1948.

THE PARLIAMENT OF THE COMMONWEALTH OF AUSTRALIA.

TWENTY-SECOND ANNUAL REPORT

OF THE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

FOR THE

YEAR ENDED 30TH JUNE, 1948.

PRESENTED BY THE MINISTER IN CHARGE, THE HON. J. J. DEDMAN, M.H.R.

Presented pursuant to Statute; ordered to be printed, 17*th November,* 1948.

[*Cost of Paper.*—Preparation, not given; 682 copies; approximate cost of printing and publishing, £210.]

Printed and published for the GOVERNMENT of the COMMONWEALTH OF AUSTRALIA by L. F. JOHNSTON, Commonwealth Government Printer Canberra

(Printed in Australia.)

32 [GROUP F.]—F.6278.—PRICE 8s.

CONTENTS.

	Page.
I. Introductory—	
1. General	7
2. Council	7
3. Division of Tribophysics	7
4. Wool Production and Textile Research	7
5. The Development of the North	7
6. Building Research—Visit of Sir Reginald Stradling	7
7. Fuel Research	8
8. Australian Goodwill Scientific Delegation to India	8
9. Australian Leather Research Association	8
10. New Publication—Australian Journal of Scientific Research	8
11. Overseas Training	8
12. Collaboration with the Universities	8
13. Finance	9
II. Plant Investigations—	
1. General	9
2. Pasture Investigations	9
3. Weeds Investigations	14
4. Plant Introduction	15
5. Take-all of Wheat	16
6. Fruit Investigations	16
7. Drug Plant Investigations	17
8. Tobacco Investigations	18
9. Vegetable Investigations	18
10. Virus Investigations	19
11. Investigations in Northern Australia	19
12. Other Investigations	20
III. Entomological Investigations—	
1. General	20
2. Cattle Tick	21
3. Insect Physiology and Toxicology	21
4. Biological Control	22
5. Population Dynamics	23
6. Locusts and Grasshoppers	23
7. Pasture Cockchafers	23
8. Red-legged Earth Mite	24
9. Insect Vectors of Plant Viruses	24
10. Field Crop and Vegetable Pests	24
11. Termites	25
12. Miscellaneous Pests	25
13. Taxonomy	25
IV. Animal Health and Production Investigations—	
1. General	26
2. Animal Health Research Laboratory, Melbourne	26
3. McMaster Animal Health Laboratory	27
4. The F. D. McMaster Field Station	30
5. Wool Biology Section	31
6. Regional Pastoral Centre and Laboratory, Armidale, New South Wales	31
7. National Field Station, "Gilruth Plains", Queensland	32
8. Other Activities	33
V. Biochemistry and General Nutrition—	
1. General	33
2. Nutrition and Wool Production	33
3. Metabolic Studies	34
4. Vitamin A Requirements of the Sheep	34
5. Physiological and Tissue Metabolism Studies	35
6. Chronic Fluorosis	35
7. Minor Elements and Animal Nutrition	35
8. Minor Elements and Plant Nutrition	36
9. Accessory Food Factors and Food Composition	37
10. Analytical Chemistry	37
11. Equipment	37
VI. Soils Investigations—	
1. General	37
2. Soil Survey and Pedology	37
3. Soil Chemistry Section	38
4. Soil Microbiology Section	39
5. Soil Physics and Mechanics Section	39
6. Overseas Research	41

PAGE.

VII. IRRIGATION SETTLEMENT INVESTIGATIONS—

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

1. General .. 41
2. Irrigation and Reclamation .. 42
3. Land Use .. 42
4. Horticulture .. 42
5. Plant Work .. 43
6. Pests and Diseases .. 43
7. Fruit Processing .. 44
8. Vegetables .. 44
9. Finance .. 44

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

1. General .. 45
2. Field Experiment with Orange Trees .. 45
3. Irrigation Investigations .. 45
4. Rice Field Investigations .. 45
5. Drainage Investigations .. 45
6. Soil Reconditioning Investigations .. 45
7. Salt Investigations .. 45
8. Vegetable Investigations .. 45
9. Plant Physiology .. 46
10. Frost Investigations .. 46
11. M.I.A. Agricultural Extension Service .. 46
12. Publications .. 46

VIII. FOREST PRODUCTS INVESTIGATIONS—

1. Introduction .. 46
2. Wood Structure .. 47
3. Wood Chemistry .. 49
4. Timber Physics .. 51
5. Timber Mechanics .. 52
6. Timber Seasoning .. 53
7. Timber Preservation .. 55
8. Veneer and Gluing .. 56
9. Utilization .. 57

IX. FOOD PRESERVATION INVESTIGATIONS—

1. General .. 59
2. Physical Investigations .. 59
3. General Chemistry .. 59
4. Microbiology .. 60
5. Meat Investigations (Brisbane) .. 60
6. Fish Preservation Investigations .. 61
7. Fresh Fruit and Vegetable Storage (in co-operation with New South Wales Department of Agriculture) .. 61
8. Dehydrated Foods .. 62
9. Canning and Fruit Products Investigations .. 63

X. FISHERIES INVESTIGATIONS—

1. General .. 65
2. Operations of Fishing and Research Vessels .. 65
3. Fisheries Biology .. 66
4. Shellfish Investigations .. 68
5. Hydrology .. 69
6. Plankton Investigations .. 70
7. Aerial Work .. 70
8. Taxonomy .. 71
9. Muttonbirds .. 71
10. Other Investigations .. 71

XI. METROLOGY—

1. General .. 71
2. Measurement of Length and Associated Quantities .. 72
3. Measurement of Mass and Associated Quantities .. 73
4. Applied Mechanics .. 73

XII. ELECTROTECHNOLOGY—

1. General .. 73
2. Direct Current .. 73
3. Alternating Current .. 74
4. Audio Frequency .. 74
5. Radio Frequency .. 74
6. Properties of Materials .. 74
7. Applied Electronics .. 75
8. Mathematical Instruments .. 75

XIII. PHYSICS—

1. General .. 75
2. Heat .. 76
3. Light .. 77
4. The Physical Properties of Wool Fibres .. 79

CONTENTS—*continued.*

PAGE.

