenced during the past year. There is general agreement on the distribution of sexes into schools, areas used for breeding and nurseries for the young sharks, but there are many conflicting data regarding the seasonal migration of the schools of shark. Squid and octopus form the main food of this species.

Tagging of sharks is being planned to obtain information on migrations, seasonal distribution, and growth rates.

(*b*) *Statistics.*—In Western Australia, selected personnel in the various fishing areas have been provided with special forms on which are tabulated regularly biological and statistical data concerning the catches.

(ix) *Mullet Investigations.*—The collection of Western Australian scales have been read and the results are being analysed. Analysis of the stocks from market and field measurements continues. It is evident that the fishery exists almost entirely on a single year class (2nd year fish) which has not previously spawned. Routine investigations on mullet are being continued in Western and Eastern Australia. Tagging operations are being included.

From November, 1945, to January, 1946, the conservation programme instituted in 1942, as a result of recommendations by the Division, was temporarily relaxed in the three chief western estuaries. The objective was to assess whether variations have taken place in the size-composition of the fish or in their abundance in the intervening period. No apparent increase in size was found, though this was not unexpected, since fish in the region referred to are of one (the second) age group. It is hoped that by continuing observations during a further period of relaxation of restrictions it will be possible to determine whether an increase in abundance has occurred.

(x) *Oyster Investigations.*—(*a*) *Winter mortality.*—Analysis of the experiments so far carried out gives the following information:—(1) Mortality declines upstream. (2) The peak of the mortality occurs at approximately the same time each year. (3) Degree of crowding of the oysters is not significant. (4) The "growing level" generally adopted by oystermen appears also to be the level of maximum killing. (5) Transplanting to a lower level reduces mortality. (6) Oyster stock, brought to a test area from different localities, shows no difference in killing rate if established for some time; but if moved just before winter significant differences occur. (7) By means of a special resistance thermometer, temperature data of the mud and water at selected points on Shell Point lease were obtained it seems evident that the temperature of the water's edge will drop to very low levels in the late winter and early spring, and that if this is proved to be so, temperature can be considered as the dominating causal factor of winter mortality.

The conditioning of the oysters during the preceding summer thus appears important, and it seems that oysters physiologically debilitated are unable to withstand the winter cold and eventually succumb. There may possibly be the complication of virus or bacterial infection, though there is not incidental evidence of it.

The work during the winter of 1946, therefore, will be directed towards three investigations:—(1) The possibility of virus or bacterial infection. (2) The effect of considerable lowering of growing level. (3) More detailed study of temperature effects (studied in conjunction with Hydrology Section).

(*b*) *Spatting.*—Routine observations have continued on spat-fall and occurrence of larvae in Port Hacking. The heavy spat fall is evidently achieved by long spread falls, rather than a single (or a few) heavy catches, and indicates that Port Hacking may be typical in this regard.

(xi) *Black Bream Investigations.*—A programme of tagging of black bream (*Acanthopagrus australis*) was begun during the past twelve months and preliminary tests were carried out on the practicability of tagging this species. To date about 1,500 bream have been tagged in New South Wales and Queensland estuaries, namely Port Hacking, Hawkesbury River, Tuggerah Lakes, Lake Macquarie, Wallis Lake, Manning River, Watson-Tylor's Lake, Hastings River, Nambucca River, Bellinger River, Clarence River, Richmond River, Moreton Bay, Bribie Passage, Noosa River, Mary River, Hervey Bay, and Elliot River. Coastal surveys have been made for this purpose during June-July, 1945, August, 1945, November, 1945, April, 1946, and May-June, 1946. To date only nine tags have been returned, all being from the Tuggerah Lakes, and it appears that these fish have moved little since their release and mostly appear to be injured by the tag. Data derived from this programme are calculated to afford information on local movements, seasonal coastal migrations, and confirmation of the estimated growth rate.

Field observations have confirmed that the growth of bream during the first year is of the order of three inches, which agrees closely with former conclusions based on scale reading methods. It has been established that postlarval bream cease to be planktonic at a length of 12 mm., after which they begin to assume their adult coloration and inhabit the sheltered *Zostera* weed beds in close proximity to the river mouths where spawning had taken place during the winter months. Post-larval stages were described and illustrated in an article published in *Mem. Qld. Mus.*

Further progress has been made with the proposed taxonomic revision of Australian breams. All available relevant literature on the group has been fully examined and representative materials were received from Victoria and Western Australia.

(xii) *Perth Herring Investigations.*—Routine investigations are being continued, supplemented by a tagging programme.

(xiii) *Scallop Investigations.*—Biological work is being maintained on samples obtained at frequent intervals from the D'Entrecasteaux Channel grounds. The tagging programme has been extended. Of 988 scallops tagged in 1945 some 52 were recaptured. A preliminary report has been prepared on this work. In April, 1946, a greatly increased number of scallops (5,000) were tagged.

Following the receipt of reports of the occurrence of scallops in the vicinity of Port Albert, Port Welshpool, and St. Leonards, Victoria, preliminary tests were undertaken at Port Albert to establish if possible the existence of workable beds. These were unsuccessful, but further tests in these areas are contemplated.

(xiv) *Marine Crayfish (Panulirus longipes* and *Jasus lalandii).*—In a series of field trips the Western Australian coast was roughly surveyed from Point D'Entrecasteaux on the south coast to Dongarra on the west, a coastline of 600 miles. At least 400 miles of this possesses fringing or offshore reef systems, presenting an exceedingly treacherous lee shore. The coastal roads over the area between Perth and Dongarra are either difficult or non-existent and although this does not represent a bar to the sampling of the landward reefs (which was done with a light boat hauled in with a utility truck as conditions permitted) it renders economic exploitation by road doubtful.

Wherever sampled in this area between Perth and Dongarra, immature *P. longipes* were present, mature crays also occurred close inshore but in deeper water. (In the Jurien Bay area immature crayfish were abundant up to 5 miles off-shore, mature fish being taken at depths of 20–25 fathoms.)

Since a large extent of this coastline (200–250 miles) is virtually unfishable by existing methods in Western Australia, the area must be regarded as representing a sanctuary contributing through the medium of larval distribution to the maintenance of the commercial fishing grounds at the northern and southern ends (Abrolhos-Geraldton and Garden Is.).

The limits of the northern distribution of *P. longipes* are at present unknown. The species extends at least to Dirk Hartog Island as the dominant species. Southerly, the distribution has been traced around Cape Naturaliste to Cape Leeuwin which appears to be its terminal point. Between the two capes its season appears to be short (October to April), perhaps depending on the algal growth on the granite reefs.

Over the range of the species, tissue-water determinations have been made as a means of assessing intermoult stages. Much further work is required but there are indications that this water content may furnish a useful index of the optimum range of the species in its adult phase.

The status of the so-called Dongarra cray has been investigated. It is an immature *P. longipes* with an increase in development of internal organs against total length and carapace spine formation. The cause is unknown.

Juveniles (1–2½-in.) of *P. longipes* have been taken rarely on the reefs examined although they were fairly common in growths of the sea grass *Cymodocea,* at least from October to December. (The New South Wales marine crayfish (*Jasus verreauxi*) shows a preference for *Gracilaria* beds in this phase.)

Preliminary analysis of length frequencies and gonad samples indicates that the main Abrolhos fishery is on early maturity crayfish, possibly of the second and third year group. Tests in deeper water suggest that the escapement into deeper water of larger size groups is fairly high.

The southern marine crayfish (*Jasus lalandii*) appears in some numbers at Cape Naturaliste although the species has been reported as far northward as Rottnest Island. The species is the same as that found in south-eastern Australian waters but in its overall facies resembles Tasmanian rather than South Australian specimens. Its proportion to *P. longipes* in the Yallingup-Cape Naturaliste area is about 1 in 5 of the catch, but between Namelin Bay and Cape Leeuwin it is about 3 to 1 in favour of *J. lalandii.* Little is known at present of its easterly range in Western Australian waters.

(xv) *Estuarine Fishes in General.*—Routine observations are being continued in Western and South-eastern Australia.

(xvi) *Sea-bird Fluctuations.*—This investigation continues in south-eastern Australia and will be extended during the following year.

(xvii) *Littoral Ecology.*—In conjunction with the crayfish surveys in Western Australia, attention has been given to the general littoral and sub-littoral ecology. Material has been gathered and distributed to specialists for working out. Particular attention has been paid to latitudinal distribution of seaweeds and marine invertebrates while traverses have been made at Sandy Cape, in the Jurien Bay area, and at Rottnest Island.

Of very great interest is the existence of small, isolated, oases of fringing reefs and ledges, richly populated with invertebrates and algae, at irregular intervals along otherwise barren cliffs and ledges. The problem is complex, and each possible explanation breaks down in one area or another. Offshore the reefs appear to be fairly equally well populated.

It is of very great importance in the general biology of *P. longipes* to determine whether the species is one which is colonizing relatively cooler waters from a warm subtropical centre or whether it has successfully adapted itself to a slight cooling of its original range. In the first case the species is likely to fluctuate fairly widely in numbers while the larvae might have a low survival rate; in the second it would be likely to be fairly stable with a reasonably high larval survival rate.

Accordingly, attention was paid to the possibility of sub-fossil occurrences in the coastal cliffs which would give evidence of earlier conditions. During one joint trip, Dr. Rhodes Fairbridge of the Department of Geology of the University of Western Australia was fortunate in finding massive corals in a conglomerate band at the Moore River about 45 miles north of Perth. This is some indication of an earlier, recent, warmer phase. Such corals, living, are now found at the Abrolhos Is. about 200 miles north of Perth.

4. *Freshwater Fisheries Investigations.* — (i) *Tasmania.*—The Division has acted in an advisory capacity to the Salmon and Freshwater Commission of Hobart, Tasmania. Arrangements have been made for sampling the brown and rainbow trout of Great Lake during the next spawning season, and a creel census system will be introduced to determine the productivity of the more important trout waters. The new trout hatchery to be constructed at Cora Lynn, near Launceston, will incorporate recommendations on pond design and layout submitted by the Division. Investigations into the serious spawning season mortality among brown trout at Lake Leake resulted in the isolation of a bacterium (*Pseudomonas fluorescens* strain) lethal to brown trout. This work was carried out with the assistance of Dr. Campbell Duncan, Government pathologist, Hobart, and a joint report of the

investigations has been prepared. Data are being accumulated to permit the formulation of a programme of stream and lake improvement in Tasmania.

(ii) *Kosciusko State Park.*—Assistance and advice have been afforded the State Park Trust in relation to development and improvement of trout waters. A preliminary survey was made of the southern end of the area. A programme of stream improvement and lake development has been drawn up for consideration by the Trust, and arrangements have been made, as in Tasmania, to secure data on the productivity of the streams.

5. *Hydrology.*—(i) *Oceanic Investigations.* — (*a*) *East Australia.*—Routine investigations of hydrological conditions in the shelf waters off Port Hacking, Eden, and eastern Tasmania have been continued. Shelf stations off Port Stephens and Eden have been established and will be worked at monthly intervals.

In order to expand the deep sea oceanographical programme of the Division, considerable discussion has taken place with certain branches of the Royal Australian Navy and, recently, with Navy staff in Melbourne, regarding the possibility of collaboration.

Mean sea level studies based on records obtained with the Division's tide recorder in Port Hacking have been continued.

(*b*) *Western Australia.* — The routine releases of drift bottles in the Geraldton-Albany area have been continued. Special attention has been given to the autumn and spring periods, when there is a reversal of the coastal currents.

(ii) *Estuarine Investigations.* — (*a*) *New South Wales.*—Routine investigations of hydrological conditions in Port Hacking, George's River-Botany Bay, Port Stephens, Middle Harbour, and Lake Illawarra have been continued.

A comprehensive water and bottom mud survey of the Hawkesbury River estuarine system was made in September, 1945, and a regular monthly sampling of this system has been carried out since that date. Similar comprehensive surveys of the Clyde River, Shoalhaven River, Wagonga Inlet, Moruya River, and Tuross River were carried out in November-December, 1945. Regular monthly sampling in Wagonga Inlet was commenced in December, 1945.

(*b*) *Victoria.*—A survey of the water and bottom mud conditions existing in the Gippsland Lakes and associated river systems was carried out in February, 1946.

(*c*) *Tasmania.*—The mid-summer survey of the water and bottom mud of the Derwent River and its associated rivers and lakes was carried out in January, 1946. Routine investigations of the waters of the scallop beds in the D'Entrecasteaux Channel have been continued.

(*d*) *Western Australia.*—A mid-winter hydrological survey of the Swan River and principal south-western estuaries was made in 1945. The semi-annual survey (hydrology and plankton) of the principal S.W. inlets and estuaries has been continued, with a more frequent sampling of the Swan River system.

(iii) *Oyster Investigations at Shell Point.* — (*a*) *Enrichment Experiments.*—As a result of estuarine investigations, it is felt that the adsorbed phosphorus content of the bottom muds determine the fattening potential of an oyster bed. Accordingly, the Division has laid out some experimental plots on its lease at Shell Point, and will shortly introduce phosphates into one of these plots, using a method which should enable adsorption to take place. By subsequent chemical and bacteriological tests of the mud and the control plots, plus biological and chemical tests of oysters from the various plots, it is hoped to establish any future commercial possibilities of this technique.

(*b*) *Winter Mortality.*—By means of a special resistance thermometer developed by the Council for Scientific and Industrial Research National Standards Laboratory, Sydney, some data on the temperature of the mud and water at selected points on the Shell Point lease have now been obtained. Although the critical period for winter mortality is not until August-September, it is becoming very evident that the temperature of the water's edge will drop to near freezing point during that period, and will be markedly different from the general temperature of the water over the lease. It is felt that if these expectations are borne out, temperature can be considered as the dominating causal factor of winter mortality and remedies suggested accordingly.

(*c*) *Oyster Spawning.* — With the availablity of electricity on the Division's lease at Shell Point, it is hoped to put the spat-tank unit into early operation. Towards this end, the Council for Scientific and Industrial Research National Standards Laboratory, Sydney, has been designing special types of heating elements to enable the temperature of the water in the experimental side tanks of the unit to be varied over a wide range of temperatures and held at any desired temperature.

6. *Plankton.*—(i) *Western Australia.*—The plankton, submarine light collections and stomach content material taken by Mr. G. P. Whitley on the *Isobel* were examined. These indicate that, over the period of the cruise, the larvae of bottom-living invertebrates (chiefly Crustacea) comprised about 75 per cent. of the zooplankton mass. This is in contrast to the position in eastern Australian waters where the proportions are reversed.

The Euphausiid *Nyctiphanes,* so important in the food chain in south-eastern Australian waters, has not been found, its place being taken by *Pseudeuuphausia latifrons,* which shows a shift southwards of about 5 degrees as compared with its east Australian range. The absence of *Nyctiphanes* from the food chain is made up for by the continuous presence of the larvae of bottom-living Crustacea. In addition many invertebrates, generally regarded as southern, are found as far northerly as Dampier Archipelago.

It is apparent that the Western Australian shelf must be regarded as an area with distinct characteristics. Extrapolation from knowledge of other areas is not warranted.

A comprehensive series of plankton and submarine light hauls, including an hourly survey by plankton net and submarine light over a period of 24 hours, was made at Rottnest Is. to test the extent and characteristics of the night rise of benthic organisms.

During the whole of the Western Australian work, considerable assistance has been received from the Departments of Biology and Geology of the University of Western Australia, from units of the Royal Australian Navy, from resident officers of other Divisions of the Council, and from officials of the State Department of Fisheries.

(ii) *General Plankton Work.*—The reports on the growth, development, range, and distribution of the Euphausiids of eastern Australia have been completed. Rechecking and tabulation for papers on the *Warreen* zooplankton and Cronulla plankton respectively have also been done.

The B.A.N.Z. Antarctic Research Expedition plankton material for 1929-30 has been rechecked and the results for the N100 net series have been tabulated, the 1930-1931 material has been measured and sorted.

A series of tests comparing the displacement and settlement methods of measuring plankton volumes were made on this material. The results have been written up for publication.

(iii) *Fish Eggs and Larvae—Estuarine Plankton.*—Further collections of plankton have been made during several different months in most of the principal estuaries of New South Wales and southern Queensland, together with correlating observations on temperatures and salinities. These have reference particularly to spawning seasons and spawning grounds of fish species and the characterization of their eggs and larvae. Similar extensive material collected in southern Queensland (namely Noosa River and Moreton Bay) during the past two years has been completely sorted and much is ready for detailed description for publication. This includes *Mugilidae, Atherinidae, Bothidae, Ambassidae, Gobiidae, Gerridae, Hemirhamphidae* and less complete series of other forms. Post-larval and larval stages of eight common species were described in an article in *Mem. Qld. Mus.* In respect to spawning behaviour generally, it has been observed that practically all spawning of estuarine fish, commercial species and others that have come under notice, occurs in the vicinity of river mouths. Also, spawning occurs mainly at night and appears to be associated with lunar influence.

(iv) *Warreen Collections.*—A preliminary sorting of fish eggs and larvae from the bulk collections made by the vessel during 1940 and 1942 has been completed. A systematic grouping of previously sorted collections made by the vessel during 1938 and 1940 into families and genera is now under way. An attempt is being made to work up the numerous little-known representatives of the families included in the orders *Isospondyli* and *Iniomi* which represent a high percentage of the larval forms present in these collections, particularly those made in deep water at the offshore stations. The flatfish, leather jacket, cod, and carangid families are also receiving preliminary attention.

A full year's series of fish eggs and larvae have been sorted out from hauls made monthly at six localities in D'Entrecasteaux Channel, Tasmania.

7. *Seaweed Investigations.*—(i) *Agar—Technological.*—A bulletin discussing the production of agar in Australia and giving details of laboratory results is in the press. Further work, including a study of viscosities and setting points of *Gracilaria* agar prepared under different conditions, is in hand. It has been found in practice, and confirmed in the laboratory, that considerable further research is necessary to improve the quality of dry agar made from Eucheuma in Western Australia. Up to the present, unfrozen gel has been used very successfully by adding it directly to meats in cans, but it is yet hoped to produce a fine agar from this seaweed.

Field work on seaweeds has in recent years been reduced to a minimum owing to shortage of staff and facilities, but the position is now sufficiently improved to warrant the resumption of full monthly surveys of the main beds, fuller studies of further beds or potential beds, and greatly extended plot culture experiments.

Work is continuing on commercial samples of agar, especially in relation to export material which this Division has been asked to certify on shipment. During the past year the chief manufacturing firm attained a production rate of several thousand pounds of good quality agar per month. The greater portion of this production is exported to the United Kingdom, and enquiries for supplies have been received from several countries including the United States of America, Canada, and South Africa.

(ii) *Agar—Taxonomy and Distribution of Seaweeds.*—Systematic and taxonomic studies have been continued in the algae (seaweeds). Further work also is adding to the knowledge of the range, distribution, and seasonal growth of elements of the local marine flora. This work forms a necessary foundation for the sound development here of any industrial enterprise using seaweed for its products.

The algal genus *Gracilaria* is the one most used in Australia in connexion with the agar-production programme. During the present year a taxonomic survey has been completed of this genus in Australia. In this work several new forms have been described, and the distribution and intergradation of species is discussed.

One of the results of the *Isobel* survey in Western Australian waters was the discovery for the first time on any considerable scale of the growth *in situ* of the local agar-producing seaweed *Eucheuma.* It was found that the weed grows attached to living coral, in extensive stands, and growing very close to the shore in very quiet water. Hand-harvesting could be done very easily, but difficulties present themselves at present regarding mechanical harvesting.

(iii) *Seaweed as Fodder.*—Last year, while the country was experiencing drought conditions, the suggestion was made that certain seaweeds could be of use as fodder during drought periods. This suggestion was not followed at the time, but later, in association with the Department of Agriculture, chemical and biological tests of local seaweed were carried out. The results of these tests were encouraging, and the study is now being carried further by personnel of the Glenfield Veterinary Research Station.

8. *Bacteriology.—Shark Spoilage.*—A paper on the production of ammonia in stored shark flesh has been prepared. It describes experimental evidence regarding the cause of spoilage, and contains recommendations based on the findings in the field, for the control, through better handling, of ammonia production in the flesh. Much work remains to be done on the bacteria related to shark spoilage. A note on *Sarcina ureae,* a spore-forming motile sarcina, has been published. High concentrations of urea (1.5-2 per cent.) have been shown to be present in shark flesh, blood, heart, liver, and skin. The bacteria isolated from the above are allied to, if not identical with, certain soil bacteria, and the great majority can produce ammonia from shark flesh. The commonest genus is *Corynebacterium.*

9. *Anti-fouling Investigations.*—During the war, much attention was directed to the study of the fouling of ships' bottoms as well as of marine structures and, at a meeting held in Melbourne during the year, between representatives of the Council's Divisions of Fisheries and Forest Products, and also of the Munitions Supply Laboratory, it was decided that the continuation of fouling research in peace-time is highly desirable owing to the long-term nature of such work. A survey of damage due to fouling and marine borer is being made to enable the national importance of such work to be assessed. It was decided that the Division should pursue biological investigations in fouling. That work has been commenced and is already yielding interesting results on the nature of fouling and the rate of growth of the organisms concerned.

10. *Aerial Observations of Pelagic or Surface Swimming Fish.*—During the year, observations in aircraft allotted by the Royal Australian Air Force for the purpose were continued.

(i) *5th July to 8th November,* 1945.—Most of the flights during this period were made in Western Australia and covered the whole coast of that State with the exception of the relatively small portion eastwards of Cape Talbot, in the north, at the head of Napier Broome Bay. This series of observations was really part of that which began at Melbourne on 15th May, 1945, and extended westwards to Western Australia but which was interrupted towards the end of June, 1945.

On 20th October, the return to Melbourne began from Perth coastwise and including the north coast of Tasmania. Melbourne was reached on 8th November.

The main purpose of this survey was to maintain contact with the vast occurrence of pilchards and blue mackerel found in the western portion of the Great Australian Bight on 20th May, 1945, and again observed in the same area on 3rd June when Mr. G. P. Whitley, of the Australian Museum, who accompanied the flight on the latter occasion, estimated the number of shoals at 60,000.

Another objective of this series of flights was to co-operate as scout with the ketch *Isobel* which had been chartered for a preliminary survey of the waters of north-west Australia.

Abnormally boisterous and wet conditions prevailed in the southern half of Western Australia during the period June to September; in fact, the rainfall during that time constituted a record. It was intended that *Isobel* should, when ready, proceed to the south coast to study the great occurrence of fish found in the western part of the Great Australian Bight on 20th May and 3rd June, 1945, but the plan was abandoned owing to bad weather, the lateness of the season (*Isobel* was not ready to proceed southwards from Fremantle until the middle of July), and the fact that further aerial observations in the area where the great occurrence was first noted suggested that the bulk of the fish had migrated. As an alternative to an inspection of the whole of the southern coast by *Isobel*, arrangements were made for surveys on suitable occasions in the vicinity of Albany by a chartered fishing boat working from that port. It is necessary to remember that there were no really suitable fishing vessels in Western Australia at the time to make a survey of the great southern coast where navigational facilities are far less than could be desired.

Aerial observation on 14th July, disclosed a large concentration of pelagic fish between Fremantle and Busselton. At least 500 shoals of this concentration were within fifteen miles of Fremantle. *Isobel* was directed to this near concentration but the fine weather broke and so prevented effective observations. However, these were resumed a few days later and numerous shoals of pilchards, some of them acres in extent, were located in the area indicated by the plane. Specimens were obtained by rifle fire, there being then no lampara or other circle nets available for pelagic fishing investigations in Western Australia. The shoals examined were within fifteen miles of Fremantle and only a few miles off the coast. Notwithstanding their nearness to this main port, not a boat was in the vicinity of the shoals when the original observations were made from the plane and no reports of the presence of these fish had been received from private sources.

Further observations from the plane on 25th July, disclosed that pilchards, apparently travelling north, were plentiful between Fremantle and Geraldton. This confirmed the decision to send *Isobel* northwards rather than to the south coast. After an abortive attempt due to a heavy gale and further delay at Fremantle by continued bad weather, *Isobel* eventually got away on 16th August, about three months behind the time originally set for the commencement of her work. In the meantime the plane had discovered pilchards and tuna plentiful as far north as Geraldton and a series of flights was begun ahead of the boat as far north as Cape Londonderry. These disclosed that fish, very much like pilchards and accepted as such, were present as far north as Shark Bay. Tuna were seen in scattered shoals over most of the area covered but were most plentiful in the Shark Bay area and in that broadly between Broome and Cape Leveque.

The plane returned to Perth for overhaul and met *Isobel*, which had been held up by bad weather, at Geraldton. The results of the aerial observations were conveyed in detail to Mr. G. P. Whitley who was the scientific officer in charge of *Isobel*.

Aerial co-operation with *Isobel* was resumed later and contact between the plane and the vessel was made near Broome on 29th September. The aircraft then carried out a necessarily brief survey as far north as Cape Talbot at the head of Napier Broome Bay. On its return to Broome, and since the period for which the aircraft had been made available was to expire on 30th October, at Melbourne, contact was broken between plane and boat at Broome on 7th October, and the plane returned to Perth coastwise and then after overhaul to Melbourne, via the south coast of Australia to King Island in Bass Strait, thence along the north coast of Tasmania to Furneaux Group and thence to Melbourne on 8th November.

The general results of the *Isobel's* work appear elsewhere. Valuable experience was gained in respect of direct co-operation between the aircraft and the boat. The Royal Australian Air Force kindly installed a wireless set on *Isobel* and provided an operator.

One of the outstanding discoveries of this series of flights in Western Australia, apart from that of the immense concentration of fish in the Great Australian Bight in May, 1945, was the quantity of pilchards off the west coast of Western Australia from Busselton to Shark Bay. This is of special significance in view of the fact that, in October, 1944, a large concentration of small fish containing about 1,000 shoals was found by the plane in Shark Bay but could not then be positively identified owing to there being no boat at hand. However, from specimens of pilchards secured by Mr. G. P. Whitley in this area during shark repellent investigations in 1944, and from further specimens of the same species secured by *Isobel* in the same area in 1945, it is reasonable to assume that the large occurrence of small fish noted from the air in this region in 1944 was also made up of pilchards.

So far as the aerial survey northwards from Broome is concerned, tuna were observed, but not plentifully, as far as White Island (Lat. 15° 05′ S., Long. 124° 24′ E.). Conditions north of this island were generally unsuitable for observation or rather for the manifestation of pelagic fish on the surface but, nevertheless, it is believed that pelagic fish were scarce north of this island. This conforms with the findings in this area in late October and early November, 1944.

White Island is the roosting place of about 5,000 brown gannets or booby birds; northwards of this sea-birds were very scarce as in 1944. Adelie Island (Lat. 15° 32′ S., Long. 123° 10′ E.), broadly south-west of White Island, is the northernmost large breeding place for sea-birds in Western Australia as far north as Cambridge Gulf (Wyndham), or so it appears from the aerial surveys. It is, of course, possible that there may be large sea-bird colonies on some of the reefs and small islands far distant from the Australian coast (on the Sahal shelf) in this area but it has not been possible to examine these during the pelagic fishery survey.

It is clear that the area between North-west Cape and Adelie Island contains important colonies of nesting sea-birds, especially mutton-birds (*Puffinus pacificus*), terns (various species), silver gulls, masked gannets (*Sula dactylatra*), brown gannets or boobies (*Sula leucogaster*), lesser frigate-birds (*Fregata ariel*), pelicans, and pied cormorants (*Phalacrocorax varius*). Mutton-bird colonies were not found to extend past 118° E. (Forestier Islands), and are more densely concentrated between Long. 114° E. and Long. 117° E.

Aerial observations of the distribution of sea-birds in Australia, especially in the little-known parts, have provided most valuable photographic and other data.

A few scattered tuna shoals were found along the coast westwards fom Broome to North-west Cape on the flight southwards after leaving *Isobel* at Broome on 29th September, 1945. Rough weather prevented effective observation of the area south of North-west Cape to Perth. Whales were noticed still moving southwards.

The only appreciable body of pelagic fish seen during the flight from Perth to Melbourne was one comprising salmon, in the region of Hopetoun, Western Australia, where three shoals, probably totalling at least 5,000 tons were seen at what is known as the "Twelve-Mile", near Hopetoun. Subsequently, a few smaller shoals aggregating about 500 tons were seen east of this area to Cape Arid. So far, the occurrences of salmon seen from the air in Western Australia have been much smaller in the aggregate than those of south-east Australia; but the individuals comprising the shoals in Western Australia are generally bigger than in south-eastern waters.

Boisterous conditions at sea were a feature of the flights eastward to Melbourne, and so the opportunity was taken to survey such portions of the shore of the Great Australian Bight as might be suitable for salmon shoals between Israelite Bay in the Western Australian section to the head of the Bight in South Australia. Much of the beach area in this region is unsuitable for netting, and is frequently fringed with rocks and ledges. Elsewhere in this area, comprising about half the shoreline, there are perpendicular cliffs of from 200 to 250 feet with no sandy beaches at their base. No notable pelagic fish occurrences were found elsewhere.

(ii) *Eastern Bass Strait and Southern New South Wales.*—An aerial survey was made in this area between December 14, 1945, and January 3, 1946. This arose out of a request for aerial assistance by Consolidated Fisheries of Narooma, who were endeavouring to develop the tuna fishery. The survey covered the Victorian coast east of Melbourne, the Furneaux Group in Tasmania, and the South Coast of New South Wales as far north as Jervis Bay.

Salmon had been reported to be very scarce on the New South Wales coast. Aerial observations on December 22 disclosed a large occurrence of salmon and striped tuna up to 15 miles offshore, broadly between Eden and Bermagui. This is the first occasion during aerial observations in this area on which salmon have been seen in such large quantities offshore. In the past, they have been observed mostly inshore on the beaches. The occurrence was seen again on the following day. Many of the shoals were accompanied by mutton-birds but other sea-birds were very scarce.

Bad weather delayed these observations, and subsequent searches in the same area on December 29 and January 1 disclosed only shoals offshore and a complete absence of the previously plentiful mutton-birds.

Practically the whole of the beach area from Corner Inlet, in Victoria, to Jervis Bay, in New South Wales, was traversed during the survey. Salmon were very scarce on the beaches and most of those seen were on the Victorian beaches between Cape Everard and Seaspray. This scarcity of salmon on the New South Wales coast was not unseasonable but, nevertheless, the fish were scarcer than usual. Large sharks (mostly travelling westward) were plentiful on the Victorian beaches in the area just mentioned but scarce on the New South Wales beaches. No less than 89 large sharks were counted in the beach shallows of 20 miles of shore west of Lakes Entrance. Most of these were within 100 yards of the shore and many within only a few yards.

Fishermen at Eden were successfully directed to a shoal of salmon on the beach at Disaster Bay and a catch of 240 boxes was made.

With the exception of mutton-birds, sea-birds were very scarce over the whole area of the survey. Mutton-birds (*Puffinus tenuirostris*) were especially plentiful within about 10 miles radius south-west of Wilson's Promontory, where several large rafts, totalling probably millions of birds, were seen. It is noteworthy that these were observed in this locality at the beginning and end of the survey; this emphasizes how localized such large marine occurrences can be.

(iii) *Victoria, Tasmania, South Australia, and Western Australia.*—It was hoped that an aerial survey, especially of the Great Australian Bight and south-west coasts of Western Australia, would commence on February 15, 1946. One of the objects of this survey was to contact the vast occurrence of blue mackerel (*Scomber australasicus*) and pilchards (*Sardinops neopilchardus*) found in Western Australian waters in May, 1945, and, if possible, to gain more information about the seasonal distribution of these fishes in that area and in South Australia.

Unfortunately, facilities could not be made available at the required time, and the survey did not start until March 28. It was necessary to use an aircraft with a longer endurance than usual since the survey was to embrace the Great Australian Bight, and direct flights between far-distant points, such as Ceduna and Esperance, were involved. The aircraft allotted for the purpose was required to return from Ceduna to Melbourne on April 16 for overhaul before reaching Western Australia.

The survey was resumed from Melbourne on May 2, and after a visit to Flinders Island in Bass Strait, Perth was reached after coast-wise flights on May 15. About half the available endurance of the aircraft had been expended in these flights from Melbourne to Perth, and, since the remainder was required for the return flights from Perth to Melbourne, it was impossible to carry out immediately the extensive survey of the west and south-west coasts of Western Australia, as had been intended. Very bad weather intervened at this stage and it was also necessary for the aerial observer to return to Melbourne for a departmental conference. Eventually, arrangements were made for the use of an Anson aircraft from the Royal Australian Air Force Station, Pearce, Western Australia, and the first of the flights with this aircraft (Perth to Busselton) began on June 15.

The first stage of this series of flights (March 28 to April 23, 1946) covered eastern Bass Strait and the east and north coasts of Tasmania, and the waters of South Australia, as far west as Ceduna. Generally, conditions for observations were unsuitable but, nevertheless, some large occurrences of fish were seen.

A large body of salmon, migrating northwards, was observed (at about the same time as in 1945) broadly between George Rocks (north-eastern Tasmania) and Flinders Island. Experience in southern New South Wales in December, 1945, and during the survey under review, shows that salmon when migrating may surface under much more disturbed conditions than is usual for them.

A few shoals of tuna were observed from 10 to 12 miles east of Babel Island (east of Flinders Island) but the conditions were unfavorable and no definite conclusion could be drawn from this restricted work. However, the signs were not promising.

A fairly large concentration of horse mackerel (*Trachurus novae-zelandiae*) was found on the northern portion of the east coast of Tasmania but elsewhere on this coast as far south as Bruni Island, conditions for observation were unsuitable. However, it was clear that the associated predatory bird life (gannets and albatrosses) was much more numerous in the area where the fish were observed than elsewhere. These horse mackerel were found in an area north of that

traversed by the Tasmanian research vessel *Liawenee* which, up to that time during this season, had not been successful in its search for this species.

Pilchards were plentiful in the lower portion of Spencer Gulf, South Australia. Some of the shoals were observed to be feeding on krill (*Nyctiphanes australis*). This is the first time such an interesting spectacle has been seen during the aerial observations though, of course, it is known from stomach examinations that pilchards feed freely on krill.

Gannets were plentiful in South Australian waters, especially near Ceduna, where a flock of about 800 was observed. This must represent a considerable proportion of the total population of the southern gannet (*Sula serrator*). Unfortunately, the sea surface conditions at the time were unsuitable for surface manifestations of pilchards, which were probably present in the vicinity of the birds.

It is clear from aerial observations that a considerable body of the total population of the Australian gannet migrates to South Australia and westwards of that State at this time of the year. This migration is highly significant, in the light of the discoveries of large bodies of pelagic fish in South Australia and Western Australia. These birds have also been found in association with large bodies of pelagic fish on the west coast of Western Australia as far north as Shark Bay. This long migration on the western side of the continent (that on the eastern side extends only to Moreton Bay, Queensland) is all the more remarkable when it is remembered that their breeding grounds are Victoria and Tasmania. It is significant also that the northernmost range of this bird on the western side of the continent corresponds with the known northernmost limits of the pilchard (*Sardinops*).

Tuna were found in moderate quantities on the west coast of South Australia, but, as was to be expected at this time of the year, the season for this species appeared to be waning.

The second stage of this series of flights (May 2 onwards) which, at the time of writing (June 15), is incomplete, began with a survey in the vicinity of Flinders Island, Bass Strait. Tuna were not sighted but salmon were again found in large quantities, mostly migrating northwards. Local fishing interests were informed of the whereabouts of large shoals lying on the beaches.

No really effective observations were possible on the flights from Flinders Island to Western Australia owing to the limited flying time available and to unfavorable weather conditions. The last stage (from, broadly, Albany westwards) had to be abandoned on account of weather.

During the flights across the Great Australian Bight, gannets, which are such important indicators of the presence of certain species of pelagic fish, such as mackerel and pilchards, were relatively plentiful.

Much of the time of the aerial observer after his arrival in Perth on May 15 was taken up with organizational details in respect of the Division's research vessels, *Warreen* and *Taipan*. The former is undergoing a refit after a period of service with the Royal Australian Navy and the latter has been acquired from the Royal Australian Navy and is undergoing preliminary refit as a research vessel.

11. *General.*—(i) *Statistical and Documentary Work.*—The revision of earlier catch records of the Tasmanian fisheries has been continued. A map showing the distribution and importance of the various fisheries of that State, with a short accompanying text, was prepared for the State Economic Planning Authority, and has been printed.

(ii) *Meetings with Oystermen.*—A series of meetings was held during the latter part of 1945 with members of the George's River Oystermen's Association, at which members of the staff lectured on overseas methods of oyster culture, the biology of oysters, and the hydrological aspects of environment. Discussions were held on the problems of oyster-farming.

(iii) *University Schools in Marine Biology and Biochemistry.*—(*a*) *Spring School in Marine Biology* 1945.—During the period 13–25 August, 1945, the Fisheries Division of the Council for Scientific and Industrial Research in collaboration with the Departments of Biochemistry and Zoology of the University of Sydney, conducted the third school in marine biology at the Council for Scientific and Industrial Research Marine Biological Laboratory, Cronulla. Including staff and students, visitors from every State of the Commonwealth were present, numbering 28 zoologists, 1 botanist, and 37 biochemists.

On this occasion the school was taken as an opportunity to demonstrate the methods by which economic problems in marine biology are to be approached, i.e., by a fundamental study of the biology of the organisms concerned. For this purpose the Australian rock oyster was chosen as an example of ecological specialization and various phases of its biology and the biology of other marine types were studied. A special handbook on the biology and economics of the oyster was prepared for the school and distributed on the first day.

(*b*) *Autumn School in Marine Biology* 1946.—During the period 25–31 May, the Departments of Biochemistry and Zoology of Sydney University took advantage of the facilities offered at the Council for Scientific and Industrial Research, Marine Biological Laboratory, Cronulla, to conduct an independent short-term school in marine biology. Including staff and students there were present 25 visitors including a number of zoologists from States other than New South Wales.

The biochemists concerned themselves with experimental measurement of the effect on blood and tissue chloride of different external salinities and examined the effects of storage upon sea-water from different depths under various nutrient conditions. The zoologists examined the effect of varying salinity upon the kymographic response of *Anadana*, the effect of varying salinity upon its ciliary movement, and the response of certain planktonic organisms to light stimuli.

A demonstration of deep sea collection of water and plankton material was given to all students. The school concluded on the Friday with a student symposium.

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

Kesteven, G. L. (1946).—A procedure of investigation in fisheries biology. Coun. Sci. Ind. Res. (Aust.), Bull. 194.

May, V. (1945).—Report of systematic work on red algae in Australia. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 62-8.

——(1946).—Studies on Australian marine algae. 11. *Proc. Linn. Soc. N.S.W.* 19: 121-4.

Munro, I. S. R. (1945).—Post-larval stages of Australian fishes, No. 1. *Q'land. Mus. Mem.* 12: 136-53.

Wood, E. J. F. (1945).—The sources of agar in Australia. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 263-72.

XI. METROLOGY.

1. *General.*—Work for the various Production Directorates of the Ministry of Munitions has now been brought to a conclusion, except for the equipment

store to which departmental annexes are sending precision measuring equipment for inspection before disposal. Prior to its liquidation, the gauge reserve pool of the Ministry handled over a quarter of a million transactions, the duties being carried out with great efficiency by a very small staff. A final order for twelve pitch-measuring machines was completed for the Ministry of Munitions. All outstanding orders for slip gauges have been cancelled, and the staff of the flat laboratory is now reduced so as to meet only Divisional requirements.

Other Divisions of the Council have taken advantage of the Division's facilities to have special equipment designed and constructed, and also to have precision equipment, such as balances, overhauled and reconditioned. The loss of experienced staff has proved a considerable embarrassment which has been intensified by inability to replace them. This has contributed considerably to the retardation of development along the lines for which the Division was established.

The Division is represented on many committees of the Standards Associations of Australia and presented many reports for the clarification of various issues. The Division also continues to supply lecturers in their specialized fields to the University of Sydney and to the Sydney Technical College.

Formal visits have been paid by groups from engineer institutions, educational establishments, and manufacturers.

2. *Standards, Gauges, and Measuring Equipment.*—The Division issued 418 certificates, reports, and statements of examination during the year.

With the cessation of Ministry work, a start was made on the overhaul of the laboratory measuring equipment. This, however, has been postponed to give assistance to an aircraft-engine project for which approximately 7,000 gauges have already been examined.

Consideration is being given to the equipment required for standards purposes and quotations have been obtained from abroad for the various comparators necessary for line standards work. Certain end standards were circulated to other national institutions for measurement and for comparison of results of different methods. These standards are expected to be returned at an early date.

A series of interferometry studies have been commenced, and it is hoped to improve the order of accuracy obtainable from the length interferometer.

Determination was made of the coefficient of expansion of each of seven Invar surveying tapes, which were forwarded to the Laboratory after having been used in the Northern Territory. Determination was made over a range of 30° C., the tapes being heated by passing a current through them and the uniformity of temperature being observed by means of thermocouples. The method proved very successful.

Government departments and industrial organizations are using the Division increasingly for advice and for the undertaking of work beyond their normal facilities. For the New South Wales Water Conservation and Irrigation Commission, measurement was made of a valve housing at Wyangala Dam and also of the needle valve. Equipment designed and made in the Laboratory enabled the valve to be made in the dockyard and measured without removal from the machine. The diameter of the needle valve was 6ft. 6 in.

The Grayson diffraction ruling machine bequeathed to the Laboratory by the late Sir Thomas Lyle has been received in the Division and assembled, but serious work will not be possible on the machine for some little time. The 40 in. circular dividing engine by *Société Genevoise* has been received and installed and work is about to proceed on checking the accuracy of graduation for comparison with results shown on the maker's certificate.

A report on frictional forces in dial gauges has been completed. An investigation of particle size distribution in fine abrasives and on the measurement of very fine particle size is now proceeding. On behalf of the Commonwealth Films Board, enquiry is proceeding into the quality of 16 mm. projectors of local manufacture. The extensometer comparator designed in the Division and made in the Laboratory workshop has proved most successful and is now in use on a continuous flow of work.

3. *Mass.*—Three of the balances ordered for standardization of mass have been set up in the balance room recently set aside for the purpose. The collimation system has been designed and constructed, and as set up has proved to be very satisfactory. While the Division is able to meet present demands, the standards now held are not sufficiently good for the requirements of a national institution. It will be essential to obtain a standard of more permanent material than that of the existing standard.

4. *Volumetric Glassware.*—All the balances on order have now been received and installed. A regular flow of work comes from other Government bodies, manufacturers, and industrial laboratories. Much work has been done on behalf of the Scientific Glassware Committee of the Standards Association, in the preparation of notes and reports for the guidance of the committee in the discussion of new specifications.

5. *Applied Mechanics.*—At the request of the Inspection Services, examination of various test houses, equipment, and personnel is being continued. Attention is being given to further development of portable equipment for the standardization of testing machines.

Industry continues to forward instruments for examination, and equipment has been set up for special tests such as the determination of the characteristics of a hydraulic coupling. Balancing of sine wave alternators has been undertaken and also the torque and slip testing of special motors. Advice and information has been given to a great number of firms over a large field of enquiries.

The design of a micro-hardness tester is now in hand in the Division and an experimental set-up is expected to be available shortly.

6. *Barometry.*—Attention will shortly be given to the design of a standard barometer. The present equipment, however, has been sufficient to meet demands.

7. *Time.*—The quartz clocks have not yet been received. These clocks are to form the frequency standards maintained by the Division of Electrotechnology and will be the source of time-keeping for this Division. Demands are very slight and can be readily met.

XII. ELECTROTECHNOLOGY.

1. *General.*—The work of the Division since June, 1945, has been devoted almost entirely to the establishment of the facilities required for the maintenance of standards and for measurements. This has required a great deal of detailed experimental work, which does not lead to results of general interest, but which is necessary in order that the standards of measurement may be established on a sound basis. This report will deal, therefore, with the facilities which are in the process of construction or installation, and, where possible without undue technical detail, with the progress that has been made in each field.

The measurement work is conveniently divided into sections dealing with different frequency ranges, as follows:—(*a*) direct current, (*b*) alternating current (power frequency), (*c*) audio frequency, (*d*) radio frequency, (*e*) ultra-high frequency.

The Division's work on the tropicproofing of electrical equipment was continued until the end of the war, but, except for several investigations which it was convenient to complete, the applied work was dropped by the end of the year, and the staff diverted to other work. The more fundamental aspects have been carried on, as they are concerned with the properties of dielectric materials, in which the Division will be closely concerned in the future.

A small group has been set up to deal with problems of applied electronics, but its activities have so far been confined to meeting the internal requirements of the Division. Another group is being established to deal with the development of certain mathematical instruments.

2. *Direct Current.*—The D.C. laboratory is in a position to undertake almost any measurement or calibration required of it to a high order of accuracy. Various improvements have been made to some equipment to deal with a steadily increasing flow of measurement work.

The working standards and principal measuring equipment have now been steadily observed over a period of some years, and it is possible to carry out measurements of the highest precision with full confidence in the stability of the equipment. Calibrations of laboratory standard or similar equipment have been carried out for the Postmaster-General's Department, the Ministry of Munitions, Service establishments, Universities and Technical Colleges, various engineering industries, and other Divisions of the Council for Scientific and Industrial Research. The Division has recently undertaken the calibration of standard resistors and a potentiometer for the Dominion Physical Laboratory, New Zealand.

3. *Alternating Current.*—Many measurements can be undertaken to a sufficient degree of accuracy to meet normal requirements, but it is not yet possible to use the facilities of the A.C. Section to the highest attainable order of accuracy. Errors introduced by slight intermittent vibrations of the building and by ambient temperature changes have caused a great deal of trouble, and it has been necessary to redesign some of the basic equipment. Most of the sources of error have now been traced, and it should be possible within a few months to establish A.C. measurements on a sound basis.

Shortage of suitable research staff has so far prevented the development of some branches of this work, and it has not yet been possible to undertake regular measurements of energy or of the magnetic properties of materials.

4. *Audio Frequency.*—Most of the demands on this Section are for the measurement of impedance. At present, these measurements are made in terms of a standard of capacitance, consisting of three mica capacitors, one of which was completely destroyed recently in transit from the United States of America after calibration by the National Bureau of Standards. The present programme is directed towards the establishment of a system of bridges which will allow all impedance measurements to be made in terms of the standards of resistance and frequency. The advantage of this system is that the standard of resistance is extremely stable and therefore only requires infrequent intercomparisons with overseas standards, while the standard of frequency can be maintained entirely without such intercomparisons. In this connexion, equipment is on order from the British Post Office for the Postmaster-General's Department, the Commonwealth Observatory, and the Division of Electrotechnology, which will enable a standard of frequency to be maintained with a stability of the order of one part in 10^8. Its calibration will be in terms of time-interval measurements, based on transit observations by the Commonwealth Observatory.

It is anticipated that all electrical measurements will eventually be made in terms of the metrological standards and of the fundamental electrical standards of resistance and e.m.f. Substantial progress has been made, and is being maintained, in this fundamental work and, in the meantime, the available standards are adequate for most purposes.

It is not considered desirable at this stage to undertake "absolute" measurements of electrical quantities in terms of the metrological standards.

In the meantime, a constant-frequency generator with a stability of approximately one part in a million has been set up for experimental work, pending the arrival of the frequency standards from the British Post Office. Measurements and calibrations of various kinds have been undertaken for research establishments and industries. In co-operation with the Division of Physics, tests are being carried out on the acoustical systems of cinema projectors.

5. *Radio and Ultra-High Frequencies.*—In collaboration with the Division of Radiophysics, experimental work is now in hand to establish a sound link between measurements at very high frequencies and the fundamental electrical and metrological standards The general aim is to correlate the ordinary circuit methods used at the lower frequencies with the transmission line and cavity techniques which are applicable at high frequencies, the final objective being to establish in the laboratory a series of equipments which will provide for measurements of impedance, frequency, power, and associated quantities throughout the frequency spectrum. At present, attention is being paid mainly to the frequency range from 20 to 200 megacycles per second, in which, for the most part, the transition from the ordinary circuit methods to those employing lines and cavities takes place. The importance of this range of frequencies will increase with the development of television and frequency modulation transmission in this country.

6. *Electrical and Magnetic Properties of Materials.*—Considerable progress has been made with research in the surface properties of glass and ceramics, and with the treatment of surfaces to provide improved electrical properties. This work, in which the Division of Industrial Chemistry has collaborated, will be extended to the fundamental examination of the internal, rather than superficial, structure of dielectric materials, as far as they affect the electrical properties. In particular, the effect of surface treatment of glass and ceramics by surface-active amines has been carefully studied, and it has been found possible to increase very greatly the surface leakage resistance when the material is exposed to high humidity.

Equipment has been developed for the provision, in a testing cabinet, of atmospheric conditions which can be accurately controlled in temperature and humidity. The use of these cabinets makes it possible to examine the effects of various treatments with a much higher degree of reproducibility than hitherto.

7. *Applied Electronics.*—The development of various electronic control devices, to meet the needs of the Division and of other bodies, has been carried on during the year. These devices have been used for the precise control of the speed and voltage of alternators and for the stabilization of D.C. and A.C. power supplies, driven by A.C. mains. Research carried out during the last few years into methods of accurate measurement of inductance has enabled advice to be given to several enquirers regarding the automatic detection of iron objects in materials which are being processed.

8. *Mathematical Instruments.*—Progress has been made towards the construction of a Differential Analyser, primarily to aid mathematical research in radio propagation by the Division of Radiophysics.

9. *Miscellaneous.*—The Division has dealt with many requests for technical assistance from other Divisions and from outside sources. An officer of the Division was made available for several months to the Munitions Supply Laboratories, Maribyrnong, to assist in the setting up of climatic testing equipment, and several officers of those Laboratories have paid extended visits to the Division to gain experience in methods of measurement.

Close liaison has been maintained with the Standards Association of Australia and other kindred bodies.

10. *Publications.*—It has not been possible to publish the results of most of the work of the Division, for security reasons, but a number of internal reports have been issued during the year, including ones dealing with tropicproofing telecommunication and electrical equipment, the protection of mica capacitors against humidity, climatic testing equipment for ETS 4 procedures, the N.S.L. 5 cubic feet humid cycling chamber, the effect of high relative humidity on phenolic resin moulded cases for electrical indicating instruments, treatment of ceramic and glass surfaces with surface-active amines in order to produce high surface electrial resistance at high relative humdities, the effect of humidity on the leakage resistivity of electrical insulating materials, waxes and bitumens and sealing compounds for electrical equipment for use under tropical conditions, and mathematics in scientific research and industry. A patent was also published:—

Clothier, W. K. (1945).—Improved method and apparatus for winding precision resistance coils. Aust. Pat. 120, 173, Dec. 10.

XIII. PHYSICS.

1. *General.*—The normal work of the Division can be considered under the general headings of: (*a*) the maintenance of standards of physical quantities, (*b*) the calibration of equipment in terms of these standards, (*c*) physical investigations and tests of direct value to industry, many of an *ad hoc* nature, and (*d*) long range and fundamental physical research. During the war the attention given to some of the above aspects of the Division's work was necessarily disproportionate to that which would be given under normal conditions. Such standards as were of immediate importance were maintained, and a very large volume of testing in terms of these was undertaken, but little attention was given to the establishment and maintenance of other standards of lesser importance. Many investigations on specific problems were carried out for the Services but long range fundamental research was, of necessity, virtually non-existent.

With an approach to normal conditions a re-adjustment has been made in the attention given to the various aspects of the Divison's work. By far the greatest part of the routine testing done by the Division has, in the past, been undertaken on behalf of the Services and the Ministry of Munitions, and the discontinuance of this work has markedly reduced the amount of routine testing. With the release of staff from the pressure of this type of work an effort has been made: (*a*) to complete the establishment of the physical standards with which the Division is concerned and to put these standards in such a state that their maintenance will be a straightforward matter; and (*b*) to organize the testing facilities so that tests and calibrations can proceed satisfactorily with the minimum of attention from senior scientific staff. In this way it is hoped that officers will be able to devote a reasonable proportion of their time to research.

In addition to research in fields already established, consideration has been given to work in important branches of physics not previously included in the work of the Division. Fundamental investigations on the physics of wool fibres, particularly in relation to their frictional properties, have been continued and extended to include studies of the ultimate structure of the fibres. Work on various problems connected with wool is also proceeding in other Sections of the Division. The nucleus of a Section on the physics of solids has been formed. The question of whether the Division should undertake work in nuclear physics has naturally been brought into prominence during the last year by the spectacular developments in atomic energy. Decisions regarding such policy are obviously of such magnitude as to require national consideration. Pending such a determination a small amount of work of a general and preliminary nature has been commenced in this field. Work in the Heat and Light Sections has continued and has included some new lines of work referred to in later sections of this report.

During the year, 257 certificates, reports, and statements of examination were issued, giving the results of tests and calibrations made by the Division. During the latter part of the year the Chief of the Division has been abroad in the United Kingdom and the United States of America on behalf of the Department of External Affairs as scientific adviser to the Australian representative on the Atomic Energy Commission of the United Nations Organization.

2. *Heat Section.*—(i) *General.*—There has been a marked diminution in the amount of routine work undertaken by this Section. Most of these routine tests were for the Services or the Ministry of Munitions, and with the virtual cessation of calls from the Services and the winding up of the pyrometric programme for the Ministry of Munitions there has been an opportunity to place the work of the Section on more of a peace-time basis. Facilities for tests for industrial firms and other bodies are maintained and are being made use of, but particular attention has been given to putting these facilities and the standards on which they are based in such a state that they can be readily maintained. In this way it is planned to provide for greater attention being given to fundamental and applied research. Investigations already started have been continued and plans have been made for fresh lines of research in the Section.

(ii) *International Temperature Scale.*—The maintenance of the International Temperature Scale has always been regarded as one of the important functions of the Section. Further work has been done on this with a view to completely maintaining the Scale so as to be quite independent of secondary standards calibrated elsewhere. The Scale is now maintained from 0° C., to 2,300° C., with an accuracy sufficient for present requirements, and steps are being taken to improve this accuracy to meet any future requirements and also to realize the Scale to its lower limit, i.e., to cover the range 0° C. to —190° C.

The accuracy with which the freezing points of silver and gold can be realized has been improved and equipment has been set up for the realization of the boiling point of oxygen, all these being fixed points used in maintaining the International Temperature Scale.

A standard disappearing-filament optical pyrometer has been designed in conjunction with the Light Section, and the construction of this is now complete. It will be used for the more precise establishment of the International Temperature Scale above the melting point of gold (1,063° C.).

In addition to the work on the direct realization of the International Temperature Scale, referred to above, other investigations have been made on related matters. These have included studies of the accuracy obtainable from the use of the sublimation point of carbon dioxide and the melting point of palladium as secondary fixed points; the production of pure alumina crucibles for metal melting points; and an investigation of the accuracy with which the steam point can be realized using hypsometers of simplified construction.

(iii) *Industrial Pyrometry.*—The main programme of pyrometric testing undertaken on behalf of the Service Inspection Authorities and the Ministry of Munitions has been discontinued, but a similar service has been given to some industrial firms. The assistance given to firms and other organizations in the past, whereby selected personnel were trained in practical aspects of pyrometry, has been continued, eight persons having received such training.

Investigations carried out in industrial pyrometry included measurements of the temperatures in the glue lines of wooden aircraft under construction, an examination of methods of calibrating and using gasket thermocouples on aircraft and other engines, and the development of improved methods for the calibration of thermocouples for the measurement of surface temperatures.

(iv) *Hygrometry.*—Work undertaken in the first place at the request and in conjunction with the Tropicproofing Section of the Division of Electrotechnology, on the measurement and control of humidity in enclosed spaces, has been continued in conjunction with officers of the Division. Further experience has been gained in the use of thermocouple psychrometers for humidity measurements at low air speeds and the electronic humidity controller developed for this work has proved capable of giving very satisfactory results throughout a cycle of temperature and humidity conditions. The requirements for tropicproofing tests were for close control at high humidities, but tests are now being made of the adaption of the instrument to control much lower humidities. The Section has continued to collaborate with the Division of Electrotechnology on other tropicproofing matters, particularly in relation to the formulation of an Australian specification for the tropic-testing of electrical materials, components, and equipment, and in the critical analysis of overseas specifications for such tests.

Detailed comment on a British Draft Standard on "The Humidity of Air" has been prepared after careful analysis of the physical principles involved in various types of humidity measurement, a matter on which some confusion has been found to exist.

The design of an automatic dew-point hygrometer, using photoelectric methods for detecting the formation of dew, is proceeding. Arising out of a problem in humidity measurement submitted by the Department of the Navy, a special instrument for humidity measurement, using elements of the resistance (radio-sonde) type, has been developed, after detailed investigation of the behaviour of this type of element.

(v) *Moisture Content.*—Many electrical methods of obtaining a measure of the moisture content of particular materials have been described by other workers. Most of these are of only limited applicability or are suitable only for rough measurements. An instrument for the measurement of the moisture content of grain was recently developed at the National Physical Laboratory, England; it seems to have notable advantages over most other types of electrical moisture meter. Considerable work has been done in the Section on the further development of the National Physical Laboratory type meter to make the instrument more universal, particular attention having been paid to its adaption to the measurement of the moisture content of wool and other fibres. The results so far obtained are very promising.

(vi) *Special Devices for Temperature Measurement and Temperature Control.* — An instrument for the measurement of the temperatures of estuarine muds and waters has been successfully developed for the Division of Fisheries. In the course of its development useful information on the resistance to corrosion of various plated metal finishes was obtained.

A commercial thermometric recording controller has been converted into a programme controller for the Division of Food Preservation and Transport. It was required that the instrument should be capable of being set to different programmes and should be able to follow a programme in which there were sudden and considerable variations in the rate of change of temperature. The instrument, in the design and construction of which the officers of the Laboratory workshop played a prominent part, includes many novel features.

There have been numerous other requests for advice or assistance in unusual problems of temperature measurement, many of which have required special methods for their solution.

(vii) *Viscometry.*—An investigation on the viscosities of urea-formaldehyde wood adhesives, referred to in the previous report, has been completed. The special methods developed for these measurements by the Electrotechnology Division are being incorporated in a standard falling-sphere viscometer with a view to increasing the accuracy of such an instrument by the virtual elimination of observer's errors.

The calibration of U-tube type viscometers has been made a matter of routine, the use of an electronic temperature controller, to control accurately the temperature of the viscometer bath, having greatly assisted in this.

(viii) *Thermal Conductivity.* — An apparatus for the measurement of the thermal conductivities of small flat specimens, four inches in diameter, has been put into use during the year. The experience gained with the instrument has been of considerable value in the design of a larger apparatus suitable for 12 in. by 12in. specimens and capable of being used for measurements at subzero temperatures. The design of this apparatus is complete and that of an apparatus for the measurement of the thermal transmission of wall structures is nearly so.

(ix) *Anemometry.*—Arising out of the requirements of the Division of Electrotechnology for the exploration of the air circulation in humidity testing cabinets, some progress has been made in the design of low air-speed, hot-wire anemometers.

3. *Light Section.*—(i) *General.*—The termination of the Division's association with the Scientific Instruments and Optical Panel of the Ministry of Munitions, due to the disbanding of that body on the cessation of war, and the closing down of the annexe set up for the manufacture of optical glass, has led to a considerable change in the nature of the work undertaken by this Section. The testing of optical glass, including the measurement of refractive indices, has virtually ceased, as has also the routine testing of optical instruments. It was to be expected that work in photometry and colorimetry and the design of special optical and photometric instruments would correspondingly become of greater importance, particularly for industrial needs, and this has, in fact, been borne out by the trends of the work in the Section during the period under review.

(ii) *Optical Instruments.*—Microscopes for student use are in urgent demand by the Universities Commission and, with a view to their local production, the Scientific Instruments and Optical Panel before it disbanded drew up a specification for what it considered to be a suitable instrument. It was agreed that the Division should take part in the testing of prototype instruments made to this specification, and facilities for such tests have been set up and used to test the instruments and components that have been submitted.

To meet the severe shortage of 16 mm. sound and film projectors for instructional purposes, several local manufacturers have undertaken their production. The Division has been asked by the Commonwealth Film Board to co-ordinate tests on prototype units, the

Divisions of Metrology and Electrotechnology co-operating with this Division in the actual tests, which cover all aspects of the units: mechanical, optical, electrical, and acoustical. All necessary equipment has been acquired and some tests have been made.

A vertical projection microscope of fixed magnification (500X) has been designed and a number are under construction in the Laboratory's workshop. This type of instrument is of basic importance for dimensional measurements on wool fibres and has, up to now, been used for routine measurements in this work. The instruments are required particularly by the Fleece Analysis Laboratory of the Division of Animal Health and Production.

(iii) *Evaporation Plant.*—Equipment for the evaporation of aluminium and other substances onto glass surfaces, for the production of mirrors and special non-reflecting surfaces, has been designed, constructed, and put into operation. It is anticipated that the plant will be of considerable use to this and other Divisions.

(iv) *Distribution of Light Intensity Across Sources of Finite Width.*—Arising out of the design of an optical pyrometer for the Heat Section, a theoretical investigation has been made of some aspects of the diffraction of light from sources of finite width, and these results have been applied to the problem of the apparent lack of uniformity in the brightness of the filament of a disappearing-filament optical pyrometer. It has been shown that diffraction plays only a minor role in the effect and it has been experimentally demonstrated that the effect is principally due to a departure from Lambert's law for light emission at various angles to the surface for the filaments under consideration. The theoretical investigation has, however, other applications than to the case from which it arose and it is proposed to publish the conclusions reached.

As a development from this work it is proposed to investigate the spectral emissivities of tungsten and other materials at various angles to the normal.

(v) *Optical Devices for Use with Radar.*—At the close of the war attention was being given, in co-operation with the Division of Radiophysics, to the design of optical aids which would allow of the more ready comparison of maps with the corresponding images obtained from the air by radar methods. The devices developed include a means of distorting a map image to simulate the effect of the beam-width spread of the radar image. This device was subsequently introduced operationally for the briefing of pilots. A modification of this in which the map was replaced with a contour model was used by the Navy to illustrate radar shadows. A third device was developed to convert the distorted Cartesian "B-scope" display back to its normal polar form.

(vi) *Spectrophotometry.*—The measurement of the spectral reflectances and transmissions of substances, from a knowledge of which their colours under various conditions of illumination may be computed, is a service for which the demand has continued and may be expected to increase. The provision of facilities for the rapid routine spectrophotometry of their products would be of considerable value to many industries. The paint, paper, textile, dyeing, and some of the chemical industries are likely to be particularly interested in such facilities, which have now become available for the first time in Australia as a result of the installation by the Division of a General Electric recording spectrophotometer. The instrument automatically records a spectral transmission or reflectance of a sample in the range of wavelengths 400 to 700 mμ, the normal time taken for the completion of a record being about three minutes.

(vii) *Colorimetry.*—A photoelectric tricolorimeter has been developed for the direct measurement of colour and the instrument operates very satisfactorily under laboratory conditions of use. It is, however, not considered to be in a suitable form for use as an industrial instrument and, since such an instrument would have very useful applications in many industries, suitable modifications are being made to it.

(viii) *Photometric Instruments.*—Problems in photometry continue to be submitted to the Section and the solution of many of them involves the design of special instruments. In this category is a photometer head suitable for the measurement of the radiant flux density under grasses and the foliage of small plants, it being required that the head shall be small and the response shall be independent of the direction of the incident light. The instrument, which is required by the Division of Plant Industry, incorporates some novel features. Another unusual photometer head is under consideration for the Division of Fisheries, this being required for the measurements of the intensity of illuminations under water.

A photo-electric haemoglobinometer, an instrument previously designed in the Section for the rapid estimation of the haemoglobin concentration in the blood, is now in commercial production. A glossmeter, suitable for the measurement of gloss on textiles, paints, papers, and similar surfaces, has been designed and constructed. A high-speed automatic recording microphotometer has been acquired and put into operation.

(ix) *Protection of the Eyes from Radiant Energy.*—Further to previous work undertaken on the protection of the eyes from harmful exposure to radiant energy, and partly as a result of the representation of the Division on the Standards Association of Australia Sub-committee for Eye Protection, a survey has been made of all the quantitative figures available dealing with the injurious effects of radiation on the various eye tissues, and the results used in the preparation of a draft specification for standards of welders' eye-protection glasses. It has been found that it will be possible to adopt less rigorous requirements than those recommended in certain of the overseas specifications, while still giving complete safety to the user.

4. *Solar Physics.*—Research has recently been commenced in the Division into some aspects of solar physics. From a theoretical investigation into the effects of the induced electric fields surrounding sunspots when the magnetic flux through the spot is changing, it has already been possible to propose a mechanism which is thought to be responsible for chromospheric flares, the solar phenomena associated with radio fade-outs. These researches, which are continuing, represent a completely new approach to the explanation of many important solar phenomena and show promise of producing very valuable results in this field.

5. *The Physics of Solids.*—(i) *General.*—The physics of the solid state deals with the structure of matter and the explanation of many physical properties and phenomena in terms of that structure. It is of fundamental importance in many industries, notably in connexion with the metal industries, textiles, plastics, and ceramics. It is also of basic importance in many fields of scientific study besides physics, such as in the study of the structure of biological materials. It is a fertile field for research and one which has been receiving increasing attention in recent years.

The nucleus of a section to work in this field has been established, and the project has received the financial support of the Broken Hill Proprietary Co. Limited, which has appointed an officer to work on the physics of solids as a member of the section.

(ii) *X-ray Diffraction.*—X-ray diffraction represents the most important investigational method used in this field at present and the assembly of suitable equipment for this type of work has been the first concern of the group. X-ray diffraction apparatus which will be suitable for many different types of

diffraction measurements has been designed and partially constructed. It is hoped to have it operating soon.

The investigations proposed will deal with, in the first place: (*a*) metals, refractories, and allied materials, and (*b*) biological materials.

Under (*a*) will be considered matters of industrial importance such as fatigue, temper brittleness, and recrystallization, and these investigations will be made in close co-operation with industrial firms. Under (*b*) work will be done on wool and other textile fibres, and a suggestion that work should also be done on chromosomes has been received from a University Botany Department.

In addition to its investigations it is proposed that the facilities of the Section should be made available for the training of selected personnel in X-ray diffraction methods. This service is likely to be of value to certain large industries and also to scientists engaged in particular fields of research where such methods would be of use.

6. *Wool Investigations.*—(i) *General.*—The physical investigations undertaken by the Division in connexion with wool, of which mention was made in the previous annual report, have been continued and extended. Besides a section carrying on active research on the frictional properties of wool and other fibres and on the structure of keratin fibres other sections have undertaken work on wool problems: in particular the Light Section has been concerned with the design of equipment for the measurement of fibre diameters, and the Heat Section is working on apparatus for the measurement of the moisture content of wool.

(ii) *Frictional Properties of Textile Fibres.*—A detailed investigation has been made of the frictional properties of wool and other fibres in an endeavour to explain the behaviour of the fibres in fabrics and yarns and to obtain information on the mechanism of the shrinking and felting of woollen materials. It has been shown that the wool fibre exhibits two principal coefficients of friction, one for a movement towards and the other for a movement away from the root end of the fibre, and that the difference between them is the initiating cause of the tangling which is wool felting. Measurements on wool fibres in the condition in which they would be used commercially have shown that several factors which change the rate of felting cause the frictional difference to vary in the same way. The effect of shrinkage-reduction treatments is to reduce the value of the frictional difference. A surprising result is that exceptionally clean wool has quite different frictional behaviour from ordinary wool. The behaviour of industrially "clean" wool, which is so important from the manufacturer's and the user's standpoint, is largely due to the film of grease and oil remaining on the fibres of this wool.

In some work just initiated by the Light Section an attempt is being made to actually observe the complete mechanism of felting as it occurs in the movements of the individual fibres. Harsh wools can be softened by the action of softeners, which reduce the average coefficient of friction. Frictional measurements have also been made on other fibres, both natural and artificial, in an endeavour to correlate their behaviour with their frictional properties.

(iii) *The Structure of Wool Fibres.*—In conjunction with the Division of Industrial Chemistry, an investigation of the structure of wool fibres has been made, making use of electron microscope, X-ray diffraction, and electron diffraction techniques. Two components have been distinguished in the cuticle (or scale) cells—an enzyme-resistant reinforcing structure and a cementing, amorphous component. This latter component is initially attacked by enzymes and reagents and its partial removal results in the eating away of the scale edges, which, by reducing the frictional difference, reduces the tendency of the wool to felt. Similarly, two components have been distinguished in the cortex, the elastic element of the fibre. This appears to consist of an amorphous matrix in which are embedded longitudinally aligned fibrils.

The above results, obtained in the first place from an examination of fragments of wool fibre with the electron microscope, have been substantiated by X-ray and electron diffraction studies, in which a fibre diagram has been found to be superimposed on a system of diffuse diffraction rings, suggesting that the fibrils are responsible for the fibre diagram and that the amorphous phase gives rise to the ring system.

(iv) *Fibre Diameter Meters.*—Considerable progress has been made in the development of more rapid methods of determining the diameter of fibres from wool samples. The standard method of making these measurements, and the one adopted up to the present for most routine work, has been to use a projection microscope to view the fibre sections and to measure them individually. The main objection to this has been the large number of individual measurements that have to be made for an analysis of a single sample of wool. To reduce the time and fatigue involved, a simple linear integrator has been developed by means of which the mean and grouped distribution of diameters can be determined.

A new type of fibre diameter meter has now been completed by means of which the mean diameter of the fibres in a bundle may be determined without the necessity of making individual fibre measurements. This instrument, which was developed by the Light Section, consists of a photometer which measures the light intercepted by a group of teased-out fibres. The result so obtained may be combined with the mass of the same fibres to give a measure of their mean diameter. The method is speedy and the results agree well with those obtained with the projection microscope. The Fleece Analysis Laboratory of the Division of Animal Health and Production has requested several of these instruments.

Experiments are also proceeding in an attempt to measure the coefficient of variation of the diameters of the fibres in a bundle, by optical means, without the necessity for measurements on individual fibres.

7. *Atomic Physics.*—As stated in section 1 of this report, extensive work on atomic physics has not been undertaken by the Division, but some attention has been given to the construction and acquisition of some of the equipment necessary for work in this field.

A very important tool in nuclear research is equipment for the acceleration of particules to high velocities for purposes of atomic bombardment. A group working in the Vacuum Physics Laboratory of the Division of Radiophysics has been concerned with the development of linear accelerators suitable for this and other purposes and one of the officers of the Division of Physics has been attached to this group. After initially assisting in the development of apparatus for the linear acceleration of electrons, he has been engaged on the application of similar principles of particle acceleration to the production of high speed protons and deuterons. The particular aspects of the work with which this officer has been concerned have been: (*a*) theoretical consideration of the optimum operating conditions in single and multiple gap linear accelerating systems; (*b*) the design and construction of the accelerating equipment; and (*c*) the design and construction of ion sources capable of giving much greater ion currents than have been available hitherto.

Good progress has been made in all these lines of work, particularly promising results have been obtained with a new type of ion source developed in the Physics Department of the University of Sydney.

8. *Publications.*—Mimeographed reports have included work on a photoelectric haemoglobinometer, the stability of light absorption properties of oxyhaemoglobin, the effect of atebrin on haemoglobin estimation, the internal reflection coefficient for a transparent body, the brightness of a partly blackened fluorescent particle, and scientific aspects of eye protection glasses. The following papers were published:—

Mercer, E. H. (1945).—The frictional properties of wool fibres. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 188-200.

Mercer, E. H., and Lipson, M. (1946).—The frictional properties of wool treated with mercuric acetate. *Nature* 157: 134.

Mercer, E. H., and Makinson, K. Rachel (1946).—The handle of wool. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 200-1.

Mercer, E. H., and Rees, A. L. G. (1946).—The structure of the cuticle of wool. Ibid. 157: 589.

XIV. AERONAUTICAL INVESTIGATIONS.

1. *General.*—The establishment of the Division of Aeronautics was begun before war broke out, but hostilities commenced before any of its laboratories were built and the original research plans had to be drastically altered. During the war years, force of circumstances necessitated a considerable curtailment of fundamental work and placed emphasis rather on short-range projects and problems of immediate importance. With the return to peace the Division is able to concentrate on the more fundamental and long range aspects of aeronautical research. The field to be covered by the Division during the post-war period has been explored with some thoroughness, and a comprehensive programme of work has been drawn up. It has already been circulated amongst interested parties.

One of the most important items which has come to the fore during the year under review has been the general subject of turbine engine research in which such great strides have been made in Great Britain and the United States of America. Four members of the Division's staff have been overseas studying various aspects of the subject and have now returned. Preliminary plans for a programme of work which might be undertaken by the Division have now been drawn up and a start has already been made on a small scale.

The organization of the Division has been changed slightly. Previously a joint Physical Metallurgy Sub-Section was operated in conjunction with the Division of Industrial Chemistry. This arrangement has now been terminated and the whole of the metallurgical facilities have become part of the Division of Aeronautics. Other extensions to facilities have been considered, of which the more important are a towing tank for model investigations on ships and seaplanes and the establishment of a Research Flight. No final decision has been reached yet regarding the latter, but it has been agreed that there is no need for a towing tank for some years.

Overseas liaison has been extended by the visit of two members of the Division to Japan to study the progress of aeronautical research there and by the visit of the Chief and another member of the Division to England to participate in the British Commonwealth Aeronautical Research Conference as two of the official representatives for Australia.

Officers of the Division have continued to take part in the work of the Australian Council for Aeronautics, and as in previous years the Division has published much of its work through that body.

An important development during the year was the inauguration of an Engineering Group Committee on which the Division is represented with other interested sections of the Council for Scientific and Industrial Research and the Munitions Supply Laboratories. This committee examines fields of work of the various groups at regular intervals and acts as a co-ordinating body.

2. *Structures and Materials Section.*—Considerable assistance has been given to the Royal Australian Air Force, the aircraft industry and other organizations; in addition it has been possible to devote more attention than previously to theoretical and experimental work on long range problems. The more important subjects dealt with are described below.

(i) *Strength, Stiffness and Stability of Plates and Shells.*—In connexion with the design of flat and curved plates subjected to forces in their own plane a question of stability is involved; that is to say, although the ultimate strength of the material may not have been reached, at a certain stress the plate will buckle and so will no longer act fully as a load-carrying component. This behavior has received considerable study in the Section, and the instability characteristics of flat and curved plates of both isotropic and orthotropic material have been investigated. On the theoretical side work has been carried out on the buckling of thin plates and cylinders subjected to end compressive load, and of a thin curved plate under shear forces. As the solutions are approximate, emphasis has been on the upper and lower limits of the buckling load. The above problems have been treated by what is known as "small deflection" theory. In some instances, however, the results so obtained may be misleading, so that it becomes necessary to use a more refined (and more difficult) theory known as "large deflection" theory. Using this the buckling of a curved panel under shearing forces has been investigated. The method involves the approximate solution of two simultaneous differential equations involving an infinite number of unknowns. It has not been completely successful as, when applied to the problem of a plate having clamped edges, the series did not converge. Attempts to overcome this difficulty are still proceeding.

On the experimental side of this stability problem, work on plywood plates subjected to end compression has been carried further during the current year. A report has been issued on panels in which the grain of the veneers is at $\pm 22\frac{1}{2}°$ to the direction of loading; the strength of these was found to be between the 0° and 90° panels tested previously. The work on curved panels was taken as far as it is intended to go at present. Tests conducted on panels having the grain of the outer veneers at 45° to the direction of load give results which agree well with those of 0° and 90° panels. During tests on wooden aircraft wings, failures frequently occur prematurely at holes in the plywood skin on the tension side. Failure occurs even when the holes are reinforced and is due to the stress concentration effects of the holes. As no theoretical or experimental data were available, an investigation has been carried out to determine the effects of stress concentrations in plywood under tension. The plywood strips tested had the outer grain veneers at 90°, 45°, and 0° to the direction of loading. Further tests are under way to determine the effect of size of specimen on the results.

The assessment of the present state of knowledge of stiffened plate and shell structures has continued. This work is necessary if aircraft structural designers are to have readily available the latest developments in these topics. Tests were made on two standard stiffened flat panels, typical of construction used by the Commonwealth Aircraft Corporation, and the results of these and other tests were compared by alternative design methods. A natural extension of this work was to the design of stiffened shells. Again a number of alternative methods are available, and these are now being applied for a thin walled and a thick walled circular cylinder, in both instances the cylinders being reinforced with conventional stiffness.

The application of the approximate numerical methods of computation, known as relaxation methods, continues to be extended to other types of problems arising in stress analysis. Problems of elastic instability of isotropic plates under different types of forces and edge conditions have been completed, and work has been carried out on the satisfaction of the mathematical boundary conditions associated with problems of plane stress.

(ii) *Open Thin-walled Sections in Compression and Bending.*—A new project that has been commenced is the study of the strength and stability of thin-metal open sections, such as channel and Z, commonly used in aircraft construction. This information is also related to the design of aircraft structures. The existing theories of behaviour, including failure, have been studied, from which it appears that agreement with experimental data depends on accurate determination of the effect of the modulus of elasticity. The existing experimental information is far from complete, however, and to extend this as well as to test the validity of the theories, an experimental programme has been arranged. The necessary sections are being made up.

(iii) *Dynamics.*—The vibration characteristics of an airscrew have been investigated theoretically, using several different approximations regarding the degrees of freedom of the system. Further work is being done on the effect of aerodynamic loading on the natural frequencies of the airscrew. The first few natural frequencies have also been measured experimentally as a check on the theoretical work.

The vibration of a truncated wedge has been studied mathematically and a discrepancy has been revealed in the accepted relation between the true natural frequencies and the approximate ones obtained by the use of Rayleigh's principle.

For use in the fatigue testing of beams and wings, formulae are being derived giving vibration characteristics of beams of uniform cross-section having concentrated masses located at various positions along the span. If this information can be sufficiently extended, it may become possible to induce predetermined bending moments, shears, and torques in wings during tests involving the application of rapidly alternating forces. This is very desirable if laboratory fatigue tests of complete wings are to be reasonably representative of the natural life history of such structures.

(iv) *Life of Aircraft Structures.*—Of recent years it has become increasingly obvious that, from a strength point of view, an aircraft structure does not have an unlimited life. The effect of impulsive loads caused by gusts, for example, is of great significance. The available literature, which is very meagre, has been studied and certain tentative conclusions reached regarding the frequency of occurrence of high and low velocity gusts. The information, however, may have little relation to Australian flying conditions, and accordingly a test programme has been drawn up involving the installation of V-g recorders and N.A.C.A. flight recorders in aircraft operating in Austalia. In due course the records obtained from these instruments will enable a fairly clear and complete picture to be obtained of local conditions. This project is being arranged and carried out in conjunction with the Department of Civil Aviation and the Royal Australian Air Force.

(v) *Repeated Load Tests on Wings.*—The hydraulically controlled wing test rig, by means of which complete wings are statically strength-tested to destruction, has been mechanized so that it is now possible to apply automatically to a wing repeated loads between any prescribed limits of positive loading, and at a rate of up to five cycles per minute. As far as is known, no wing testing rig capable of this performance exists elsewhere in the world. Several wooden Mosquito wings have been tested under various loading conditions, one test involving 3,000 repetitions within the range of 25 to 75 per cent. of the design ultimate load, while another was of 2,500 cycles within the range 25 to 75 per cent. followed by 2,500 cycles at 25 to 82½ per cent. Results to date indicate that these loadings, severe as they are, have little effect on the ultimate static strength of the wings. It will be necessary, however, to extend the scope of the tests considerably before final conclusions can be given.

(vi) *Electric Resistance Strain Gauges.*—Work continues on the development and application of electric resistance strain gauges. They have been applied to a wide variety of experimental work in the Division and in industry. One interesting sample of the latter was the application to a special torque measuring device which was used as a means of obtaining the efficiency of a large mine ventilating fan. The problem was one of some difficulty as the strains to be measured were only of the order of a few parts per 100,000. Despite this an accuracy of 1 per cent. was attained.

(vii) *Other Research Projects.*—The investigation of the strength of wooden box spars has been extended to include mountain ash as well as hoop pine. The resulting design curves for the mountain ash spars are different to those previously obtained for hoop pine. The work is almost completed.

Another project recently commenced is the investigation and compilation of stress concentration factors. A knowledge of these is of great importance in the design of structures or machines which may be subject to conditions of rapidly alternating load. In such circumstances stress concentrations are potential sources of failure by fatigue. An investigation complementary to this, on the notch sensitivity of metals, is also being undertaken.

A comprehensive mathematical monograph on the subject of plane stress has been commenced, and an improved theory of the Bourdon tube has been evolved.

(viii) *General Investigations.*—An investigation has been made of temperatures attained inside aircraft wings operating under tropical conditions. On a Beaufort aircraft operating in Queensland during September, a maximum skin temperature of 84° C. was observed, together with a maximum temperature in the wing fuel tanks of 39° C. Similar observations made at Alice Springs showed maximum temperatures of 85°C. and 40°C.

Further tests were conducted on a novel type of Army suspension bridge consisting of a band of wire mesh over which a heavy vehicle may cross. The bridge has the double advantage of lightness and extreme rapidity of erection. The objects of the tests were to obtain details of the manner in which a wheel load becomes distributed into the wire mesh and also knowledge of the fatigue life of a wire constituting one thread of the mesh, so that if possible the design could be further improved by reducing weight and increasing strength.