XIV. AERONAUTICAL INVESTIGATIONS—

1. General 79
2. Structures 79
3. Engineering Materials 81
4. Aerodynamics 81
5. Aircraft Propulsion 83
6. Electronics and Instruments 84
7. Applied Work 85

XV. INDUSTRIAL CHEMISTRY—

1. General 85
2. Minerals Utilization Section 85
3. Cement and Ceramics Section 86
4. Foundry Sands Investigations 87
5. Physical Chemistry Section 87
6. Chemical Physics Section 87
7. Organic Chemistry Section 88
8. Biochemistry Section 89
9. Chemical Engineering Section 90

XVI. RADIOPHYSICS—

1. Introduction 91
2. Extra-Terrestrial Noise 91
3. Radio Reflections from the Moon 92
4. Temperature of the Moon 92
5. Radio Meteorology 92
6. Mathematical Physics 92
7. Electronic Computation 93
8. Vacuum Physics 93
9. Measurements and Standards 93
10. Civil Aviation 94
11. Radar Aids to Ground and Aerial Survey 95
12. Radio Control of Model Aircraft 95

XVII. TRIBOPHYSICS—

1. Introduction 95
2. Friction and Lubrication 95
3. Metal Physics 96
4. Explosives 97
5. General 97

XVIII. BUILDING MATERIALS RESEARCH—

1. General 97
2. Information and Library 98
3. Physical and Mechanical Testing Laboratory 98
4. Concrete Investigations 99
5. Masonry Investigations 99
6. Surfacing Materials Investigations 100
7. Building Boards and Insulating Materials Investigations 101
8. Organic Materials Investigations 102
9. The Decoration of Fibrous Plaster 103

XIX. FLAX RESEARCH—

1. General 104
2. Agricultural 104
3. Processing 104
4. Chemical Properties of Flax 105
5. Physical Properties of Flax 105

XX. DAIRY PRODUCTS RESEARCH—

1. General 105
2. The Utilization of Skim Milk Solids 105
3. The Manufacture of Butter without Washing 106
4. Weed Taint in Butter 106
5. Testing of Continuous Butter Processes 106
6. Use of Rennet Casein for Glue 107
7. Miscellaneous 107

XXI. MATHEMATICAL STATISTICS—

1. General 107
2. Assistance to Divisions 107
3. Assistance to Outside Organizations 109

XXII. OTHER INVESTIGATIONS—

1. Radio Research Board 109
2. Mineragraphic Investigations 109
3. Ore-Dressing Investigations 110
4. Physical Metallurgy 110
5. Meteorological Physics 111
6. Atomic Physics 111
7. Tracer Elements 112
8. Electrical Research Board 113
9. Rubber (Guayale) Investigations 113
10. Oenological Research 113

CONTENTS—*continued.*

PAGE.

XXIII. INFORMATION SERVICE AND LIBRARY—

A. Information Service—

1. General .. 113
2. Information Section .. 113
3. Translation Section .. 114
4. Cine-Photographic Section .. 114
5. Central Information Service Activities .. 115
6. Commonwealth Agricultural Bureaux .. 115
7. Dairy Production Abstracts .. 115

B. Library .. 115

XXIV. FINANCIAL MATTERS, STAFF, PUBLICATIONS AND COMMITTEES—

1. Finance .. 116
2. Contributions and Donations .. 118
3. Wool Research Trust Account .. 120
4. Staff .. 120
5. Publications .. 130

XXV. ACKNOWLEDGMENTS .. 136

APPENDIX—

Personnel of the Council and Committees Advising on the Council's own Work or on Co-operative Work in which the Council is assisting .. 136

COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

TWENTY-SECOND ANNUAL REPORT (FOR YEAR ENDED 30TH JUNE, 1948).

I. INTRODUCTORY.

1. General.

The Council for Scientific and Industrial Research was established in 1926 by the re-organization of the existing Institute of Science and Industry. The powers and functions of the Council are defined by the *Science and Industry Research Act* 1920-1945, 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. Council.

Further changes in the membership of the Council took place during the past year. Mr. R. J. Donaldson, Chairman of the Queensland State Committee, retired, and Mr. A. F. Bell, Under Secretary, Queensland Department of Agriculture and Stock, was appointed to the resultant vacancy. Professor F. M. Burnet, Director, Walter and Eliza Hall Research Institute, and Mr. C. E. Young, of "Noondoo", Queensland, were co-opted as members for a period of three years, filling two of the three vacancies caused by the retirement of Mr. J. P. Tivey and the deaths of Professor H. C. Richards and Mr. M. T. W. Eady.

3. Division of Tribophysics.

The status of the Section of Tribophysics has now been changed to that of a Division. Dr. S. H. Bastow is Chief of the new Division.

4. Wool Production and Textile Research.

The major activities associated with the programme of biological research in the field of wool production are reported among the investigations of the Divisions of Animal Health and Production, of Plant Industry, and of Biochemistry and General Nutrition. Reference was made in the previous report to wool textile research, and some progress has been made in this field in the year under review. A site for a Division of Wool Textile Technology has been acquired at Geelong and temporary accommodation is being erected. The Textile College at the Gordon Institute of Technology, Geelong, is providing accommodation for some workers, and other researches are in progress in various Divisions of the Council.

A study is being made of the wool carbonizing process, pilot plant is being constructed for the study of solvent degreasing, investigations are being extended to include biochemical studies of the protein structure of wool, equipment such as the electron microscope is being applied to studies of the fundamental structure of wool fibre and the keratin molecule, and work is being initiated on wool wax. The Council is also providing financial assistance to help the work of the British Wool Industries Research Association at Leeds and to assist the work being carried out at the Gordon Institute of Technology, Geelong, on the significance of the uniformity of wool fibre characteristics to the wool buyer and the wool manufacturer.

5. The Development of the North.

The increased world demand for food production has made it essential that Australia, as an important food exporting country, should do its utmost to assist. Progress in the south has been considerable in the past few decades but, if the continent is to be developed fully, attention must be paid to the more sparsely settled northern areas. Before any major developmental schemes can be undertaken, the first requirement is a thorough survey of the present potentialities and the initiation of research programmes to meet the particular needs of this portion of the continent. With this in mind the Council, at the request of the Northern Australia Development Committee, has undertaken a soil and vegetation reconnaissance survey of the most favorable portions of the country. Last year's programme included a study of the Darwin-Katherine region; the survey party is now occupied with the Barkly Tableland. In co-operation with the Department of Agriculture, Western Australia, investigations are also being carried out into the possibility of an irrigation programme in the Kimberley-Ord River region of the north-west of Western Australia.

Potentialities for development have already been demonstrated in certain areas of Queensland, and the Council is co-operating with the Department of Agriculture and Stock, Queensland, in investigating the possibilities of new areas. To facilitate this work, arrangements have now been made for the establishment of a regional head-quarters laboratory at St. Lucia in association with the University of Queensland, where facilities will be available for general soils, crop, and pasture studies. Field studies will be continued at Gatton, but, in addition, the Council is undertaking extensive investigations in the Burdekin River region where the development of irrigated pastures for cattle fattening and of irrigated tobacco production appears promising.

6. Building Research—Visit of Sir Reginald Stradling.

Sir Reginald Stradling, Chief Scientific Adviser to the Ministry of Works in the United Kingdom (and formerly Director of the Building Research Station of the Department of Scientific and Industrial Research), visited Australia at the end of 1947, at the invitation of the Council, to report on building research and associated activities. As a result of his recommendations, closer collaboration has been established between the Council's Building Materials Research Section and the Commonwealth Experimental Building Station of the Department of Works and Housing. The work of the Council's Section is no longer limited to materials and, in consequence, its title has been changed

to Building Research Section. Provision has been made for closer liaison with the building industry by the setting up of a Building Research and Development Advisory Committee under the Department of Works and Housing, and a Building Research Committee under the Council. The latter replaces the Building Materials Research Advisory Committee.