3. *Physical Metallurgy Section.*—(i) *High Temperature Metals.*—Preliminary work on tungsten-chromium alloys has been undertaken as the first step in investigating high temperature alloys. This work has necessitated the examination of high frequency induction heating as a means of sintering metals of high melting point. The preliminary work in a 20 KW 450 kc. unit has been successful and a unit of the same type with additional temperature controls has been ordered. It is anticipated that temperatures of the order of 2200° C. will be obtained in this furnace.

Progress has been made in the preparation of compacts of tungsten-chromium containing up to 30 per cent. chromium, both with the determination of the optimum sintering conditions and with the identification of phases in the alloys. More experimental

work is being done on the phases present and on the melting point of chromium with the object of constructing the equilibrium diagram of the W-Cr system.

(ii) *Powder Metallurgy.*—The investigation into the principles of powder metallurgy which was initiated during the war in order to help in the production of sintered bronze bearings, has been continued because of its bearing on the production of high temperature resistant alloys. For this work, powder metallurgy has two basic advantages:

(1) It enables the production of alloys of high melting point metals which could not be produced by ordinary fusion methods.

(2) It confers greater control over the purity of the resulting alloy.

For the continuation of this study, apparatus is being constructed for the determination of the effect of particle size and shape on the sintering operation, and for investigation of the mechanism of sintering. The apparatus includes a light extinction sedimentometer for the measurement of particle size and a combined dilatometer and electrical resistivity apparatus. This latter apparatus will measure simultaneously changes of dimensions and of electrical resistivity of pressed compacts up to sintering temperature of 1100° C.

(iii) *Corrosion Research.*—(*a*) *Aero Engine Cooling Systems.*—Tests on corrosion of the alloys of mock-up cooling systems by inhibited and uninhibited ethylene glycol have been continued with a coolant containing sulphonated gyro-oil as an inhibitor. These tests have shown a reduction in the extent of corrosion but at the same time a slight reduction in cooling efficiency of the system by the deposition of a film on the radiator tubes.

Fundamental investigation, which was instrumental in explaining the effect of tri-ethanolamine phosphate in glycol, has not indicated why this increase in corrosion resistance should have occurred. In fact, because of the effect of the oil addition on the electrical resistivity and pH value of the coolant, it has indicated that corrosion should have increased. This work is continuing.

(*b*) *Fundamental Studies.*—A study has been made of the mechanism of corrosion and film formation in aluminium and its alloys. From the results of this work charts which show the effect of aeration and de-aeration on the breakdown and building up of the protective oxide film, and the relations between time, temperature, and the electrode potential, have been prepared.

The effect of film breakdown has been studied by causing silica powder to impinge on an aluminium electrode under the liquid. The rapid breakdown of the film is observed by potential determinations and the recovery of the film in aerated solutions is indicated by the same means. It has been possible to establish the presence of stable and unstable oxide films and to indicate on the potential-aeration-deaeration-temperature chart the zones in which they occur.

During this work it has been observed for the first time that the corrosion of aluminium may take place by the mechanism of hydrogen evolution in neutral solutions as opposed to the more usual type of differential aeration. It has been shown that this occurs immediately before a ruptured oxide film has had time to reform.

(*c*) *Condenser Tube Corrosion.*—The cause and possible remedies for serious pitting in condenser tubes at Newport Power House has been investigated. The effect of mussel and seaweed debris in the formation of oxygen screens and also the complex ion-forming tendency with copper, &c., of the liquid extracted from these organisms has been investigated by the electrochemical technique. Results are still incomplete.

(iv) *Fatigue of Metals.*—Work has been commenced on the study of the fatigue properties of S.A.E. 4140 steel. In the course of the investigation the effect of surface finish on fatigue strength will be studied. Apparatus is being built for the determination of surface finish by three methods: (1) taper sectioning and microscopic examination, (2) electrical amplification of the movement of a stylus, (3) interferometer measurements. The study of electrolytic polishing of steels is proceeding with a view to using this method to polish fatigue specimens; results are promising, although pitting round inclusions is still objectionable. Progress has also been made with electrolytic polishing of aluminium alloy specimens as part of the project of studying fatigue failures in overheated duralumin-type alloys.

Several cases of fatigue failure of light alloy airscrew blades have been investigated. One such instance showed an unusual combination of fretting corrosion and faulty micro-structure resulting in local stress concentration.

(v) *Welding and Furnace Brazing.*—A series of specimens designed to show the effect of brazing time, temperature, and gap on the shear strength of copper brazed joints has been tested. The tests indicate (i) that specimens brazed at 1,180° C. had consistently higher shear strengths than those brazed at 1,120° C.; (ii) that for joints within the range of zero to 0.008 in., those with smaller gaps had higher strengths than those with larger gaps; (iii) that time of brazing had no distinct influence on shear strength.

Microscopic examination of the brazed joints showed a fine dispersion of an iron-rich phase in a matrix of copper-rich solid solution. The possibility of precipitation hardening in this copper-rich phase is being investigated.

The spot-welding of aluminium alloys, and mild steel coated with tin, zinc, nickel, chromium, and cadmium, has been studied. A test on the coated mild steels indicated that the spot-welding had not affected the protective function of the coatings.

(vi) *Australian Aircraft Steels.*—The programme of work on mechanical properties and other characteristics of Australian aircraft steels has been advanced further by the completion of reports on S.A.E. 2330, S.A.E. 4140, B.S. S1, and B.S. S90, in which valuable data, including hardenability results, are presented. Particular attention has been given in conjunction with the steel manufacturers to the strain aging of B.S. 3S1. This investigation has shown that silicon aluminium killed S1 steel is susceptible to considerable strain-aging in the cold-drawn condition.

Normalizing at 860° C. prior to cold drawing followed by stress relieving at 620° C., was found to be the only thermal treatment which would satisfactorily inhibit strain aging. Material in this condition gave satisfactory Izod properties when tested six months after treatment. It had been suggested that methods of preparation of specimens for Izod tests might have some effect on the results but no appreciable influence on the shape or position of Izod-tempering curves has been shown. A programme of work on causes of strain aging, which at the same time may have a bearing on other precipitation phenomena, has been initiated.

(vii) *General Investigations.*—A hand-book of steels suitable for automotive work is being prepared for the Institution of Automotive Engineers and should be valuable for rationalizing the various steels used in the Australian automotive industry.

Amongst a large number of investigations of defective materials and failures was the fatigue failure of an exhaust valve stem which was found to have originated at one of the usual fine cracks found in chromium which had been used as a plating to build up the stem. The crack had acted as a stress-concentrator and had effectively reduced the service life of the valve.

4. *Aerodynamics Section.*—(i) *Applied Aerodynamics.*—During the year a considerable amount of work was done in the 9 ft. by 7 ft. wind tunnel assisting the Australian aircraft industry in various design problems.

(*a*) *C.A.15 fighter.*—The tests on the C.A.15 fighter designed by the Commonwealth Aircraft Corporation Pty. Ltd. were completed. Measurements were made on the basic wing fuselage combination and on the contributions to lift, drag, and pitching moment due to the cockpit canopy, the tailplane, and the fin and rudder. Exhaustive tests failed to produce a wing root-fuselage fairing that completely removed a somewhat unsteady inflow along the upper surface of the wing trailing edge near the root. However, flight tests made by C.A.C. on a tufted Mustang and information obtained from American reports suggested that this phenomenon was an inherent peculiarity of three-dimensional aerofoils having a cusped trailing edge with forward sweep.

In the tunnel, stalling and general characteristics were observed with flaps deflected and readings were taken of the downwash at the tailplane to assist in fixing the tail-setting angle. To evaluate the high speed characteristics of the design, pressure distributions were determined around the fuselage and radiator cowling in the vicinity of the wing root and the pressure distribution was measured over the forward part of the fuselage to provide a basis for the structural design of the engine cowlings; radiator characteristics were also determined. A general report is in preparation.

(*b*) *D.A.P. E.C. 1 design.*—Another aircraft design upon which wind tunnel tests were commenced was a three-seat civil aeroplane E.C. 1 being designed by the Department of Aircraft Production. Two versions of the aircraft are proposed, mid-wing and high-wing, both with pusher airscrews. Since there is little published data on pusher types, it is proposed to include the effect of slipstream in the test programme.

(*c*) *Fan design.*—To simplify the analysis of ducted axial flow fans when operating under conditions other than those for which they are designed, a series of nomograms based on fan design methods developed in the Division have been developed.

To provide data for the design of efficient axial flow fans using easily produced blades, a series of tests was carried out on aerofoil sections made from curved plates. The two-dimensional characteristics of a flat plate aerofoil were determined and a set of circular arc plate aerofoils was tested under two-dimensional conditions with a range of cambers from 0 to 8 per cent. It is proposed to apply the results to the design of fans with simple curved plate blades.

(ii) *Stability.*—The arrangement under which a small number of staff are seconded from Fishermen's Bend to engage in extra-mural work at the Department of Aeronautical Engineering at Sydney University continues. A programme of experimental work on the measurement of derivatives of modern aeroplane types is in hand both at Fishermen's Bend and Sydney. Available information on the measurement and estimation of derivatives *lp, np, lr,* and *nr,* has been collated. Irregularities of motion were observed during free rolling experiments but the cause was found and eliminated.

At Sydney a six-component strain gauge balance had been designed to fit entirely in the hollow fuselage of a complete aeroplane model. The model can be mounted on a single spear in a tunnel or on a whirling arm, minimizing the effects of centrifugal force.

(iii) *Fluid Motion.*—During the past year work has continued on a long range project to determine the effect of turbulence on the boundary layer formed on the surface of bodies moving through the air. Necessary equipment for such work includes a wind tunnel with an air stream of very low but definitely measured turbulence. The low turbulence tunnel described in the last Annual Report has been further improved, but certain fluctuations in velocity have been found particularly difficult to eliminate. The cause of these has now been found.

Hot-wire anemometry for turbulence measurement has been improved in accuracy by attention to equipment and technique. A series of measurements of the effect of screens on turbulence has been made in order to achieve minimum turbulence. The lateral components of turbulence are being studied experimentally by hot-wire anemometry.

The theoretical study of hydrodynamic stability continues, in particular, on the effect of viscosity on the stability of a laminar wake. The design of bell-mouth entries to determine the optimum shape has also been studied theoretically.

The design and performance of conical diffusers is important in jet engines and industrial applications. Two families of diffusers (large diameter for low speed and small diameter for high speed) have been made up and tests of the small ones begun. No results are available yet.

(iv) *Gasdynamics.*—The variable pressure high speed wind tunnel described in the last Annual Report, which is intended for the study of "shock waves" due to the compressibility of the air at sonic speeds, has now been running for three months.

The tests carried out so far have been in the nature of preliminary calibrations. Special attention has been paid to the wide-angle expansions before the contraction into the working section. This is a feature of the tunnel which enables a high contraction ratio to be used without requiring an excessive length of tunnel. The break-away of the flow which would be expected in the sudden expansion leading to the bulge is prevented by placing high resistance screens across the maximum section. Besides stabilizing the flow they are also used to control the turbulence. It has been found that the addition of one 30 mesh per inch screen in the bulge reduces long period velocity fluctuations in the working section to the low limit of not more than $\pm \frac{1}{2}$ per cent. and gives a turbulence there with a longitudinal component of about 0.1 per cent. These results are very satisfactory and are as predicted in design. The balance to measure aerodynamic forces and the Schlieren optical gear for the photography of shock waves require a great deal of complex and detailed work before they will be ready for investigational work to start.

(v) *General Investigations.*—Various anemometers and venturies have been calibrated and special purpose small wind tunnels designed for other organizations. A "cycling chamber" to simulate the humidity cycles of the tropics was designed for the Ministry of Munitions.

A large mine ventilation fan at Broken Hill was investigated both aerodynamically and structurally (see under Structures and Materials) and the cause of its low efficiency determined. As the fan was very inefficient and fuel costs at Broken Hill are high, the improvement designed by the Division to improve the efficiency will result in a saving of £3,000 per year.

The spraying of fruit trees by means of an air blast which would carry the spray into the trees would be a great improvement on existing methods. A blower unit has been constructed for experiments with the Victorian Department of Agriculture.

5. *Engines and Fuels Section.*—During the war the Section was principally concerned with problems of immediate practical importance to the Royal Australian Air Force and the aircraft industry. With the return to peace, the volume of this work is decreasing and officers of the Section, in common with those of other Sections of the Division, are able to devote more time to fundamental research. The advent of the gas turbine engine, which will supersede reciprocating aircraft engines in most categories within a few years, has dictated a complete reorientation of the research programme. It has been decided that investigations in

the turbine engine field will be undertaken, a research programme has been drawn up, and preliminary parts of the work are being actively pursued.

(i) *Research and Development Projects (Reciprocating Engines).*—(*a*) *Piston ring lubrication investigation.*—An R.1340 single cylinder engine has been modified for this work, the aim of which is to examine the conditions of lubrication between piston rings and cylinder wall by measuring the changes in electrical conductivity of the oil-film. Breakdown of the oil-film leads to direct metal-to-metal contact, with consequent wear of both cylinder and rings. Studies of this sort have already been made with small engines running at low speeds and under artificial conditions; the present work is an attempt to extend the measurements into the operating range of aircraft engine cylinders. A satisfactory mechanical and electrical arrangement has been evolved and the investigations are proceeding.

(*b*) *Rotary valve engine.*—Work on the development of the E39 rotary valve engine, which was mentioned in the last Report, has continued. Several modifications of the valve lubrication system were tried, with the object of reducing oil consumption at part throttle; a satisfactory system was finally devised. The original valve design has been modified to increase the port area, and has given improved volumetric efficiency with consequent power increase, particularly at high rotational speeds. Another type of valve suitable for multi-cylinder in-line engines has been constructed and has given results which, while slightly inferior to those of the original valve, are much better than those which are normally obtained with engines of the conventional poppet-valve type. At the request of the Royal Australian Air Force, a design has been prepared for a small twin cylinder rotary valve engine suitable for driving a portable generator, this engine will be built by the Royal Australian Air Force.

(*c*) *Air filter investigations.*—The programme of work outlined in the last Report has continued. The performance of several current aircraft filters has been examined on the test plant, and the effect of the geometrical configuration of filters on pressure drop and cleaning efficiency is being studied. The ultimate aim of this work is the provision of data to permit the design of filters of adequate cleaning efficiency with minimum pressure drop.

(*d*) *Air miles-per-gallon indicator.*—An instrument showing fuel consumption in relation to distance flown would be of great assistance to pilots, enabling them to select engine operating conditions for maximum range. A project for the development of such an instrument was initiated some years ago, but other more urgent tasks held up the work. During the year under review the project has been revived and two devices have been tried. The first, which relied on diaphragms for the transmission of pressures determined by fuel flow and air speed, was abandoned following extreme difficulty in devising diaphragms with the desired characteristics. The second design employs two metal capsules which deflect cantilever springs fitted with electric resistance strain gauges. One pressure capsule is actuated by fuel flow and the other by air speed and the electrical output of both strain gauges is fed into a ratiometer to read directly in miles per gallon. The development is not yet complete but results obtained so far are promising.

(*e*) *Distribution of fuel anti-detonant.*—Arising from *ad hoc* tests of a Merlin engine an investigation of the distribution of anti-detonant (tetraethyl lead) between the cylinders of multi-cylinder engines has been undertaken. The effects of unequal distribution of fuel between cylinders have been realized for some time, but it has only recently been shown that the tetraethyl lead and ethylene dibromide may not be distributed in the same proportions as the petrol. This means that detonation is likely to occur in those cylinders which are not receiving their fair share of anti-detonant and that lead deposits may cause harmful effects in those which receive excessive amounts. A method of estimating the amount of lead fed to each cylinder is being developed, using a single-cylinder engine; the method will subsequently be applied to a multi-cylinder engine.

(ii) *General Investigations.*—(*a*) *Merlin engine tests.*—At the request of the Royal Australian Air Force, air consumption and carburation of Rolls Royce Merlin 66 (Spitfire VIII) and Packard Merlin V.1650-7 (Mustang) engines has been investigated. These measurements were required in order that engine operating conditions for maximum range could be specified. A Merlin 31 (Mosquito) has been set up on the test bed for similar measurements and for evaluation of the effect on cooling characteristics of the addition of anti-corrosion oil to the glycol-water coolant. This engine is also being used for the lead distribution investigation (A.5).

(*b*) *Cooling tests of "Al-fin" cylinders.*—At the request of the Commonwealth Aircraft Corporation an investigation was made into the relative cooling characteristics of normal cylinders and "Al-fin" cylinders, which have the barrel finning formed in an aluminium muff, for the R.2000 engine. Tests showed that the mean barrel temperatures of the "Al-finned" cylinders were 10-20° C. cooler than those of the conventional steel-finned cylinders, but that the barrel finning did not affect the mean cylinder head temperature.

(*c*) *Tractor tests.*—During the year tests were carried out on two tractors, one an Australian built unit and the other an English tractor. The standard test methods developed by the University of Nebraska were employed to make possible a comparison with Nebraska figures for American tractors. These tests consist essentially of measurements of belt pulley and drawbar horsepower and fuel consumption under various operating conditions, followed by endurance tests and an inspection of working parts on completion. This work was undertaken by the Division because facilities for its performance did not exist elsewhere in the country. It is understood that appropriate equipment will now be installed in another Department.

(*d*) *Small engines.*—Six small engines of local manufacture, including petrol and diesel types, intended for stationary and marine applications, were tested during the year. In several instances modifications to the design were suggested and were incorporated by the manufacturers, with consequent improvement in performance. Advice has also been given to other manufacturers who are designing small engines. A diesel engine of the Kadenacy type is now under test.

(iii) *Turbine Engine Research.*—Several research projects have been initiated and it is hoped to commence investigations in the near future. It may not be possible to go very far with this work until the complete plant which is at present being designed is available, but certain phases of the work can be undertaken in the meantime. The main projects are as follows:—

(*a*) *Combustion.*—Two research projects are being commenced. The first concerns the effect of air turbulence on combustion. Design of apparatus is under way and fans have been ordered to provide a temporary air supply at comparatively low pressure until high pressure air compressors can be obtained. The second project is a long range investigation of the possibility of the use of brown coal, or its derivatives, in gas turbines. Active investigations of this problem will be commenced in the near future.

(*b*) *Fuel and control systems.*—Apparatus for making functional measurements on fuel system components is being designed; this equipment is essential both for research on fuel and control systems and as an adjunct to engine test and combustion work. A review of existing and possible methods of fuel system control is being undertaken as a basis for future research.

(*c*) *Compressors.*—A low speed cascade wind tunnel is being designed for an investigation into fundamental problems of compressor and turbine blade design. It is hoped to establish some agreement between blade design theory and actual performance; practically no such correlation yet exists.

(*d*) *Engine testing.*—Two Rolls Royce Welland engines have been acquired from England and are to be run for staff educational purposes and to try out certain ideas regarding test-stand suspensions. As a temporary measure the engines are being set up in No. 3 Engine Test House, but this location will not permit of adequate silencing and a more satisfactory permanent arrangement is under consideration. Two Derwent engines have been ordered and it is intended that they shall be used for investigating proposals arising from the fuel and control system and combustion investigations.

6. *Instruments Section.*—The Section's function is to design and construct instruments required for the research projects of the Division of Aeronautics and other Divisions of the Council for Scientific and Industrial Research and also to develop and examine instrument equipment required or submitted by other authorities such as the Royal Australian Air Force, and the Departments of Civil Aviation and Aircraft Production. A selection is given of the great variety of projects handled.

(i) *Projects Originating Within the Council for Scientific and Industrial Research.*—The Engine Section investigation of the oil film on the cylinder walls of engines while running by measuring and recording the conductivity of the film, required the development of switching unit, blue trace oscillograph, direct-coupled amplifier, and power supply unit. These were completed as was also a fuel meter giving both total quantity and instantaneous rate of flow.

Improvements to the hot wire equipment for study of turbulence were made for Aerodynamics Section. The first unit for the electromagnetic balance of the variable pressure high speed wind tunnel was handed over to the Section, and following experimental work on control amplifiers, construction of the complete installation is in hand. An instrument for recording pressure fluctuations in wind tunnels is also being built.

The electro-magnetic fatigue machine of Structures and Materials Section has been modified to use greater power for tests on non-magnetic materials. For electric resistance strain gauge work a cathode ray oscillograph with very low frequency response and a drum camera have been built.

For the Division of Industrial Chemistry a capacity strain gauge to measure rapid small changes of pressure and an electronic system to stabilize the temperature of oil baths were developed.

(ii) *Projects Originating Outside the Council for Scientific and Industrial Research.*—Locally made small electric motors for use in aircraft have been tested against specification for the Department of Civil Aviation.

For the Royal Australian Air Force, the design and construction of a Mach number indicator for high speed flight is in hand and has progressed to the stage of prototype design. The suitability of Australian-made bimetallic strip for overload circuit breakers has been established.

In addition a great number of smaller projects have been completed including the construction of instruments for the Melbourne Technical College and calibrations of tachometers, inertia switches, revolution counters, and pressure gauges.

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

(i) *Division of Aeronautics*—

Dale, F. A. (1946).—Wood laminating and moulding. C.S.I.R. Forest Products News Letter No. 141.

Paterson, M. S. (1946).—Damping capacity measurement and relation to cold-work in mild steel. Adelaide University (Thesis).

Thompson, P. F. (1946).—Some aspects of the corrosion of aluminium. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 157.

Woods, M. W. (1945).—Jet propulsion and the gas turbine aircraft engine. *J. Inst. Aut. Eng. Aust.* 4: 94 (Nov.).

(ii) *Australian Council for Aeronautics*—

Batchelor, G. K. (1945).—Sound in wind tunnels. Report ACA-18.

Dale, F. A., and Smith, R. C. T. (1945).—Grid sandwich panels in compression. Report ACA-16.

Love, E. R., and Silberstein, J. P. O. (1945).—Elastic vibration of a fan. Report ACA-15.

Shaw, F. S., and Silberstein, J. P. O. (1945).—Stress analysis of an engine mount. Report ACA-17.

Willis, J. B. (1945).—Review of hot wire anemometry. Report ACA-19.

XV. INDUSTRIAL CHEMISTRY.

1. *General.*—With the cessation of hostilities the special war-time advisory work of the Division has come to an end. Its officers, freed from committee work, have been able to give full attention to peace-time projects. All short-term war-time activities have ceased, but some longer-term projects undertaken to assist the war effort were so near to completion that work on them has been continued with a view to publication of the results obtained.

Liaison with other sections of the Council has been strengthened, and the Division now has six officers seconded to other Divisions. This is in accord with a policy that while one or two chemists may be required in laboratories specializing in other fields, those chemists should have easy access to consultation with, and promotion in, a Division where chemistry is the major interest. An officer of another Division has worked for several months at the Division, using equipment not available elsewhere in Australia. In addition, the Division has a number of officers working in University and Technical College laboratories.

Conferences have been arranged in Melbourne and Sydney—the latter by the Australian Chemical Institute—to consider the lines along which the Section of Chemical Engineering should develop in order to be of greatest service to industry. Many leading chemists and chemical engineers attended these conferences, which approved the lines along which collaboration with industry has developed over the past five years. As a result of these conferences it is possible to define more clearly the future policy of the Division in this regard. There was general agreement that:—

(i) In dealing with established industries the Division should, in general, confine its attention to the problems common throughout an industry or a group of industries.

(ii) Interchange of staff between industry and the Division should be continued and extended.

(iii) Special investigations for individual companies should be undertaken only when the Division possesses special skills or equipment not available elsewhere in Australia, or where the investigation would provide valuable experience for the officers concerned.

(iv) The results from such special investigations should be published.

(v) The initiating company should contribute towards the cost of an investigation conducted on its behalf to an extent dependent on the value of the results to other companies or industries.

(vi) The Section of Chemical Engineering should aim to build up a research team each member of which becomes expert in, and acts in an advisory capacity concerning, some unit process.

(vii) Closer liaison is needed with industry in order that the research work of the Division may be more widely applied, and so that the major problems of industry may be ascertained with greater precision.

With respect to Item (ii), the Division has already had guest workers from industry and has sought experience in industry for some of its officers. For guest workers the following arrangements have been found suitable—(*a*) In general six months is regarded as the minimum useful period. (*b*) The company pays the salary of the guest worker. (*c*) The Division provides all necessary facilities for the research work undertaken. (*d*) Patents arising from the work are regarded as the property of the Council for Scientific and Industrial Research, but it may be assumed that no royalties would be charged for their use by the sponsoring company. (*e*) The results of research are published if publication is warranted, and the guest worker will usually be cited as a co-worker. (*f*) Any information gained by the guest worker about projects other than that upon which he is engaged is to be regarded as confidential unless he is authorized by the Council for Scientific and Industrial Research to divulge it.

To meet an urgent need by the growing munitions industry a small Section was established for research work in the field of secondary metallurgy. It rendered valuable service during the war, mostly confining its attention to *ad hoc* investigations of a fairly long-term nature. Meantime the Division of Aeronautics built up a somewhat larger team of physical metallurgists to assist in the development of the aeronautical industry and the two teams have worked closely together under one administrative head.

When the Council recently decided to support the establishment of a research school of secondary metallurgy at the University of Melbourne, it seemed unnecessary for this Division to continue work in the same field. The Section is therefore being wound up and its officers are being absorbed either by the Division of Aeronautics or by the University of Melbourne.

The arrangements, referred to in the last Annual Report, for having pilot-scale tests conducted by the United States Forests Products Laboratory with a view to assessing the value of Australian timber as raw material for alcohol production, have now been put into effect. The timbers selected by the Council's Division of Forest Products on the basis of availability and in order to cover a wide range of characteristics were *Eucalyptus obliqua* (Tas.), *E. marginata* (W.A.), *E. regnans* (Vic.), and *Pinus radiata* (S.A.). The samples were each approximately ½-ton in weight and were dried and chipped before shipment. Sub-samples were retained to enable subsequent laboratory work to be compared with the pilot-scale tests, and arrangements were made to obtain samples of the lignin by-product and sub-cultures of the yeast used in the fermentations. The tests were made in duplicate and the yields of alcohol calculated as imperial gallons per long ton of timber were 48.5 for *Pinus radiata*, 44.0 for *E. obliqua*, 35.2 for *E. marginata* (jarrah), and 40.8 for *E. regnans*. An account of this work will be published in the August (1946) issue of the Council's Journal.

During the year under review twelve lectures on "Non-stoichiometric Solids" were delivered by Dr. J. S. Anderson of the University of Melbourne, and Dr. A. L. G. Rees and Mr. K. L. Sutherland of the staff of the Division. The theoretical principles expounded have already found application in several research projects of the Division.

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 workshop staff is recorded with appreciation.

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.*—Investigations concerning the preparation, by chemical means, of industrially useful intermediates, or end products, from a variety of Australian minerals have comprised the main work of the Section.

The requirements of existing industries have been considered conjointly with those of industries which may eventually be established in Australia for the processing of minerals which at present are either neglected or exported in the crude state. This continued development of the potentialities of the several minerals comprising the very extensive "black sand" deposits of the littoral areas of eastern Australia finds justification in the increasing world interest in the industrial possibilities of the chemical derivatives of the minerals of these lesser known chemical elements. The work of the Section has also emphasized the advantages to be gained by chemical beneficiation and enrichment of such minerals as are not amenable to further improvement by ore-dressing methods.

(i) *Chromite.*—The process devised for the preparation of various chrome chemicals from chromite by an acid treatment reached an advanced stage in pilot plant tests by the Chemical Engineering Section. Laboratory investigations of certain phases of the method were continued. The process admits, if necessary, of the utilization of a grade of chrome ore of lower tenor than that acceptable to manufacturers of chrome chemicals by the ordinary alkaline frit method. The industrial potentialities of several deposits of Australian chrome ore have thus been increased. Another advantage of the method is that it admits of the direct manufacture of chromic anhydride which for certain purposes is a more versatile chromium intermediate than the sodium dichromate made by the conventional process. In this, as in certain other investigations undertaken by the Section, emphasis has been placed on the industrial advantages of obtaining from any one mineral some versatile derivative which, by comparatively simple modification, can be made to serve varied requirements. Chromic anhydride, which is readily converted into alkali chromates, chrome pigments, chrome tanning salts, and is the basis of chromium plating baths, fulfils these requirements.

(ii) *Monazite.*—This is a minor component of the "black sands" of the eastern Australian beaches and is recoverable as a by-product during the separation of the associated minerals. Monazite is a very versatile mineral as regards the wide variety of products obtainable, by chemical means, from the several rare earth metals and thorium which enter into its composition.

Earlier work on this mineral was devoted to the methods best suited to the production of cerium oxide polishing powders for polishing glass optical components, sparking "flints", and rare earth fluorides for

the cores of searchlight carbons. An extension of this work on monazite during the present period has been directed towards improving the methods for the chemical isolation of cerium, thorium, and lanthanum compounds. This work involved much detailed investigation of the fundamental properties of the oxalates and other compounds of these elements. The object of the work was to provide an adaptable method for the isolation of a variety of compounds from any of the several rare earth minerals that occur in Australia. The varied and increasing industrial uses of such materials have made it desirable to have a general process for the chemical treatment of such minerals in contrast to specific methods for each component which are customarily used. As a result of this work pilot plant tests were undertaken by the Chemical Engineering Section.

(iii) *Rutile.*—The very extensive deposits of rutile and ilmenite in the "black sands" of the eastern Australian coast justify a continued research programme on the industrial application of titanium compounds. Earlier work on the production of titanium tetrachloride from rutile was extended to explore alternative uses for this substance which can be regarded as an excellent intermediate for the production of other pure titanium compounds. Various titanium esters were investigated, particularly with a view to their incorporation in heat-resistant paints and films. Portion of this work was done in co-operation with the Munitions Supply Laboratories at Maribyrnong and a patent was granted to cover the most satisfactory formulae evolved.

(iv) *Zircon.*—Zircon, which is essentially a silicate of the metal zirconium, forms the main component of the detrital heavy mineral sands of the eastern Australian seaboard. These deposits of zircon sand are the largest known anywhere in the world. For this reason, and because of the growing recognition of the manifold industrial uses and potentialities of zirconium derivatives, a long-term programme on this mineral has been planned. Preliminary separations, on a fairly large scale, of the zirconium and subordinate hafnium have been studied. Hafnium is difficult to separate from zirconium by known methods. Much of the existing knowledge concerning the properties of "zirconium" compounds is based on composite material which contains hafnium in small amounts; for certain industrial purposes this is of no particular consequence. The limitations of certain of the separation methods have been revealed in this work, and modifications have been introduced to improve the separation methods. In the course of the investigations the methods available for the decomposition of zircon have been studied conjointly. Anhydrous chlorination and alkaline fusion methods have been investigated with the object of obtaining the widest variety of industrial products, or intermediates.

(v) *Torbernite.*—In the previous annual report an outline was given of the cyclic process devised for the recovery of uranium compounds from this low grade copper uranium phosphate ore from Mount Painter, South Australia. This work has now been extended by a further study of the many variables involved in a selective leaching of torbernite from a manganiferous ironstone matrix and the recovery of the dissolved uranium by specific precipitation.

(vi) *Graphite.*—In continuation of previous work the purification of Australian flake graphite concentrate by chemical means was continued. Anhydrous chlorination was shown to be capable of reducing the interlaminated gangue impurities to negligible proportions, economic rather than technical aspects being the limiting factor. The greater part of the work done on graphite in this period was in conjunction with that done on manganese dioxide purification. These two materials form important ingredients of electrical dry cells, and the effectiveness of the beneficiations is, for this purpose, best integrated by the performance of experimental dry cells made up with the treated materials. The importance of particle size of the graphite to cell performance has led to investigations of different methods of grinding it, and of methods of determining particle size distribution.

(vii) *Manganese Dioxide.*—Work on the chemical beneficiation of manganese dioxide for use in dry cells and experimental dry cell manufacture incorporating the various products was continued. Cells with consistently good initial performance can now be made from several depolarizers prepared from local raw materials. The tests conducted on a large number of manganese ores and artificial oxides in collaboration with an Australian manufacturer of dry cells have now been completed and have shown that several Australian ores give performances comparable with imported ones. Subsequent work suggested that the artificial oxides, which gave poor performances in the above tests can, nevertheless, be made to produce satisfactory cells provided certain changes are made in the other constituents and in the cell construction. Classification of the many types of manganese oxides under investigation was assisted by X-ray diffraction studies conducted in collaboration with the Munitions Supply Laboratories.

(viii) *Fluorite.*—As the primary source of most fluorine compounds, this mineral and its transformations merit special consideration. During the period under review attention has been directed to the synthesis of aluminium fluoride, which is used in conjunction with cryolite in aluminium production. Its synthesis offers scope for using various intermediates other than hydrofluoric acid. For this reason work has been continued on the production of sublimed ammonium fluoride by the interaction of fluorite and ammonium salts. Methods for the elimination of silica from such intermediates have continued to receive attention.

Much of the work on the derivatives of fluorite is of general applicability to the programme of the Section because the industrial processing of the ores of zirconium, titanium, beryllium, and many other minerals, and metals apart from aluminium, frequently involves fluoride technology. The work undertaken on fluorides and their complexes has also served to indicate the limitations of certain constructional materials such as lead, and magnesium alloys, commonly used in processing fluorides. Chemical methods for minimizing such corrosion, or for eliminating introduced corrosion products, have formed a subsidiary and collateral part of the investigations.

(ix) *Beryl.*—The chlorination of beryl was studied with a view to the direct production of anhydrous beryllium chloride from which beryllium metal may be produced by electrolysis. The elimination of the silicon and aluminium chlorides that are concurrently formed introduced some unforeseen difficulties that limited the applicability of the method somewhat, but the process involves principles applicable to the chlorination of crude beryllium compounds obtained by other means as well. This investigation was completed during the year.

4. *Alunite Investigations.*—The Division has continued to assist in the development and utilization of Western Australia's alunite resources. Two of its officers have worked on various aspects of the processes described in the last annual report under the direction of Professor N. S. Bayliss of the University of Western Australia.

5. *Cement, Ceramics and Refractories Section.*—The Cement and Concrete Association of Australia gives both financial and practical co-operation to the cement investigations of this section.

(i) *Cement Investigations.*—The study of the deterioration of concrete through reaction between its cement and aggregate components has shown some new aspects of the problem. A survey of Australian aggregate materials has revealed that some aggregates have produced expansion of concrete after the lapse of one or two years. Although such concrete did not expand during the first year, there were indications that reactions were taking place and that undesirable components were present in the aggregate. It has also been shown that some aggregates, which were formerly believed to produce expansive reaction only with cements rich in the alkali metals, will also promote deterioration when used with low alkali cements although, in this latter case, the reaction may be delayed and the concrete does not necessarily expand to any great extent. The conditions and mechanism of these reactions have been the subject of laboratory studies.

The chemistry of portland cement clinker and its components is being studied by various methods. Synthesis and examination of the pure compounds is supplemented by the preparation of clinkers of carefully controlled composition. The properties of cements made from such clinkers are being studied by petrographic and chemical methods.

(ii) *Refractories Investigations.*—Investigations concerning refractory materials have been largely directed towards those suitable for use in the high temperature zones of cement kilns. Both basic and aluminous refractories are being studied, and particular attention is being paid to the use of Australian raw materials.

(iii) *Ceramics Investigations.*—A survey of Australian ceramic materials is the initial objective in these investigations. Deposits are being examined in the field and samples collected. These samples are then subjected to chemical, physical, and mineralogical investigation in the laboratory.

6. *Foundry Sands Section.*—Close contact with the foundry industry has been maintained through the section's testing and advisory service on moulding sand problems. Surveys indicating the quality and distribution of sands and clays required for foundry purposes have been continued, and bibliographies on certain aspects of foundry practice have been compiled.

(i) *Moulding Sands.*—The survey of moulding sands in the several States has been continued in collaboration with the respective Mines Departments. The results of the surveys in New South Wales and Western Australia are now ready for publication and those of the South Australian survey were published in a bulletin recently issued by the Council. Laboratory testing of samples collected during the field survey of the Queensland moulding sands is proceeding. In Victoria a number of new deposits near Melbourne have been tested with a view to obtaining alternative sources of supply of grades in danger of depletion; in addition, tests have been conducted on a number of samples from country districts.

(ii) *Investigation of Australian Clays.*—Further data have been obtained concerning the properties of several Australian clays which show promise as substitutes for American bentonite. Further attention is being given to the Yarramen (Q.), Marchagee (W.A.), and Trida (N.S.W.) clays with a view to the elimination of variations in quality occurring during mining and processing, and the correlation of their properties in synthetic sands with their fundamental constitution.

(iii) *Determination of "Clay Substances".*—An apparatus for the estimation of clay substances which renders automatic the successive operations of stirring, settling, and siphoning, has been designed. Its use has resulted in a considerable economy of time.

(iv) *Permanent Moulds.*—The majority of castings are prepared from sand moulds which suffer from the disadvantage that they can be used only once. When a large number of similar castings are to be made, it may be more economical to use metal moulds which are not destroyed and can therefore be re-used. A comprehensive bibliography of the literature on this permanent mould process is being prepared for publication.

7. *Physical Metallurgy Section.*—Attention has been chiefly directed to the investigation of several practical corrosion problems submitted to the Division.

(i) *Corrosion in Aircraft Engine Cooling Systems.*—Attempts have been made to determine the relative merits of various means proposed for combating corrosion in the cooling systems of modern aircraft engines. Small-scale cooling systems were used in a series of long-term corrosion tests, the results of which were of immediate practical value to the Royal Australian Air Force. The investigations demonstrated the inadvisability of the continued use of the type of coolant which has been used as standard practice during the last five or six years. A number of alternative coolants were tested, the least corrosive being a mixture of ethylene glycol, water, mineral oil, and a small quantity of a surface active agent which enabled a relatively stable emulsion to be formed.

(ii) *Corrosion in Condenser Tubes in Power Generating Plant.*—An investigation was undertaken with a view to reducing the incidence of tube failures in the condensers of a major power generating unit operated by the Victorian Railways. The various factors affecting the corrosion of condenser tubes were examined both from the basic electro-chemical point of view and from the practical standpoint. In view of the impracticability of removing dissolved oxygen which is the chief factor responsible for corrosion, attention has been directed to other factors, having a bearing on the incidence and speed of localized corrosion. Those at present being examined are: the clarification of the seawater to remove suspended solids, the use of alternative alloys for the construction of the tubes instead of the Admiralty brass at present used, and improvement of the surface finish of the tubes.

(iii) *Production of Beryllium-Copper Alloys.*—A study of the main factors affecting the production of beryllium-copper alloys by reducing beryllium oxide with carbon in the presence of molten copper in an arc furnace was continued.

(iv) *Minor Corrosion Investigations.*—Among the short-term investigations were the deterioration of tinplate containers for blowfly dressings, the selection of materials for the construction of tanks for the retting of flax, and the prevention of corrosion in copper heat-exchange coils of a hospital heating system.

8. *Physical Chemistry Section.*—The Section has continued its work on surface chemistry with particular reference to aspects affecting the flotation process for the separation of minerals.

(i) *Separation of Minerals by the Flotation Process.*—Attempts at correlating laboratory tests with flotation in batch cells has been continued, and a wide range of techniques, including the use of the micromanipulator and microscope, has been employed to study flotation phenomena with particular reference to the separation of topaz from quartz.

(ii) *Study of the Flotation Process.*—There is a considerable discrepancy between the efficiency expected of flotation cells and that obtained in actual practice, and any considerable increase in efficiency will depend on a more thorough understanding of the fundamental principles involved in the flotation process. To this end a theoretical and practical study of the collision and adhesion of air bubbles and suspended mineral particles has been undertaken, and a hypothesis has

been developed which is being checked by a comprehensive series of practical tests. These studies have as their objective not only the improvement of flotation practice of value to the mining industry, but application to a wide variety of problems such as frothing, and the formation of emulsions, which involve selective adsorption.

A number of organic compounds used as collectors have been prepared in a high state of purity. Since these substances are often present to the extent of only a few parts per million of water, it has been necessary to devise methods for estimating them with accuracy. Using these poor reagents it was found that the adsorption of the collectors on fluorite was a function of the acidity of the solution, and the best flotation corresponded to the conditions under which maximum adsorption occurred.

One of the oldest problems of flotation is the relationship between the structure of a collector molecule and the tenacity with which an air bubble will hold a mineral particle submerged in the collector solution. With surface-active substances such as soaps this was shown to be complicated by the slow rate at which equilibrium conditions are attained, and it has been possible to explain many apparent inconsistencies in existing data.

By these methods of attack it is hoped to be able to predict from theoretical considerations the most suitable method of effecting mineral separations by the flotation process.

(iii) *Adsorption of Surface-active Agents from Organic Solvents.*—Although a great deal is known about adsorption of surface-active agents from water, very little is known about their behaviour in organic solvents. In particular instances, it would be desirable to float minerals or materials such as cement or other water-reactive substances, in an organic medium. Again, it has been shown that the performance of a boiler or of a condenser can be improved by pretreatment with surface-active agents. Studies of these aspects of surface chemistry have enabled conditions for successful adsorption in particular instances to be defined.

(iv) *Miscellaneous.*—The spreading of anti-malarial oils was determined for the Division of Economic Entomology, and the stability of emulsions such as those of DDT have been measured, using as an indicator the coalescence of the two droplets, with the object of devising a simple field test.

9. *Chemical Physics Section.*—In planning the scope and organization of this Section it was considered that its functions were twofold, namely, the establishment of modern physical techniques for both internal and extramural use, and the execution of fundamental chemico-physical research.

(i) *Chemico-physical Techniques.*—Since facilities for general use were considered to be most urgently required, efforts have been directed towards the establishment of a range of techniques applicable to a wide variety of scientific problems. Delays have been experienced in obtaining the necessary equipment from overseas, but an electron microscope and an X-ray diffraction unit have been installed and used for some months on a variety of problems, and an electron diffraction camera has been designed and constructed in the Division's workshops. Facilities for spectroscopic and mass spectrometric work await delivery of equipment. An instrument shop, comprising an instrument machine shop, an electrical instrument laboratory, and a glass-working shop, for general use throughout the Division, is in process of establishment.

(ii) *Structure of the Wool Fibre.*—This project has been conducted in collaboration with an officer of the Division of Physics, who has spent some four months as a guest worker in this Section. Electron microscopical studies have established certain features of morphological structure of the wool fibre previously unsuspected and have demonstrated the mode of action and site of attack of shrinkproofing agents. Data obtained by the application of electron microscopy, X-ray, and electron diffraction have proved the existence of three physically, and possibly chemically, distinct components of the fibre: a resistant component of the cuticle cells, a fibrillar component of the cortical cells, and an amorphous inter- and intra-cellular matrix. Observations of the elasticity of cortical cell pigments and intra-cellular matrix, taken in conjunction with X-ray diffraction evidence, throw doubt on the current structural formulae for the keratinous protein.

(iii) *Imperfect Crystalline Solids.*—In recent years many phenomena of vital importance to the electrical industry, of which luminescence and thermionic electron emission from oxide cathodes may be cited as examples, have been found to be associated with crystalline solids possessing imperfections. These imperfections may be due to minute amounts of impurity incorporated in interstitial or vacant sites in the crystal, to excesses of one or other component over the stoichiometric ratio, to displaced lattice ions, or to vacant sites in the lattice. Electron diffraction methods have been employed in the study of simple oxides belonging to this class of solids and have revealed new effects which can only be ascribed to the slight deviations from ideality. Further study of such effects may lead to a thorough understanding of the phenomena mentioned above.

(iv) *Molecular Potential Energy Relationships.*—The use of spectroscopic data in the evaluation of thermodynamic functions (of importance in the study of chemical reactions) requires a precise knowledge of the molecular potential energy functions in order that the inevitably incomplete spectroscopic data may be extrapolated as desired. Analytical expressions previously suggested are of an approximate character and laborious graphical procedures alone give the precise relationship.

A theoretical relation between potential energy and internuclear distance has now been derived for diatomic molecules, and the merits of the relation have been demonstrated in the interpretation of some aspects of the molecular spectrum of bromine.

(v) *Electron Microscopical Examination of Alunite and Associated Products.*—An electron microscopical study of alunite from Lake Campion, Western Australia, and of various derived and related products has provided information about the constitution of the alunite deposit and on the changes occurring during processing under various conditions.

(vi) *Miscellaneous Investigations.*—Numerous short-term investigations have been undertaken for industrial concerns and technical organizations; these include an electron microscopical examination of spent shale dust, electron microscopical studies on certain pigments in relation to a pilot plant process for their production in Australia, and an X-ray diffraction study of synthetic compounds of aluminium and fluorine.

10. *Organic Section.*—During the war many of the activities of this Section were directed to the solution of problems arising from war conditions; during the present year two longer-term investigations concerning the recovery of sugar-cane wax and alkaloids from Australian sources were begun.

(i) *Sugar-cane Wax.*—Estimates of the amount of sugar-cane wax potentially available annually as a by-product of the Australian sugar industry all exceed 1,000 tons and rise as high as 4,000 tons. Since sugar-cane wax is a hard wax which can be used in various

types of boot and floor polishes and in the production of carbon paper and ribbons, its recovery on this scale would comprise a very considerable industry.

The attempt to establish such an industry is not a novel commercial venture, and this wax has been produced both overseas and at Nambour, Queensland, where a plant has been operated during the past three years. Although there has been a steady improvement in its quality and it is the equal of carnauba wax in polishing power, its solvent retention and colour need further improvement if it is to compete freely with carnauba wax. Before sugar-cane wax can become a sound commercial proposition, it will be necessary to study some of the phases in its isolation, and to investigate its chemical composition with the object of separating fractions having uniform standards of quality. These are the lines on which these investigations will be developed.

(ii) *Australian Alkaloids.*—Although some Australian native plants contain relatively large quantities of valuable alkaloids, as witness some species of *Duboisia* with their high contents of hyoscine and hyoscyamine, the alkaloid contents of Australian plants have received but little attention in comparison with the amount of effort devoted to the examination of their essential oils. In collaboration with the Division of Plant Industry and with the Departments of Physiology of the Universities of Melbourne and Queensland, it is proposed to conduct a long-term investigation of alkaloid-bearing Australian plants. During the past year officers of the Division of Plant Industry collected much new material in Northern Queensland and have shown that some of these plants are rich in alkaloids. The physiological examination of this new material is in progress at the universities named, and, as the physiologically active materials are sifted out, it is intended to undertake their chemical examination in this section of the Division of Industrial Chemistry. Meanwhile, the chemical work has been directed towards solving the structures of related alkaloids present in considerable quantity in some of this Queensland plant material.

(iii) *Isolation of Mannitol from the Exudate of Sugarwood (Myoporum platycarpum).*—Attention has been largely devoted to pilot scale isolation of mannitol. The chief difficulties in the isolation have always been associated with the removal of dark gum-like materials. These, it has been found, can be removed and the mannitol isolated by processes analogous to those normally used in preparing sugar from cane juice. It has been possible to obtain 50 per cent. of the total mannitol present in the exudate; thus from some 300 lb. of dry manna, 100 lb. of pure mannitol were obtained. It has been possible to eliminate the bleaching operation with its use of charcoal. Just as in the recovery of sugar a portion remains in the molasses, so the remaining 50 per cent. of the mannitol forms part of a thick molasses from which further recovery is difficult. No adequate survey has been made of the amounts of manna that could be collected easily in Australia, but it would seem that there should be sufficient to produce several tons annually. The discovery of how the manna or exudate is produced and of how to induce its formation in the tree at will, appears to involve difficult botanical problems, outside the scope of a chemical division, but for which, nevertheless, solutions are needed before this source of mannitol could be regarded as an assured one.

(iv) *Saffron Thistle Oil.*—The character and composition of this oil have been determined and published.

(v) *Investigations in Catalysis.*—(*a*) *Catalytic oxidation of ethylene to ethylene oxide.*—The preliminary examination of the changes in the yield of ethylene oxide brought about by variations in the principal factors affecting the reaction has now been completed. In order to obtain further knowledge of this reaction and of its scope, the study has been extended to some simple substituted olefines. Further advance in improving this synthesis must involve the suppression of the reaction leading to complete oxidation of the ethylene, and requires a more thorough knowledge of the mechanism of the reaction.

(*b*) *Catalytic dehydration of 2, 3-butanediol to butadiene.*—The results of the first study of the direct dehydration of 2,3-butanediol to butadiene were described in the previous report. It was shown that yields of butadiene could be obtained from this reaction which might make it possible to side-step the lengthy acetylation and deacetylation processes. Again, the result of efforts to increase the yield still further has led to the conclusion that such could be achieved only by closer study of the mechanism of the reaction.

Both of these investigations have thus become fundamental studies in the field of heterogeneous catalysis and it is planned to continue along these lines.

(vi) *Furfural Production.*—The laboratory work has been designed to give a clearer conception of the conditions prevailing in a large-scale plant during the process of liberating the furfural from the pentosan material (oat hulls, corn cobs) in a pressure digester. Especial attention has been given to the equilibria existing between vapour and liquid for the complete range of furfural-water mixtures at pressures from 70 to 140 pounds per square inch.

(vii) *Ketone Waxes.*—A satisfactory batch method for the ketonization of higher fatty acids was worked out some time ago. The ketones can be used as cheap waxes and waterproofing agents. The major difficulty to be overcome was the association of a sudden evolution of carbon dioxide with uncontrollable frothing. Examination of the mechanism of ketonization has given the reason for this sudden liberation of carbon dioxide and shown the factors which control frothing.

(viii) *Insect Repellents.*—A number of organic compounds have been synthesized and submitted to the Division of Economic Entomology for assessment of their value as mosquito repellents and as activators in fly sprays. These compounds are all closely related to chemicals present in certain Australian essential oils and had been found by the Division of Economic Entomology to be effective as mosquito repellents (see Eighteenth Annual Report).

(ix) *Synthetic Resins.*—(*a*) *Aniline formaldehyde resins.*—These are useful synthetic resins which could easily be manufactured in Australia. Articles moulded from them possess some considerable advantages over phenol-formaldehyde resins, but as moulding materials they have defects which have restricted their use. Attempts have been made to overcome these defects, the chief of which are the poor flow properties of the heated powder and the lack of a pronounced thermo-setting character. A little progress has been made, but it seems likely that means of eliminating these defects will become apparent only when the chemistry of resin formation is better understood.

(*b*) *The testing of plastics.*—The Standards Association of Australia is considering the setting up of Australian standard methods for testing plastics. The weaknesses of both British and American tests were made manifest during the war when a limited amount of specification testing was undertaken here for the services. Since then, systematic tests of certain specifications have been made to determine whether British or American procedure should be followed or whether modifications are desirable. The water absorption of phenolic resin mouldings has been examined in detail.

It has been shown that the assessment according to specification is sensitive to factors affecting the moisture contents of moulding powder or moulded specimen. The existing specifications do not adequately control conditioning of the specimens and place no restrictions on the treatment of powders before moulding. The standard test does not measure the amount of water absorbed at saturation, and being empirical gives comparable rates of penetration only when similar materials are used.

11. *Biochemistry Section.*—(i) *Fellmongering Research.*—Contact with the fellmongers has been strengthened during the past year by the distribution of the first of a series of "Circulars to Australian Fellmongers" These will contain brief comments on current investigations not sufficiently advanced to warrant publication. They will also refer to short-term experiments not reported elsewhere and to proposals for further research. The first of the series was released in January, 1946, and it is proposed to issue others at six-monthly intervals.

(*a*) *Wool loosening by sweating.*— Isolation and characterization of bacteria from local and overseas sheepskins has been continued during the year with the object of identifying causes of pelt damage and of detecting new species which loosen the wool. The control of temperature during sweating has been strongly advocated in Council for Scientific and Industrial Research publications and it is gratifying to learn that in fellmongeries where refrigeration and other temperature control equipment has been installed, the quality of the pelts has been improved and the incidence of pelt damage has been appreciably reduced.

(*b*) *Wool loosening with depilatories.*—Attempts to devise a lime-free paint have led to the development of a modified painting process which shows considerable promise. The method involves soaking the skins in a dilute solution of soda ash before painting with a solution of sodium sulphide thickened with kieselguhr. Soaking in the alkali solution raises the pH value in the skin tissues to approximately 11 at the level of the wool roots. At this alkalinity the sulphide-reduced keratin in the wool roots is dispersed and the wool can be easily pulled. Measurements of tensile strength and dye absorption tests, together with reports of examination by wool experts, indicate that the wool is undamaged in this process, and the pelts yield satisfactory basils on tanning. It is possible that the additional handling required in soaking the skins in alkali may hinder the adoption of the method in the fellmongery for treating green skins, but it would be particularly suitable for treating dried skins since they normally require double soaking and therefore no additional handling would be involved. Moreover, alkali hastens the penetration of water into dried skins and thereby shortens the soaking period. Attempts were made to increase the pH value in the tissues by incorporating alkalis other than lime in the paint, but such procedures were liable to damage the pelt.

Variations in the ease of penetration of sulphide and hydroxyl ions through different areas of the sheepskin have been clearly demonstrated. Studies have been undertaken to correlate wool-loosening by alkalis and reducing agents with their swelling and digestion of the bulb and the shaft of the wool root. A method is being developed for the estimation of sulphydryl groups in wool for use in assessing the wool damaging action of various chemical and physical agencies.

(*c*) *Recovery of wool from skin pieces.* — Further attention has been given to the production of a mould protease and its use in the recovery of wool from skin pieces. The mould is grown on 250 lb. of sterilized bran spread on trays in a large air-conditioned cabinet. Towards the end of the four-day incubation period, the bran culture is allowed to dry and the dry mouldy bran stored until required. The protease is extracted with water when required and the extract employed at 40° C. in 100 gallon tanks arranged on the counter current system, to digest the skin tissues in heads, shanks, and skin pieces which have been previously shrunk at 70° C. The many difficulties which arise when operations are translated from a laboratory scale to a pilot plant scale are being negotiated with the help of the Chemical Engineering Section.

Laboratory work to assist in the development of the new process, has been largely concerned with studies of the denaturation of the collagen. This fibrous protein must be thoroughly denatured or shrunk in order to render it susceptible to proteolysis, and methods have been developed to achieve this shrinkage at lower temperatures. In the course of this work new protein denaturants have been found which may have application in other biochemical fields, and much evidence has been accumulated to emphasize the importance of the salt linkage in maintaing collagen in the native unshrunken condition.

(ii) *Fermentation Research.*—This year it has again been necessary to restrict attention to established fermentation processes.

(*a*) *Lactic acid.—Lactobacillus bulgaricus* has been grown in hydrolysed flour for the production of lactic acid. This hydrolysate is likely to be used in certain parts of Australia so that lactic acid production can be maintained when cheese whey, the substrate normally employed in this fermentation, is in short supply or no longer available. Improvements in the rate of fermentation have been effected by enriching the medium with inorganic salts. The beneficial effect of adding materials containing bacterial growth factors has also been demonstrated.

(*b*) *Power alcohol.*—Using various concentrations of sucrose and yeast no significant improvement due to agitation under anaerobic conditions was revealed in large-scale experiments. Agitation was effected by means of a stirrer in a stationary vessel in some experiments and by use of a rotary fermenter in others.

(*c*) *2, 3-Butanediol.*—In the fermentation of wheat mash by *Aerobacillus polymyxa* for the production of 2, 3-butanediol inhibition occurs when the medium is enriched with molasses, whereas enrichment by sucrose has no repressive effect. The inhibitor occurs partly in the ash of the molasses and partly in its organic matter. Precipitation methods have been developed for the removal of the organic inhibitor. A low temperature vacuum-drying assembly has been employed to dry cultures of various strains of *A. polymyxa* isolated from Australian soils. In this condition the organism can be stored without serious loss of activity. One of the principal enzyme systems of *A. polymyxa,* formic hydrogenlyase, has been studied using the Warburg manometer. The conditions for cultivating the organism for optimum production of the enzyme have been established and several enzyme inhibitors have been demonstrated. Washing the cells readily removes one of the essential components of the hydrogenlyase system and studies are in progress to determine its nature.

12. *Chemical Engineering Section.*—(i) *Pilot Plant Production of Chromic Anhydride.*—The pilot plant investigation of the process developed by the Minerals Utilization Section for producing chromium compounds from Australian chromite ores has been continued. The investigations have permitted the determination of satisfactory conditions and the development of satisfactory equipment for most of the unit processes involved in the preparation of chromic anhydride. Some chromic anhydride has been produced in the pilot plant.

(ii) *The Pilot Plant Production and Purification of Furfural from Agricultural Waste.* — During the year a pilot plant capable of digesting 200-250 lb. of oathulls and producing 30 lb. of distilled furfural per batch has been operated to permit the collection of data necessary for the rational design of a commercial production unit. Most of the necessary data have now been collected and are being assembled for publication. Active interest in this developmental work has been shown by a number of private companies.

(iii) *The Production of Non-felting Woollen Goods by the Freney-Lipson Process.*—The results of the pilot plant investigation of this process are awaiting publication.

(iv) *The Production of Rare Earth Oxides from Monazite.*—The results of this pilot plant investigation are awaiting publication.

(v) *The Pilot Plant Investigation of an Enzyme Process for the Recovery of Wool from Sheep Skin Pieces.*—The pilot plant investigation of this process developed by the Biochemistry Section is proceeding. Fairly satisfactory conditions have been determined for the growth of the mould from which the enzyme is extracted. Some work has been done on the digestion of the skin protein on a pilot plant scale.

(vi) *Vapour Condensation Investigation.* — Preliminary work has commenced on an investigation of the condensation of vapour molecules on cooled surfaces with the object of determining the reason for the high rates of heat transfer occurring during dropwise condensation.

(vii) *Minor Investigation.* — During the year a minor investigation on the pilot plant preparation of aluminium-ethylate for use with oleic acid as a fuel thickening agent was completed.

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

Alderman, A. R., Gaskin, A. J., and Vivian, H. E. (1945). — A qualitative test for cement-aggregate reaction. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 433-40.

Cornelius, H. S., and Stephens, H. A. (1946).— Foundry sand resources of South Australia. Coun. Sci. Ind. Res. (Aust.), Bull. 190.

Ellis, W. J. (1945).—A note on sterol production by *Aspergillus flavus-oryzae* with special reference to its anti-rachitic potency. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 314-7.

Ellis, W. J., and Lennox, F. G. (1946).—Euphorbain: A protease occurring in the latex of the weed *Euphorbia lathyrus*. *Biochem. J.* 31: 465.

Fookes, R. A. (1946).—An apparatus for measuring the tensile strength of wool fibres. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 195-9.

Hackman, R. H. (1946).—The preparation of some emulsions containing DDT. Ibid. 19: 77-95.

Hall, M. N. A, Martin, S. L. H., and Rees, A. L. G. (1945). — The solubility of hydrogen in zirconium and zirconium-oxygen solid solutions. *Trans. Farad. Coc.* 41: 306.

Hatt, H. H. (1946).—Alcohol: Its place in synthetic organic chemical industry. Coun. Sci. Ind. Res. (Aust.), Bull. 187.

Hatt, H. H., and Reid, H. (1946).—New compounds. *Aust. Chem. Inst. J. Proc.* 13: 204.

Hatt, H. H., and Troyahn, W. J. (1946).—The seed oil of the saffron thistle (*Carthamus lanatus* L.) *J. Coun. Sci. Ind. Res.* (Aust.) 19: 86-95.

Hills, G. Loftus (1946).—Some theoretical aspects of the "New Way" butter process. *Aust. J. Dairy Tech.* 1: 43.

Hills, G. Loftus, and Conochie, J. (1945).—The oxidant effect of commercial salt in fats and oil. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 355-65.

Hills, G. Loftus, and Conochie, J. (1945).—Measurement of the gas content of concentrated butter and other fat products. Ibid. 18: 366-72.

Lord, M. P., and Rees, A. L. G. (1946).—The behaviour of zinc sulphide phosphors under conditions of periodic excitation. *Proc. Phys. Soc.* 58: 280.

Lord, M. P., and Rees, A. L. G. (1946).—Note on the rapid determination of decay characteristics of luminescent solids. Ibid. 58: 289.

Mercer, E. H., and Rees, A. L. G. (1946).—Structure of the cuticle of wool. *Nature* 157: 589.

Mercer, E. H., and Rees, A. L. G. (1946).—An electron miscroscope investigation of the cuticle of wool. *Aust. J. Exp. Biol. Med. Sci.* 24: 147.

Morell, D. B., Conochie, J., and Hills, G. Loftus. (1946).—Determination of the oxygen content of fats and oils. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 190-4.

McTaggart, F. K. (1945).—Mineral chlorination studies. 2. — The production of phosphorus oxychloride by direct chlorination of phospate rock. Ibid. 18: 424-32.

Plante, Enid C. (1946).—Emulsions and emulsifying agents with special reference to DDT. *Aust. J. Sci.* 8: 111.

Scott, T. R. (1946).—The determination of silica in the presence of fluorine. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 103-16.

Scott, T. R. (1946).—Anomalous behaviour of fused cryolite. *Nature* 157: 480.

Scott, T. R., and Dixon, P. (1945).—A colorimetric method for the determination of uranium in leach liquors. *Analyst* 70: 462.

Sutherland, K. L. (1946).—Flotation machine efficiency. *Eng. and Min. J.* 147: 84.

Urie, R. W., and Wylie, A. W. (1946).—Glass polishing with rare earth oxides. *Chem. Eng. and Min. Rev.* 38: 125.

Walkley, A. W. (1946).—The significance, measurement, and control of hydrogen ion concentration. Coun. Sci. Ind. Res. (Aust.), Ind. Chem. Circ. 5.

Winfield, M. E. (1945).—The catalytic dehydration of 2, 3-butanediol to 1, 3-butadiene. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 412-23.

XVI. RADIOPHYSICS.

1. *Introduction.*—The return of peace-time conditions has brought to an end the major part of the work carried out by the Division of Radiophysics for the Australian and Allied Armed Forces. During the past year it has been possible to transfer the Laboratory's efforts to the prosecution of more fundamental researches and to the application of techniques developed under stress of war to the peace-time needs of Australia. In returning to the pursuit of fundamental problems in radio and radar, emphasis has been placed on researches into the propagation of radio waves, atmospheric physics, and vacuum physics. Radar has at least as many applications to the peace-time activities of mankind as in war, and in selecting the applied problems to be investigated in the Laboratory, preference has been given to those which are likely to prove of most use to the people of Australia and which promise to be fruitful in opening up still further fields of investigation of a basic character.

2. *Propagation of Radio Waves.*—Perhaps the outstanding example in radio of the importance of academic investigations is provided by studies of

the propagation of radio waves. It was known for many years that long-distance short-wave communication took place via the ionosphere. Investigation of the properties of the ionosphere was carried out purely for scientific purposes, but the results obtained were applied with conspicuous success to the practical solution of many military communication problems, while the methods of investigation which were used led directly to the development of radar itself.

The extension of the electro-magnetic spectrum to the ultra high frequency region during the war revealed that propagation at these frequencies is affected to a marked extent by the properties of the lower atmosphere. A new field of investigation known as "superrefraction" has therefore opened up; it promises to be at least as fruitful as the ionospheric work of previous years.

(i) *Superrefraction.*—During the war, the main objective of superrefraction investigations was to assist the Services in appreciating the influence of the phenomenon on their detection and communication equipment, in deducing the probable effect on enemy equipments, and in attempting to forecast its occurrence from a knowledge of meteorological conditions. The studies can now turn to more basic aspects of the problem, and the Laboratory is at present engaged upon them.

(*a*) *Experimental investigations of special phenomena.*—The type of superrefraction which has received greatest attention overseas, both from an experimental and theoretical point of view, is that which arises when relatively warm dry air passes from a land mass out over a cool sea. A survey of Australian conditions shows that many other effects occur in warm temperate regions, two of special importance to Australia being—

The radiation inversion which occurs inland at night. This inversion is known to exist here but its magnitude and intensity have never been investigated, while its influence on radio and radar propagation is completely unknown.

The coastal front which exists in summer over most of the coast of Australia south of latitude 30° and is particularly noticeable over the coast of New South Wales. It is important both from the point of view of its effect on the propagation of radio waves and because it appears to be the major meteorological factor influencing Australian weather in coastal regions during the summer.

During the past year, effort has been concentrated on the construction of equipment for the experimental investigation of these phenomena. It consists of:—Temperature and humidity measuring equipment for use with balloons and kites, and the associated measuring equipment on the ground; temperature and humidity measuring equipment for use in aircraft with a recording camera for automatically photographing instrument readings; light-weight ultra high frequency transmitting and receiving equipment for determination of propagation conditions over a given path.

Experimental investigation of the "radiation inversion" is proceeding at Hay in New South Wales, and activities during the winter months will be confined to this problem. During the summer it is planned to continue the investigation of the New South Wales "coastal front", for which purpose an aircraft has been made available by the Royal Australian Air Force. As it is thought that the "coastal" effect exists for many hundred miles out to sea, a flying boat has also been promised by the Air Force in order that the measurements can be completed in the seawards direction.

(*b*) *Survey of superrefraction in and around Australia.*—During the war, a programme of regular observations of superrefraction was carried out over a widespread area by the Armed Forces at the request of the Radiophysics Laboratory, and as a result a fairly complete set of data has been obtained from which the incidence of superrefraction in and around a large part of Australia can be determined. The study has involved the reduction and analysis of an enormous number of results, and it has shown that the frequency of occurrence and the intensity of superrefraction in these regions is greater than in England and also that many different mechanisms are involved. A report on these studies in course of preparation is likely to provide a sound basis for future superrefraction studies in Australia.

(ii) *Scattering of Radio Waves by Water Drops.*—In the operation of microwave equipment it has been found that heavy storms can be detected at distances up to more than 100 miles because of scattering from water drops or ice particles in the clouds themselves. Theories of water drop scattering have been worked out, but there is poor correlation with experiment, and the exact mechanism of reflection is incompletely understood. The phenomenon is of direct interest to the forecasting meteorologist, is important in the study of the propagation of radio waves, and, when the process of scattering is more fully understood, it will furnish a powerful method for the study of cloud structure, air flow, turbulence, formation of convection currents, squalls, fronts, and the like.

To obtain experimental data on cloud echoes, radar sets operating on wavelengths of 3 and 10 centimetres have been installed on the roof of the Radiophysics Laboratory. Observations on rain and storm clouds are made at regular intervals, and when interesting examples are observed the radar screen is photographed at slow motion for subsequent analysis. Liaison is being maintained with the Weather Bureau in Sydney. Other developments are in hand in the Laboratory which will allow this information to be broadcast in pictorial form to any bodies interested in short-term forecasting of storm movements—the Weather Bureau, Civil Aviation authorities, &c.

The work is being extended to include observations of drop size and particle type in the clouds themselves. These observations will be made in an aircraft flying through the storm areas. The Royal Australian Air Force has indicated its willingness to co-operate by supplying a rugged aircraft for this purpose.

(iii) *Solar and Cosmic Noise.*—It has been known for some time that it is possible to receive radio noise from the sun when the aerial of a radar receiver is pointed in that direction. Early measurements on short wavelengths indicated that the noise was of the same order as that expected from a black body at the sun's surface temperature of 6000° K. Later observations on metre wavelengths brought to light the fact that on these wavelengths the noise was considerably greater than expected and that there were occasional variations with time. The Radiophysics Laboratory was able to show that these variations are closely associated with sunspot activity and in fact correlate directly with sunspot area. Measurements of the precise locations of the noise source within the sun's disc have also been carried out and they have been shown to coincide with the observed position of sunspots.

In all, three distinct phenomena have been distinguished on a receiving frequency of 200 Mc/s. The first of these is the reception of a steady day-to-day excess noise level whose origin is almost certainly thermal in character coming from a source at a steady temperature of a million degrees absolute. The evidence suggests that the noise comes from the sun's corona, the observed temperature agreeing closely with a number of other estimates of the temperature of the corona. The second phenomenon is the appearance

of short bursts of noise of a few seconds or minutes duration at an intensity which indicates their origin in an electrical discharge phenomenon. These bursts are probably associated with solar flares or prominences in the corona, but in spite of careful observation no visual confirmation of this hypothesis has yet been obtained. Finally, there is the general increase in noise level during periods of sunspot activity referred to above. It is possible that this noise has its origin also in electrical discharges as in the case of the bursts.

Close collaboration is being maintained with the Commonwealth Observatory at Canberra, and equipment has been made available to officers there in order that they may make radar observations in parallel with their solar observations. The work is being extended to the reception of noise from other parts of the universe, certain galaxies being prolific sources of radiation similar to that from the sun; it is thought to be of the same character and to have its origin in similar effects.

(iv) *Noise Level Due to Atmospherics.*—The lack of even an approximate idea of the noise level due to prevailing atmospherics at many points on the earth's surface became apparent in the operation of communication networks during the war. It is essential to have this information before a reliable communication circuit can be laid down between any two points. With the co-operation of the Services, an extensive series of measurements of noise levels at representative points throughout Australia has been made and the results of the analysis made generally available.

(v) *Ionospheric Work.*—At the request of the Services, an analysis has been made of the results obtained from a year's operation of the chain of Loran stations in north-west Australia. The results of the analysis have been of practical importance in connection with the operation of this navigational system in Australia and have also yielded interesting information on the behaviour of the E region of the ionosphere at Loran frequencies.

The Radiophysics Laboratory has undertaken the construction of additional ionospheric recording equipment required by the Australian Radio Propagation Committee. The first of these has been completed, and two others are in an advanced stage of construction. Assistance has also been given to the Royal Australian Air Force in calibrating automatic recorders which had previously been delivered.

(vi) *Theoretical Work Associated with Radio Wave Propagation.*—A Mathematical Section was recently formed within the Radiophysics Laboratory. It is intended largely as a pure research section for the study of problems connected with the propagation of radio waves and partly as a section to deal with other theoretical problems which may arise within the Laboratory.

A computing staff has been assembled and is undergoing training in computing and numerical processes of an analytical character. The Section is equipped with a number of calculating machines which will be increased in number and broadened in type to facilitate more rapid calculations. Co-operation is being maintained with the Division of Electrotechnology on the design and construction of a differential analyser.

Work in progress at the present time consists of a comprehensive theoretical study of superrefraction under conditions of ground-based trapping. These studies will be extended to problems of atmospheric circulation, to certain branches of electro-dynamic field theory and possibly to the propagation of waves in the upper atmosphere. The Section works in close co-operation with others dealing with the practical aspects of wave propagation and particularly in conjunction with the Radio Meteorological Section in the study of coastal circulation and the formation of radiation inversions at night.

3. *Vacuum Physics.*—During the war, techniques appeared which opened up entirely new fields of investigation in the centimetre wave region. It is now clear that an equally important field of investigation awaits development in the millimetre wave region. It is important not only from the point of view of practical application but more particularly in relation to studies of the molecular state, since many molecular resonance phenomena occur in this wavelength range.

With this main end in view, laboratory facilities for research in vacuum physics have been set up during the year, and a well-equipped vacuum laboratory is now available, housed for the time being in the University's Department of Electrical Engineering. Pending the commencement of work in the millimetre field, effort is at present concentrated along the following lines:—

(*a*) *Gas discharge work.*—Little systematic research in electrical discharges of gases at very high frequencies has so far been carried out. A knowledge of the behaviour of gases at such frequencies is not only of fundamental interest but is likely to be important in problems connected with the generation and detection of millimetre waves. Equipment has been set up and measurements begun on the field strength necessary to initiate a discharge at microwave frequencies in a gas of various pressures.

(*b*) *Acceleration of elementary particles.*—There are a number of ways in which the techniques developed for radar can be applied to particle accelerators of the cyclotron and betatron variety. A study of the problem has shown that the pulse technique can more readily be applied to the linear accelerator than to any other, and there are indications that this is likely to produce a device of performance comparable to a moderately sized cyclotron but of simpler and cheaper construction. The importance of such a machine for the acceleration of elementary particles cannot be overemphasized, either as a tool for nuclear research or as a method of producing radio-active materials. The work in this field consists of:—

(1) *Single acceleration of electrons.*—Using a single resonant cavity excited by the output of a readily available radar transmitter, electrons have been accelerated to a velocity corresponding to an energy in excess of half a million electron volts.

(2) *Multiple acceleration of electrons.*—As an extension of the above activities, experiments are proceeding on a multiple cavity resonator which is expected to produce electrons of still higher energies. By this method there is a good possibility of producing electrons of some ten or twenty million electron volts.

(3) *Acceleration of protons.*—Similar principles can be applied to the generation of high energy protons, but owing to their greater mass, trouble is experienced in the initial acceleration. Several alternative methods of doing this are being investigated and, once a sufficiently high starting velocity has been achieved, further acceleration will be relatively simple.

(4) *Production of high voltage X-rays.*—The ease with which high energy electrons are produced by this process suggested its adaptation to the production of a high voltage X-ray machine. It would have the same advantages of economy and small size and, furthermore, would be stroboscopic in action, thus allowing radiograms of moving machinery to be obtained. The design of a million volt stroboscopic X-ray machine along these lines is well advanced.

4. *General Radio and Radar Research.*—The foregoing propagation and vacuum researches cover the

bulk of the more academic studies associated with radio and radar. Allied with them are many aspects of circuit theory and general experimental work which are equally important. They involve basic improvements in the design of aerials, radio frequency parts, methods of generating very short pulses, receiver and display systems, &c., and a section of the Laboratory is continuously working on these problems.

Test Room.—A comprehensive range of test equipment has been obtained for the use of the Laboratory. Existing accuracies are checked and calibrated at regular intervals and laboratory testing services supplied where necessary.

Establishment of High Frequency Standards.—The design of test and measuring equipment and the establishment of standards did not keep pace with the great extension of the frequency spectrum which occurred during the war. A programme of work to establish standards and testing procedures in the high frequency region has therefore been initiated. It is being undertaken in collaboration with the Division of Electrotechnology which body will ultimately be charged with responsibility for the establishment and maintenance of such standards.

5. *Radar Aids to Civil Aviation.*—Until recently Australia played little part in the research and development associated with navigational aids to civil aviation. The importance of the whole problem to methods of transportation to be used in this country in the future and the existence of a radar laboratory now provide an excellent opportunity for valuable activity in this field.

An Aviation Radio Research Committee has been established under the auspices of the Council to deal with matters arising from Empire and international conferences on navigational aids, and to advise the Council for Scientific and Industrial Research on the research and development programme which might be followed. The Committee has operated for fifteen months and has sent representatives to the First, Second, and Third Empire Civil Aviation Conferences in London, Toronto, and London, respectively, and to the United States Army Air Force Conference in Washington. Representatives will also be sent to the Technical Conference of the Provisional International Civil Aviation Organization at Montreal and to the Fourth Empire Conference which will precede it.

The research progamme recommended to the Radiophysics Laboratory has resulted in the design, construction, and preliminary test of four devices particularly suited to the solution of certain problems of civil aviation in Australia. These have resulted from the application of well-known techniques, but nevertheless many new fields of investigation have been revealed. The programme is largely complete from the Laboratory's point of view and the equipment is in the process of being handed over for trial by the Department of Civil Aviation. The separate items under this heading are as follows:—

(i) *Distance Indicator.*—One of the obvious applications of radar to civil aviation is the provision of a device by means of which a pilot may read off the distance of his aircraft to or from a selected airport. An equipment called the Distance Indicator has been designed for this purpose; it displays distance in miles to the selected point on a meter on the pilot's dashboard. It has been adopted for use by the Australian Department of Civil Aviation, and arrangements are being made for the installation of a complete system for trial between Sydney and Melbourne. The ground stations are nearing completion, and airborne units will be supplied to commercial aircraft flying the route so that trials may be carried out under operational conditions.

An additional airborne unit is being installed on a flying boat on the Sydney-London service to obtain experience in the operation of the device on the Empire route. When it arrives in England, the equipment will be handed over to a British radar laboratory for examination and further test. It will then be included as the Australian contribution to the demonstrations of navigational aids being given in the United Kingdom to international civil aviation delegates in September, 1946.

(ii) *Multiple Track Radar Range.*—The method of airline navigation in use in most parts of the world is the radio range which defines a track in and out of an airport to a distance of some 80 or 120 miles, depending on flying height. Existing systems suffer from a number of deficiencies, the two most serious being their failure to define an adequate number of tracks and their dependence on the careful siting of the transmitting station. This latter is a disadvantage which is seen at its worst in mountainous terrain. A requirement therefore exists for a new type of range which is comparatively site-independent and defines a large number of radial tracks about a central point.

To meet this requirement, a proposal has been made in Australia for a pulsed radar range whose characteristics depend only on the time of transmission of radio waves. Since time of transmission is independent of site and not influenced by propagation conditions to a noticeable extent, the system is free from site errors. Furthermore, it is possible to define as many as sixty tracks into or out from an airport, distributed over most of the 360 degrees. A complete system along these lines has been developed in the Laboratory and has been the subject of flight tests for many months. It has proved extraordinarily successful and compares favorably with other systems developed overseas. An invitation has been received to demonstrate it in North America before delegates of the Technical Conference of the Provisional International Civil Aviation Organization, and plans have therefore been made to set up a station at Ottawa for the purpose.

Until international agreement has been reached on the future form of this type of aid, it is not possible to proceed with large scale installation in Australia. The Department of Civil Aviation has agreed, however, to undertake operational trials of the system, and stations are being installed at Melbourne, Sydney, and an intermediate point for this purpose. Six airborne units which will be used for trial in both test and commercial aircraft, are being constructed.

(iii) *Airways and Airport Control.*—The safe and efficient operation of airlines depends largely on the adequacy of the ground organization. With increases in traffic density it is becoming more and more necessary that the position of all aircraft be definitely known to the ground organization. This type of information can readily be provided by adaptation of military air-warning techniques. The problem divides naturally into two parts, one of plotting aircraft positions while they are flying the main air routes, and that of close supervision while leaving or arriving at a terminal airport, particularly under conditions of poor visibility. These two requirements are met by radar systems called Airways Control and Airport Traffic Control respectively.

(*a*) *Airways Control.*—The Airways Control system consists of a high power radar set which is placed at a site chosen to give the best possible coverage of the air routes surrounding the area being served. Indications of the plan position of aircraft from this radar set are relayed by radio link to the airport control centre for the use of the flight checking officer. Work on this project is well advanced, and experimental trials with

a laboratory model have demonstrated the feasibility of the scheme. It is intended to install a complete system for user trials at Mascot Aerodrome.

(*b*) *Airport Traffic Control.*—The Airport Traffic Control system consists of a small radar set placed on the airfield itself, having sufficient performance to detect aircraft up to a range of fifteen miles. The display, again a plan position indicator, is relayed by cable connexion to the control tower where the traffic control officer makes use of the information to supervise the departure and landing of aircraft. An experimental set of this type has been operating satisfactorily at Mascot for some time, and work is now proceeding on the installation of a display system in the control tower for full operational trials.

6. *Radar Aids to Ground and Aerial Survey.*—The chief contribution which radar can make to existing ground and aerial survey work is the direct measurement of distance between two points. The measurement is accomplished by determining the time of transmission of radio waves between the points, which may be separated by a distance not exceeding the line of sight. Using very refined methods, the timing accuracy can be as good as 1 in 10^9 (that is a few feet in a million miles), but in practice the accuracy of measurement is limited by atmospheric conditions to nearer 1 in 10^5. This is not quite as good as can be achieved by standard surveying methods over short distances, and radar is therefore unlikely to replace them in their present form. The cases where the most valuable contribution can be made are those in which the determination is made over a distance of from 100 to 250 miles at the one time. This can be done when the reference point is on the ground and the measuring point is in an aircraft at some considerable height.

The Laboratory's programme of work on aids to surveying consists of observations of the precision with which small time intervals can be measured and of the influence of atmospheric conditions on the propagation of radio waves. These points are being investigated theoretically and by a continuous measurement of distance from the Laboratory to a beacon on the Blue Mountains approximately 50 miles away. Its distance can be measured to an accuracy of ± two yards in a single observation, and with further developments it is expected that this will be improved five or ten times.

Work is also proceeding on the practical application of these techniques to surveying in Australia. Perhaps the most important of these is the simultaneous measurement in aircraft of distance to two ground beacons which may be separated by as much as 500 miles. It will, for example, allow the distance from Sydney to Melbourne to be measured in a single observation to the precision quoted above. The importance of this application is that very long-base triangulation can be carried out over large tracts of Australia, fixing relative position in a manner which could not be obtained in any other way.

A second important application is the ground control of photographic survey aircraft, which is accomplished by measurement of distance to two ground beacons in known locations every time a survey photograph is taken. The application of this method depends on the procurement of certain equipment from overseas; when it is received, the Laboratory will proceed to modify it for this purpose. It has been calculated that this aid alone can save a total of £1,250,000 in the national survey of Australia during the next five or ten years.

7. *Work for the Services.*—The work of the Laboratory for the Armed Forces has been considerably reduced since the end of hostilities. In the last years of the war, a developmental programme had been initiated to design and produce a high-power radar set on a new frequency capable of giving air warning at maximum ranges and a direct measure of the height of the aircraft. It involved development of the radar system and the necessary test equipment to cover the new frequencies contemplated.

By the end of the war the Laboratory was well advanced on the production of well-engineered prototype equipment, and had provided full technical information and assistance to Messrs. Amalgamated Wireless Australasia Limited who were selected to undertake quantity production of the set. At the end of the war, the Royal Australian Air Force requested that this work should proceed to the completion and demonstration of two stations only.