7. Fuel Research.

For some time the Council has been giving attention to an extension of its activities to include fuel research. Following the visit to Australia of the late Professor T. David Jones mentioned in the previous report and the recommendations of its Coal Utilization Research Committee, the Council has decided to concentrate attention initially on work on the microstructure of coal, and a survey of the properties of Australian coals. Further attention is to be given to problems of coal utilization.

Work on the microstructure of coal is being commenced in the Council's Mineragraphic Section and in collaboration with the Botany Department of the University of Melbourne. A Coal Survey Section has been established to assist in the carrying out of a comprehensive survey of the physical and chemical properties of coals from all the main Australian coal-fields. This work will be undertaken in close co-operation with the Joint Coal Board, the State Mines Departments, and other authorities. An Officer-in-Charge has been appointed and will have his head-quarters in Sydney. A Fuel Research Advisory Committee has been set up to advise the Council on all aspects of fuel research.

8. Australian Goodwill Scientific Delegation to India.

Following an invitation from the Government of India, an Australian goodwill scientific delegation toured India in January and February, 1948. The Delegation also paid a short visit to Pakistan. It attended the annual meeting of the Indian Science Congress Association at Patna, and visited a large number of universities, government research institutes, and industrial undertakings. In this way a comprehensive picture of the scientific potential of India was obtained and many useful contacts were made which have since been used to advantage for the exchange of scientific information and material. The Government of India has been invited by the Prime Minister to send a delegation of Indian scientists to Australia to return the visit. The membership of the Delegation was as follows:—Sir John Madsen, Professor of Electrical Engineering, University of Sydney (Leader); Sir Kerr Grant, Professor of Physics, University of Adelaide; Professor J. A. Prescott, Director of the Waite Agricultural Research Institute; Mr. R. G. Thomas, Council for Scientific and Industrial Research Division of Industrial Chemistry; and Mr. G. B. Gresford, Assistant Secretary, Council for Scientific and Industrial Research (Secretary).

9. Australian Leather Research Association.

During the year under review the Australian leather industry established the Australian Leather Research Association. This body, which has the legal form of a non-profit making company registered under the New South Wales Companies Act, is similar to the research associations operating in Great Britain under the aegis of the Department of Scientific and Industrial Research. It is financed by subscriptions from the industry and is at present establishing laboratory facilities in Sydney in order to carry out a comprehensive programme of research. Under powers given to it in its Act, the Council is supporting the Association by providing a grant at the rate of £ for £ on all money spent by the Association on scientific research up to a maximum of £5,000 per annum. The Council for Scientific and Industrial Research has two representatives on the Council of the Association.

10. New Publication—Australian Journal of Scientific Research.

The Council, in collaboration with the Australian National Research Council, has undertaken responsibility for the establishment of a new scientific periodical, entitled the "Australian Journal of Scientific Research", which will be printed in two series: Series A (Physical Sciences) and Series B (Biological Sciences). The first issues of Series A and B appeared in March and February, 1948, respectively, and subsequent issues will be quarterly for the time being. The Journal will be used as a medium for the publication of research papers of outstanding merit, and will be open to receive contributions from research workers, irrespective of country or of the organization to which they are attached. Dr. N. S. Noble has been appointed as Editor, and editorial policy will be decided by an Editorial Board under the chairmanship of the Editor, and comprising as members—Professors W. J. Dakin, E. J. Hartung, L. H. Martin, and J. G. Wood.

11. Overseas Training.

Previous reports have outlined the arrangements the Council has adopted for sending officers overseas to collect information on new developments in scientific research and to acquire general experience in research and a training in new techniques. At the 30th June, 1948, 31 officers are abroad. A number of studentships have also been created with a somewhat similar purpose in view, but more particularly for the training of recent graduates. At the close of the year under review 31 students are receiving training in laboratories in the United Kingdom and the United States.

12. Collaboration with the Universities.

The Council has for long adopted the policy of co-operating with other organizations to the greatest possible extent. As a result, the volume of its work in which various scientific bodies, and in particular State Departments of Agriculture and Universities, are interested has now grown to large dimensions and is mentioned in the main body of the report that follows.

With the development of the Council's investigations in the physical sciences, the help afforded by the Universities has become increasingly important. For example, in Sydney, the National Standards Laboratory, the Radiophysics Laboratory, and the McMaster Laboratory are all accommodated in the grounds of the University. Similarly, in Melbourne, the Division of Tribophysics is housed in the University's Department of Chemistry, and the Division of Animal Health in the grounds of the Veterinary Research Institute, while in Adelaide, the Division of Biochemistry and General Nutrition is located in the University grounds and the Soils Division at the Waite Institute. The close proximity of these laboratories to University facilities and the opportunities for consultation and exchange of views with members of the University staffs are of the greatest benefit.

In developing new lines of work, particularly on the more fundamental side, the Council frequently turns to the Universities for assistance. Thus, in Melbourne the Council is collaborating in nuclear physics research at the Physics School and in metallurgical research at the Research School of Metallurgy. In Sydney, the work of the Radio Research Board has been carried out in close collaboration with the Electrical Engineering Department over a long period of years. More recently co-operative investigations have been initiated within the Department of Chemical Engineering.

13. Finance.

Section XXIV. of this Report gives details of expenditure by the Council of a sum totalling £1,674,295. Of this amount £116,176 was contributed other than directly from the Commonwealth Treasury and this amount included £41,432 expended from the Wool Industry Fund. In addition, the sum of £166,045 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 outside 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 Cattle Research Association, the New South Wales Department of Agriculture, the New South Wales Water Conservation and Irrigation Commission, the Cement Manufacturers Association, the National Gas Association, the Rural Bank of New South Wales, the Dried Fruits Control Board, the timber industry, and the pulp and paper industry.

II. PLANT INVESTIGATIONS.

1. General.

During the year the Division of Plant Industry continued to find the shortage of buildings in Canberra (particularly for pasture work, physiology, and chemistry) a serious retarding influence in developing the various research programmes. There are indications that shortages of staff and equipment should largely be overcome within a year or two, but the outlook for obtaining adequate laboratory accommodation is depressing.

The development of the Regional Station at Deniliquin has proceeded satisfactorily and a tender has now been let for the erection of the Regional Laboratory. The results of the first series of trials at the Station have been analysed and preparations are now in hand for the investigation of particular aspects of the establishment of irrigated pastures in that region.

A property of 6,000 acres has been acquired near Kojonup in the south-west of Western Australia for the purpose of studying pasture problems of that region, especially those related to clover-grass balance.

With the co-operation of the Queensland authorities, accommodation has been obtained in the buildings of the new University, at St. Lucia, near Brisbane. A number of officers of the Agrostology, Drug Plant, Plant Introduction and Tobacco Sections of this Division have been located at St. Lucia, working in association with members of the Division of Soils based there.

During the past twelve months it has been possible to develop the Katherine Experiment Station and also, in co-operation with the Western Australian Department of Agriculture, to commence a programme of investigations at the Kimberley Research Station near Wyndham, Western Australia.

The Northern Australia Regional Survey made a reconnaissance during 1947 of the Barkly Tableland and in the winter of 1948 surveyed particular areas in more detail.

During the year the Senior Plant Introduction Officer spent about six months in South America with an officer of the U.S. Department of Agriculture for the purpose of collecting seeds and plants of wild species of peanuts, grasses, and pasture legumes. Many of the samples obtained are now being sent to Australia and they will be grown and studied under a range of environmental conditions.

Progress is being made towards the development of new lines of potatoes which combine good agronomic property with disease resistance. Numbers of hybrids developed by this Division have been grown by State Departments of Agriculture, which are selecting the best of these for further tests.

As in previous years, it is a pleasure to acknowledge the help obtained from State authorities interested in the various investigations in which the Division has been engaged. With the shortage of buildings, materials, and personnel the results achieved would have been very much less significant had the co-operation received been less wholehearted.

2. Pasture Investigations.

(i) *Canberra, A.C.T.* (1) *Studies on Sown Pastures.*—(*a*) *Wimmera Ryegrass-Subterranean Clover.*—Studies to determine the factors associated with the rapid decline in productivity of Wimmera ryegrass in swards of Wimmera ryegrass and subterranean clover in this region are being continued. Among the aspects already examined are density of the cover, the influence of the associated subterranean clover, the nitrogen status, and the influence of various grazing practices. Experimental work has shown that the density of the cover is of very limited significance and that the poor development of the individual plant is the principal contributing factor to decline in yields of Wimmera ryegrass as the pasture ages. Responses to nitrogen by the diminutive Wimmera ryegrass plants in an old clover-dominant sward were not significant. On the other hand, when the clover was removed from the sward a substantial increase in the yield of Wimmera ryegrass followed, but yields were still only of the order of 7 cwt. per acre. No response to sulphate of ammonia occurred on the plots from which the clover had been removed. It is tentatively considered that the decline in Wimmera yields is due at least in part to increasing, but as yet undefined, competition from the subterranean clover as the stand ages.

(*b*) *Phalaris-Subterranean Clover.*—Work on this type of pasture is currently confined to population studies and harvesting problems. Increasing the seed rate of Phalaris from 2 to 5 lb. per acre gave approximately 50 per cent. more plants but no increase in yield of herbage per acre. Yield of Phalaris and of subterranean clover was unaffected by doubling the seed rate of subterranean clover from 2 to 4 lb. per acre.

A trial was conducted in co-operation with the Farm Mechanization Section of the Department of Commerce and Agriculture, on the harvesting of seed of *Phalaris tuberosa*. Direct heading gave a yield of 39.7 lb. of first grade seed per acre (29.4 per cent. of the seed available), while stooking and threshing gave a yield of 83.5 lb. per acre (46.0 per cent. recovery).

(*c*) *Pasture Establishment under Cover Crops.*—Work is continuing on the establishment of various pasture species when sown with cereal crops. While satisfactory procedures are possible to enable the establishment of annual species with cereals, the results with *Phalaris tuberosa* are not promising. Little increase in establishment of this species was secured by sowing the cereal in alternate rows only, and the density of the stand was still much below that of the pasture species sown without a cover crop.

(*d*) *Field Germination of Subterranean Clover.*—Studies were commenced in 1945 to determine the fate of the crop of subterranean clover seed set in any particular season by each of four varieties of subterranean clover. After the crop was set, seedlings were counted and removed as they appeared. The results to date indicate clearly that at least in this environment the proportion of seed remaining ungerminated twelve months after the crop is set will

probably not exceed 10-20 per cent. of the total depending on conditions experienced. This work must necessarily continue over a period of many years.

(2) *Mineral Nutrition Investigations.*—Responses of subterranean clover to molybdenum were obtained in 1947 on diverse soils at the Dickson Experiment Station, Canberra, and in trials at Booroowa, Carrick, and Goulburn. Wherever responses to molybdenum occurred the subterranean clover was well nodulated. The molybdenum content of clover plants from the Dickson Experiment Station was particularly low. Most samples contained less than 0.1 p.p.m. of molybdenum. Lucerne and the grasses and other non-legumes did not respond to molybdenum in any trials nor was response to any species secured to copper, zinc, manganese, iron, magnesium, or boron in any of the trials.

At six centres in the Southern Tablelands of New South Wales a nodulation problem has been identified. Nodulation and growth were normal only in the presence of applied lime, even though inoculated seed was used. Other nutrients were ineffective.

Work is continuing on the inter-relationship of applications of lime, phosphorus, and molybdenum on the Dickson Experiment Station where both deficient molybdenum and excess manganese are factors affecting growth. Weekly measurement of reducible and exchangeable manganese over the growing period of lucerne showed no marked seasonal fluctuation in available manganese. The manganese is present in the soil as concretions (7.5 per cent. Mn) and toxicity symptoms at any point depend on the abundance of these concretions.

Pot culture studies on the red basaltic soils of the North Coast of New South Wales were commenced in 1947. Results so far obtained indicate that nitrogen is the limiting factor for the growth of Paspalum on these soils. On the other hand, the growth of white clover was poor even where essential major and minor elements were provided. There is no doubt that the problem of satisfactory legume development is critical to satisfactory pasture development on this soil.

(3) *Vegetation and Pasture Surveys.*—The vegetation and pastures of an area bounded approximately by Narromine, Gulgong, Mittagong, and Ardlethan are being surveyed. The survey of the north-west sector of the region has been completed. Survey is also proceeding on a portion of the southern Riverina, lying west of a line from Albury to Yass. The study of the phenology of the *Stipa-Danthonia* pastures of the Canberra region and of the degeneration of the climax grassland under the influence of grazing is continuing.

(4) *Toxaemic Jaundice Studies.*—Co-operative work with the Division of Animal Health and Production and the New South Wales Department of Agriculture is in progress in connexion with the incidence of the sheep disease toxaemic jaundice. The botanical composition of pastures on which pilot flocks of sheep have been running has been measured by the weight estimate method. An attempt has been made to relate the botanical composition of the swards to changes in the copper status of sheep grazing on the pastures. To date, however, there does not appear to be any direct relationship between copper build-up and botanical composition. Because of the extremely high standard error attaching to attempts to determine "amounts eaten" under commercial grazing, effective studies of the actual diet are difficult. Modifications in technique are, however, being adopted in an attempt to obtain at least a crude account of the botanical composition of the diet in contrast to that of the sward.

In 1947 a pot culture study was conducted to determine the relationship of soil type to the copper and molybdenum content of three pasture species under glasshouse conditions. The main findings were that the molybdenum content was well related to soil pH, but showed no consistent relationship as between species. On the other hand, the copper content showed poor relationship with soil pH but in almost all instances showed the highest level in *Erodium cygnorum* followed by *Medicago denticulata* and *Hordeum leporinum.*

(5) *Danthonia Investigations.*—Following consultation with officers of the U.S. Department of Agriculture and the treatment of semi-commercial quantities of seed, it is now evident that the fluffy glumes of *Danthonia* species can be removed to give a high yield of naked unbroken caryopses. Satisfactory field establishment of such treated seed has been secured with supplementary watering and tests of field establishment with natural rainfall are proceeding.