All the radar units for one station have been completed, and the second set of units is in an advanced stage of construction. Construction of the aerial system and huts has been carried out to the Laboratory's basic design by the New South Wales Government Railways, and tests on a completely assembled station will have begun before this report is printed.

8. *Publication of Information on Radar.*—The wartime work of the Laboratory was of a secret character, and open publication of the results was prohibited. During those years, a total of no less than 270 scientific reports and 230 technical reports was written. They were distributed to the Armed Forces in Australia and overseas, to industry, and to the Allied laboratories engaged on similar work. The volume of written material was such that it justified the establishment of a special Publications Section within the Laboratory for the preparation of reports in a uniform style.

At the end of the war, secrecy lapsed and the majority of these reports can now be more widely circulated. Plans have been made to re-write and publish the best work through the usual channels, and it may be expected to appear during the course of the next few years.

In order to bring the mass of scientific and technical information on radar before the greatest number of people in a compact form, considerable effort has been expended during the past year in writing a textbook of radar. It is of a standard suitable for graduate and research students of universities and technical colleges, research and development engineers in industry, &c. It is being issued by a well-known publishing firm and will be released for sale to the public in 1946. In the absence of a similar work overseas, negotiations have also taken place for publication in the United States and the United Kingdom.

Another method which has been used with considerable success to make radio and radar information more generally known is the Symposium, one of which was held in December, 1945. It was attended by representatives of the universities, technical colleges, industry, other Divisions of the Council for Scientific and Industrial Research, &c., and a series of lectures and demonstrations lasting three days was given by members of the staff.

Finally, invitations were sent to the Australian universities for members of the staffs of their Physics and Electrical Engineering Departments to spend some part of their long vacation at the Radiophysics Laboratory. The offer was accepted by the Universities of Tasmania, Adelaide, and Western Australia, with encouraging results. The visits were effective in making more generally known the techniques with which the Laboratory has become familiar.

XVII. TRIBOPHYSICS.

The name of this Section has been changed from Lubricants and Bearings to Tribophysics; though the new title (from "tribos", rubbing), may at first sound unfamiliar, it is a fairly accurate description of the range of work that the Section covers.

Broadly speaking tribophysics is concerned with the study of what happens when solid surfaces rub against each other. The surfaces may be lubricated, as in a journal bearing, to reduce friction and wear, or one surface may be used, as in a lathe, to cut or abrade another. The field of tribophysics, therefore, covers a wide range of industrial and engineering processes, as well as a great deal of the everyday mechanics of life.

The problems being studied by the Section include such diverse subjects as breakdown of lubricants, wear in piston rings, fatigue in metals, hard rock drilling, and the performance of a journal bearing. With the cessation of war work, it has been found possible in addition to undertake a considerable amount of more fundamental chemical and metallurgical work on the mechanics of the sliding process.

The work on explosives, which began as a purely war-time project, has produced important developments of the theory of propagation of explosion in nitroglycerine, and is being continued. The muzzle velocity equipment described in earlier reports has been perfected and handed over to the Services. A device for the measurement of recoil pressures in Army field guns is now being completed.

Despite the great pressure on laboratory accommodation in Melbourne University, the Section, owing to the generosity of Professor Hartung, is still housed in the Chemistry Building. The work of the Section is assisted considerably by active co-operation with the University, in particular the Chemical, Metallurgical, Engineering, and Physics Departments which continue to give very valuable collaboration and to allow the Section the use of many of the University facilities. The Physics Department of the University of Adelaide is also giving valuable assistance.

Three officers of the Section are working with the Research Group for the Study of Physics and Chemistry of Rubbing Surfaces at Cambridge University, under the direction of Dr. Bowden. The two laboratories work in close collaboration, and there is complete interchange of results and ideas. It is hoped that in future there may be a continuous interchange of personnel. This should be of considerable value in training Australian research workers and maintaining close liaison with the latest scientific developments in Europe.

Although the Section functions as a single research group, its work can conveniently be classified under the following headings:—

1. *Lubrication and Friction.*—(i) *Mechanism of Boundary Lubrication.*—Work is continuing on the mechanism of boundary lubrication by surface-active compounds, such as fatty acids, soaps, alcohols, esters, and also hydrocarbons. As described in earlier reports, good boundary lubrication is attained by adsorption on to the sliding surfaces of a surface layer of these compounds, which may be only one molecule in thickness. Frictional measurements on artificially prepared molecular layers of these substances have been carried out in parallel with electron diffraction studies, in order to elucidate their action as lubricants. Some relationship has been found between the frictional properties of bulk lubricants, the friction obtained with mono- and tri-molecular layers, and the orientation of the layers as measured by electron diffraction technique. This applies particularly to the changes produced with increasing temperature.

An attempt is also being made to measure the degree of adsorption of surface-active compounds by measurement of the contact angle of lubricants on metal surfaces.

Compounds which contain "active" chlorine were found to give good boundary lubricating properties in solution in mineral oils, particularly with steel surfaces. This has been found to be due to the formation of an iron chloride film on the surface. Both ferrous chloride and ferric chloride films, artificially prepared on steel surfaces, produced excellent low friction properties, though it seems more likely that the ferrous compound is formed by the lubricants. However, slight traces of moisture completely destroy the lubricating properties and start corrosion.

The problem of finding a satisfactory boundary lubricant for silver surfaces has received considerable attention. Various fatty acids, soaps, solutions of acids and soaps in oil, sulphurized oils, oils containing chlorine, and colloidal graphite have so far been tried, but none reduced the friction sufficiently to be classified as a good boundary lubricant.

(ii) *Surface Damage and Wear.*—A new technique for measuring the extent of surface damage and metallic transfer between sliding surfaces has been developed, using radio-active tracers. If one surface consists of a radio-active metal and slides over an inactive surface, the amount of metal transfer can be measured by use of a Geiger counter or, more conveniently, by placing the previously inactive surface on a photographic plate and obtaining a "radio-autograph" of the radio-active metal transferred in sliding. The technique has been applied successfully with a lead sphere sliding on lubricated and unlubricated steel, copper, and lead. Minute detail of the track left by the passage of the slider, could be detected by this method; very appreciable differences were found between the behaviours characteristic of lubricated and unlubricated sliding.

(iii) *Wire-drawing Investigations.*—Some research on the lubrication of the wire-drawing process has been commenced, and two small testing machines for measuring die-pull are in use. A machine for dealing with larger quantities of wire to measure die wear is also being designed. In conjunction with this work an investigation on the frictional properties of die materials, such as tungsten carbide and diamond, is being carried out. One outstanding result from this work is that these hard materials sliding together have an exceptionally low friction even when not lubricated.

(iv) *Aero Engine Lubrication.*—The Section has co-operated in an investigation by R.A.A.F., M.S.L., and oil companies on the sludging and gumming of aero engine oils. "Topping up" with an oil different from the original oil sometimes causes excessive sludging, and a test was designed to ascertain the combinations of oils in stock which were incompatible in this respect. The test is being carried out on the four engines of a Liberator bomber in continuous use.

The Section has also assisted in collaboration with a commercial aviation company and several oil companies in an investigation into the improvement of piston ring performances, oil consumption, and cylinder wear in commercial aircraft, particularly during the running-in period.

(v) *Silicones.*—Considerable interest has been aroused recently overseas by the introduction of synthetic lubricants consisting of organo-silicon polymers together with a large number of other products of similar constitution, such as plastics, hydraulic fluids, synthetic greases, synthetic rubber, waterproofing compounds, &c. The most valuable property of these lubricants and greases is that their viscosity changes very little with temperature. In some cases one lubricant can operate satisfactorily over a temperature range of from −40° C. to 200° C.

Syntheses of some organo-silicon polymers are being carried out in the laboratory with a view to preparing the lubricants and examining the behaviour of these substances generally. Silicone compounds are capable

of forming mono-molecular layers on surfaces. The lubricating properties of films formed by mono-layers are also being determined.

(vi) *Single Cylinder Test Engine.*—Some work has already been published on the lubrication between the piston ring and cylinders of an internal combustion engine. The method used was to obtain a continuous cathode ray trace of the conductivity between the ring and cylinder. This gave a record of the extent of breakdown of the lubricant film. However, the results were of a qualitative nature only and applied mainly to the engine driven by an external motor. Alterations have been made in the installation to provide for better control of the variables with the engine running under power, and attention has been given to the question of engine efficiency so that the range of pressure variation in the cylinder will be the same as in a normal engine. With these improvements in the test engine it is hoped to place the results on a quantitative basis.

This work is being carried out in co-operation with the Division of Aeronautics.

2. *Surface-Active Compounds and Mechanical Properties.*—Recent overseas publications (particularly from Russia) have described the remarkable effect of surface-adsorbed compounds on the tensile strength and hardness of metals. The presence of adsorbed molecules reduces both these properties considerably. A preliminary investigation by the Section has indicated an effect on properties depending on the hardness of both metal and non-metallic surfaces, and the work is being followed up by tensile tests on single crystals of metals. Similar types of surface-active compounds are known to reduce metallic friction, and it is probable that there is a connexion between the two phenomena.

3. *Bearings and Bearing Metals.*—(i) *Problems Relating to Bearings.*—During the war the Section has collaborated actively with the staff of the Pilot Bearing Annexe of the Department of Aircraft Production. The purpose of the annexe was to develop techniques for the manufacture of the major types of aircraft bearings required by the Royal Australian Air Force. With the war over, such an annexe was no longer needed, and the equipment of the annexe foundry has been kindly made available to the Section by the Department of Aircraft Production. The Section will thus be well equipped to deal with problems concerning the future design and development of journal bearings.

The Section has continued to serve as a consultant on bearing problems encountered by industry, and several such problems have been successfully dealt with during the year. In addition, work of a more fundamental nature has thrown light on the cause of failure of bearing alloys in service.

(ii) *The Deformation of Metals by Heating and Cooling (Thermal Fatigue).*—An investigation into the cause of deformation produced in certain metals by heating and cooling has been completed, and a detailed report of the work is in course of publication. It has been shown that this deformation is limited to metals possessing a non-cubic crystal structure and occurs as a result of the anisotropy of thermal expansion inherent in these metals. This is of considerable significance in the casting and annealing of non-cubic metals. For example, it has been shown that it is not practically possible to obtain such metals in a completely undeformed condition. The extension of this investigation to embrace certain alloys has led to information which should prove of value in the selection of bearing alloys for severe service. Two papers describing the significance of the effect in bearing practice are in course of publication.

(iii) *Bearing Testing Methods.*—Electrical conductivity measurements between moving surfaces, using the cathode ray oscillograph as the means of obtaining a continuous record, have also been applied to the study of journal bearings. Results to date have been only qualitative and have not been correlated with friction. Some difficulties have been experienced in the design of a friction balance for this work, but design investigation is proceeding and it is expected that suitable equipment will soon be available.

4. *Wear.*—(i) *Wear Properties of Cast Iron.*—The main advance in this field has been in the evaluation of various methods of surface preparation used for producing clean metallic surfaces so that authentic figures for the wear properties of the metal can be obtained. A large number of lapping and grinding processes have been examined and rejected on the grounds of contamination or deformation of the surface. At present an electrolytic polishing method is being examined, and several new re-agents have been developed and tested for application in this work.

Concurrently, an investigation of the modes of occurrence of graphite in cast iron is being undertaken to ascertain whether there is any correlation between graphite distribution and the results of wear tests. Experiments on the recrystallization of carbon at high temperatures and pressures are also being carried out.

(ii) *Wear of Gun Barrels.*—An investigation into the wear in gun barrels in relation to frictional effects was carried out at the request of the Armament Research Department, Fort Halstead, England. Shells were forced through the barrel of a two-pounder gun under controlled conditions, and the barrel was then sectioned and examined microscopically.

It was established that during firing, frictional heating causes local hardening at certain points in the barrel, and this hardening contributes to subsequent wear of the barrel in service. This conflicts with the theory, generally held, that the heating and hardening are mainly caused by the hot gases following the shell.

(iii) *Abrasive Wear.*—The investigation into the mechanics of abrasive wear of sliding metal surfaces has been continued. It has been established that, for a given charge of abrasive, rate of metallic wear between smoothly sliding surfaces decreases rapidly to a constant value. Any slight mechanical disturbance of the surfaces greatly increases the rate of wear during subsequent smooth sliding. Abrasive action is now being studied microscopically.

5. *Metallurgy.*—(i) *The Deformation and Recrystallization of Duplex Alloys.*—A study has been made of the relative deformation and recrystallization characteristics of the phases in duplex (60-40) brass. An X-ray technique has been developed by means of which interesting differences in the behaviour of the two phases have been observed. Metallographic investigations have confined the results given by X-ray diffraction. This work will shortly be extended to other alloys in an attempt to determine the underlying general principles involved. Results should be of some significance in the working and annealing of industrially important complex alloys.

(ii) *Wear of Duplex Alloys.*—Parallel with the above work, an investigation is being made into the wear of alloys consisting of two or more phases. The preliminary experiments have been done on duplex (60-40) brass. The method of investigation involves the taking of a section at an acute angle along the track made by a spherical contact moving over a brass plate. The magnified section ("taper section") of the track cross section is then examined under a microscope at high magnification. The work will be extended later to steels and cast iron, in an effort to determine some of the factors governing the wear of these materials.

(iii) *Electrolytic Polishing of Metals.*—In recent years, methods of polishing metal surfaces by controlled dissolution of the metal in an electrolyte by

application of an electric potential have been developed overseas. These methods have found wide industrial application in England and America, where they are used to polish a wide range of ferrous and non-ferrous alloys. Electrolytic polishing methods have proved equally useful in fundamental metallurgical investigations.

In the Section, the work on electrolytic polishing has fallen into two parts. Firstly, apparatus has been constructed and used for the polishing of metal surfaces for research purposes, e.g. surfaces for frictional measurements and metallographic studies. Secondly, some attempt has been made to investigate the fundamental principles of electrolytic polishing. In addition, the Section has been frequently asked to advise on problems connected with the application of electrolytic polishing to industrial processes. A comprehensive index of papers on the subject has been prepared.

(iv) *Preparation of Metallic Single Crystals.*—A method has been developed for the preparation of single crystals of low melting point metals such as tin. These single crystals are required for work on the effect of lubricant films on the strength of metals (described elsewhere).

(v) *X-ray Diffraction Unit.*—In view of the increasing amount of X-ray work involved in the thermal fatigue and recrystallization projects, a small X-ray diffraction unit is being constructed. This unit will be simple in design and will use sealed-off tubes with four-tube windows allowing multiple exposures to be made. The power unit is capable of delivering a peak voltage of 100 k.v. It is hoped that the unit will be completed by the end of 1946.

6. *Flame Throwers and Blaze Bombs.*—Work continued during the year to improve the flame-thrower fuel mentioned in last years' report. Assistance has been given on methods of increasing production. The gelling agent used for the petrol was an aluminium oleate, prepared under closely defined specifications of moisture content, degree of unsaturation, Al_2O_3 content, free acid content, and percentage of sodium salts. Each of the above factors has a marked effect on the gelation properties and gel stability, and had to be carefully controlled.

An alternative method for gelation of petrol was also developed. The material used seems to be more easily prepared than aluminium oleate, and the conditions for successful manufacture are less critical. The Division of Industrial Chemistry had started pilot plant preparations of the material when the war ended.

Both aluminium oleate and the new material have been tested in large incendiary "blaze bombs" containing gelled petrol, at the request of, and in co-operation with, the Royal Navy and the Royal Australian Air Force. Both substances gave satisfactory results, and a modified aluminium oleate was produced for exclusive use of the Royal Navy. This work has now been discontinued.

7. *Explosives.*—Fundamental work on the mechanism of detonation in liquid explosives is being continued. The principal effects associated with the study of explosive substances are the initiation process and the propagation of the explosion which follows. Both these phenomena are being investigated.

(i) *Initiations.*—Earlier experiments had shown that in certain easily realizable circumstances the sensitiveness of liquid explosives is enormously increased by the presence of very small amounts of air. Experiments have been carried out in an apparatus in which it is possible to vary the pressure of air or to substitute other gases at known pressure. Comparison of the effects of air at different pressures, and of gases of different specific heats, has confirmed previous indications that the sensitivity effect of air is mainly due to adiabatic compression of one or more tiny air-pockets entrapped by the liquid during impact. The sensitivity of nitroglycerine has been studied under conditions of impact such that extreme care was taken to obviate the possibility of entrapping of air. In such circumstances it was found that the sensitiveness falls to a low figure.

(ii) *Propagation.*—The work on propagation has been devoted mainly, but not exclusively, to a study of the growth of the explosion through the first few centimetres of the explosive adjacent to the point where initiation is effected. Investigation of this phase of the explosion has hitherto been largely neglected. The passage of the explosive process through the material has been followed by means of a high-speed rotating drum camera specially adapted for the investigation. The results obtained are of considerable fundamental interest. It has been found that under suitable conditions the explosion begins at the comparatively low rate of 400 metres/sec. and then suddenly accelerates to 1,800 metres/sec. In other (reproducible) circumstances it begins at very high velocity (5,000 metres/sec. or greater), falls suddenly to 400 metres/sec. and then accelerates again to 1,800 metres/sec. A number of phenomena of great interest and complexity have been found to be associated with the sudden changes in velocity.

The rotating drum camera has also been used to examine the structure of the zone of detonation as it proceeds through the explosive, as well as the movement of the gaseous explosion products in the first instant after their liberation from the detonation zone. Some promising results have been obtained which may be of considerable theoretical interest on further elucidation.

A new revolving mirror camera with a greatly increased writing speed and higher resolving power than that of the present camera is in course of construction. This will enable a more detailed examination of the complexities of the propagation mechanism and of the structure of the detonation zone.

These experiments are of some practical interest from the point of view of rocket fuel research. It is intended to extend the work to substances more specifically associated with the rocket propulsion.

(iii) *Variation in Specific Heats of Gases under Rapid Compression.*—An investigation into the variation of the ratio of specific heats of gases under very high rates of compression is being carried out in parallel with the work on the initiation of explosion by adiabatic compression. The gas will be compressed very rapidly by means of a piston moving in a cylinder and the pressure and volume at any instant measured by electronic devices. The construction of the apparatus has been commenced, and it is expected that it will be ready for preliminary experiments within the next few months.

8. *Muzzle Velocity of Projectiles.*—The 70 ft. model skyscreens for the measurement of muzzle velocity were completed early in July 1945, and the initial trials at Fort Gellibrand proved successful. Preparations were immediately made for the calibration of the main armament of a battleship but, owing to the termination of the war, this was delayed for several months. The visit of H.M.S. *King George V.* to Melbourne in November, 1945, provided the first opportunity for a calibration, which was carried out very successfully. This was probably the first occasion in naval history on which the complete main armament of a battleship was calibrated while the ship was still at sea. A similar calibration was carried out in H.M.S. *Anson* in April, 1946. The P.C.C. (30 ft.) Equipment (Aust.) No. 2, Naval, mentioned in previous reports, has now been completed and units sent to R.N. Bases in England, Malta, Trincomalee, Hong Kong, and Sydney.

9. *Electronics.*—(i) *Secondary Emission Photo-tubes.*—During the development of satisfactory sky-screens for muzzle velocity measurements, it was found necessary to obtain additional information to that issued by the manufacturers on the characteristics of secondary emission photo-tubes. This investigation developed into a separate project which has now been completed.

(ii) *The Study of Transient Phenomena.*—A mathematical analysis of the behaviour of a video type amplifier to a transient has been carried out. A report containing this analysis will be issued shortly.

(iii) *Measurement of Recoil Pressures.*—An electronic device for measuring the instantaneous recoil pressures and forces induced in artillery during firing has been developed following a request from the Army. The pressures are measured by their effect on the frequency of an oscillator. The change in frequency is converted into a change in voltage which is amplified and used to deflect the beam of a cathode ray oscillograph. The trace of the oscillograph is photographed by means of a revolving drum camera.

Though developed for the Army, this device has been found to be so remarkably sensitive and accurate, that it is planned to use a similar apparatus as a laboratory tool for the accurate measurement of small and rapid displacements (e.g. 7 (iii) above).

10. *Miscellaneous.*—The Section has continued to give assistance and advice to the Department of Aircraft Production, to government organizations, and to industry on a wide variety of problems. Members of the Section are assisting, or acting on various committees such as the Australian Council for Aeronautics Bearing Panel and Cylinder and Piston Ring Panel. Through the Engineering Group Committee the Section also continues to keep in close touch with work going on at the Division of Aeronautics, National Standards Laboratory, and Munitions Supply Laboratories. This committee has already indicated some useful lines of work, such as the examination of shot peening, in which the Section is collaborating.

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

Bowden, F. P. (1945).—The physics of rubbing surfaces. *J. Proc. Roy. Soc. N.S.W.* 78: 187.

Bowden, F. P., Gregory, J. N., and Tabor, D. (1945).—Lubrication of metal surfaces by fatty acids. *Nature* 156: 97.

Bowden, F. P., Mulcahy, M. F. R., Vines, R. G., and Yoffe, A. (1946).—Detonation of liquid explosives by impact. Ibid. 157: 105.

Courtney-Pratt, J. S., and Tudor, G. K. (1946).—Lubrication between piston rings and cylinder walls. *Engineering* 161: 69.

Gregory, J. N. (1946).—Radioactive tracers in the study of friction and lubrication. *Nature* 157: 443.

——(1946).—The gelation of petrol for use as flame-thrower fuel. *J. Coun. Sci. Ind. Res.* (Aust.) 19: 153.

Gregory, J. N., and Hughan, R. R. (1945).—Analysis of silver plating solutions. *Ind Eng. Chem.* 17: 109.

Vines, R. G., and Mulcahy, M. F. R. (1946).—The initial stages of the explosion of nitroglycerine. *Nature* 157: 626.

XVIII.—BUILDING MATERIALS RESEARCH.

1. *General.*—In the last annual report it was recorded that the Officer-in-Charge, Building Materials Research, had been appointed to make a detailed survey of the building industry for the purpose of deciding which of its problems were the most urgent and capable of being investigated by existing laboratories. This survey revealed that, although many problems could be dealt with by existing laboratories, there were a number of very important problems which did not fall naturally within the fields of activity of these laboratories. As a result, it was recommended that a new Building Materials Research Laboratory be established.

This recommendation was endorsed by the Council in July, 1945, and the Officer-in-Charge was authorized to make the necessary arrangements for the establishment of the laboratory and the appointment of staff. Considerable difficulty was encountered in obtaining a suitable building. It was at first hoped that new laboratory buildings would be erected on a site of 14½ acres at Highett, Melbourne, taken over by the Council from the Department of Aircraft Production. However, it was soon evident that, because of shortage of labour and materials, it would be between one and two years before the buildings could be erected, and it was accordingly decided to seek temporary accommodation. Even this was difficult to locate, and it was not until January, 1946, that it was possible to move into portion of a large workshop located at Highett, adjacent to the 14½ acres referred to above, and recently vacated by the Department of Aircraft Production. The workshop, although of modern design and excellently provided with services, was naturally not ideally suited for use as a laboratory, and a considerable amount of work was involved in its conversion. This work is in progress at the time of writing, and it is anticipated that several months will elapse before it is completed.

Because of the policy of appointing only officers with high qualifications, considerable difficulty has also been encountered in obtaining staff. Several senior officers have been appointed and started duty in February and March, 1946, but, up to date, it has not been possible to obtain officers qualified to take charge of the important concrete and masonry investigations. There has been particular difficulty in obtaining the more junior research staff, with the result that work on many important problems cannot be undertaken.

In appointing the research staff, an attempt was made to build up a balanced team of officers with varying basic training and experience. Most of them have had little previous experience with building materials, but they have been selected on their academic record, research and other experience, adaptability, and personality, and, as they gain experience, they should become a very effective team.

The work is directed along the following broad lines:—(*a*) Assessment of the properties of existing materials where such information is not already available. (*b*) Determination of the properties and uses of new materials. (*c*) Study of methods of improving existing materials. (*d*) Development of new materials. (*e*) Technical assistance to industry in the improvement of present products and processes, and the development of new materials and processes. (*f*) Supply of information to the building industry.

The ultimate aim is a judicious blending of fundamental and applied research, but in the early stages the emphasis will be on applied research in order that immediate assistance can be given to industry. As the staff gains experience and the confidence of the industry is obtained, increasing attention will be given to more fundamental work.

In order to ensure that the necessarily limited staff and facilities will be used in the best interests of the building industry, a Building Materials Research Advisory Committee, consisting of representatives of the Department of Works and Housing, private architects, engineers, manufacturers, and builders, has been appointed. This Committee held two meetings during

the year under review, and has been of great assistance, particularly in advising on which of the many problems awaiting solution should be given priority.

Close liaison has been maintained with the Commonwealth Experimental Building Station of the Department of Works and Housing, and the Officer-in-Charge is a member of the Advisory Committee appointed by that organization. Excellent relations have been established with all branches of the industry, including Commonwealth and State authorities, architects, engineers, builders, and manufacturers. The Section is represented on the various committees of the Standards Association dealing with building materials and equipment, and the Officer-in-Charge is a member of the Housing Standards Committee appointed by the S.A.A. to determine policy and co-ordinate the work of the various specialist committees.

For convenience of organization, the work of the Section has been subdivided as follows:—(*a*) Information and library, (*b*) mechanical and physical testing laboratory, (*c*) concrete investigations, (*d*) masonry investigations, (*e*) surfacing materials investigations, (*f*) building boards and insulating materials investigations, and (*g*) organic materials investigations.

2. *Information and Library.*—The establishment of a Building Materials Research Information Service was begun just prior to the end of June, 1945, in temporary quarters at the Division of Forest Products. Originally, it was intended that the service should be relatively small and should be dependent largely upon the information available in other libraries, particularly the Council for Scientific and Industrial Research Head Office library. With the increase in the scope of the investigational work to be undertaken by the building materials research laboratories, and the proposal to move to new quarters at Highett, it was soon evident that greater self-contained library facilities would be needed and that more demands would be made on the information staff. Revised plans were made, therefore, to increase the staff and to obtain the necessary reference material.

The chief aim has been to provide information on building materials and allied subjects for the specialist research officers in the laboratory, as well as various government and private bodies interested in building materials. To this end the work has centred on the establishment of a library and indexing system, the answering of some of the enquiries which have been directed to the Section, the compilation of lists of references relating to matters under investigation, and the preparation of comprehensive reports on subjects likely to be of general interest.

(i) *Library.*—The chief subjects on which the library is based cover architecture, building practice, all branches of concrete manufacture and utilization, brickwork and masonry, clay products, bituminous materials, and plastics and glass as applied to building. Reference books on a wide range of related subjects are also available, so that the library is able to provide information on most matters connected with building.

The library consists of approximately 300 reference books and a large number of pamphlets, reprints, and trade catalogues. In addition, 65 periodicals are received regularly and a further 70 are routed from other Council for Scientific and Industrial Research libraries. In order to provide ready access to the information available, a detailed index is being compiled, using the Universal Decimal Classification. The index is intended to provide information in a minimum time without undue searching. A comprehensive index to Australian manufacturers and trade names of building materials is also being compiled. The library is fortunate in having a complete set of the "Building Science Abstracts" produced by the Building Research Station in Great Britain, and other abstracting and indexing journals have been ordered.

A feature of the work in the library has been the preparation of a monthly bulletin consisting of an accession list and an abstract section. This bulletin is now distributed to over 100 Government and private organizations. The abstract section of the bulletin thus serves to bring before a large number of readers references to new developments in building materials and related subjects which have been published in current local and overseas periodicals.

(ii) *General Enquiries.*—A large number of enquiries on various subjects have been received from Government departments, architects, manufacturers, and builders. While many of these were handled by specialist research officers, the following enquiries are typical of those dealt with by the information service:—Utilization of earth as a building material, manufacture of concrete blocks, tiles, and other precast concrete products, manufacture of clay bricks and tiles, driers for roofing tiles, tunnel kilns for brick manufacture, alternative materials for clay bricks, manufacture of sand-lime bricks, electronic heating of bricks, mortars for masonry, waterproofers for masonry, cleaning cement-rendered walls, roughening concrete floors, removal of rust stains from concrete, substitutes for white cement, manufacture of insulating boards, synthetic "marble" wall tile from magnesium oxychloride, prevention of mould growth on plaster, thermal conductivities of building materials, recovery of carbon dioxide from lime kilns, corrosion of galvanized iron sheet and wire, painting of galvanized iron.

(iii) *Reports and Information Summaries.*—Some replies to enquirers involve a large amount of work, and where the subject is likely to be of somewhat wide interest, it is the practice to prepare the information in the form of reports or summaries which can be distributed to interested bodies. Reports on the manufacture and uses of sand-lime bricks, the protection of steel and non-ferrous metals from corrosion, alternative materials for clay bricks, thermal conductivities of building materials, damp-proof course materials, have been compiled up to the present.

(iv) *News Letters.*—Although the abstract section of the library bulletin assists in the dissemination of information on building materials, it is not the complete answer to the problem of supplying architects, builders, and manufacturers with data on new developments in the building industry. It is proposed, therefore, to supplement the bulletin with periodical news letters which will contain such information in a condensed form, and will provide a means of publishing short progress accounts of the investigations being carried out by the research staff. Such a plan involves quite a large amount of work to ensure regular publication. Up to the present, sufficient staff has not been available to permit a start to be made, but, with the appointment of another information officer, it is hoped that the news letters will be available during the latter half of 1946.

(v) *Photocopying.*—Some difficulty has been experienced in the supply of really helpful information on certain subjects, particularly to enquirers who are not located in centres having access to technical libraries. This may be largely overcome by the use of photocopying. Suitable photographic equipment, which has been ordered, will facilitate supply of information in this way and will also cater for the photographic requirements of the Section as a whole. In addition to supplying information to enquirers, this equipment will be of value in preparing photo-reprints of reference materials for the library files.

3. *Mechanical and Physical Testing Laboratory.*—The Officer-in-Charge of the Mechanical and Physical Laboratory began duties in that capacity in March, 1946. The four months which have elapsed since that date have been spent largely in obtaining and designing equipment and in surveying literature on building materials with a view to planning future activities and the equipment necessary for their fulfilment. So far, practical testing has been limited by lack of equipment, but strength and other tests on a number of terra-cotta and cement tiles have been made.

(i) *Conditioning Rooms.*—Plans have been made for the erection of a fog-room for concrete curing, two cycling, and two constant condition rooms. After a survey of Australian and overseas specifications on tests involving the curing of concrete and the conditioning of building materials, the following operating conditions were chosen:—The two constant condition rooms to have a temperature range from 65°-85° F. ± 1°, and relative humidity of 40-90 per cent. ± 2 per cent.; the two cycling rooms to have a temperature variable from 35°-130° F., and relative humidity depending on requirements, with lower limits of 17 per cent. at 130° F. and 40 per cent. at 35° F., and upper limits of 80 per cent. at 130° F. and approximately 100 per cent. in range 35°-100° F.; the fog-room to have a temperature of 70° F. ± 1° and a relative humidity above 95 per. cent.

Unfortunately, funds are sufficient only for the erection of the fog-room and one cycling room at present, but the initial installation will include sufficient refrigeration and heating capacity for the proposed additional rooms. Each room will be approximately 14 feet deep by 13 feet high (internal). All but the fog-room will be 13 feet wide, the latter being 9 feet 6 inches.

As mentioned above, the humidities and temperatures attainable in the various rooms were chosen to satisfy a number of requirements of existing specifications, but, at the same time, they were made sufficiently flexible for investigating materials under the diverse conditions most likely to be encountered in this country.

(ii) *Accelerated Aging of Materials.*—Obviously, when dealing with materials which are expected to endure for long periods, some form of accelerated test is desirable. An Atlas twin arc, horizontal-vertical weatherometer is on order for such tests on small specimens, while the proposed cyclic room should serve for aging large sections. Infra-red and ultra-violet equipment has been obtained and will also be utilized in such tests. The need for accelerated aging has been experienced particularly in connexion with cement roofing tiles, where unproven methods of mixing and colouring are being put forward. A special weatherometer is being built for this purpose.

(iii) *Apparatus.*—So far, no mechanical testing machine has been installed, but a 1,000,000-lb. universal machine is being obtained. A considerable portion of this machine and complete blue-prints are on order from America. On account of the unfavorable dollar position, it is intended to complete the machine in Australia. Final installation is not expected until late in 1947. Meanwhile, necessary tests have been made by the Divisions of Aeronautics and Forest Products.

In many instances, the testing of building materials, such as tiles, wall boards, and mortar joints, requires a low capacity universal machine with considerable working space, and designs of a suitable machine are being prepared. The machine will be hydraulically loaded and will be fitted with three ranges of Heise pressure gauges; the maximum capacity will be 5,000 lb.

A considerable amount of physical apparatus and general laboratory equipment has been obtained. This includes balances, a drying oven, a mechanical sieve shaker and standard sieves, a psychrometer, comparators, electric meters, ball mills, and the like. Apparatus for estimating the permeability of walls is ready for installation.

(iv) *Cement Tiles.*—The acute shortage of roofing materials has given rise to a widespread consideration of the potentialities of cement (or concrete) tiles. Originally, a request was made by a potential manufacturer for a report on cement tiles in general, and in particular on those made on an automatic machine developed in Melbourne. In this connexion a number of hand-made tiles, varying in age from 18 years (in service) to two weeks, were tested for strength in bending and for water absorption. Similar tests were carried out on unexposed tiles made on the above machine some eight years previously. The hand-made tiles were obtained from the same manufacturer. The general appearance and colour of roofs laid by this same manufacturer, and varying in age up to 20 years, were noted. Strength and water absorption tests were also made on a wide range of terra-cotta tiles and the results compared. These investigations showed that considerable satisfaction can be expected from well-made cement tiles. New cement tiles are considerably weaker than similar terra-cotta tiles, but, after some time in service, may be stronger than some of the latter. On the question of colour retention and general appearance in service, it is of interest to note that roofs up to fifteen years were inspected and found to be in very good condition. At 13 to 14 years some dirt and a little vegetation were in evidence, but these factors were not serious. Natural grey and green roofs up to twenty years in service were inspected. These were still quite solid, but the green colour had mainly disappeared. Vegetation was more in evidence, particularly on low pitched tiles. It is considered that incidence of vegetation depends on the surface finish of the tiles, is most severe on natural grey and weathered green, but should not cause any concern with better finishes under twenty years.

Contrary to a common belief, cement tiles absorb less water (when immersed) than many terra-cotta tiles. The average weights for equal coverage of wet cement and terra-cotta tiles examined were almost identical. The favorable impression created by the examination of these cement tiles makes it clear that this type of tile can be very satisfactory. On the other hand, some unsatisfactory tiles from a different manufacturer have been examined. These were very weak and their colour poor. In this case, the local sand seems to be at fault, but this point is not yet definitely established. This emphasizes the necessity for standardization and technical assistance.

Numerous inquiries from builders, architects, and potential manufacturers for technical advice and for an independent opinion on tiles, have been answered.

A personal survey of cement tile manufacturing methods and the quality of the tiles produced in all States has been started. Some Victorian manufacturers have already been visited, and it is intended to extend the investigations to Tasmania.

(v) *Terra-cotta Tiles.*—As already mentioned, a number of tests have been made on terra-cotta tiles to provide a basis of comparison for the work on cement tiles. Tiles were obtained from all but one metropolitan manufacturer and from Bendigo. The Section's investigations were welcomed and, in some cases, technical assistance was requested in connexion with drying before burning. The need for a research organization was generally expressed.

4. *Concrete Investigations.*—Because of the inability to obtain research staff, the work relating to concrete investigations has been largely confined to a survey of the literature, preliminary studies in connexion with

the preparation of a programme of work, the selection of equipment, and the answering of inquiries. It has been found that there is a great deal of interest in modern developments, such as light-weight concrete, cement dispersion, air entrainment, electric membrane, and other accelerated curing methods, vacuum drying, &c., and the time of the single officer dealing with concrete has been mostly taken up in answering from existing data inquiries on these and other matters.

Pending the appointment of an officer to take charge of the experimental work, no definite programme has yet been determined, but the Building Materials Research Advisory Committee has recommended that attention should be given to the following as soon as possible:—(i) Methods of waterproofing concrete walls, (ii) methods of manufacture and study of the properties of light-weight concrete, (iii) development of high strength concrete, (iv) methods of accelerating the rate of increase of the strength of concrete, and (v) compilation of data on the properties of Australian aggregates.

5. *Masonry Investigations.*—Up to date, it has not been possible to obtain staff qualified to undertake masonry investigations and work has been confined to the dealing with inquiries by the Information Service. The Building Materials Research Advisory Committee has recommended that the following work should be undertaken as soon as staff is obtained:—(i) Methods of manufacture and study of the properties of concrete bricks and blocks, (ii) study of the factors affecting the permeability of masonry walls, and, (iii) study of the properties of mortars.

6. *Surfacing Materials Investigations.*—The officer in charge commenced duty in March, 1946, and his time has been devoted chiefly to general background reading, the planning of the immediate future development of the work, and the literature surveys necessary as a preliminary to commencing work on the two major projects at present under consideration, namely:—(*a*) the development of a satisfactory substitute for ceramic tiles as a bathroom wall surface, and (*b*) the development of a means of surfacing concrete floors which will be acceptable for use in dwellings. In addition, a number of minor investigations have been made in connexion with inquiries submitted by the public.

(i) *Bathroom Wall Surfaces.*—A plan of work has been drawn up covering the accelerated testing of commercially available finishes. A circular to manufacturers likely to be interested is being prepared, inviting their co-operation and the submission of samples of products considered by them to be likely to give satisfaction. It is hoped to commence experimental work as soon as the necessary apparatus has been constructed. A literature survey is being prepared by the Information Service.

(ii) *Concrete Floor Surfaces.*—In view of the saving in cost possible, on level sites, if a concrete slab, poured on the ground, could be used as the floor of a dwelling in place of the usual raised wooden structure, several requests have been made for a means of covering such a floor in order to provide a surface which will be warmer, softer, and quieter than a bare concrete floor and at the same time act as a moisture barrier to enable secondary floor coverings, such as rugs, linoleum, &c., to be laid without danger of damage by water or its usual accompaniment, microbiological attack.

Pitch mastics have been used extensively for this purpose in England and, it is claimed, with considerable success. In America, asphalt tiles seem to be preferred. The immediate problem is whether pitch mastics can be used in Australia as in England. This resolves itself mainly into three questions:—(*a*) Can mastics with similar properties to those used in England be prepared from Australian pitches? (*b*) Will such mastics be unfavorably affected by the higher temperatures normally experienced in Australia? (*c*) Will the behaviour reported from England as "satisfactory" be regarded as satisfactory by Australians?

Three small samples (4-in. square slabs) of mastic have been received from England and subjected to a simple indentation test by placing them under the legs of an office table in a room where the temperature rarely rises above 20°C. (68°F.). One sample (black) showed serious deformation after a few days, and a second (pigmented with iron oxide) showed noticeable marking after three weeks. If these are typical of what are regarded in the United Kingdom as suitable mastics for floors, it is extremely doubtful if the Australian public would be prepared to accept them. Larger samples have been requested from England, and when they arrive and a hardness tester (in which they can be checked for conformity with British Standard Specifications) has been constructed, further tests will be made.

A serious difficulty encountered in the work on floor-surfacing materials is the lack of factual data on the desirable properties of a floor from the point of view of comfort. Following a suggestion from Professor D. H. K. Lee, of the University of Queensland, that measurement of pressures and temperatures on the sole of the foot may give results of value, arrangements have been made with Professor R. D. Wright of the Department of Physiology in the University of Melbourne, for a co-operative investigation on these lines. The design of the equipment required for the work is now under consideration.

Another approach to the problem which is being planned is to make by means of slow motion cinephotography, a qualitative examination of the foot and the floor when an observer walks over a number of different floor types. The results so obtained will be correlated with the subjective evaluation of the comfort of the floors by a panel of testers.

A standard overseas test for hardness of flooring materials is to allow a 1-in. diameter steel ball to fall from 6 feet on to a piece of writing paper placed over a sheet of carbon paper resting on the material to be tested. The diameter of the resultant circular mark on the paper is then taken as an inverse measure of hardness. Tests made on a number of different types of floors and flooring materials indicate that this test does not measure merely the hardness of the material forming the surface of the floor, but that the results are influenced at least to some extent by the structure of the floor. It is proposed, as soon as staff is available, to begin an extensive series of tests to determine, if possible, the value of this test and the variables which affect the results.

(iii) *Apparatus.*—The following specialized apparatus is being arranged for:—(*a*) An English-type hardness tester for pitch mastic has been designed and drawn ready for manufacture. (*b*) A preliminary design has been drawn up in consultation with the Seasoning Section, Division of Forest Products, for an accelerated testing unit for bathroom wall finishes.

(iv) *Miscellaneous.*—Samples of magnesium oxychloride boards submitted by a firm in Queensland, for use as flooring and walling, were examined and reported on. A procedure was devised and a qualitative analysis carried out on microscopic fragments (< 0.005 inch diameter) of foreign material isolated from stained fibrous plaster. Tempered hardboard coated with cellulose lacquer is being examined for the resistance of the surface coating to various household hazards.