(6) *A.C.T. Survey.*—The Division is co-operating with the Commonwealth Bureau of Agricultural Economics in a survey of a section of the properties of portion of the Australian Capital Territory, designed to determine the economics of pasture improvement, wool production, fat-lamb raising, and cereal cropping. The physical data determined on each holding include topography, soil type, natural vegetation, and the area and condition of natural and sown pastures.

(ii) *Trangie, New South Wales.*—A large-scale grazing trial to be conducted in co-operation with the New South Wales Department of Agriculture at their Experiment Farm at Trangie, was commenced in March, 1948. The main objective of the trial is to determine the influence of rate of stocking and of spring and autumn deferment respectively, on the botanical composition and the condition of a *Stipa-Chloris* pasture, and on the relationship of such pasture changes to the live weight and wool production of Merino wethers. A contour survey, a soil survey, and a detailed pasture survey were made prior to commencement of the experiment in order to permit optimum placement of blocks and treatments. Pasture cuts were made in October, 1947, when the winter annuals (*Medicago* spp. and *Erodium* spp.) were the principal contributors to a mean over-dry yield of 17.2 cwt. per acre; and in March and May, 1948, when *Stipa* and *Chloris* spp. were the principal contributors to mean yields of 2.69 and 5.04 cwt. per acre respectively. These cuts have also clearly indicated the value of the pre-experimental studies, since the October and March cuts gave closely comparable treatment means. The maintenance of the trial will involve bi-monthly pasture cuts, sheep weighing, and determination of fibre diameter in a mid-side position on the sheep. The basal area of the perennial grasses was determined on 432 permanent open quadrats (2 m. by 1 m.) prior to commencement of the experiment, and these quadrats will be re-surveyed at annual intervals.

Mapping of the vegetation of the region is proceeding. Attention is being paid to the pasture disclimaxes which appear when the various vegetation communities are cleared and grazed. Studies have also been commenced on the incidence and development of "scalds" and the relationship of botanical composition to intensity of stocking and trampling. Root studies on the principal pasture types are being initiated.

(iii) *Wagga, New South Wales.*—A comprehensive trial has been planned in co-operation with the New South Wales Department of Agriculture at their Experiment Farm at Wagga, New South Wales. This trial is designed to determine trends in fertility and in production under various systems of land use. The variables include the proportion of arable and pasture phase and the use of different types of pasture. Detailed studies of physical and chemical changes in the soil and their relationship to pasture, crop, and wool production will be undertaken.

(iv) *Deniliquin Regional Pastoral Laboratory.*—The Falkiner Memorial Field Station was occupied early in 1947 and irrigation development works were undertaken to enable planting of irrigated pasture trials in the autumn and spring. Ninety acres have been fully developed for irrigation, set down in pasture experiments, and fenced.

(1) *Plant Investigations.*—(*a*) *Irrigated Pastures and Fodder Crops.*—Establishment trials were initiated with winter and summer growing pastures and cover crops on two soil types. Of these soils, one is a levee soil of light surface texture and the other is one of the "plains" soils of Prescott's "grey and brown soils of heavy texture".

Autumn-sown Wimmera ryegrass-subterranean clover pastures were established with clover crops on both soils; they were better on the lighter soils. Later sowing (mid-May), so that the pasture seeds are germinated by the early winter rains rather than by irrigation in late autumn, appears preferable. The type of cover crop, the rate of its seeding, and its spacing had no appreciable effect on the first season's growth of the pasture.

Spring-sown pastures of perennial ryegrass-white clover were not satisfactorily established, irrespective of soil type or nurse crops used. Perennial ryegrass emerged, though sparsely, on the light soil but neither species established on the plains soil. This, and the previous experiments, demonstrate conclusively the need to overcome the difficulties presented by the instability of the aggregates of the surface soils to water, and the consequent poor establishment of pastures germinated by flood irrigation. Reliable establishment can be expected only if sowing can be carried out in late autumn, and normal winter rains provide the surface moisture for germination. Sowing in spring when temperatures are higher and rainfall is uncertain or absent (so that crops must be germinated by flood irrigation) is at best unreliable, and on most soils seems certain to fail.

Paspalum scrobiculatum, sown in swards and in rows under irrigation, developed well.

Pre-treatment crop trials were sown in autumn 1947 to determine their effect on soils and on the subsequent establishment of pastures. Wheat, oats, and rye corn were used as winter species and Japanese millet, Poona peas, Liverseed grass, and rice as summer species. All crops established well. Yields of the cereals were better on the lighter-textured soils. The pastures were planted in autumn 1948. Lucerne and field peas were unthrifty and etiolated during the season of establishment. As a result, trace element trials have been set down on areas of lucerne and of perennial ryegrass.

(*b*) *Natural Pastures.*—The vegetation and pasture survey of the Field Station was completed during winter and spring 1947, and quantitative sampling of the pastures and the statistical analyses have been concluded. The pasture types have been adequately defined and mapped. The experiments being conducted at Barooga with the Division of Animal Health and Production and associated with the Toxaemic Jaundice Investigations, have been terminated.

(2) *Soils and Irrigation Studies.*—Preliminary field determinations of permanent wilting percentage and of field capacity have been made on the two soil types being irrigated on Falkiner Station. It has been found that normal irrigation does not wet these soils to a greater depth than two feet. Infiltration runs are showing a correlation between soil infiltration rate and pre-infiltration soil moisture. Further work is being done on this aspect.

In preliminary trials with border and contour methods of irrigation no difference has been observed in the amount of irrigation water used or in crop response. Preliminary work has been done on the relationship between rate of advance of the irrigation water front, and irrigation flow rates on light soil border irrigation bays with slopes of 0.2 to 0.3 per cent. The establishment of a Wimmera ryegrass-subterranean clover pasture with subsequent irrigation in 1946 and the structure deterioration accompanying this treatment caused the infiltration rate of the soil to be halved. In its third season of pasture the infiltration rate of the soil is still only half that of similarly cultivated plots left unsown and unirrigated. The pasture has not yet been responsible for improvement in surface structure.

(v) *Armidale, New South Wales.*—(1) *Grazing Management Studies.*—Experiments on the natural pastures of the New England Region involving a comparison of (*a*) different rates of stocking and (*b*) continuous versus rotational grazing have been commenced in co-operation with the Division of Animal Health and Production. In these experiments a study is being made of the effects of different grazing treatments on: (*a*) parasitic infection, (*b*) wool production, (*c*) liveweights and growth of the sheep, (*d*) yield and botanical composition of the pasture, and (*e*) chemical composition of the pasture. During the year the fencing was erected and preliminary pasture sampling to evolve a technique suitable to the experiments was carried out.

(2) *Species Trials.*—The trial of a number of forage grasses and legumes on the three main soil types of the Region has been continued. This trial is directed towards determining the most suitable species for the New England environment, particularly with regard to their capacity to provide forage during the critical winter months.