7. *Building Boards and Insulating Materials Investigations.*—Investigations of the properties and development of building boards and of thermal and acoustical insulation have been initiated during the year. Before proceeding to the major section of the work, namely that of development of improved boards and insulation, it is obviously necessary to study the properties and shortcomings of existing products and to standardize a series of tests for laboratory determinations of service suitability.

As the work was not commenced until March, 1946, progress has principally been confined to an examination of literature and the purchase and/or design of necessary equipment. Throughout, the necessity of obtaining results at an early date (even if these are only approximate) has been kept continually in mind, and equipment improvised in cases where more elaborate or imported equipment is desirable. It is proposed to obtain preliminary results with this rapidly built equipment, for in the case of many enquiries received, the answer is needed now.

Consideration of priorities, and of the staff position, has led to the decision that, for the present, acoustical work will be held somewhat in abeyance, thus allowing attention to be directed towards the provision of equipment and the establishment of testing techniques in the fields of building boards and thermal insulation. It has been decided that approximately equal attention shall be given to these two major divisions.

(i) *Building Boards.*—With the desire for prefabrication of houses and attempts at reduction of costs by sheathing applied in large panels, a large number of types of material have been produced in sheet form. These are given the generic name of building boards. As with most building materials, the use of a particular type is dependent on such factors as cost per unit area, strength (flexure and impact), surface finish, appearance, heat insulation, sound absorption and dimensional stability. Consequently, laboratory evaluation must attempt to measure, in addition to the normal mechanical strength, the subjective qualities of dimensional stability (and consequent cracking) and surface finish.

With these objects in mind, the literature on the subject has been consulted in order that initial testing shall fall in line with overseas practice. Information available shows that sizes of test specimens are far from standardized, and that no suitable specification is available. In the initial stages, therefore, work (except for comparison) will be directed towards fixing the optimum size of test specimens and the correlation of results with practical experience. It is hoped that a set of significant tests, small in number, will be evolved so that a rapid evaluation of the possibilities of a new material can be made.

Construction has commenced on apparatus designed to perform a number of these tests. A small machine capable of loading building board samples in bending is nearing completion, and work has started for two conditioning cabinets and a modified cathetometer to be used to measure the dimensional changes of boards with changes of moisture conditions. In addition, design work has commenced for a small universal testing machine. Work was begun on a sub-project, the object of which is to determine whether any suitable substitute for sisal fibres, for use as reinforcement in fibrous plaster sheets can be found. Scrim hessian was one possible substitute suggested in the original enquiry, but it has been shown that this material is unsuitable.

(ii) *Thermal Insulation.*—Little or no information can be found of the thermal characteristics of Australian building materials. The Information Service has issued a report of the thermal conductivity of building materials as obtained from overseas information, but the necessity for such information on local products is great. It is intended to measure these using a guarded hot plate method, drawings of a unit having recently been received from the Division of Physics.

In addition to the thermal conductivity, the specific heat and the infra-red reflectivity of materials influence the temperature inside buildings, and it is intended to develop methods and apparatus for their measurement. Consideration has been given to the possibility of simultaneous measurement of thermal conductivity and specific heat of materials and the mathematical treatment of a number of experimental conditions has been undertaken. From this, one has been chosen and exploratory work is envisaged to determine its suitability.

8. *Organic Materials Investigations.*—Of the investigations recommended by the Building Materials Research Advisory Committee for early attention, two have been allocated to the Organic Materials laboratory, namely, a study of the properties of caulking compounds, and an examination of the relative merits of natural and residual bitumens for building purposes. Of these, the former is regarded as the more urgent and has been selected as the first research project. Experimental work has not yet commenced, but progress has been made with the necessary preliminaries to this research.

(i) *Apparatus and Equipment.*—Matters relating to the selection and purchase of laboratory apparatus have absorbed a considerable portion of the period under review. Efforts have been made to secure from local sources as many as possible of the items needed to commence experimental work. Orders for a representative selection of standard apparatus were placed without undue difficulty, and much of this has now been received. Other items, specifically ovens, a thermostatically controlled bath, a vacuum pump, analytical weights, and standard volumetric glassware, are not readily available, and the delivery date of this apparatus is uncertain. Some specialized equipment for the work envisaged is unobtainable and is being constructed in the laboratory's workshops. In this connexion the Munitions Supply Laboratories have been of assistance and have made available patterns and drawings of a bitumen testing penetrometer which is required for examination of the consistency of mastics.

(ii) *Research Programme.*—A search of the literature had indicated that the only previously reported investigation into the properties of caulking materials is the work of the team attached to the National Bureau of Standards, Washington, United States of America. It is apparent that this work, which resulted in the adoption of a Federal Specification for caulking materials, has introduced in America a wider appreciation of the functions and requirements of these materials than appears to exist in this country. Caulking materials have been marketed in Australia for some time. However, recent trends towards prefabricated methods of construction, where great reliance is placed on the efficacy of the jointing materials used, have emphasized the shortcomings of many of the locally marketed proprietary brands. In the circumstances it has been felt that the research programme should in the first instance embrace an examination of the quality and performance of commercially available materials, since this would be of immediate benefit to architects and builders in selecting the best material available for the particular purpose in hand. A working plan has therefore been evolved with the object of acquiring these data and incorporating them in an Australian Standard Specification and Code of Practice.

With a view to obtaining as wide a range of caulking products as possible, over 170 firms, comprising all known manufacturers of caulking materials, together with all marketers and manufacturers of oil, paint, bituminous and rubber products, have been contacted by circular letter. Replies to these letters have been encouraging; 36 products have been advanced as being suitable for caulking purposes and many offers of co-operation in the proposed research have been received. Advantage has been taken of these offers by seeking interviews with representatives of the firms concerned, as a result of which useful technical information has been acquired.

Information on overseas developments in caulking materials has been obtained, chiefly through the Council for Scientific and Industrial Research liaison officers in London and Washington. It has been learned that the Building Research Station of the British Department of Scientific and Industrial Research recently embarked on a similar course of study and details of some of the techniques employed by this body have been received. Additional technical information has been acquired by direct communication with an English firm specializing in the manufacture of mastic materials.

(iii) *Paint Research.*—Although the Section is not directly concerned with research on paints, since full facilities for this work are already available at the Munitions Supply Laboratories, a general interest has been taken in this field, and steps have been taken to establish a liaison between the Munitions Supply Laboratories on the one hand, and various "user" bodies on the other. As a result of this liaison, conferences were arranged at which Munitions Supply Laboratories and Section representatives met the Panel of Architects of the Victorian Housing Commission and the Assistant Director-General of the Commonwealth Department of Works and Housing. Reactions were sought at these conferences to the following proposals:—(*a*) That the Munitions Supply Laboratories should undertake a programme of work involving examination of the quality and performance of Australian proprietary brands of ready mixed paints. (*b*) That the data so obtained should be made available to Government and semi-Government users of paint to assist these bodies in the selection of satisfactory products in their constructional and maintenance programmes. (*c*) That the facilities of the Munitions Supply Laboratories should be made available for the purpose of checking at any time whether or not paints being used on the job confirmed in quality to the standards originally approved.

The utility of these proposals was commended by both the authorities consulted, and the Munitions Supply Laboratories have now undertaken to obtain and test all available brands of paints in colours and types of interest to the participating bodies.

9. *Publications.*—During the year a paper was given on plastics for buildings, and mimeographed reports on sand-lime bricks and thermal conductivity of building materials were issued.

XIX. FLAX RESEARCH.

1. *General.*—Investigations concerned with the processing of linen flax have been actively pursued by the Council for some years. From 1937 to 1945, work was carried out at the Division of Forest Products on processing problems in general but with special emphasis on retting. In July, 1945, this work was transferred to a new Flax Section; later it was agreed that the work of the vegetable fibre section of the Division of Plant Industry, which was interested in flax as well as other vegetable fibres, should also be transferred to the new Section. The scope of the new Section thus includes work on any vegetable fibres which may be of interest in this country, although at present most of the Section's activities are devoted to flax.

Temporary accommodation for the Flax Research Laboratory is being provided in the former D.A.P. machine shop at Highett. This is conveniently situated adjacent to the site recently purchased by the Council for Scientific and Industrial Research for the permanent laboratory. Already, part of the flax work is being carried on at Highett where the experimental retting tanks have been re-installed and where deseeding and scutching equipment, kindly loaned by the Flax Production Committee, is being set up. The other activities of the Section will be transferred to Highett as soon as the necessary alterations are made to the building and the laboratory fittings installed.

2. *Retting.*—(i) *Water Retting.*—Flax grown in Australia presents peculiar difficulties in regard to the normal bacterial method of retting in water in concrete tanks, in that the bacterial action appears to cease before the straw is sufficiently retted to ensure the desired softness of fibre. Every effort is being made to overcome this difficulty. One possible solution to the problem appeared to be the addition to the retting water of various chemicals which would act as bacterial nutrients or stimulants. This line of investigation is being carefully followed, although so far without any outstanding success. The use of aerated rets, wherein aerobic bacteria predominate instead of the usual anaerobic type, has also been tried but the results have not been encouraging.

The whole question of water retting is now being studied from the fundamental aspect of the bacteria involved and their characteristics. It is anticipated that from information of this nature more positive progress will be possible than has been the case with the empirical methods that have previously been used.

Periodic visits are made to the tank-retting mills of the Flax Production Committee to keep in touch with the practical side of the work and determine what problems are being encountered. As a result of such visits, laboratory tests are frequently made to enable advice to be given. For instance, in commercial retting tanks, temperature losses over a 24-hour period during the winter time may amount to as much as 3 or 4° F. It was thought that this daily drop in temperature may have a retarding effect on the retting. However, laboratory tests have shown that, provided the average temperature is maintained at the correct level, temperature drops considerably greater than those encountered must occur before there is any significant effect on the retting.

Other tank retting investigations have been concerned with the possibility of eliminating the preliminary wash, on the one hand, as a means of conserving water and with the use of a final wash, on the other hand, as a possible means of improving fibre quality. In neither case are the results so far obtained sufficiently definite to enable any general recommendations to be made.

One aspect of tank retting causing concern in this country, as in most other places, is the disposal of the effluent. Considerable attention is being given to methods of treating the effluent to render it less objectionable. At the same time a careful check is being kept of the pollutional effects on the streams and lakes into which the effluent eventually discharges.

(ii) *Chemical Retting.*—Samples of the fibre produced last year by chemical retting at the Ballarat pilot plant were sent to the Linen Industry Research Association in Northern Ireland for spinning tests. The results of these tests, which took some nine months to prepare, have recently come to hand and, although promising, indicate that improvements in the treatment

are desirable. On account, however, of the impracticability of waiting for results from overseas, it has been decided to defer any further work on chemical retting until suitable experimental spinning machinery is available in Australia.

3. *Processing Machinery Investigations.*—In co-operation with the Flax Production Committee, investigations are being made of the performance of various items of processing machinery with the object of improving their efficiency. In addition, new types of equipment and accessories are to be manufactured and tested.

So far attention has been given mostly to the straw butting attachment for the pick-up binder and deseeder. The performance of this portion of the machines has not been satisfactory in the past, but modifications which have now been evolved will, it is expected, overcome previous difficulties. The manufacture of a new pattern straw humidifier has been commenced at the laboratory workshop. This is for use in conjunction with scutching machines during hot, dry weather when the low moisture content of the straw normally results in heavy fibre losses.

4. *Fibre Evaluation.* — (i) *Chemical.* — Detailed studies have been made of the relation between the chemical composition of flax fibre and (i) the duration of the retting treatment, and (ii) fibre quality. Both single and double retting methods have been examined, and the analyses made have furnished valuable information on the chemical changes involved in the processes.

A preliminary study has also been made of the mineral constituents of flax as related to quality; it is planned to extend this phase of the work during the coming year. Other work planned includes the study of the structure of fibre cellulose by such methods as the determination of carboxyl groups and viscosity measurements.

(ii) *Physical Tests.*—Microscopic studies of Australian fibre to compare it with high-grade Belgian flax have shown, amongst other things, that the dimensions of the ultimate fibres of Australia fibre are usually appreciably greater than those of the overseas material. Agricultural practices and the selection of conditions which produce flax with small uniform fibres would appear desirable. Simplified techniques for measuring fibres and fibre properties have been developed and used in this work.

Another physical property which has been investigated with the object of throwing light on the performance of flax fibre in spinning is its electrical resistance. Electrical methods of determining the moisture content of fibre have also been examined. The latter work was subsequently extended to testing linseed; an electrical moisture meter developed is now in commercial production.

Another line of work has been the development of a machine for use in extracting the fibre from small samples of straw. The straw is chemically retted before treatment on the machine, the whole procedure taking only a few hours. Total fibre values obtained are closely reproducible, and it is anticipated that the technique will be of particular value to flax breeders and others interested in very small samples of straw.

(iii) *Agricultural Field Trials.*—The work of extracting and evaluating the fibre from the flax straw grown in agricultural field trials continues to occupy a good deal of the Section's time. However, it is felt that the work is well worth while as the importance of determining the best variety of flax and the best growing conditions cannot be over-emphasized.

5. *Survey of Factors Affecting Fibre Yield and Quality.*—Flax quality is known to be closely related to fibre structure and is largely inherent in the straw. To determine the factors responsible for the quality of the fibre in the straw, a survey is being made of agricultural conditions relating to ten flax crops in each of six different districts in Victoria. Consideration is being given to the previous history of the field, preparation for sowing, time of sowing, weather conditions during the growing period, percentage germination, maturity at harvest, and treatment of the crop after harvesting. Special attention is being paid to the soil type and the effect of manurial treatment on the uptake of nutrients by the flax, as it seems probable that these factors influence the fibre structure and consequently the quality.

6. *Flax Seed Investigations.*—Microscopic examination of flax seed has shown that a considerable amount of mechanical damage in the form of cracks in the seed coat is occurring during the cleaning processes. It is thought that this damage may contribute to the much lower percentage germination obtained in the field as compared with the results of laboratory tests. As good germination is important to both grower and processor, an examination is being made of samples of all seed consignments for this type of injury prior to sowing. At the same time investigations are being made to determine where the damage occurs and if possible to eliminate the cause of the trouble.

7. *Miscellaneous Fibres.*—During the year investigations have been made on behalf of the New South Wales Department of Agriculture in connexion with the processing and fibre evaluation of samples of Sunn hemp and Deccan hemp. In addition, information has been supplied as requested by various Government and other bodies in regard to jute, coir, ramie, sisal, and ox fibre.

XX. OTHER INVESTIGATIONS.

1. *Dairy Research.*—(i) *General.*—During the year the work of this Section has been directed increasingly towards normal problems in dairy manufacture and away from the special problems which arose during the war. The unusual techniques and manufacturing procedures developed in the war-time projects have provided a new outlook on some problems. As an instance, the taking apart of butter and the detailed study of changes in the fat constituent, originating in the war-time need for production of dry butter-fat, has led to new work giving further insight into some of the changes which occur in butter during cold storage. Practical problems arising in the industry have been investigated, and more fundamental studies have been pursued whenever possible. Considerable time has been devoted to the solution of difficulties and the development of improved procedures in butter and cheese manufacture. However, the stage of development of the dairy industry in Australia is such that over the next decade a major concern of the industry must be the better use of all the milk constituents. The utilization, concentration, and drying of whole-milk, skim milk, and whey are therefore being given increasing attention.

(ii) *The Manufacture of Butter without Washing.*—When butter is made without washing the buttermilk from the outside of the butter granules, the content of milk solids-not-fat is raised appreciably and factory over-run is increased to the benefit of the manufacturer. Large quantities of filtered, purified, and chilled wash water are no longer necessary, and this cheapens the cost of production and simplifies factory operations. Attracted by these advantages a number of butter factories have been omitting the washing of the granules in butter manufacture. In accepted buttermaking procedure, washing is considered necessary to prevent bacterial deterioration, but such experimental evidence as is available to support this conception was obtained when butter manufacture was a very different process. A large-scale experiment was therefore arranged in co-operation with the Commonwealth Department of Commerce and Agriculture and the Victorian Department

of Agriculture to determine the extent to which the curd content is increased by not washing, and the effect this practice has on the quality of the resultant butter. Five butter factories participated in the investigation which extended for three months during the export season. The results showed that by not washing, the solids-not-fat content of the butter was increased from an average of 1.10 to 1.52 per cent. The quality of the butter at the first grading showed practically no difference in the two methods of manufacture. After three months storage, however, the unwashed butters graded lower, losing on an average 1.71 points against 1.23 points for the washed butters. This difference in keeping quality was not correlated with differences in curd content, with initial quality of the butter, nor with any measured difference in the bacteriological condition of the butter. At some factories there was very little difference in keeping quality between the two types of butter; at other factories the inferiority of the unwashed butter in this respect was marked. Under some conditions washing may safely be omitted, but under other conditions this is dangerous. Definition of these conditions will be the objective in further work.

(iii) *Weed Taint in Butter.*—In some parts of Australia, particularly northern New South Wales and Queensland, weeds in the pasture at certain periods of the year are the source of objectionable flavours in the butter. Unlike feed flavours derived from grass or clover, some of these weed flavours are intensified by normal butter manufacturing processes. Weed-tainted butter has caused so much concern to the industry that investigations are being undertaken in Queensland, and the necessary preliminary preparations have been made. The Queensland Agricultural High School and College and Queensland Butter Board are co-operating in this work.

(iv) *Concentrated Hardened Butter.* — Fundamental, manufacturing and control problems in connexion with concentrated hardened butter have been given attention during the year. The use of such edible antioxidants as soya-bean lecithin, and finely ground sucrose or icing-sugar has been studied, but in general oxidative change is now of less importance in the product than the minor chemical changes involved in such alterations as the loss of brightness of flavour. Flavour examination of various experimental samples, incubation tests, studies of variously treated salts, and other minor investigations were carried out. Assistance was given in the establishment of suitable analytical control.

(v) *The Effect of Sodium Chloride on the pH of Milk and Butter Serum.*—The pH of butter serum is, apart from heavy metal content, the major factor in controlling the keeping quality of salted butter in cold-storage. While the addition of sodium chloride to milk always lowers the pH, the relationships observed by various workers between the pH of cream and the pH of the serum of salted butter made from it are most irregular. Experiments showed that the pH of solutions of salts containing some of the ions present in milk serum was depressed on adding sodium chloride, apparently because of specific ionic association. When a precipitated alkaline phase was present as in neutralized cream, this pH change was reduced or reversed, possibly by increased solubility of the alkaline calcium phosphate in sodium chloride solutions. These facts made it clear that variation in many of the treatments to which cream is subjected before and during manufacture into butter will affect the change in pH when sodium chloride is added, and hence the relationship between the pH of the cream and the pH of the salted butter churned from it. The results incidentally make it clear that the only satisfactory method of controlling this important quantity in practice is the direct one of pH measurement on the butter serum. This work has been described in a paper submitted to the *Journal of Dairy Research.*

(vi) *The Oxidation of Butterfat.*—The fact that the oxidation of the fat of cold-stored butter is accelerated by high salt concentration combined with high acidity, in practice excludes the high-acid highly flavoured butter from the types which Australia can satisfactorily export, and to that extent restricts the capacity of the industry to supply butter suited to particular markets. The effect of sodium chloride and acidity in accelerating oxidation is not dealt with in the literature on fat-oxidation. Following the studies on the effect of magnesium chloride on the oxidation of fat, reported last year, investigation was undertaken of the mechanism by which acid and sodium chloride accelerate oxidation.

Initial tests showed that it was possible to use for this purpose the technique of adding a percentage of high-melting-point fat to butter, so that an added solid or liquid phase remained dispersed at 40° C., and incubating 5-14 days at that temperature. When butter itself was treated in this way it was possible to reproduce in a week the effect of salt and acid shown only after long periods in cold storage. There was, however, in spite of pasteurization, constant danger of interference with the chemical action by the growth of micro-organisms. It was soon found that butterfat with a dispersed emulsion containing only the inorganic constituents of butter serum was equally subject to oxidation by acid and sodium chloride. This rendered simpler the further study of the problem, and also made it clear that no other butter constituent, such as the phosphatide, was necessary as an intermediary in the reaction.

At the pH of acid butter, about 5.0, commercial salt accelerated the oxidation of fat somewhat more than sodium chloride freed from traces of heavy metals by extraction with dithizone, but the major part of the action was due to sodium chloride itself. Study of the oxidant activity of sodium chloride and of several other sodium and potassium salts at various pH levels showed that the oxidation was a function of the concentrations of chloride and hydrogen ions. Investigation was then made of the possibility that traces of chlorine, known to accelerate some other oxidations of the chain-reaction type, might be formed by inter-action of some of the initially formed fat hydroperoxide with the hydrogen and chloride ions. Demonstration of this reaction was difficult because of the rapid further reaction of chlorine with the fat, but it proved possible to detect chlorine with o-tolidene when oxidized fat was mixed with acid sodium chloride solution. Oxidized fat immediately released chlorine from concentrated magnesium chloride solutions without the addition of acid. The strong catalytic action of chlorine on the oxidation of fat was shown by holding butterfat over a layer of dilute chlorine water at 40° C. The mechanism suggested by these results for the oxidation of fat by acidic solutions of sodium chloride will also explain the previously observed activity of magnesium chloride in dry salt in butterfat. This work has been prepared for publication.

(vii) *The Role of Phosphatides in the Deterioration of Dairy Products.*—Since about 1930, many overseas workers have presented evidence that it is oxidation of the phosphatide, not the butterfat, which is responsible for incipient oxidized flavours in milk, ice-cream, and other dairy products. Theoretically, there is reason to expect that this might be so. On the other hand, much of the evidence presented can be interpreted in other ways, and some practical evidence, such as the good keeping-quality of dried buttermilk, which is rich in phosphatide, does not support the theory. The difference in physical distribution of the fat and the phosphatide in dairy products makes this matter

of considerable importance in the understanding, and hence in the control, of oxidative deterioration in dairy products. The literature on phosphatides in dairy products has been extensively reviewed, and a plan of research prepared. As a first step in this work it was necessary to have a satisfactory technique for the estimation of small amounts of phosphatide; a promising method has been developed.

(viii) *The Keeping Quality of Whole Milk Powder.*—Satisfactory keeping quality of whole milk powder can only be obtained by removing air from the tin after packing and replacing it with an inert gas such as nitrogen. To control this process of gas-packing in the factory, it is necessary to be able to analyse the final head-space gas in the tin for oxygen content. Conventional sampling and gas analysis methods are not well suited to factory use, and special apparatus for the purpose has therefore been devised. Metal construction has been used instead of glass, as far as possible, and simplicity of sampling procedure and rapidity of determination were aimed at. The apparatus finally produced has proved highly satisfactory in laboratory tests and in commercial use. A description of the apparatus is being published.

Copper is a very strong catalyst for oxidative deterioration in dried whole milk. In practice it is only in factories where copper contamination has been reduced to the minimum that powder of satisfactory keeping quality can be produced. Normal methods for the estimation of copper in milk powder require preliminary wet or dry ashing of the sample. The former is a difficult procedure and the latter is time-consuming and involves risk of contamination. For factory-laboratory use a method avoiding these procedures would be very suitable. Investigation has been made of the possibility of extracting the copper from the milk powder with acid solutions. It is necessary to have a solution active enough to free the copper from copper-protein complexes, but one which will not dissolve proteins which interfere with subsequent stages of the determination. Some success has been achieved along these lines, but it has not yet been found possible to devise a method giving complete extraction.

(ix) *Compressed Sugar and Full-cream Milk Powder.*—The previously reported experimental shipment of compressed whole milk powder containing 20 per cent. added cane-sugar proved successful, and trials of this procedure have been continued by the confectionery manufacturers concerned. General advice and assistance has been given in this work.

(x) *The Utilization of Skim Milk Solids.*—During the year, largely through the Australian Society of Dairy Technology, the attention of the industry has been directed towards the enormous waste of valuable human food which is involved in the feeding of skim milk to pigs. Only about 15 per cent. of the high quality protein and none of the valuable calcium of the milk are returned as pork. One obvious way of making better use of skim milk is to dry it and add the skim milk powder to bread, as is commonly done in some other countries, notably the United States. The characteristics of Australian flours make this more difficult under local conditions. The problems involved are being studied with the co-operation of the William Angliss Food Trades School where baking trials are being conducted. Before being dried, skim milk must be specially heated if it is to be successfully incorporated in bread. During pre-heating there is an increase in the sulphydryl groups, and this is supposed to be closely correlated with the baking quality of the resultant skim milk powder. A method for estimating these sulphydryl groups has been successfully applied. Arrangements have been made with milk-drying factories for the manufacture of a number of samples of specially pre-heated spray and roller dried powders. The effect of the incorporation of these in flour on the quality of bread made from it using normal and modified bread-making procedures will be studied.

(xi) *The Pliofilm-wrapping of Cheese.*—The maturing of cheese in pliofilm, so avoiding rind formation, and its presentation to the consumer in small packages wrapped in pliofilm, has been tested with success in the United States. In this way it should be possible to combine some of the advantages of processed cheese with the stronger flavour of matured natural cheddar. As the supply of pliofilm available was limited, the Section undertook the testing under Australian conditions of the process as developed in the United States. Complete inhibition of mould growth was not achieved in any of the experiments. The procedure, at any rate in its present stage of development, does not seem well suited to existing Australian methods and facilities for handling cheese in wholesale and retail trade. Time was available for little developmental work on the process, which must still be regarded as of potential value. Experiments have also been conducted with pliowax for the waxing of cheese.

(xii) *Cheese Mites.*—Early in the year under review a large consignment of cheese was prohibited from export because of heavy infestation with cheese mites, and assistance was given to the Department of Commerce in this problem. This directed attention to the question of cheese-mite control generally and the efficiency of known procedures in combating this problem in the cheese industry. With an officer of the Division of Economic Entomology, a number of cheese factories, stores, and cool-stores were visited and enquiries made into the trouble caused by cheese-mites, the degree of infestation normally experienced, and methods of control employed. In all places visited, the control of mites is only achieved by thorough and constant attention to the cleanliness of cheese rooms and stores and the regular scraping of shelves and the turning and wiping of cheeses. The provision of some simple method of control would cheapen and simplify the handling and storage of cheese generally. Where infestation has occurred and large quantities of cheese are involved, the only remedy appears to be fumigation. The most suitable fumigant for this purpose and the conditions of its application are subjects on which there is little unanimity, and further research appears to be desirable. Action in this direction has been left to the Division of Economic Entomology.

(xiii) *Concentration of Whey.*—Although there are reliable formulae for the calculation of the total-solids content of concentrated whole milk and skim milk from specific gravity data, no such formula is available for condensed whey. A study was undertaken to determine the relationship between hydrometer-measured specific gravity and total solids in whey over the range from 6 to 30 per cent. total solids, for the convenient use of factories condensing and drying whey. Some observations were also made on factors causing the browning of whey during drying.

(xiv) *Publications.*—Papers published by this Section during the period covered by the Report were:—

Lawrence, A. J. (1946).—The relation between specific gravity and total solids of whey. *Aust. J. Dairy Techn.* 1: 48-9.

Loftus Hills, G. (1946).—Some theoretical aspects of the "new way" butter process. Ibid. 1: 43-7.

Loftus Hills, G., and Conochie, J. (1945).—The oxidant effect of commercial salt in fats and oils. *J. Coun. Sci. Ind. Res.* (Aust.) 18: 355-65.

Loftus Hills, G., and Conochie, J. (1945).—Measurement of the gas content of concentrated butter and other fat products. Ibid. 18: 366-72.

Thiel, C. C. (1945).—Studies on compressed whole milk powder. Ibid. 18:391-406.

Thiel, C. C., and Pont, E. G. (1945).—The keeping quality of Australian milk powders. Ibid. 18: 373-90

Wiley, W. J., and Coombs, G. W. (1946).—The manufacture of dry butterfat and of "Butter Concentrated Hardened". Ibid. 19: 140-6.

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 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. These data are published monthly as Radio Propagation Bulletins, which are now available to the public.

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.

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.*—Sixteen 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 or recovery of the valuable minerals.

Two of these investigations concerned the nature of the tin losses in mill products from the Aberfoyle tin mine. Most of the tin in the Aberfoyle lode occurs as cassiterite, but a small amount of stannite is associated with the accompanying sulphides. The tin losses in the discarded floated sulphides are chiefly due to this stannite. The tin losses in the discarded tailings from the coarse jigs are largely due to small particles of cassiterite embedded in chalcopyrite and other sulphides and only in small degree to intergrown stannite.

Copper ore from the Lady Inez mine, Glassford Creek, Queensland, was found to contain an unusual association of silver, lead, and bismuth tellurides and free gold. Small composite particles occur in chalcopyrite, containing hessite and gold in association with either altaite or tetradymite and account for the silver and part of the gold in the ore. Part of the gold also occurs in massive magnetite which has been invaded by the chalcopyrite.

The examination of electrostatic test products from a tantalite concentrate from Greenbushes, Western Australia, revealed not only that coarse inclusions of tantalite occur in crystals of cassiterite but the interesting fact that crystals of cassiterite are sometimes studded with minute, ex-solution bodies of tantalite.

The investigation of South Australian talc deposits has been continued. High-quality talc has been described from an occurrence near Mt. Fitton, Northern Flinders Range, associated with schistose dolomite. Talc desposits at Tumby Bay and their associated jasperoids occur in a zone of shearing along the margin of a broad bed of dolomite. The magnesia in this talc was probably derived from the dolomite, and the development of the talc and its associated jasperoids was associated with the introduction of siliceous solutions, related in origin to the adjacent pegmatitic dykes. Study of the talc deposits at Kenton Valley has disclosed that the biotite of the biotite schists has reacted with incoming pegmatitic solutions to form talc. Albite is formed at the same time but has largely migrated to the margins of unreplaced schist, producing large bodies of pure talc contaminated only by a little disseminated albite and rutile.

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

4. *Ore-Dressing Investigations.* — These 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 are co-operating were continued throughout the year. At Kalgoorlie, the main projects related to gold deposits; ore from Nullagine, Bullfinch, Greenbushes, Broadarrow, Beria, and Linden were examined. In addition, the magnetic separation of cassiterite-tantalite concentrate from Greenbushes was studied. An investigation was also made into a method of assay fluxing of an auriferous cassiterite concentrate.

In Adelaide, most attention has been devoted to industrial minerals. A graphite ore from Watsonville, Queensland, was examined at the request of the Mineral Resources Survey to determine whether a high grade concentrate could be prepared from it. Much attention was also given to the beneficiation of Gumeracha talc. At the request of the South Australian Department of Mines, an extensive programme of testing of this product has been pursued with a view to developing a method of producing high grade talc concentrates from local deposits. Some attention has also been given to various problems relating to the utilization of Leigh Creek coal.

In Melbourne, work for the year has mainly been confined to base metals and to the ilmenite zircon rutile sands from Queensland beaches. The concentration of this material by gravity and electrostatic methods has been studied in some detail. In addition, some attention has been given to the treatment of auriferous concentrates from Woods Point (Victoria) and to the extraction of gold from concentrates of the Lake George Mine, New South Wales.

5. *Mathematical Statistics.*—(i) *General.*—As was the case at the time of submitting the 1944-45 report, ability to meet the increasing demands made upon the Section is limited by the scant supply of personnel appropriately trained for inclusion on its staff. The situation has been eased in part by the addition of three appointees, but the future outlook is far from satisfactory, if the many requests for assistance from the various Sections of the Council and from outside bodies are to be met.

In an attempt to sponsor interest in the subject and provide possible staff within the immediate future, a number of studentships in mathematical statistics were created by the Council during the year, and trainees are now undergoing advanced courses in the theory and application of the subject. Some improvement in the

supply of graduates is also expected from the courses provided by arrangement with the University of Adelaide.

Extraneous appeals for assistance, although mainly received from the Universities, Commonwealth and State departments, and research establishments have included also commercial and individual pursuits. Contact with the Council's many Divisions has continued throughout the year. Assistance of an advisory nature has been provided, in addition to the designing of experiments and analysis of the subsequent results. Greater detail in this regard is given below.

(ii) *Division of Aeronautics.*—Assistance has been provided in the analyses of an experiment designed to test the effect of varying diameter and depth of notch, on Izod results for steel bars; and of a factorial experiment concerned with the effect of sheet thicknesses, weld spacing, and number of welds per specimen on strength of spot welds.

(iii) *Division of Animal Health and Production.*—The Section continued with the analysis of data obtained from the nutrition experiment conducted at Adelaide, interest centering mainly on fitting curves to follicle populations and body dimensions to determine their temporal trend. Other work for the Wool Biology Section included the completion of the analysis of data from the progeny-testing trials at "Noondoo", Queensland, further studies on fleece sampling, and routine computations associated with the long-term experiment in progress at the McMaster Laboratory for studying the response of two breeds of sheep to various levels of nutrition.

Parasitology has continued to be a major interest. Probit analyses have been conducted on dosage-mortality data obtained from experiments in which phenothiazine has been used as an anthelmintic, and the analysis of data from the Canberra rotational grazing trials has been completed. The effects of astringents in producing the oesophageal reflex have been studied, and numerous routine analyses of field trials have been made. Considerable time has been devoted to the planning of a large-scale trial at Armidale on the effect of different rates of stocking and rotational grazing on parasitism and grazing.

A further year's data in the classing trial at Gilruth Plains have been analysed, studies of value per head in the original classing groups again being made.

At the McMaster Field Station, apart from a number of minor analyses, assistance has been given in an experiment designed to provide the most reliable measurements as an indication of sheep size. In addition, a discriminant function analysis is in progress on the use of skin fold scores.

(iv) *Division of Biochemistry and General Nutrition.*—Work for this Division has included the analysis of data of trace element deficiencies affecting sheep, the concentration of vitamin A in the blood of sheep, the interpretation of interactions, the determination of confidence limits for energy relationships, and the response of Mutooroo ewes at Robe to varying doses of copper supplements.

(v) *Division of Economic Entomology.*—The principal work this year has again consisted of the designing and analysis of dusting and spraying trials against a variety of fruit and vegetable pests. Other experiments receiving statistical treatment have included the variation in morphological ratios for grasshoppers with different histories of aggregation, and the influence of location on relative frequency of occurrence of strains within grasshopper species. In addition, an hypothesis to account for the excess over random variation in Peet-Grady uniformity data was examined.

(vi) *Division of Food Preservation and Transport.*—Assistance was given in the planning of various dehydration experiments, by the provision of factorial designs to test the effect on different vegetables of type of blanching, drying temperature, moisture content, and gas-packing.

(vii) *Division of Forest Products.*—Co-operation with this Division has been consistent and varied throughout the year. For the Chemistry Section studies have been of the effects of acids and dissolved salts on the properties of paper sheeting, and various aspects of pulp beating and sheet testing have been examined with a view to more complete standardization of these operations. The relationship between equilibrium moisture content, temperature, and relative humidity has been investigated for the Timber Seasoning Section; and the influence of temperature and moisture on the mechanical properties of wood, the frequency distribution of properties of various species, and the reflectance of paints have been studied for the Section of Timber Physics.

The work for Timber Mechanics included the analysis of experiments on box types, plywood flooring, masonite and caneite building boards. Correlations were obtained between strength properties of experimental floors, and the mechanical properties of specimens cut from them. Diffusion studies were carried out for the Preservation Section, and the validity of Fick's law of diffusion of salt solutions, when applied to timber, was tested. Designs were provided for various experiments on *Lyctus* attack, decay, and preservation methods. The Section of Veneering and Gluing was assisted in the analysis of experiments on the strength of glued joints and the determination of correlations between density and moisture content of wood. Four Queensland sawmills were studied intensively with regard to efficiency, production rate, costs, and lay-out for the Timber Utilization Section. Work for the Flax Section comprised the design and analysis of field trials, the effects of various factors in retting, and a study of fibre measurements and chemical composition in relation to grade of flax fibre.

(viii) *Division of Plant Industry.*—Assistance was given in the designing of several long-term grazing trials for the Agrostology Section, as well as numerous small-scale trials on the establishment and maintenance of improved and ley pastures, and the evaluation of pasture species under grazing. Designs and analyses of numerous varietal trials and data on the effects of green manures, frequency of cutting, and fertilizers were undertaken for the Plant Introduction Section. Many trials with vegetable and drug crops were designed and analysed for variety comparisons in yield resistance to disease, and in ascorbic acid or drug content. In addition, trials on the effects of cultural practices, spacing, fertilizers, and frequency of watering for vegetable and fruit crops were considered in plan and again as final data. Several trials involving the use of fungicides or weed-killers were analysed, as were also pot culture trials. Additional work of an advisory nature included the derivation of a transformation for the analysis of variance for pasture yield data.

(ix) *Division of Soils.*—Further assistance has been provided in the analysis of data concerning rainfall distribution at Dookie Agricultural College, while the length of effective rainfall period at three centres in Tasmania has been similarly treated.

(x) *General.*—During the past few years increasing demands have been made upon the Section's services by external organizations and private individuals, and the position has now been reached where this work constitutes a major part of the Section's activities. The bodies mainly concerned are listed below, together with several Divisions and Sections of the Council not mentioned in the more detailed statements given earlier in this report:—Council for Scientific and Industrial Research Divisions of Fisheries, Industrial

Chemistry, Radiophysics; and Irrigation Research Stations at Griffith and Merbein. *Commonwealth Department of Health*—Institute of Anatomy and Commonwealth Serum Laboratories. *New South Wales*—Soil Conservation Service and Forestry Commission. *Queensland*—Forest Service. *Victoria*—Department of Agriculture, Forestry Commission, Australian Newsprint Mills, and Directorate of Explosives Supply. *South Australia*—Department of Mines, Department of Lands, Department of Engineering and Water Supply, University of Adelaide, and Waite Agricultural Research Institute.

6. *Rubber (Guayule) Investigations.*—At the Waite Institute under the direction of the Council, the investigation of growth development and rubber accumulation of *Parthenium argentatum* (guayule) has proceeded systematically. Samples have been collected at progressive intervals of from three to six months under widely divergent conditions, the plants in some cases growing under entirely natural conditions and in others under a system of controlled periodic irrigation. At a recent date plots established with plants from an American strain of seed and hitherto not sampled have been brought into the investigation as a comparison with plots laid down at an earlier date using Australian-grown seed of early origin.

The results so far are extremely interesting in showing variations in behaviour of the plant under varying conditions of soil and climate with and without irrigation. Size of plant, proportion of rubber in the dry matter, and total rubber accumulation are all affected. In general in each particular area both the proportion of rubber in the plant and the yield increase with time. Larger plants frequently have a lower rubber percentage than smaller plants but the total yield is higher. It would appear, however, that the highest yields of rubber per acre are given by plants of moderate size produced under proper treatment and containing intermediate proportions of rubber in the dry matter. On one such area three years after seed sowing an average yield of 400–500 lb. per acre has been obtained.

This work has been in progress for three years and is proceeding as part of a long term programme over a period of five years depending on results shown. As an extension of the investigation, samples of guayule grown at Canberra and also in Queensland by the Plant Introduction Section of Division of Plant Industry are also being analysed. The main examination in the past has been with material grown in South Australia.

7. *Oenological Research.*—In June, 1934, the Wine Overseas Marketing Board requested the University of Adelaide to arrange for investigations to be carried out concerning the nature, cause, and control of a type of spoilage which had been noticed in many Australian fortified wines. The Board agreed to meet the cost of the necessary investigations, and a graduate in Agricultural Science was appointed to carry out the work, which commenced in the Department of Pathology of the University in November, 1934. The investigations were transferred to the Waite Institute in February, 1935.

In 1937, the functions of the Wine Overseas Marketing Board were taken over by a newly constituted body, the Australian Wine Board, which continued to finance the investigations. During 1938, there was formed, on the suggestion of the Federal Viticultural Council, a Committee on Oenological Research, consisting of representatives of the Council for Scientific and Industrial Research, the University of Adelaide, the Federal Viticultural Council, and the Australian Wine Board. This committee exercises general supervision over the nature of the research being carried out, and advises the Australian Wine Board on matters connected with oenological research.

In October, 1945, the officer carrying out the investigations joined the staff of the Council, and it is contemplated that the programme of research will be extended.

(i) *Spoilage of Australian Fortified Wines.*—This was the first problem on which the Australian Wine Board sought assistance. The spoilage was shown to be caused by several closely related bacteria of the genus *Lactobacillus,* which were found to be widely distributed in Australian wineries. The influence of various factors on the growth of these organisms in wine was determined and, as a result, effective control measures were formulated. The investigation of this problem was terminated early in 1943, and the results were published by the Australian Wine Board in August, 1943, in the form of a monograph entitled "Bacterial Spoilage of Fortified Wines".

(ii) *Sherry Investigations.*—During recent years, the growth and metabolism of the film-forming yeasts (sherry "flor") which are responsible for the characteristic flavour and aroma of Spanish "Fino" sherries, have been the subject of study. Present investigations are concerned with the factors influencing the changes brought about in wines and in artificial media by the sherry yeasts.

(iii) *Sweet Wine Investigations.*—An investigation of the relationship between the stage of ripeness at which grapes are picked and the quality of the sweet wines made from them, was commenced during the last vintage season. This investigation is to be continued over a number of years and involves the co-operation of winemakers in making experimental wines, under industrial conditions, from several varieties of grapes each picked at three different stages of ripeness. Owing to the abnormal weather experienced during the 1946 vintage season, however, several of the wineries were unable to commence the programme this year and only two experimental wines were made.

XXI. INFORMATION SERVICE AND LIBRARY.

A. Information Service.

1. *General.*—It will be recalled that in April, 1945, with the transference of the Scientific Liaison Bureau to the Council for Scientific and Industrial Research, and its merger with the Council's Information Section the resultant organization assumed temporarily the title of Scientific Liaison and Information Bureau. This title was retained until December, 1945, when with the completion of the war-time activities of the Scientific Liaison Bureau, and a clearer definition of its post-war policy, the joint organization assumed its present title of Information Service. At the same time, owing to the limited space available at Head Office, it was deemed expedient that the Service should find temporary accommodation elsewhere, and in consequence it transferred to its present temporary quarters at 425 St. Kilda-road.

The war-time activities of the Scientific Liaison Bureau declined sharply following the cessation of hostilities, and during the latter part of 1945 the members of the Tropical Scientific Section were withdrawn from New Guinea. Upon completion of its outstanding reports the Section was virtually disbanded. Concurrently the representation of the Bureau by Honorary Liaison Officers in Queensland, Tasmania, South Australia, and Western Australia was terminated. Meetings of the various Inter-Services Committees were held late in 1945, following which the activities of these Committees were suspended pending a decision as to the post-war organization of the Services. It is noteworthy that Inter-Services Committee No. 6 recommended that post-war investigations should be organized to cover marine problems of fouling,

underwater corrosion, and marine borer attack; as a first step along these lines a small advisory committee is collecting data from harbour and marine authorities throughout Australia. The remaining functions of the Bureau have been integrated with those of the present Information Service.

An office has been established in Sydney to cater more directly for the needs of industry in New South Wales.

2. *Information Section.*—(A) *Head-quarters, Melbourne.*—(i) *General.*—The Information Service accepts inquiries relevant to any scientific and technical field and deals with them either by giving the information direct when competent to do so, or by referring the inquirer to an appropriate outside authority.

Of its own volition, the Service also prepares reports and reviews for general distribution upon scientific subjects of interest and importance to both primary and secondary industry. These functions are performed with the aid of the Council's extensive Head Office technical reference library, the libraries maintained by the various Divisions and Sections of the Council for Scientific and Industrial Research and by the Munitions Supply Laboratories, and all available public and university libraries. Material not available in Australia is procured from overseas, usually in microfilm form via the Scientific Liaison Offices in London and Washington.

A further function relates to the abstracting of scientific material published in Australian journals and other publications. At present only chemistry is covered, but it is planned to extend this work in the near future to include original work in agricultural science and, later, to all other fields of science. The chemical abstracts are published by the Australian Chemical Institute as "Australian Chemical Abstracts", a supplement to the Institute's Journal and Proceedings.

The Service is also responsible for the dissemination within Australia of scientific material being received from overseas in the form of the Bibliography of Scientific and Industrial Reports, published by the United States of America, Department of Commerce, and for procuring from Washington copies of the reports abstracted in this bibliography, on request. In this and similar activities the Service operates in close co-operation with the Technical Information Section of the Munitions Supply Laboratories and the Secondary Industries Division, Department of Post-war Reconstruction. For the purpose of co-ordinating this work a committee, the "Industrial Information Advisory Committee" consisting of representatives of each of the three bodies, meets regularly to consider matters of mutual interest.

With the changeover from war to peace, there has been a marked change in the relative volumes of the various types of inquiries and also in the sources from which they arise.

While there has been a falling off in the inquiries from Departments concerned with war-time needs, this has been far more than offset by the increasing volume from private individuals and industrial firms and organizations. In the past year the questions have been mainly concerned with problems arising from the changeover of many concerns from war-time to normal activities and the general re-establishment of peace-time industry. Compared with the previous year the number of inquiries from private individuals, particularly from ex-service personnel concerned with post-war rehabilitation, have materially increased. On the agricultural side, ex-servicemen in particular have shown a marked interest in the possible development of semi-tropical and tropical crops in Northern Australia and New Guinea. On the secondary industry side, many requests for information have related to the future development of plastics and other materials developed during the war, references to which have only recently appeared in scientific journals and the press. Over the past twelve months, inquiries from the various Divisions and Sections of the Council have accounted for 10 per cent. of the total, those from government departments for 23 per cent., from private individuals 27 per cent., and the largest proportion, 40 per cent., has come from industry. In all, the Service has handled some 1,430 inquiries during the period under review, 1,160 at its Head-quarters in Melbourne, and 270 in its Sydney Office. These figures are exclusive of minor telephone inquiries and certain personal interviews.

(ii) *Reports.*—The Information Service commenced recently a series of "T" reports on subjects of industrial importance, both in the primary and secondary fields. During the year, four further reports in the series were commenced on the following subjects—the control of dingoes; wool wax; the chemistry and practical applications of the new series of silicon-containing organic compounds known as Silicones; and liquid-liquid extraction.

(iii) *Inquiries.*—The more important inquiries dealt with are discussed below, according to the various categories within which they naturally fall.

(*a*) *Pure Science.*—Requests have from time to time been received for detailed methods of preparation of materials on a laboratory, rather than on an industrial, scale. Information of this nature has been given on the preparation of mono- and tri-chloroacetic acid, o-nitroanisole phenyl isocyanate, thioglycollic acid, ethylmercuric phosphate, DDT, and various chemical smokes, and on the nitration of phenol and chlorobenzene. Information has also been given on paludrine, the generation, detection, and uses of supersonic oscillations, magneto-optical methods of analysis, the chemistry of the setting of gypsum plasters, the chemistry of the silicones, and the theory of wet batteries.

(*b*) *Primary Industry.*—In the field of primary industry by far the greatest number of questions have related to agriculture; a few have been concerned with mining and others with the fishing and related industries. (1) *Agriculture.*—In response to numerous requests, information has been supplied on the commercial possibilities of such crops as kudzu, tung-trees, cocoa, rubber, cotton, *Asclepias* spp., drug plants, soy beans, kapok, papaw trees, vegetables, and basket willows. Questions relating to the destruction of weeds, blackberries, and bracken fern and the control of various animal pests have received continued attention. Many requests for a summary of information on the destruction of blackberries prepared by the Service, were received during the year. Information was also supplied on the use of flame throwers and hormones as weed killers, on the control of dingoes, rabbits, and flying foxes, and on the use of supersonic oscillators for repelling pigeons. At the request of U.N.R.R.A., an annoted bibliography was prepared on animal diseases in countries to the north of Australia. Other agricultural subjects dealt with included soil erosion and control, soil irrigation and management, trace elements in relation to plant growth, hormones as growth promoting substances, flora conservation, biodynamics, hydroponics, the use of flame throwers and chemical smokes in frost prevention, breaking dormancy in potatoes, storage of gladioli corms, keeping qualities of cut flowers, cultivation of mushrooms, bird-scaring devices, earth worms, the fattening of poultry, and glasshouse and wool-shed construction. (2) *Mining.*—Information on the gypsum and diatomaceous earth deposits of Australia, on salt production in Australia, and statistical data in relation to various minerals and metalliferous ores in this country has been given during the year.

(c) *Secondary Industry.*—Inquiries in the field of secondary industry have ranged from simple requests for the properties of materials or the sources of supply of raw materials, and the general principles underlying manufacturing processes to detailed information on these processes. As a result of inquiries submitted concerning chemical engineering problems, and plant design particularly, it has been brought home to the Service time and time again that throughout Australia there is available to the smaller industrialist a marked absence of qualified chemical engineers competent to advise on even the more elementary problems of chemical engineering and plant design. The Section thoroughly endorses the recommendations of the Australian Chemical Institute that the local training of chemical engineers is of vital importance to the success of the chemical industry in Australia.

Various inquiries relating to secondary industry, on which advice has been given, are listed under appropriate headings below.

(1) *Manufacturing processes* (other than those listed under specific headings below).—Sodium and potassium sulphides, calcium metaphosphate, acetaldehyde and metaldehyde, phenothiazine, citric acid by mould fermentation, mothballs, chalks, crayons and slate pencils, luminescent materials, cold moulding materials, coconut shell charcoal, lead-acid storage battery plates, fly papers, soft soaps, soap powders, permanent waving solutions, coir fibre, flower perfumes, sulphonation of whale oil, blooming of glass, and waterproof whitewash.

(2) *Products and product uses* (other than those listed under specific headings below).—Dicyanamide, ethyl formate, amyl salicylate, potato flour and starch, mica, moulding powders, plastic wood, tannins, and cream of tartar, preparation, properties, and uses of apricot kernel oils, isolation of lactones from *Angelica* spp., uses of essential oils in ventilating systems.

(3) *By product utilization and disposal.*—Waste products generally, sunflower seeds, sawdust, winery wastes, neutralization and disposal of acid pickling, electroplating, and cyanide solutions, utilization of cull peaches and pears.

(4) *Instruments, machines, &c.*—Instruments for measuring the moisture content of wool, charging continuous absorption refrigerators, ignition systems, induction furnaces for zinc oxide, punches and dies for cannister forming.

(5) *Metallurgy.*—Electro-deposition of iron, impurities in the anodizing of aluminium, metal spraying of tanks, electrostatic separators, aluminizing of steel, metallizing ceramics, induction methods for heat-treating of steel, spot welding thin wires, manufacture and testing of tin cans, electrolytic polishing, insulation of normalizing lead baths, electrodeposition of gold alloys, manufacture of steel wool, silvering and desilvering of mirrors, preparation of coppered glass mirrors.

(6) *Foods and food products.* — Manufacture of: tomato, banana, pineapple, and papaw products, rennin, pear essence, sugar from artichokes, and malt extract powders; storage of fruit juices, processing of honey, blending and testing of wines, curing of fish, quick freezing, processing of peanuts, extraction of ginger and citrus oils, food yeast, bibliography on the dehydration and storage of vegetables commenced in June, 1943, kept up to date.

(7) *Plastics and rubber.* — Chemistry of silicone varnishes, list of Australian plastic trade names and manufacturers brought up to date, use of plastics for lining brewery tanks, improving the finishes of plastics, use of plastics in kitchen utensils, plastics as substitutes for glass, concentration of liquid rubber latex.

(8) *Textiles.*—Fast printing inks for textiles, Trubenizing process for production of semi-stiff collars, shirt fronts, &c., composition of lacquers for screen printing of textiles.

(9) *Miscellaneous.*—Bibliography of all papers published in Australia on fuels since 1930, ultraviolet irradiation of the air, germicides in ink.

(d) *Maintenance and Pest Control.*—It is convenient to consider under this heading inquiries which, while relating to problems of the industrialist, have a more general application than those classified above. Problems of maintenance included: causes and prevention of road corrugation, prevention of corrosion of galvanized piping, purification of stored water, desalting of salt water, and the destruction of mussels in cooling-water piping circulating seawater. In response to many requests, summaries of information on rat poisons, including 109 and 1080, and rat control have been supplied. Requests for information on the insecticide DDT have continued unabated.

Methods for the specific control of Argentine ants, bedbugs, bats, silverfish, fleas, daddy-longlegs, cockroaches, clothes moths, and carpet beetles, have been given in answer to inquiries regarding these various pests.

(B) *Sydney Office.*—The Sydney Office is receiving a steady flow of inquiries. By far the greatest number come from secondary industry, and this trend is increasing. Inquiries received have been concerned mainly with methods of manufacture, for example, of chemicals, coir fibre, electroformed iron, luminescent paint, agar, plastic models, &c. Others have related to the availability, disposal, and substitution of chemicals and to the question of waste utilization generally. Information on various industries, such as bee keeping, food processing, galvanizing, building construction, and building materials, as well as on industrial hazards have been requested.

The answering of inquiries by reference to relevant authorities is a much more significant part of the work of the Sydney Office, owing to its small staff, and limited facilities, than is the case at the head-quarters of the Service in Melbourne. Requests for literature researches and bibliographies are accordingly referred to the Melbourne Office.

3. *Translation Section.* — The operation of the Foreign Journal Service, which was established in 1942 as a means of making available the information contained in some 200 German, Italian, Russian, and French scientific journals obtained in the form of photographic microfilm from London during the war, and the mounting requests for translations of the material contained in these and other scientific journals, had for a long time emphasized the need for a central translation service within the Council in order to meet the demands of the officers of the Council itself and outside organizations and individuals. In order therefore to meet these demands the Foreign Journal Service was expanded during the year into a Translation Section, with the appointment of two further full-time translators, and a third to join the staff during July. With the cessation of the war it was expected that the main functions of the Foreign Journal Service, i.e. the circulation of contents lists and photostats from the journals, would soon be unnecessary, and arrangements were in consequence made to undertake immediately an increased amount of translation work. However, contrary to expectation this work has not diminished but has expanded, since a very large amount of back material is still being received and the demands for it are extremely heavy.

The continuance of this work has necessarily slowed down the translation programme somewhat. Nevertheless a plan has been drawn up for the translation

and distribution on a bigger scale of the increased amount of Russian scientific and technical literature becoming available.

4. *Editorial Section.*—During the year consideration was given by the Executive Committee to the important question of the editing, production, and distribution of the Council's publications, which had in the past been a joint function of the Secretariat and the Information Service. After due consideration, it was decided that the editing and production of publications should be a function of the Service while the distribution should be carried out by the Secretariat.

5. *Film Unit.*—In order that the facilities for scientific research available in the Council's laboratories throughout Australia should be presented in a clear and concise manner to the Royal Society and Official Conferences in London in June and July, 1946, the Executive Committee decided that a cine-film record of such facilities should be prepared, with a duration of approximately two hours.

The project of preparing this film was entrusted to the Information Service late in 1945, and a unit was immediately set up to carry out the work. After careful consideration it was realized that in order to cover the major facilities of the Council for Scientific and Industrial Research in the limited time of showing it would be impossible to dwell on any particular aspect, or in fact, on any of the actual activities of the 26 Divisions and Sections of the Council. In consequence it was decided that the film should take the form of a series of illustrations depicting the principal facilities of the Council as they related in general to its major activities, and the manner in which the Divisions and Sections grouped themselves in regard to these activities.

An early attempt was made to use Kodachrome film but unfortunately the speed of this film was such that sufficient light for many of the essential interior views of the laboratories and workshops was impossible to arrange in view of the time and equipment available. Recourse had therefore to be made to black and white film. The final film entitled "C.S.I.R. Research and Facilities" was therefore 16 mm. black and white with sound on film commentary, divided into the following five sections: Part 1—Introduction and Organization; Part 2—Agriculture, Fisheries, and Food; Part 3—The Pastoral Industry; Part 4—Secondary Industry Research; Part 5—Physical Science.

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

Hosking, J. S. (1946).—DDT and its use as an insecticide. *Aust. Municipal J.* 25: 437-9; also issued as a leaflet (1945) by the Victorian Branch of the Health Inspector's Assoc. of Aust.

——(1946).—Second Toxicology Conference of C.S.I.R. *Aust. J. Sci.* 8: 123-6.

B. Library.

During the past year the supply of overseas publications has continued to improve and various series of journals published on the Continent during the war years have now come to hand. To date, however, it has not been possible to obtain any of the German publications, other than those which have been reproduced elsewhere. A special effort, which has met with some success, has been made to build up the Russian section of the Library, and fairly complete sets of the war-time volumes of some of the more important physical, chemical, and biological journals, as well as a selection of the special publications from the Academy of Sciences, the Lenin Academy of Agricultural Sciences, and similar institutions, have now been obtained.

Thanks to the assistance of the Council's Liaison Officers in London and Washington, increasing help is being given, not only to Council for Scientific and Industrial Research sectional libraries but also to other libraries and to individual enquirers, by obtaining for them film copies of references not available in Australia. This service practically brings within range of a research worker, who has an extensive bibliography the various items of which he wishes to consult, not only the resources of Australian libraries, but also those of Great Britain and the United States.

The revision of the Catalogue of Scientific and Technical Periodicals is taking longer than was first anticipated, and the manuscript is not likely to be ready for forwarding to the printer for at least another year. One reason for this is the change that has taken place in periodical holdings as a result of the end of the war. The renewal of publication of many English and American journals, which had been suspended during the war period, and the resumption of communication with scientific institutions and publishing bodies on the Continent has meant continual amendment of library holdings.

XXII. FINANCIAL MATTERS, STAFF, AND PUBLICATIONS.

1. *Finance.*—The statement of expenditure from 1st July, 1945, to 30th June, 1946, is as follows:—

	£	£	£
(1) **Salaries and contingencies**			53,857*
(2) Remuneration of Chairman and Members of Council			2,487†
(3) Investigations—			
(i) Animal Health and Production Problems		76,466	
Less contributions from—			
Wool Research Fund	9,386		
Commonwealth Bank	4,100		
Department of Agriculture and Stock, Brisbane	1,000		
George Aitken Pastoral Research Trust	1,100		
Australian Cattle Research Association	3,750		
Australian Wool Board	5,305		
Australian Meat Board	135		
Alexander Fraser Memorial Fund	175		
Ian McMaster Estate	82		
Revenue Funds—			
Vaccine	1,311		
Pleuro Pneumonia	460		
Mastitis	730		
Toxaemic Jaundice—Barooga	115		
F.D. McMaster Field Station	496		
"Gilruth Plains" National Field Station	3,992		
"Gilruth Plains" Reserve	663		
Toxaemic Jaundice	301		
Parkville	126		
		33,227	
			43,239

* 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.

	£	£	£
(ii) Biochemistry and General Nutrition Problems		28,384	..
Less contributions from—			
Commonwealth Bank	1,400	..	..
George Aitken Pastoral Research Trust	900	..	..
Australian Wool Board	3,852	..	..
Wool Research Fund	979	..	..
		7,131	..
			21,253
(iii) Plant Problems—Division of Plant Industry		82,442	..
Less contributions from—			
Australian Wool Board	1,500	..	..
Department of Supply and Shipping	1,947	..	..
Department of Commerce and Agriculture	890	..	..
Wool Research Fund	1,524	..	..
		5,861	..
			76,581
(iv) Entomology Problems—Division of Economic Entomology		34,474	..
Less contributions from—			
Australian Wheat Board	460	..	..
		460	..
			34,014
(v) Horticultural Problems of the Irrigation Settlements—			
(*a*) Citricultural—Research Station, Griffith	25,083	..	..
Less contributions	7,002	..	..
		18,081	..
New South Wales Water Conservation and Irrigation Commission	2,554	..	..
New South Wales Department of Agriculture	814	..	..
Yenda Producers Co-operative Society Limited	109	..	..
Leeton Fruit Growers Co-operative Society Limited	109	..	..
Griffith Producers Co-operative Company Limited	326	..	..
Rural Bank of New South Wales	1,086	..	..
Leeton Co-operative Canneries Limited	651	..	..
Griffith Revenue Fund	1,353	..	..
(*b*) Viticultural—Research Station, Merbein	10,493	..	..
Less contributions	3,585	..	..
		6,908	..
			24,989
Dried Fruits Control Board	1,142	..	..
Irymple Packing Proprietary Limited	140	..	..
Mildura Co-operative Fruit Company	140	..	..
Red Cliffs Co-operative Fruit Company	140	..	..
Aurora Packing Proprietary Limited	140	..	..
Merbein Research Station, Revenue Fund	1,883	..	..
(vi) Soil Problems		23,936	..
Less contributions from—			
Commonwealth Bank	3,000	3,000	..
			20,936
(vii) Food Preservation and Transport Problems		37,556	..
Less contributions from—			
Commonwealth Bank	3,750	..	..
New South Wales Department of Agriculture	800	..	..
Queensland Meat Industry Board	850	..	..
Australian Meat Board	500	..	..
Metropolitan Meat Industry Commission	500	..	..
Egg Producers' Council	89	..	..
Department of Commerce and Agriculture	1,230	..	..
Lewis Berger and Sons	25	..	..
Batlow Packing Company	200	..	..
Apple and Pear Grant—Department of Commerce and Agriculture ..	121	..	..
Food Preservation Revenue Fund	75	..	..
		8,140	..
			29,416
(viii) Forest Products Problems		72,226	..
Less contributions from—			
Commonwealth Bank	3,250	..	..
Australian Paper Manufacturers Limited	500	..	..
Associated Pulp and Paper Mills Limited	500	..	..
Australian Newsprint Mills Limited	500	..	..
Miscellaneous contributions	747	..	..
		5,497	..
			66,729
(ix) Mining and Metallurgy		5,094	..
Less contributions from—			
Australasian Institute of Mining and Metallurgy		368	..
			4,726
(x) Radio Research		18,971	..
Less contributions from—			
Postmaster-General's Department	4,737	..	..
Departments of Army, Navy and Air	9,000	..	..
		13,737	..
			5,234
(xi) Information Service, including Library		18,906	..
Less contributions from—			
Foreign Journal Service		312	..
			18,594
(xii) Industrial Chemistry		97,679	..
Less contributions from—			
Australian Cement Manufacturers Association		1,500	..
			96,179

	£	£	£
(xiii) Fisheries Investigations		31,336	..
Less contributions from—			
New South Wales Government	250	..	..
Oyster Revenue Fund	106	..	..
		356	..
			30,980
(xiv) Aeronautical Research		..	114,672
(xv) National Standards Laboratory		120,750	..
Less contributions		12,669	..
			108,081
(xvi) Building Materials Research		..	14,688
(xvii) Flax Research		..	6,653
(xviii) Radiophysics Laboratory		..	121,809
(xix) Tribophysics		26,686	..
Less contributions from—			
University of Melbourne		350	..
			26,336
(xx) Miscellaneous			
(*a*) Potato Investigations		5	..
(*b*) Dairy Research		4,033	..
(*c*) Mathematical Research		8,045	..
(*d*) Various		3,485	..
(*e*) Wool Use Promotion		3,377	..
(*f*) Oenological Research		434	..
		19,379	
Less contributions—			
Wool Research Fund	3,377	..	..
Australian Wine Board	296	..	..
		3,673	..
			15,706
(xxi) Atomic Energy Research		..	929
(xxii) Metallurgical Research		..	992
Total of Item 3—Investigations		..	882,736

2. *Contributions and Donations.*—The following statement shows the receipts and disbursements during the year 1945-46 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled "The Specific Purposes Trust Account":—

	Receipts 1945-46 and balances brought forward from 1944-45.	Expenditure 1945-46.
	£	£
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)	13,191	10,677
Australian Cattle Research Association (Mastitis Investigations)	3,750	3,750
George Aitken Pastoral Research Trust (Animal Health and Production Investigations)	2,500	2,000
Queensland Government Cattle Research (Animal Health and Production Investigations—Sheep Research)	1,000	1,000
Australian Meat Board (Toxaemic Jaundice Investigations, Barooga, New South Wales)	169	169†
Alexander Fraser Memorial Fund	175	175
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	82
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)	11,063	890
Department of Supply and Shipping—Medicinal Plants (Plant Industry Investigations)	1,949	1,947
Commonwealth Bank—Bee Research (Entomological Investigations)	92	..
Australian Wheat Board—Wheat Infestation (Entomological Investigations)	464	460
Carried forward	51,280	36,650

* Includes £20 on account of 1944-45 expenditure.
† Includes £34 on account of 1944-45 expenditure.

	Receipts 1945-46 and balances brought forward from 1944-45.	Expenditure 1945-46.
	£	£
Brought forward	51,280	36,650
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)	1,323	814
New South Wales Water Conservation and Irrigation Commission (Soils and Irrigation Extension Service, Griffith)	899	554
Griffith Producers' Co-op. Coy. Ltd. (Soils and Irrigation Extension Service, Griffith)	529	326
Rural Bank of New South Wales (Soils and Irrigation Extension Service, Griffith)	1,764	1,086
Yenda Producers' Co-op. Society Ltd. (Soils and Irrigation Extension Service, Griffith)	176	109
Leeton Fruit Growers' Co-op. Society Ltd. (Soils and Irrigation Extension Service, Griffith)	176	109
Leeton Co-op. Canneries Ltd. (Soils and Irrigation Extension Service, Griffith)	1,058	651
Mildura Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	140	140
Irymple-Packing Company (Dried Vine Fruits Investigations, Merbein)	140	140
Red Cliffs Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	140	140
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	140	140
Dried Fruits Control Board (Dried Fruits Investigations)	1,200	1,142
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	228	..
Department of Supply and Shipping (Production of Pyrethrum)	52	..
Carried forward	61,345	44,001

	Receipts 1945-46 and balances brought forward from 1944-45. £	Expenditure 1945-46. £
Brought forward ..	61,345	44,001
Australian Meat Board (Meat Investigations)	625	625*
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 and Co. (Division of Food Preservation and Transport)	74	..
W. Angliss Ltd. (Division of Food Preservation and Transport) ..	352	..
L. Berger and Sons (Division of Food Preservation and Transport)	25	25
Batlow Packing House Co-op. Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations)	210	200
Ungars Peanuts Pty. Ltd. (Division of Food Preservation and Transport—Canning Investigations) ..	10	..
Lewis Berger and 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) ..	89	89
Egg Producers' Council (Watery Whites in Eggs)	2	..
Department of Commerce and Agriculture (Division of Food Preservation and Transport—Dehydration Investigations) ..	1,245	1,245†
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
Bureau of Forestry, Canberra, and Forest Services of Queensland, Victoria, New South Wales and Western Australia—Wood Structure (Forest Products Investigations)	75	..
Annual Pulp and Paper Research Conference—Division of Forest Products	250	..
Sundry Contributions (Forest Products Investigations) ..	1,925	747
Australasian Dairy Council (Wood Taint in Butter Investigations)	11	..
Department of Supply and Shipping —Flax Processing (Forest Products Investigations) ..	17	..
Brisbane Timber Merchants' Association (Division of Forest Products—Veneer and Gluing Work)	8	..
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	368	368
Postmaster-General's Department (Radio Research)	4,737	4,737
Department of Army, Navy, and Air (Radio Research) ..	9,000	9,000
Sundry Contributions (Foreign Journal Service)	312	312
New South Wales Government (Fisheries Investigations) ..	313	313‡
Wireless Equipment M.V. *Warreen* (Fisheries Investigations)	420	..
Carried forward ..	85,093	65,312

* Includes £125 on account of 1944-45 expenditure.
† Includes £15 on account of 1944-45 expenditure.
‡ Includes £63 on account of 1944-45 expenditure.

	Receipts 1945-46 and balances brought forward from 1944-45. £	Expenditure 1945-46. £
Brought forward ..	85,093	65,312
Drug Houses of Australia (Division of Fisheries—Agar Production)	25	..
National Gas Association (Gas Investigations—Industrial Chemistry)	433	..
Australian Cement Manufacturers (Cement Investigations—Industrial Chemistry Standards) ..	1,650	1,500
Department of Commerce (Apple and Pear Investigations) ..	272	121
Ministry of Munitions	11,527	11,480*
Army Inventions Directorate ..	110	110†
Department of Army	*Dr.* 186	*Cr.* 186‡
Sundry Contributors (Council for Scientific and Industrial Research —Publications)	24	..
Amalgamated Textiles (Aust.) Ltd. (Division of Industrial Chemistry)	35	..
Amalgamated Wireless (A'sia) Ltd. (Division of Industrial Chemistry)	31	..
F. Walton and 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)	1,377	..
Kelsall and Kemp (Tas.) Ltd. (Division of Industrial Chemistry)	50	..
Alfred Lawrence and Co. Ltd. Division of Industrial Chemistry)	105	..
British Industrial Plastics (Plastics Research—Division of Industrial Chemistry) ..	50	..
F. W. Hughes (Fellmongery Research—Division of Industrial Chemistry)	123	..
R. Birch (Foundry Sands Investigations—Division of Industrial Chemistry)	3	..
University of Melbourne (Friction Research)	350	350
Department of Interior (A.R.P. Expenditure)	10	..
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Production Investigations)	301	301
Revenue Fund—Contagious Pleuropneumonia Investigations (Animal Health and Production Investigations)	879	460
Revenue Fund—Helenslee Field Station (Animal Health and Production Investigations) ..	451	..
Revenue Fund—Oestrus Experiment (Animal Health and Production Investigations)	647	..
Revenue Fund—Sale of Contagious Pleuro-pneumonia Vaccine (Animal Health and Production Investigations) ..	3,656	1,311
Revenue Fund—Sale of Strain 19 Vaccine (Animal Health and Production Investigations) ..	581	..
Revenue Fund—Anaplasmosis Investigations (Animal Health and Production Investigations) ..	82	..
Revenue Fund—Parkville Laboratory (Animal Health and Production Investigations) ..	706	126
Australian Wine Board (Oenological Research)	296	296
Carried forward ..	109,216	81,181

* Includes £240 on account of 1944-45 expenditure.
† Includes £110 on account of 1944-45 expenditure.
‡ Includes £204 on account of 1944-45 expenditure.

	Receipts 1945-46 and balances brought forward from 1944-45.	Expenditure 1945-46.
	£	£
Brought forward ..	109,216	81,181
Revenue Fund—Werribee Farm Mastitis Investigations (Animal Health and Production Investigations)	3,017	730
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)	3,992	3,992
Reserve Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Production Investigations)	1,132	663
Revenue Fund—Bacteriological Investigations (Animal Health and Production Investigations) ..	157	..
Revenue Fund—Parasitological Investigations (Animal Health and Production Investigations) ..	790	..
Revenue Fund—Infertility, F. D. McMaster Field Station (Animal Health and Production Investigations)	1,735	496
Revenue Fund—Toxaemic Jaundice Investigations, Barooga, New South Wales (Animal Health and Production Investigations)	115	115
Revenue Fund—Nutrition Laboratory (Biochemistry and General Nutrition Investigations) ..	783	..
Revenue Fund—Plant Industry Investigations	1,800	..
Revenue Fund—Entomological Investigations	694	..
Revenue Fund—Griffith Research Station (Citricultural Investigations)	6,165	1,353
Revenue Fund—Merbein Research Station (Viticultural Investigations)	8,880	1,883
Revenue Fund—Division of Food Preservation and Transport ..	192	75
Revenue Fund—Egg Investigations, Egg Producers' Council (Division of Food Preservation and Transport)	147	..
Revenue Fund—Mining and Metallurgy	14	..
Revenue Fund—Ore-dressing Investigations	817	..
Revenue Fund—Fisheries Investigations	34	..
Revenue Fund—Oyster Investigations	220	106
Revenue Fund—Division of Aeronautics	100	..
Revenue Fund—National Standards Laboratory	1,075	..
Revenue Fund—Dairy Investigations	9	..
Revenue Fund—Industrial Chemistry	382	..
Revenue Fund—Merbein Research Station—Production of Pyrethrum	185	..
Revenue Fund—Information Service	76	..
Revenue Fund—Fellmongery Research	6	..
	141,796	90,594

3. *Wool Research Trust Account.*—During the year 1945-46 the Wool Research Trust Account was established following the passing of the *Wool Use Promotion Act* 1945. Initial authority to the extent of £100,000 was received from the Department of the Treasury. Expenditure during 1945-46 was as follows:—

	£	£
Division of Animal Health and Production—		
McMaster Laboratory—Parasitology Investigations ..	1,000	
McMaster Laboratory—Dipping and External Parasites ..	1,000	
McMaster Laboratory—Wool Biology	1,500	
McMaster Laboratory—Parasitology Field Investigations	688	
McMaster Laboratory—Biochemistry	1,000	
Ecological Survey of Wool Production	1,600	
National Field Station "Gilruth Plains"—Capital Expenditure	1,426*	
Toxaemic Jaundice Investigations	476	
Sheep Physiology Investigations	33	
Fleece Analysis Investigations	1,400	
Sheep Biology Investigations	96	
Physiology of Reproduction Investigations	400	
		10,619
Division of Plant Industry—		
Agrostology Investigations ..	1,524	
		1,524
Division of Physics—		
Wool Research	1,828	
		1,828
Division of Biochemistry and General Nutrition—		
Biochemical and Nutritional Investigations	979	
		979
Miscellaneous—		
Expenses associated with the visit of overseas wool textile authorities	3,036†	
Textile Research	792	
		3,828
Total Expenditure ..		18,778

* Includes £1,233 on account of 1944-45 expenditure.
† Includes £451 on account of 1944-45 expenditure.

4. *Staff.*—The following is a list of the staff of the Council as at 30th June, 1946. 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—A. E. V. Richardson, C.M.G., M.A., D.Sc.

Executive Officer—F. W. G. White, M.Sc., Ph.D.

Executive Officer—Professor I. Clunies Ross, D.V.Sc.

Secretary—G. A. Cook, M.C., M.Sc., B.M.E.

Assistant Secretary—F. G. Nicholls, M.Sc.

Assistant Secretary—H. C. Forster, M.Agr.Sc., Ph.D.

G. B. Gresford, B.Sc.

Assistant Secretary (Finance and Supplies)—M. G. Grace, A.I.C.A.

Consultant—G. Lightfoot, M.A.

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.
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.
P. Knuckey.
Clerical Assistant to Chairman—Miss A. Slattery, B.A.
Clerical Assistant to Chief Executive Officer—Miss G. Byrt.
Head Typist—Miss B. M. Thomas.
Senior Clerical Officer, Sydney—R. F. Williams.
Architect—W. R. Ferguson, B.E.
Engineer—R. N. Morse, B.Sc., B.E.

Liaison Overseas—

London—
L. Lewis, B.Met.E.
W. J. Ellis, A.S.T.C.
D. T. C. Gillespie, M.Sc.
Washington—
G. H. Munro, M.Sc.
N. A. Whiffen, F.S.T.C.
M. F. Day, B.Sc., Ph.D.
Head Office—
Miss J. Dunstone, B.Sc., Dip. Ed.

Information Service—

Administration—
Officer-in-Charge—J. E. Cummins, B.Sc., M.S.
Acting Officer-in-Charge—J. S. Hosking, M.Sc., Ph.D.
Technical Secretary—F. A. Priest, A.S.A.S.M.
Records Officer—Mrs. G. M. Kilvington, M.Sc.
Information Section—
Senior Research Officer—C. M. Gray, M.Sc.
Senior Research Officer—D. T. C. Gillespie, M.Sc. (seconded).
Research Officer—A. R. Docking, M.Sc.
Assistant Research Officer—G. J. Wylie, B.A., B.Sc.
Assistant Research Officer—N. H. Olver, M.Sc.
Assistant Research Officer—Miss J. M. Baldwin, B.Sc., Dip.Ed.
Translation Section—
Senior Translator—A. L. Gunn.
Translator—Miss E. D. Armstrong, B.A. (Hons.)
Translator—Mrs. E. Notkin, M.D. (Prague).
Editorial Section—
Editor of Publications—Miss M. E. Hamilton, B.Sc.
Film Section—
Assistant Research Officer—S. T. Evans, B.Sc.
Technical Officer—E. S. Smith.
At Sydney—
Research Officer—A. M. Andrews, B.Sc.

2. Secretaries of State Committees.

New South Wales—
A. M. Andrews, B.Sc., Phillip House, 119 Phillip-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.), Agriculture Department, Perth, Western Australia.
Tasmania—
F. J. Carter, c/o Premier's Office, Hobart.

3. Division of Plant Industry.

(Headquarters: Canberra, A.C.T.)

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).
Plant 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.Agr.Sc., Ph.D.
Assistant Research Officer—D. O. Norris, M.Sc. (Agric.)
Assistant Research Officer—Miss M. Mills, B.Sc.
Assistant Research Officer—J. H. E. McKay, B.Sc.Agr.
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—
Senior Research Officer—W. Hartley, B.A., Dip. Agr. (Cantab.).
Assistant Research Officer—S. G. Gray, B.Sc.Agr.
Horticultural and General Botany—
Principal Research Officer—C. Barnard, D.Sc.
Research Officer—K. Loftus Hills, M.Agr.Sc.
Plant Physiology—
Research Officer—J. Calvert, D.Sc.
Assistant Research Officer—R. F. Williams (seconded).
Herbarium—
Senior Research Officer—W. Hartley, B.A., Dip. Agr. (Cantab.).
Agrostology—
Principal Research Officer—J. Griffiths Davies, B.Sc., Ph.D.
Senior Research Officer—C. S. Christian, M.Sc.
Senior Research Officer—C. M. Donald, M.Ag.Sc.
Senior Research Officer—C. G. Greenham, M.Sc.
Senior Research Officer—A. B. Cashmore, M.Sc. (seconded).
Research Officer—R. M. Moore, B.Sc.Agr.
Assistant Research Officer—E. H. Kipps, B.Sc.
Assistant Research Officer—A. J. Anderson, B.Sc. (Agric.).
Assistant Research Officer—C. W. E. Moore, B.Agr.Sc.
Assistant Research Officer—E. F. Biddiscombe, B.Sc. (Agric.).
Assistant Research Officer—Miss Nancy Barrie, B.Sc.Agr.
Assistant Research Officer—Miss Helen R. Browne, B.Sc.
Technical Officer—R. J. Hutchings, Dip.Ag.D.
Technical Officer—R. E. Herrington, Q.D.Hort.
Tobacco Investigations—
Senior Research Officer—A. V. Hill, M.Agr.Sc.

Vegetable Investigations—
Research Officer—E. M. Hutton, B.Ag.Sc., M.Sc.
Assistant Research Officer—D. C. Wark, M.Agr. Sc.
Technical Officer—Miss Joan Demaine, B.Agr.Sc.

At Dickson Experiment Station, Canberra, A.C.T.—
Manager—L. Sharp, Dip.Agr.

At Cooper Laboratory, Queensland Agricultural High School and College, Lawes—
Research Officer (agrostology)—T. B. Paltridge, B.Sc.
Research Officer (agrostology)—R. Roe, B.Sc. (Agric.).
Assistant Research Officer (agrostology)—N. H. Shaw, B.Agr.Sc.
Technical Officer (agrostology)—R. J. Pack, Q.D.Agric.
Technical Officer (agrostology)—H. J. Wyndham, Q.D.D., Q.D.Hort.
Technical Officer (agrostology)—R. Milford, Q.D.Agric.
Technical Officer (plant introduction)—W. G. Robertson, Q.D.Agric. and Hort.

At "Gilruth Plains", Cunnamulla, Queensland—
Technical Officer (agrostology)—G. H. Allen, G.D.A.
Technical Officer (agrostology)—C. I. Robertson, Q.D.Hort.

At Stanthorpe, Queensland—
Senior Research Officer (horticultural investigations)—L. A. Thomas, M.Sc.

At Nambour, Queensland—
Assistant (drug plant investigations)—G. P. Kelenyi, Dip.Agr. (Dookie).

At Brisbane, Queensland—
Research Officer (plant introduction)—J. F. Miles, B.Agr.Sc.
Technical Officer (drug plant investigations)—L. J. Webb.

At Muresk, Western Australia—
Assistant Research Officer (plant introduction)—E. T. Bailey, B.Sc.

At University of Western Australia, Perth, Western Australia—
Assistant Research Officer (agrostology)—R. C. Rossiter, B.Sc. (Agric.).
Assistant Research Officer (agrostology)—H. L. Pennington, B.Sc. (Agric.).

At Falkiner Memorial Field Station, Deniliquin, New South Wales—
Research Officer (agrostology)—R. W. Prunster, B.Sc. (Agric.).
Research Officer (agrostology)—A. L. Tisdall, M.Agr.Sc.
Assistant Research Officer (agrostology)—W. M. Willoughby, B.Sc.Agr.
Assistant Research Officer (agrostology)—O. B. Williams, B.Agr.Sc.
Technical Officer (agrostology)—K. R. Brown, Dip.Ag.D.

At New England University College, Armidale, New South Wales—
Assistant Research Officer (agrostology)—E. J. Hilder, B.Sc. (Agric.).

At Huonville, Tasmania—
Senior Research Officer (fruit investigations)—D. Martin, B.Sc.

At Melbourne University, Victoria—
Assistant Research Officer (drug plants)—Miss C. Rodwell, B.Sc.

At Katherine Experiment Farm, Northern Territory—
Farm Manager—F. H. Kent.

4. Division of Economic Entomology.

(Head-quarters: Canberra, A.C.T.)

At Canberra—

Administration—
Chief—A. J. Nicholson, D.Sc.
Librarian (half time)—Miss A. Nicholson.
Senior Clerical Officer (half time)—D. Banyard (acting).