The best overall production in the two years' trial was obtained with lucerne, red clover, *Phalaris tuberosa*, and sheep's burnet (*Poterium sanguisorba*). Several strains of subterranean clover (on some soils), hairy Peruvian lucerne, Phalaris, sheep's burnet and Hispania cocksfoot were best in winter, while *Agropyron elongatum*, two *Melilotus* spp., Phalaris, tall fescue, lucerne, red clover, and *Bromus inermis* made greatest summer growth. The species that have shown most promise (they are grown in rows in the preliminary trials) are being further tested at Chiswick Field Station. In this trial various grass-legume mixtures have been sown in swards under grazing. Productivity and persistence of each species will be measured.

With predominantly summer rainfall in the New England Region it is possible that subterranean clover may not persist. To test the persistence and the seasonal productivity of a number of varieties duplicate half-acre plots of the following varieties were sown in the autumn of 1946:—Tallarook, Mt. Barker, Bacchus Marsh, and Dwalganup.

(3) *Fertilizer Trials.*—(*a*) *Exploratory Trials.*—To determine fertilizer requirements of pastures on the various soil types in the New England Region, preliminary trials have been sited at three localities (two under natural pasture and one under subterranean clover pasture). The fertilizer treatments under test were nitrogen, phosphate, potash, lime (as a nutrient), wood ash, dried blood, and three minor element dressings: (*a*) borax, (*b*) molybdenum, copper, and zinc, and (*c*) magnesium, nickel, and iron. With the grass-dominant natural pastures, nitrogen (sulphate of ammonia) gave the greatest increase in yield (up to 100 per cent.), and increases in yield from superphosphate were almost as great. On the subterranean clover pasture, 2 cwt. per acre of superphosphate gave an increase in yield of over 300 per cent. Potash, lime, and borax failed to give an increase at any locality. The other two minor element dressings and wood ash gave increases in yield at all localities.

(*b*) *Rate of application of superphosphate.*—To test the effect of different rates of application of superphosphate on sown pasture on one soil type on the Chiswick Field Station, duplicate half-acre plots of an area sown with *Phalaris tuberosa*, red clover, and subterranean clovers were topdressed with superphosphate in the autumn of 1948 as follows: (*a*) nil, (*b*) 50 lb. per acre, (*c*) 100 lb. per acre, (*d*) 200 lb. per acre, (*e*) 100 lb. per acre to be followed by 100 lb. per acre in the spring.

(vi) *Western Australia.*—(1) *Ehrharta Grazing Management Trial*—This experiment, commenced at the Institute of Agriculture, Nedlands, in 1943, was concluded in April, 1948. Throughout the four grazing years there has been a decline in the persistence of *Ehrharta,* under both continuous and six-weekly rotational grazing, though more rapid under the former treatment. By 1947 the perennial grass had virtually disappeared from the experiment. The 1947 data for both pasture production and sheep liveweight increases showed small and non-significant treatment differences. These findings are in line with those of previous years, and in substantial agreement with those of the management trial on sown pasture at Canberra. In the present instance the lack of persistence of perennial veldt grass can be largely accounted for by the high "grazing pressure" on the grass accentuated by its high palatability in comparison with the associated Dwalganup subterranean clover.

(2) *Wimmera Ryegrass Investigations.*—Experiments on the extra-grazing factors responsible for the retrogression of Wimmera ryegrass in sown pastures have been continued. Results obtained during 1947 confirmed past experience that surface cultivation is not always efficacious in stimulating growth of this grass. Primarily, low nitrogen supply is responsible for decline in yield in light textured soils. Single-plant studies were begun in 1947 in view of the importance of the grass, especially in connexion with the sheep infertility problem. It has been shown that Wimmera ryegrass is highly self-sterile.

(3) *Mineral Deficiency Studies.*—Seven field experiments were commenced in 1947—mostly in the Gingin area—to examine, in particular, the effects of potassium, copper, and zinc on sown pasture species. Neither lupins nor *Ehrharta* showed observable responses. Dwalganup subterranean clover, on the other hand, showed marked responses to all three nutrients in a number of the trials, those to potassium and zinc being most pronounced. Omission of copper frequently resulted in characteristic deficiency symptoms.

In pot culture trials on four soils from the coastal plain region, it was noted that barrel medic showed responses to copper, but not to zinc. Dwalganup subterranean clover responded to both nutrients and showed characteristic deficiency symptoms in the absence of these elements. Particular attention is being given to a siliceous sand of very low fertility (Muchea sand), on which clover will grow only in the presence of lime or wood ash, and on which lupins cannot yet be grown satisfactorily.

(4) *Pasture Investigations Relating to the Sheep Infertility Problem.*—The two grazing experiments commenced at Wandering and Narrogin in 1945 are still in progress: a third of similar design was begun at Kojonup in 1947. Botanical composition data on the pasture have been collected at specified occasions in the expectation of relating these to differences in lambing results. To date, it appears that "clover dominance" *per se* is not the only criterion of an infertility pasture. The widespread elimination of grass species from clover pastures under present methods of grazing management is considered a vital factor in the problem, and consideration is being given to grazing systems in which (*a*) grass may be retained, and (*b*) the sheep will not be forced to consume subterranean clover during the growing season. At the present time, bio-assays for oestrogen content are being done by officers of the State Department of Agriculture and C.S.I.R. on numerous strains of subterranean clover, samples of the Dwalganup strain collected from a wide range of environmental conditions, and also numerous other pasture species.

(5) *Grazing and Rotation Trial.*—This experiment is being carried out at Wongan Hills on a co-operative basis with the State Department of Agriculture and the University of Western Australia. It has now completed its second grazing year. Results over the two seasons are in general agreement in major points. During the winter, differences in sheep carrying capacity—with the exception of the volunteer pasture treatment—are not very great, and wool production per sheep is fairly constant over all treatments. The carrying capacities of the pastures in summer have been greater than in winter, and the rate of wool production less. Both volunteer pasture (chiefly capeweed) and subterranean clover plus Wimmera ryegrass produce less wool per sheep in this period than either oats alone, oats plus peas, or oats plus lupins.

(6) *Glen Lossie Field Station, Kojonup.*—Final arrangements have been made for the purchase of a 6,000 acre property at Kojonup by the Council and a research programme is planned for 1948. The acquisition of this property will greatly facilitate pasture research in the southern sheep areas of this State. Investigations on Wimmera ryegrass, introduced annual pasture grasses and legumes, row-sowing of Phalaris and *Ehrharta,* minor element studies, and the effect of phosphate on pasture production, and on soil fertility, are aspects of the work to be undertaken at this centre. Experiments on the sheep infertility problem will also comprise part of the programme.

(vii) *Cooper Laboratory, Lawes, Queensland.*—During the year there has been an extension of laboratory and research facilities of the Council in Queensland. A substantial part of the main building at the new St. Lucia University has been made available pending erection of a permanent laboratory in Brisbane, and this provides accommodation for officers of the Agrostology Section, the Plant Introduction Section, the Drug Plant Section, and the Tobacco Section of the Division. The Cooper Laboratory also is being maintained as a centre for research by the Council; field work will continue at the Lawes Agricultural College.

(1) *Row Pastures.*—Work on row pastures using *Paspalum scrobiculatum* and lucerne is continuing. Two factors affecting yields of swards and rows, water and nitrogen status, have been examined. The response to ammonium sulphate was greater on swards than row pastures. Thus this pasture grown in rows appears to suffer less from nitrogen deficiency than when grown in swards. There was generally less available soil moisture under swards, particularly below a depth of 1 foot, and a more rapid penetration and absorption of water by row pastures when good rains followed a dry spell.

The competition between grass and lucerne noted in row experiments has been studied in greater detail at Brookstead on the Darling Downs.

Observations on trial plots, in which the grass and lucerne are mixed within the row, have indicated the desirability of comparing four pastures: (*a*) *Paspalum scrobiculatum* alone, (*b*) lucerne alone, (*c*) *Paspalum scrobiculatum* and lucerne mixed rows, and (*d*) *Paspalum scrobiculatum* and *Phaseolus lathyroides.*

A further experiment is also to be conducted to determine the significance of legumes in contributing to nitrogen status. Treatments will include: (*a*) grass alone (control), (*b*) grass plus ammonium sulphate

(control), (*c*) grass plus lucerne, (*d*) grass plus *Phaseolus lathyroides,* and (*e*) grass plus lucerne, plus *Phaseolus lathyroides.*

(2) *Rhodes Grass Pastures.*—Interesting data are now accruing from an experiment designed to assess the relative value of two strains of Rhodes grass, and to evaluate lucerne as a component of Rhodes grass pastures. The experiment has been grazed by beef steers at one beast to 1¼ acres. No differences have been attributable to the grass strains (except temporarily in the winter of 1947) but lucerne has had a tremendous influence on growth increment. The mean liveweight gain over the period January, 1946, to November, 1947, was 244 lb. on the pure grass swards and 417 lb. on the grass-lucerne swards. The lucerne has been satisfactorily maintained in the mixed pasture but has never become a major constituent. The amount present has rarely exceeded 2.5 cwt. per acre and during the winter months has been less than 0.25 cwt. per acre. It is of interest that even such small amounts of lucerne have increased grass yields by 4 to 10 cwt. per acre during the growing season. The response by cattle is associated with the improved nutritive yield of the pastures rather than with the increased yield of grass.

An experiment designed to seek a strain of lucerne superior to Hunter River for growth in association with commercial Rhodes grass has failed to reveal any material superior to this standard strain.

(3) *Alternate Pastures.*—Rhodes-lucerne mixture provides excellent food in summer but has limited value in winter; row pastures of *Paspalum scrobiculatum* (in combination with a suitable legume) will provide first-class winter feed but are susceptible to overgrazing in summer. An experiment has therefore been designed to gain preliminary data on alternate grazing of these two pastures by beef cattle.

(4) *Natural Pastures.*—Work on the natural spear grass pastures (*Heteropogon contortus*) is continuing at Calliope, near Gladstone. Yield and botanical and chemical composition are being recorded at twelve-weekly intervals. First year results showed that growth was restricted almost exclusively to the period of effective rainfall between January and April, 1947, with spear grass contributing some 90 per cent. to the total yield. Young spear grass (January, 1947) contained 1.35 per cent. of nitrogen but was below 1 per cent. during the April-October period. Legumes were relatively high in protein (1.86 to 2.22 per cent.) but contributed little to yield. In the first year light cultivation increased total yield by 26 per cent. and some residual effect from this treatment was apparent during the second year. Subsequent experiments seem to indicate that benefit will be restricted to cultivation in the spring and early summer months giving a better penetration by scattered light showers. Later in the season heavy rainfall ensures wetting of the soil to considerable depth with or without cultivation.

An obvious approach to improvement in this pasture lies in the possibility of incorporating some legume in the sward. *Stylosanthes sundaica* (Townsville lucerne) was easily established by surface seeding, even into a vigorous stand of grass. Fertilizer experiments with both major and minor elements have disclosed a marked response to applications of superphosphate. An additional response has been secured from greater doses of phosphate in the presence of potash. The yield of Townsville lucerne was increased by 120 per cent. Preliminary trials have as yet indicated no legume of greater promise than Townsville lucerne for this environment.

Preliminary studies on the effect of burning of natural pasture at Lawes have shown that this treatment increases the germination and establishment of *Heteropogon contortus.* This work is continuing.

(5) *Plant Nutrition Studies.*—There is evidence that plants growing on the black soils of south-eastern Queensland suffer a nutritional defect. Poor establishment and seedling growth are common to many summer crops, though winter cereals are relatively unaffected. Trials to date with various soil ameliorants and minor elements have given somewhat confusing results, but there is evidence that the zinc, manganese, and copper nutrition of affected plants may be defective. Pot culture studies are also in progress with a number of other Queensland soils.

(6) *Lucerne Strain Trials.*—(*a*) *Selection of "Hay-type" Lucerne.*—Tests of 44 progenies of crosses between the selected Hunter River lucerne plants and commercial Hunter River lucerne and ten other lucerne strains showed that some strains out-yielded the control (commercial Hunter River) in hay yields during 1947. Work is continuing.

(*b*) *Selection of Flood-resistant Lucerne.*—A flood-resistant strain of lucerne was sought for use in areas subject to summer inundation. The work has not indicated any strain superior to commercial material in respect to flood resistance.

(*c*) *Breeding of Rust-resistant Lucerne Strains.*—The inheritance of rust resistance is genetically complex. Nevertheless, work over the past ten years has disclosed strains which are 100 per cent. rust-resistant. Though these are not commercially desirable types, a programme to incorporate rust resistance and good economic qualities can be envisaged. The material has been handed to the New South Wales Department of Agriculture, which will continue this lucerne breeding work.

(viii) *"Gilruth Plains", Cunnamulla, Queensland.*—(1) *Grazing Management Studies.*—Following the break in drought conditions at "Gilruth Plains" in February, 1947, the Mitchell grass grazing equipment was resumed. In this experiment, the effect on a Mitchell grass pasture and on the grazing sheep of light, medium and heavy stocking under both continuous and rotational grazing is being measured. On resumption, the experiment was reduced in size from ten replications to five. Though the earlier observations on the effect of the grazing treatments on the yield and botanical composition of the pasture and the wool return from the sheep are being continued, emphasis is also being placed on the measurement of changes in the density and vigour of the Mitchell grass. Under the exceptionally favorable seasonal conditions since the commencement of the second term, sheep liveweights have been maintained at comparable levels under all grazing treatments and no differences in the effect on the pasture have been apparent.

(2) *Regeneration of Semi-arid Natural Pastures.*—(*a*) *By Conservative Stocking.*—Under conditions where the stand of perennial grasses in a pasture has been thinned out, but where some plants remain to provide seed, it should be possible to improve the stand by conservative stocking. An experiment has been commenced on a pasture in which the Mitchell grass was seriously reduced during the 1943-46 drought. Previous investigations have shown that the pasture is adversely affected by over-use during the summer growing periods. In this regeneration experiment the grazing treatments are designed to spell the pasture during the growing periods, but to obtain some return from it by conservative stocking during dormant periods.