Biological Control and Museum—
Senior Research Officer—F. Wilson.
Research Officer—T. G. Campbell.
Assistant Research Officer—E. F. Riek, M.Sc.
Assistant Research Officer—P. B. Carne, B.Agr. Sc.

Physiology and Toxicology—
Senior Research Officer—D. F. Waterhouse, M.Sc.
Research Officer—D. Gilmour, M.Sc.
Assistant Research Officer—R. H. Hackman, M.Sc. (seconded from Division of Industrial Chemistry).
Assistant Research Officer—R. F. Powning, A.S.T.C.
Technical Officer—J. H. Calaby.

Blowfly Investigations—
Research Officer—K. R. Norris, M.Sc.
Assistant Research Officer—T. M. Lemerle (on special study leave).

Locust and Pasture Pests—
Senior Research Officer—K. H. L. Key, M.Sc., Ph.D., D.I.C.
Research Officer—L. R. Clark, M.Sc.
Assistant Research Officer—D. H. Colless (on special study leave).
Technical Officer—D. L. Hall, Dip.Agr. (on rehabilitation study leave).

Vegetable Pests and Virus Vector Investigations—
Research Officer—G. A. H. Helson, M.Sc.
Assistant Research Officer—T. Greaves.
Technical Officer—N. Grylls, Dip.Agr.

Termite Investigations—
Principal Research Officer—F. N. Ratcliffe, B.A.
Research Officer—F. J. Gay, B.Sc., D.I.C.

Earth-mite Investigations—
Assistant Research Officer—M. M. H. Wallace, B.Sc.

At State Animal Health Station, Yeerongpilly, Queensland.
Principal Research Officer (veterinary entomology)—I. M. Mackerras, B.Sc., M.B., Ch.M.
Senior Research Officer (cattle tick investigations)—L. F. Hitchcock, M.Sc.
Research Officer (veterinary entomology)—Mrs. M. J. Mackerras, M.Sc., M.B.
Assistant Research Officer (cattle tick investigations)—R. W. Kerr, B.Sc.
Assistant Research Officer (cattle tick investigations)—W. J. Roulston, B.Sc.
Technical Officer (cattle tick investigations)—W. R. Horne.

At Tully, North Queensland—
Assistant Research Officer (buffalo fly investigations)—G. J. Snowball, B.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.

At Trangie, New South Wales—
Technical Officer (locust investigations)—L. J. Chinnick, Dip.Agr.

5. Division of Animal Health and Production.

(Head-quarters: Cr. 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.
Senior Research Officer (pathology, bacteriology, dairy cattle)—D. Murnane, B.V.Sc.
Senior Research Officer (serological investigations)—A. D. Campbell, L.V.Sc.
Senior Research Officer (physiology)—R. H. Watson, D.Sc.Agr.
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.
Research Officer (poultry breeding investigations)—F. Skaller, B.Agr.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—M. W. Mules.
Technical Officer—E. Wold.
Technical Officer—A. E. Wright.
Technical Officer—J. J. Spencer.
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 Research 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.
Research Officer (parasitology)—W. P. Rogers, M.Sc., Ph.D.
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.
Assistant Research Officer (wool biology)—Miss P. Davidson, B.Sc.
Technical Officer—E. A. Parrish.
Technical Officer—H. A. Offord.
Technical Officer—F. J. Hamilton.
Technical Officer—H. V. Whitlock.
Librarian—Miss A. G. Culey, M.Sc.

At F. D. McMaster Field Station, Badgery's Creek, New South Wales—

Principal Research Officer and Officer-in-Charge (animal genetics)—R. B. Kelley, D.V.Sc.
Senior Research Officer (wool production)—J. H. Riches, B.Sc.(Agric.), Ph.D.
Senior Research Officer (beef cattle production)—W. A. Beattie, B.A., LL.B.
Research Officer—R. H. Hayman, B.Agr.Sc.
Technical Officer—G. D. Nation.

At National Field Station "Gilruth Plains", Cunnamulla, Queensland—

Research Officer-in-charge—J. F. Kennedy, M.Agr.Sc.
Technical Officer (overseer)—I. D. B. Yuille.

At Fleece Analysis Laboratory, Villawood, New South Wales—

Senior Research Officer (fleece analysis and wool measurement)—N. F. Roberts, M.Sc.

At Institute of Agriculture, University of Western Australia—

Research Officer (biochemistry)—A. B. Beck, M.Sc.

6. 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.
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.
Senior Research Officer—G. B. Jones, M.Sc.
Research Officer—F. V. Gray, B.Sc.
Assistant Research Officer—I. G. Jarrett, B.Sc.
Assistant Research Officer—T. A. Quinlan-Watson, M.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.
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.
Technical Officer—T. M. Rilstone.
Technical Officer—B. W. Bussell, R.D.A., H.D.D.
Assistant Librarian—Miss I. Sanders, B.A.

7. 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—J. G. Baldwin, B.Agr.Sc., B.Sc.
Assistant Research Officer—R. Brewer, B.Sc.
Assistant Research Officer—E. J. Johnston, B.Sc.Agr.
Assistant Research Officer—T. Langford Smith, M.Sc. (seconded).
Assistant Research Officer—K. H. Northcote, B.Ag.Sc.
Assistant Research Officer—G. A. Stewart, B.Ag.Sc.
Assistant Research Officer—K. D. Nicholls, B.Sc., B.Ag.Sc.
Assistant Research Officer—G. Blackburn.
Assistant Research Officer—J. S. Womersley.
Draughtsman—P. D. Hooper.
Technical Officer—E. A. N. Greenwood, D.D.A.
Technical Officer—L. W. Pym, R.D.A
Technical Officer—D. D. Suter, R.D.A.
Technical Officer—C. H. Thompson, G.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.
Assistant Research Officer—G. B. Stirk, B.Sc.

Soil Chemistry Section—
Senior Research Officer—C. S. Piper, D.Sc. (part-time).
Assistant Research Officer (spectrography)—A. C. Oertel, M.Sc.
Assistant Research Officer—H. C. T. Stace, B.Sc.
Assistant Research Officer—B. M. Tucker, B.Sc.
Assistant Research Officer—R. S. Beckwith, B.Sc.
Assistant Research Officer—J. T. Hutton, B.Sc.

Soil Microbiology—
Assistant Research Officer—T. H. Strong, M.Agr.Sc.
Assistant Research Officer—Miss M. P. Thomas, B.Sc.

At Hobart—
Research Officer (soil surveys)—G. D. Hubble, B.Ag.Sc.

At Perth—
Research Officer (soil surveys)—R. Smith, B.Sc. (Agric.).

At Melbourne—
Assistant Research Officer (soil surveys)—R. G. Downes, M.Agr.Sc.

At Deniliquin—
Research Officer (soil surveys)—B. E. Butler, B.Sc.(Agric.).

8. Irrigation Settlement Problems.

At Irrigation Research Station, Griffith—
Officer-in-Charge—E. S. West, B.Sc., M.S.
Research Officer—R. R. Pennefather, B.Agr.Sc.
Research Officer—D. V. Walters, M.Agr.Sc.
Chemist—N. G. Cassidy, M.Sc.
Plant Physiologist—R. F. Williams, M.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.
Assistant Research Officer—A. F. Gurnett-Smith, B.Agr.Sc., Q.D.D.
Horticulturist—H. J. Frith, B.Sc.Agr.
Technical Officer—B. H. Martin, H. D. A.

At Commonwealth Research Station, Merbein—
Officer-in-Charge—A. V. Lyon, M.Agr.Sc.
Senior Research Officer—E. C. Orton, B.Sc.
Research Officer—D. V. Walters, M.Agr.Sc. (seconded).
Research Officer—G. V. F. Clewett, B.E.
Assistant Research Officer—W. J. Webster, B.Sc.
Assistant Research Officer—S. F. Bridley, B.Agr.Sc.
Technical Officer—J. E. Giles.
District Officer (Wooripen)—R. C. Polkinghorne (part-time).
District Officer (Moulamein)—H. Jackson (part-time).

9. 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.
Assistant to Chief—H. E. Dadswell, D.Sc.
Librarian—Miss M. I. Hulme.
Assistant Librarian—Miss J. Butler, B.Sc.
Draughtsman—L. Santer, Dip. Eng. (Budapest).

Wood Structure Section—
Principal Research Officer-in-Charge—H. E. Dadswell, D.Sc.
Research Officer—Miss A. M. Eckersley, M.Sc.
Research Officer—H. D. Ingle, B.For.Sc. (N.Z.)
Assistant Research Officer—A. B. Wardrop, M.Sc.
Technical Officer—Miss F. V. Griffin.

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

Wood Chemistry Section—
Principal Research Officer-in-Charge—W. E. Cohen, D.Sc. (seconded).
Senior Research Officer—Miss T. M. Reynolds, M.Sc., D.Phil. (seconded).
Research Officer (acting-in-charge)—D. E. Bland, M.Sc.
Research Officer—B. J. Ralph, B.Sc.
Assistant Research Officer—A. J. Watson, A.M.T.C.
Assistant Research Officer—Miss B. M. Brims, B.Sc.
Assistant Research Officer—Miss C. M. Emery, B.Sc.
Technical Officer—A. G. Charles.
Technical Officer—Miss J. Meade.
Research Chemist—C. M. Stewart, B.Sc. (on loan from Associated Pulp and Paper Mills Ltd.).

Timber Physics Section—
Senior Research Officer-in-Charge—R. S. T. Kingston, B.Sc., B.E.
Assistant Research Officer—L. N. Clarke, B.Eng.Sc.
Technical Officer—I. G. Scott, F.M.T.C.

Timber Mechanics Section—
Senior Research Officer-in-Charge—K. L. Cooper, M.A., B.Sc.
Assistant Research Officer—N. H. Kloot, B.Sc.
Assistant Research Officer—R. G. Pearson, B.C.E.
Technical Officer—J. J. Mack.

Timber Seasoning Section—
Senior Research Officer-in-Charge—G. W. Wright, B. E.
Research Officer—J. W. Gottstein, B.Sc.
Assistant Research Officer—I. J. W. Bisset, B.Sc.
Assistant Research Officer—C. V. Lansell, B.Eng. Sc.
Technical Officer—H. D. Roberts.
Technical Officer—C. N. Pickering.

Timber Preservation Section—
Research Officer-in-Charge—N. Tamblyn, M.Sc. (Agric.).
Assistant Research Officer—G. W. Tack, B.Agr.Sc.
Assistant Research Officer—G. Christensen, B.Sc.
Technical Officer—A. Rosel.

Veneer and Gluing Section—
Senior Research Officer-in-Charge—A. Gordon, B.Sc. (seconded).
Assistant Research Officer (acting-in-charge)—H. G. Higgins, B.Sc.
Assistant Research Officer—A. W. Rudkin, B.Sc.

Timber Utilization Section—
Principal Research Officer-in-Charge—R. F. Turnbull, B.E. (seconded).
Senior Research Officer—A. J. Thomas, Dip.For. (seconded).
Research Officer—(acting-in-charge)—C. E. Dixon, M.Sc.
Assistant Research Officer—C. H. Hebblethwaite, Dip.For.
Technical Officer—G. Barrow.

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

10. Division of Food Preservation and Transport.

(Head-quarters: at State Abattoir, Homebush Bay. Postal Address: Private Bag, Homebush P.O.).

Administrative and General—
Chief—J. R. Vickery, M.Sc.,Ph.D.
Divisional Secretary—R. B. Withers, M.Sc., Dip. Ed.
Librarian—Miss B. Johnston, B.Sc.
Maintenance Engineer—T. L. Swan.

Physics Section—
Principal Research Officer—E. W. Hicks, B.A., B.Sc.
Research Officer—G. M. Rostos, Dipl. Ing. (Karlsruhe).
Assistant Research Officer—M. C. Taylor, M.Sc.

Microbiology Section—
Senior Research Officer—W. J. Scott, B.Agr.Sc.
Assistant Research Officer—D. I. Annear, B.Sc.
Assistant Research Officer—M. R. J. Salton, B.Sc.Agr.
Technical Officer—P. R. Maguire.
Technical Officer—D. F. Ohye, Dip.Ind.Chem.

General Chemistry Group—
Research Officer—F. E. Huelin, B.Sc., Ph.D.
Assistant Research Officer—H. A. McKenzie, M.Sc.
Assistant Research Officer—Miss A. White, B.Sc.

Fruit Storage Section—
Senior Research Officer—R. N. Robertson, B.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. M. Lewis, B.Sc.Agr.
Technical Officer—P. O. Thompson, A.S.T.C.
Technical Officer—R. Allan (seconded from Division of Fisheries).

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.

At Brisbane Abattoir—
Senior Research Officer—A. R. Riddle, A.B., M.S.
Technical Officer—H. J. E. Prebble, Dip.Ind.Chem.

At Australia House, London—
Senior Research Officer—N. E. Holmes, B.E.E., M.Mech.E.

11. Division of Fisheries.

(Head-quarters: Cronulla, New South Wales).

At Head-quarters—
Chief of Division—H. Thompson, M.A., D.Sc.
Senior Research Officer (bacteriologist)—E. J. Ferguson Wood, M.Sc., B.A.
Research Officer (biologist)—G. L. Kesteven, B.Sc.
Research Officer (chemist and hydrologist)—D. J. Rochford, B.Sc.
Research Officer (biologist)—Mrs. L. M. Willings, B.A.
Assistant Research Officer (biologist)—J. A. Tubb, M.Sc.
Assistant Research Officer (biologist)—I. S. R. Munro, M.Sc.
Assistant Research Officer (biologist)—W. S. Fairbridge, M.Sc.
Assistant Research Officer (biologist)—J. M. Thomson, M.Sc.
Assistant Research Officer (chemist and hydrologist)—R. S. Spencer, B.Sc.
Assistant Research Officer (biologist)—Mrs. V. Jones, M.Sc.
Technical Officer—A. Proctor (laboratory).

At Melbourne—
Principal Research Officer—S. Fowler.
Research Officer (biologist)—M. Blackburn, M.Sc.

At Perth—
Senior Research Officer (biologist)—D. L. Serventy, B.Sc., Ph.D.
Technical Officer—K. Sheard.
Technical Officer—H. M. Peddie.

At Hobart—
Assistant Research Officer (biologist)—A. M. Olsen, M.Sc.

12. 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, B.A.
Assistant Librarian—Miss E. Andrews, B.A.
Assistant Librarian—Mrs. R. Pulsford, B.Sc.

Workshop—
Foreman-Supervisor—J. Hanna.

13. Division of Metrology.

(Head-quarters: National Standards Laboratory at University of Sydney.)

Chief—N. A. Esserman, B.Sc.
Senior Research Officer—P. M. Gilet, B.Sc., B.E.
Research Officer—G. A. Bell, B.Sc.
Assistant Research Officer—E. E. Adderley, B.Sc.
Assistant Research Officer—C. F. Bruce, M.Sc.
Assistant Research Officer—W. A. F. Cuninghame, B.E.
Assistant Research Officer—Miss I. E. Dewhurst, B.Sc., B.Ed.
Assistant Research Officer—Miss M. C. Dive, B.Sc.
Assistant Research Officer—Miss M. M. Douglas, B.Sc.
Assistant Research Officer—Miss C. M. Guilfoyle, B.Sc.
Assistant Research Officer—J. A. Macinante, B.E.

* The services shown hereunder are common to the Divisions of Metrology, Electrotechnology, and Physics, housed in the Laboratory.

Assistant Research Officer—Miss M. Pearce, M.Sc.
Assistant Research Officer—J. Waldersee, B.Sc.
Assistant Research Officer—Miss P. Weine, B.Sc.
Assistant Research Officer—Miss P. Yelland.
Assistant Research Officer—Miss E. York, B.Sc.
Testing Engineer, Grade II.—R. A. Holloway, B.Sc., B.E. (on loan from New South Wales Railways).
Assistant, Clerical—Miss J. M. McKechnie.

14. Division of Electrotechnology.

(Head-quarters: National Standards Laboratory at University of Sydney.)

Chief—D. M. Myers, B.Sc., D.Sc.Eng.
Technical Secretary—L. G. Dobbie, M.E.
Senior Research Officer—W. K. Clothier, B.Sc., M.E.
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.
Research Officer—B. V. Hamon, B.Sc., B.E.
Research Officer—A. W. Love, M.A.
Assistant Research Officer—P. A. Champion, B.E.
Assistant Research Officer—D. J. Cole, B.E.E.
Assistant Research Officer—G. J. A. Cassidy, B.E.E.
Assistant Research Officer—H. W. Stokes, B.Ec.
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.
Assistant Research Officer—G. A. Day.
Assistant Research Officer—R. K. Oliver, B.E.
Technical Officer—R. W. Archer.
Technical Officer—F. C. Brown.
Assistant, Clerical—Miss G. Levy, B.A.

15. 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—
Senior 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.

Light—
Research Officer—R. G. Giovanelli, M.Sc.
Assistant Research Officer—H. F. Pollard, B.Sc. (part-time).
Assistant Research Officer—J. W. Pearce, B.Sc.
Assistant Research Officer—W. H. Steel, B.Sc.
Assistant Research Officer—G. H. Godfrey, M.A., B.Sc. (part-time).
Technical Officer—V. R. Schaefer.

Solar Physics—
Research Officer—R. G. Giovanelli, M.Sc.
Assistant Research Officer—J. K. Mackenzie, B.A., B.Sc.

Physics of Solids—
Assistant Research Officer—N. A. Faull, B.Sc.
Assistant Research Officer—Mrs. L. E. R. Rogers, M.Sc. (officer of Broken Hill Pty. Co. Ltd.).

Wool Research—
Research Officer—E. H. Mercer, B.Sc.
Assistant Research Officer—Mrs. K. R. Makinson, B.A.

Atomic Physics—
Assistant Research Officer—W. I. B. Smith, B.Sc.

Electrical Standards—
Assistant Research Officer—N. A. Faull, B.Sc.

Technical Services—
Technical Officer—J. E. Thompson.
Technical Officer—R. Sweet.

16. Division of Aeronautics.

(Head-quarters: Lorimer-street, Fishermen's Bend, Melbourne; Postal Address: Box 4331, G.P.O., 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. Willis, B.E.
Senior Research Officer—E. R. Love, B.A., Ph.D. (part-time).
Senior Research Officer—F. S. Shaw, B.E.
Research Officer—J. R. Green, D.Phil., B.E.
Assistant Research Officer—F. H. Hooke, B.Sc., B.E.
Assistant Research Officer—F. W. Hooton, B.Sc., B.E.
Assistant Research Officer—W. W. Johnstone, B.E.
Assistant Research Officer—N. B. Joyce, B.E.
Assistant Research Officer—Miss D. A. Lemaire, B.Mech.E.
Assistant Research Officer—Miss E. H. Mann, B.A.
Assistant Research Officer—M. S. Patterson, B.Sc. Eng.
Assistant Research Officer—A. O. Payne, B.E.Sc.
Assistant Research Officer—J. P. O. Silberstein, B.A.
Assistant Research Officer—R. W. Traill-Nash, B.E.
Technical Officer—C. M. Bailey.
Technical Officer—F. A. Dale.
Technical Officer—N. E. Richards.
Technical Officer—J. H. Straw.
Technical Officer—G. W. Wycherley.

Metallurgy Section—
Senior Research Officer—J. B. Dance, B.Met.E.
Adviser on Corrosion—P. F. Thompson, F.A.C.I.
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—H. T. Greenaway, B.Met.E.
Assistant Research Officer—N. M. McKinnon, M.Sc.
Assistant Research Officer—E. Lumley.
Assistant Research Officer—F. G. Lewis, B.Sc.
Technical Officer—L. M. Bland.
Technical Officer—K. R. Hanna.
Technical Officer—F. D. Rowe.
Technical Officer—H. Bellamy.
Technical Officer—M. Johnstone, B.Met.E.

Aerodynamics Section—
Principal Research Officer—G. N. Patterson, B.Sc., M.A., Ph.D. (abroad).
Principal Scientific Officer (acting officer-in-charge)—R. A. Shaw, M.A. (on loan from Ministry of Supply, London).
Research Officer—G. K. Batchelor, M.Sc. (part-time).
Assistant Research Officer—J. B. Willis, M.Sc.
Assistant Research Officer—R. W. Cumming, B.E.
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—A. F. Pillow, B.A.
Assistant Research Officer—R. H. Adair, B.E.
Assistant Research Officer—J. M. Evans, B.E.*
Assistant Research Officer—D. C. Collis, B.Sc.
Assistant Research Officer—A. N. McCleave, B.E.
Assistant Research Officer—E. R. Johnson, M.Sc.
Assistant Research Officer—F. Redlich, B.E.
Assistant Research Officer—G. J. Dailey.
Assistant Research Officer—J. K. Strachan, B.A., B.Sc.
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. J. F. Gerrand.
Technical Officer—R. A. Wallis.

* Attached to Department of Aeronautical Engineering, Sydney University.

Engines and Fuels Section—
Principal Research Officer—M. W. Woods, D.Phil., B.E., B.Sc.
Senior Research Officer—T. S. Keeble, B.E., B.Sc.
Research Officer—W. B. Kennedy, B.Mech.E.
Assistant Research Officer—J. C. Wisdom, B.Mech.E.
Assistant Research Officer—D. W. Lees, B.Mech.E.
Assistant Research Officer—M. S. Walker, B.E.
Assistant Research Officer—R. E. Pavia, M.Eng.Sc., B.Mech.E.
Assistant Research Officer—E. A. Kaye, M.Eng.Sc.
Assistant Research Officer—R. A. Wright, B.Mech.E.
Assistant Research Officer—R. V. Pavia, B.Mech. E.
Assistant Research Officer—R. L. Brooks, B.Sc.Eng.
Assistant Research Officer—A. L. Deans, B.Mech.E.
Technical Officer—M. L. Atkin.

Instruments Section—
Research Officer—A. E. Ferguson, B.E.E.
Assistant Research Officer—R. C. H. Bravington, B.Sc.
Assistant Research Officer—H. I. Pizer, B.E.E.
Technical Officer—A. N. Clowes.

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).

17. Division of Industrial Chemistry.

(Head-quarters: Lorimer-street, Fisherman's Bend, Melbourne; Postal Address: Box 4331, G.P.O., Melbourne.)

Administrative and General—
Chief—I. W. Wark, Ph.D., D.Sc.
Divisional Secretary—L. Lewis, B.Met.E. (seconded.)
Assistant Secretary (Acting Secretary)—A. E. Scott, M.Sc.

Dairy Products Section—
Senior Research Officer—G. Loftus Hills, B.Agr.Sc. (seconded).
Technical Officer—W. G. T. Laffan, H.D.D. (seconded).

Minerals Utilization Section—
Principal Research Officer—R. G. Thomas, B.Sc.
Senior Research Officer—A. Walkley, B.A., B.Sc., Ph.D.
Research Officer—A. W. Wylie, M.Sc., Ph.D.
Assistant Research Officer—P. Dixon, M.Sc.
Assistant Research Officer—F. K. McTaggart, M.Sc.
Assistant Research Officer—T. R. Scott, M.Sc., B.Ed.
Assistant Research Officer—F. R. Hartley, M.Sc.
Assistant Research Officer—R. C. Croft, B.Sc.
Assistant Research Officer—A. D. Wadsley, M.Sc.
Assistant Research Officer—I. C. Kraitzer.
Assistant Research Officer—E. S. Pilkington, A.S.T.C.
Technical Officer—H. R. Skewes.
Technical Officer—V. A. C. Bertrand.
Technical Officer—J. F. Moresby, A.S.T.C.

Cement, Ceramics, and Refractories Section—
Principal Research Officer—A. R. Alderman, Ph.D., D.Sc.
Assistant Research Officer—A. J. Gaskin, M.Sc. (part-time).
Assistant Research Officer—R. H. Jones, B.Sc.
Assistant Research Officer—H. E. Vivian, B.Sc.Agr.
Assistant Research Officer—E. R. Segnit, M.Sc.
Assistant Research Officer—C. E. S. Davis, B.Sc. (Hons.).
Assistant Research Officer—J. Coutts, A.M.T.C.

Foundry Sands Investigations—
Research Officer—H. A. Stephens, B.Sc. (Hons.).
Technical Officer—G. V. Cullen.

Physical Metallurgy Section—
Research Officer—H. W. Worner, M.Sc.
Assistant Research Officer—E. J. T. Lumley, B.Sc.
Assistant Research Officer—Miss R. I. Shoebridge, B.Sc.
Technical Officer—K. R. Hanna, F.M.T.C.

Physical Chemistry Section—
Research Officer—K. L. Sutherland, M.Sc.
Assistant Research Officer—W. W. Mansfield, B.Sc. (Hons.).
Technical Officer—L. F. Evans, D.S.M.B.
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.
Assistant Research Officer—J. M. Cowley, M.Sc.
Assistant Research Officer—J. L. Farrant, M.Sc.

Organic Section—
Principal Research Officer—H. H. Hatt, B.Sc., Ph.D.
Research Officer—J. S. Fitzgerald, M.Sc., Ph.D.
Research Officer—J. R. Price, M.Sc., D.Phil.
Research Officer—M. E. Winfield, M.Sc., Ph.D.
Assistant Research Officer—N. C. Hancox, M.Sc.
Assistant Research Officer—K. E. Murray, B.Sc.(Hons.).
Assistant Research Officer—R. G. Curtis, M.Sc.
Assistant Research Officer—R. J. L. Martin, M.Sc.
Assistant Research Officer—A. G. Dobson, M.Sc.
Assistant Research Officer—D. J. Clark, M.Sc.
Assistant Research Officer—L. K. Dalton, A.S.T.C.
Technical Officer—W. J. Troyahn, A.M.T.C. (on study leave).
Technical Officer—W. E. Hillis, A.G.Inst.Tech.
Technical Officer—R. B. Bradbury, D.Bendigo S.M.
Technical Officer—Miss F. M. Jensen.

Biochemistry Section—
Senior Research Officer—F. G. Lennox, D.Sc.
Research Officer—W. J. Ellis, A.S.T.C. (seconded).
Assistant Research Officer—W. G. Crewther, M.Sc.
Assistant Research Officer—J. M. Gillespie, M.Sc.
Assistant Research Officer—Miss M. E. Maxwell, M.Sc.
Technical Assistant—R. A. Fookes.

Chemical Engineering Section—
Principal Research Officer—E. J. Drake (seconded).
Senior Research Officer—D. R. Zeidler, M.Sc.
Assistant Research Officer—I. Brown, B.Sc.(Hons.).
Assistant Research Officer—R. W. Urie, B.Sc.
Assistant Research Officer—J. F. Pearse, B.Sc. (Hons.).
Assistant Research Officer—B. W. Wilson, M.Sc.
Technical Officer—J. L. Clay, A.M.T.C.
Senior Draughtsman—C. Simpson.
Draughtsman—H. H. Evans.
Draughtsman—L. B. Bull.

At University of Western Australia—Alunite Investigations—
Assistant Research Officer—G. H. Payne, M.Sc.
Assistant Research Officer—W. E. Ewers, M.Sc.
At Canberra, Division of Economic Entomology—
Assistant Research Officer—R. H. Hackman, M.Sc.
At Sydney, Division of Electrotechnology—
Research Officer—R. J. Meakins, B.Sc., Ph.D.
Assistant Research Officer—N. A. Gibson, M.Sc.
Library—
Librarian—Miss H. P. Meggs (part-time).

18. Division of Radiophysics.

(Head-quarters: at University of Sydney.)

Chief—E. G. Bowen, O.B.E., M.Sc., Ph.D.
Technical Secretary—A. J. Higgs, B.Sc.
Special Research Officer—D. F. Martyn, D.Sc., Ph.D. (seconded).
Propagation Research—
Principal Research Officer—J. L. Pawsey, M.Sc., Ph.D.
Senior Research Officer—E. B. Kraus, Ph.D.
Senior Research Officer—P. Squires, M.A.
Research Officer—L. L. McCready, B.Sc., B.E.
Research Officer—T. Pearcey, B.Sc.
Research Officer—F. J. Kerr, M.Sc.
Research Officer—Miss R. Payne-Scott, M.Sc.
Assistant Research Officer—G. J. Parker, B.Sc., B.E.
Assistant Research Officer—D. E. Yabsley, B.Sc., B.E.
Assistant Research Officer—K. Westfold, M.Sc.
Assistant Research Officer—D. F. Urquhart, B.Sc.
Assistant Research Officer—Miss B. Lippman, B.Sc.
Technical Officer—G. J. Stanley.
Vacuum Physics—
Principal Research Officer—O. O. Pulley, B.Sc., B.E., Ph.D.
Research Officer—S. F. Smerd, 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—Miss J. M. Freeman, M.Sc.
Assistant Research Officer—J. Symonds, B.Sc. (on overseas leave).
Technical Officer—F. C. James.
Technical Officer—R. C. Baker.
Technical Officer—R. Lorimer.
Radar Research—
Senior Research Officer—F. J. Lehany, M.Sc.
Research Officer—H. C. Minnett, B.Sc., B.E.
Assistant Research Officer—C. A. Shain, B.Sc.
Assistant Research Officer—N. R. Labrum, B.Sc.
Assistant Research Officer—T. R. Kaiser, M.Sc.
Technical Officer—C. S. Higgins.
Radar Development—
Principal Research Officer—J. H. Piddington, M.Sc., B.E., Ph.D.
Research Officer—B. F. Cooper, B.Sc., B.E. (on overseas leave).
Research Officer—M. Beard, B.Sc., B.E.
Research Officer—G. P. Brown, B.Sc.
Research Officer—J. Warner, B.Sc., B.E.
Assistant Research Officer—J. H. Gerrand, B.Sc., B.E.
Assistant Research Officer—E. B. Mulholland, B.Sc.
Assistant Research Officer—H. L. Humphries, B.Sc., B.E.
Technical Officer—K. A. Page.
Technical Officer—J. V. Hindman.
Engineering Development—
Senior Research Officer—V. D. Burgmann, B.Sc., B.E.
Research Officer—L. U. Hibbard, B.Sc., B.E.
Research Officer—A. B. Thomas, B.A.
Research Officer—J. G. Downes.
Assistant Research Officer—J. A. Fry, B.Sc., B.E.
Assistant Research Officer—E. K. Inall, B.Sc., B.E.
Assistant Research Officer—R. B. Coulson, B.Sc., B.E.
Assistant Research Officer—G. C. Dewsnap, B.E.E.
Assistant Research Officer—H. N. Edwardes, B.Sc., B.E.
Assistant Research Officer—A. A. Taylor, B.Sc., B.E.
Assistant Research Officer—E. McCarthy, B.Sc., Dip.Ed.
Technical Officer—T. D. Newnham.
Technical Officer—K. R. McAlister.
Technical Officer—G. A. Wells.
Technical Officer—O. C. Turner.
Technical Officer—D. C. Dunn.
Technical Officer—P. T. Hedges.
Engineering Services—
Assistant Research Officer—J. P. Eagles.
Chief Draughtsman—F. M. Carter.
Workshop Foreman—H. Byers.
Publications—
Assistant Research Officer—Miss L. F. Plunkett, B.Sc., Dip.Ed.

19. Section of Tribophysics.

(Head-quarters: at University of Melbourne.)

Officer-in-Charge—S. H. Bastow, D.S.O., B.Sc., Ph.D. (Cantab.).
Research Officer (chemistry)—J. N. Gregory, M.Sc.
Research Officer (metallurgy)—R. W. K. Honeycombe, M.Sc.
Research Officer (engineering)—T. V. Krok, B.E.
Research Officer (chemistry)—M. F. R. Mulcahy, M.Sc., A.G.Inst.Tech.
Assistant Research Officer (chemistry)—E. R. Ballantyne, B.Sc.
Assistant Research Officer (chemistry)—E. B. Greenhill, M.Sc. (attached to P.C.R.S. Group, Cambridge).
Assistant Research Officer (metallurgy)—M. E. Hargreaves, B.Met.E.
Assistant Research Officer (electrical engineering)—D. Michell, B.E.E.
Assistant Research Officer (chemistry)—A. J. W. Moore, B.Sc. attached to P.C.R.S. Group, Cambridge).
Assistant Research Officer (chemistry)—Miss M. Newing, B.Sc.
Assistant Research Officer (chemistry)—R. G. Vines, M.Sc.
Assistant Research Officer (electrical engineering)—G. W. West, B.E.E.
Assistant Research Officer (chemistry)—A. Yoffe, M.Sc. (attached to P.C.R.S. Group, Cambridge).
Technical Officer (photographer)—F. H. Hay.
Technical Officer (radio-physicist)—T. S. Holden, B.Sc.
Physical Metallurgist—W. Boas, D.Eng. (Berlin), M.Sc. (part-time).

20. Building Materials Research.

(Head-quarters: Graham-road, Highett, Victoria.)

Administrative—
Officer-in-Charge—Ian Langlands, B.E.E., M.Mech.E.
Technical Secretary—W. F. Evans, B.Sc.

Information and Library—
Research Officer—J. R. Barned, B.Sc., A.M.T.C.
Assistant Research Officer—Mrs. C. M. Petrie, M.A., Ph.D.
Librarian—Miss A. G. Baldwin, B.A.
Mechanical and Physical Testing Laboratory—
Research Officer—P. H. Sulzberger, B.Sc.
Concrete Investigations—
Research Officer—W. H. Taylor, M.C.E.
Surfacing Materials Investigations—
Senior Research Officer—E. H. Waters, M.Sc.
Building Boards and Insulating Materials Investigations—
Research Officer—R. W. Muncey, B.E.E.
Organic Materials Investigations—
Research Officer—B. M. Holmes, M.Sc.
Drawing Office—
Draughtsman—G. T. Stephens.
Draughtsman—D. G. Howson.

21. Flax Research.

(Head-quarters: Graham-road, Highett, Victoria.)

Officer-in-Charge—W. L. Greenhill, M.E.
Research Officer—A. M. Munro, M.A. (Oxon.).
Research Officer—Miss J. F. Couchman, B.Sc.
Research Officer—G. W. Lanigan, M.Sc.
Technical Officer—M. Tisdall.

22. Section of Mathematical Statistics.

(Head-quarters: at University of Adelaide.)

At Sectional Head-quarters—
Principal Research Officer—E. A. Cornish, M.Sc., B.Agr.Sc.
Assistant Research Officer—R. Birtwistle, B.Sc.
Assistant Research Officer—G. G. Coote, B.A., B.Sc.
Assistant Research Officer—A. T. James, B.Sc. (Hons.).
Assistant Research Officer—N. A. Munro, B.Sc.
Sectional Secretary—Miss E. M. G. Goodale.
At Division of Animal Health and Production, Sydney—
Research Officer—Miss H. A. Newton Turner, B.Arch.
Assistant Research Officer—Miss V. M. Botham, B.Sc.
At Division of Forest Products, Melbourne—
Research Officer—E. J. Williams, B.Com.
Assistant Research Officer—R. T. Leslie, B.A. (Hons.), B.Sc.
At Divisions of Plant Industry and Economic Entomology, Canberra—
Senior Research Officer—G. A. McIntyre, B.Sc., Dip.Ed.

23. Radio Research.

(Head-quarters: c/o Electrical Engineering Department, University of Sydney.)

At Sydney—
Research Officer—L. S. Prior, B.Sc.
Assistant Research Officer—C. B. Kirkpatrick, B.Sc.
Assistant Research Officer—J. A. Harvey, B.Sc.
Assistant Research Officer—A. H. Nash, B.Sc.
Assistant Research Officer—Mrs. M. Harrison, B.Sc.
Technical Officer—G. C. Morrison.
Technical Officer—Miss B. Hardwick, B.A.
Technical Officer—Miss G. Polden, B.A.
Technical Officer—Miss V. Henderson, B.Sc.
Technical Officer—Miss H. Barnes, B.Ec.
Draughtsman—R. Wark.
At Mt. Stromlo, Canberra—
Assistant Research Officer—L. H. Heisler, B.Sc.

24. Ore-dressing Investigations.

At University of Melbourne—
Officer-in-Charge—H. H. Dunkin, B.Met.E. (part-time).
Research Officer—K. S. Blaskett, B.E.
Technical Officer—F. D. Drews.
At School of Mines, Adelaide, South Australia—
Assistant Research Officer—D. R. Blaskett, B.E.
At School of Mines, Kalgoorlie, Western Australia—
Officer-in-Charge—R. W. Fletcher, B.Sc. (part-time).

25. Other Investigations.

Dairy Research Section—
Officer-in-Charge—W. J. Wiley, D.Sc.
Senior Research Officer—E. G. Pont, M.Sc.Agr.
Senior Research Officer—G. Loftus Hills, B.Agr.Sc. (seconded from Division of Industrial Chemistry).
Research Officer—R. C. Hutchinson, D.Sc.
Research Officer—J. Conochie, B.Sc. (Agric.).
Assistant Research Officer—A. J. Lawrence, B.Sc.
Mineragraphic Investigations—
Investigator—F. L. Stillwell, D.Sc.
Research Officer—A. B. Edwards, D.Sc., Ph.D.
Rubber Investigations—
Assistant Research Officer—R. E. Shapter.
Oenological Investigations—
Research Officer—J. C. M. Fornachon, B.Ag.Sc., M.Sc.

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

(i) *Bulletins.*

No. 186.—The General Ecological Characteristics of the Outbreak Areas and the Outbreak Years of the Australian Plague Locust (*Chortoicetes terminifera* Walk.), by K. H. L. Key, M.Sc., Ph.D.

No. 187.—Alcohol: Its Place in Organic Chemical Industry, by H. H. Hatt, B.Sc., Ph.D.

No. 188.—A Soil, Land-Use, and Erosion Survey of Part of County Victoria, South Australia, including the Hundreds of Belalie, Whyte, Reynolds, and Anne, and Part of the Hundreds of Caltowie, Yangya, and Bundaleer, by C. G. Stephens, M.Sc., R. I. Herriot, B.Ag.Sc., R. G. Downes, M.Agr.Sc., T. Langford-Smith, M.Sc., and A. M. Acock, B.A., D.Phil.

No. 189.—Soils of the Berriquin Irrigation District, New South Wales, by Robert Smith, B.Sc. (Agric.).

No. 190.—Foundry Sand Resources of South Australia, by H. S. Cornelius and H. A. Stephens, B.Sc.

No. 191.—Studies of the Physiology and Toxicology of Blowflies. 10. A Histochemical Examination of the Distribution of Copper in *Lucilia cuprina*. 11. A Quantitative Investigation of the Copper Content of *Lucilia cuprina*, by D. F. Waterhouse, M.Sc.

No. 192.—Investigations of Guayule (*Parthenium argentatum* Gray) in South Australia, by R. L. Crocker, M.Sc., and H. C. Trumble, D.Sc., M.Agr.Sc.

No. 193.—Post-Miocene Climatic and Geologic History and its Significance in Relation to the Genesis of the Major Soil Types of South Australia, by R. L. Crocker, M.Sc.

No. 194.—A Procedure of Investigation in Fisheries Biology, by G. L. Kesteven, B.Sc.

No. 195.—An Account of Experiments Undertaken to Determine the Natural Population Density of the Sheep Blowfly, *Lucilia cuprina* Wied., by Darcy Gilmour, M.Sc., D. F. Waterhouse, M.Sc., and G. A. McIntyre, B.Sc., Dip.Ed.

No. 196.—Transmission of Potato Virus Diseases. 5. Aphid Populations, Resistance, and Tolerance of Potato Varieties to Leaf Roll, by J. G. Bald, M.Agr.Sc., Ph.D., D. O. Norris, M.Sc. (Agric.), and G. A. H. Helson, M.Sc.

(ii) *Industrial Chemistry Circular.*

No. 5.—The Significance, Measurement, and Control of Hydrogen Ion Concentration, by Allan Walkley, B.A., B.Sc., Ph.D.

(iii) *Quarterly Journal.*

Vol. 18, No. 3, August, 1945.
Vol. 18, No. 4, November, 1945.
Vol. 19, No. 1, February, 1946.
Vol. 19, No. 2, May, 1946.

(iv) *Annual Report for the year ending June 30, 1945.*

(v) *Miscellaneous.*

"C.S.I.R.—1945", by G. Lightfoot, M.A.

XXIII. ACKNOWLEDGMENTS.

In various sections of this Report reference has been made to the valuable assistance afforded by many State Departments, Universities, 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.

DAVID RIVETT, Chairman.
A. E. V. RICHARDSON
F. W. G. WHITE
I. CLUNIES ROSS
} Executive Committee.

G. A. COOK, Secretary.
November, 1946.

APPENDIX.

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

COUNCIL (AS AT 30TH JUNE, 1946.)

EXECUTIVE.

Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S. (Chairman).
A. E. V. Richardson, C.M.G., M.A., D.Sc. (Chief Executive Officer).
F. W. G. White, M.Sc., Ph.D.
Professor I. Clunies Ross, D.V.Sc.

CHAIRMAN OF STATE COMMITTEES.

(Vacant) (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.
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, 1946).

NEW SOUTH WALES.

(Vacant) (*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.
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