(*b*) *By Reseeding.*—On many natural pastures the seed supply of the perennial grasses in the soil has been exhausted. This is evidenced by failure to re-establish during favorable seasonal conditions. Where reasonably good seed-bed conditions are available, it should be possible to re-establish the perennial grasses by reseeding. An experiment to test methods of establishment was commenced during the 1946-47 summer. A

thin stand of Mitchell grass was obtained from the first sowing, and an attempt is now being made to increase its density by conservative stocking.

(3) *Yield and Floristics Studies on Miscellaneous Pasture Types.*—To obtain preliminary information on characteristics of pasture types other than the Warrego Mitchell grass, type sites have been established at a number of centres. These are "Gilruth Plains", Cunnamulla (mulga-box); "Tilquin", Bollon (box open forest); "Riversdale", St. George (box open forest); "Bullamon Plains", Thallon (coolibah open forest); and "Noondoo", Dirranbandi (Mitchell grass). Pasture samples are cut after each growing rain. On areas from which stock are excluded, all species present are listed and the yield of grasses, legumes, and miscellaneous (herbage) species determined. Three such samplings were made at each type site during the past year.

(ix) *Burdekin Valley, Queensland.*—Preliminary examinations of the Burdekin River by the State of Queensland have indicated the possibilities of developing a major irrigation storage reservoir in the upper region of this valley. It is considered that were there such a scheme to be developed a major portion of the water available must be used for pasture and stock fodder production. At the request of the Queensland Government the Division of Plant Industry is co-operating in joint investigations concerning irrigated pastures in this region. Initially the work will be done in the delta region on the Ayr farm, which was used by the Commonwealth during the war period for vegetable production. An irrigated pasture experiment to be grazed by beef cattle has been designed. The object of this experiment is to obtain preliminary information concerning the behaviour of pasture species under irrigation in this region, and to obtain a general measure of the reaction of stock when grazed upon them. It is hoped that facilities will be available to commence this experiment during the summer of 1948-49.

3. Weeds Investigations.

With the completion in 1946 of the preliminary survey of the potentialities of plant growth-regulating substances as herbicides, attention was directed to the specific problems of the control of hoary cress (Victorian Wimmera), skeleton weed (Cowra, N.S.W.), nutgrass (Lawes, Qld.), blackberry (Ferntree Gully, Vic.), Bathurst burr (Cunnamulla, Qld.), mintweed (Darling Downs, Qld.), and galvanized burr (Warrie, Qld.). The range of compounds used in the above tests has included all the known most active formulations. It has been found that a too rapid kill of the above-ground parts of perennials results in a poor root kill, and for this reason the sodium and triethanolamine salts appear to be superior to esters on non-woody perennials. The success or otherwise of the treatments for controlling perennial weeds will not be known until the spring of 1948.

On the ecological side, a preliminary survey has been made of the Liverpool Plains area, and a number of transects at Cassilis, Murtoa, and on the Central Tablelands of New South Wales have been made as part of a more extensive programme to investigate the effects of the grazing animal on the native and exotic vegetation within defined plant communities.

Work has been initiated to investigate the basis of the differential effect of plant growth-regulating substances on monocotyledons and dicotyledons, particularly in relation to the respiratory enzyme systems of the plant, as recent work has indicated that the effect of these substances is probably through their action on these enzymes.

Further investigations on the diagnosis of dead tissues in plants by high-frequency electrical currents are in progress. The method is being used to determine the lowest point of dead tissue in the roots of poisoned plants. It also shows some promise in differentiating between healthy and virus-infected potatoes.

(i) *Hoary Cress (Lepidium draba).*—Experiments initiated at Murtoa in 1946 showed that spraying an infested wheat crop in September with plant growth-regulating substances gave a 20 per cent. increase in grain yields and a 70-80 per cent. reduction in cress density twelve months later. By the use of split-plots in 1947, half of the experiment was resprayed to determine if further reductions would occur. In addition, a new series of experiments was initiated involving all the more important herbicidal formulations of plant-growth substances, the effects of different rates of application and power-spray applications to large areas. The initial results have been promising but final evaluation will not be possible until late 1948.

(ii) *Skeleton Weed (Chondrilla juncea).*—Initial experiments using plant-growth substances on this species gave conflicting results, but in general were not promising. A series of experiments at Canberra and Cowra involving the use of different formulations at different growth stages was begun in 1947. The results show that autumn sprayings provided a measure of temporary control during the winter and spring, but regeneration occurred during the summer. Spring applications have to date been the most effective.

(iii) *Nutgrass (Cyperus rotundus).*—Field experiments were begun on this species in the summer of 1947 at Lawes, Queensland The first of the series was a test of formulations including a series of esters of 2,4-dichlorophenoxyacetic acid from the methyl to the normal and isoamyl. Several formulations have given promising initial results. Applications in lighting kerosene have proved less effective than water solutions or emulsions, and high rates do not appear to be more effective than 2-3 lb. per acre applications. Further experiments with soil fumigants at Tenterfield have shown that the minimum effective dose rate of chloropicrin is between 200 and 300 lb. and of D-D 700 lb. per acre. These dose rates were effective only when the treated area was sealed after injection.

(iv) *Bathurst Burr (Xanthium spinosum).*—An experiment at "Gilruth Plains" has shown that Bathurst burr, even when flowering and fruiting, is completely killed a month after spraying with sodium 2-methyl 4-chlorophenoxyacetate at from 1-2 lb. of active ingredient per acre. Dust applications at from ½ to 4 lb. of active ingredient per acre were ineffective. Tests are being conducted to determine the viability of fruits which developed on treated plants.

(v) *Galvanized Burr (Bassia birchii).*—As a means of controlling small areas of galvanized burr several formulations of 2,4-dichlorophenoxyacetic acid, as well as crude oil with and without a fortifying agent, dinitro secondary amyl phenol, were tested at St. George, Queensland. The results six months after application showed that ethyl 2,4-dichlorophenoxyacetate at 5 lb. per acre had given a complete kill. The effect of treatment on viability of fruits is under investigation.

(vi) *Blackberry (Rubus fruticosus).*—Following the failure of the sodium salts of 2,4-dichlorophenoxyacetic and 2-methyl 4-chlorophenoxyacetic acids to produce more than a slight epinasty of young shoots of blackberry in 1946, an experiment was laid down in 1947 on young blackberry regrowth following cutting, using various ester formulations in water emulsions and kerosene solutions. Applications of 2,4-dichlorophenoxyacetic acid and its methyl and butyl esters in lighting kerosene killed the top-growth, but vigorous regrowth followed. Applications of the butyl and ethyl

esters in water emulsions killed the leaves but only partially killed the stems which, however, still show epinastic effects and a variable amount of regrowth. A feature of the experiment was the volatility under hot conditions of ester formulations particularly in lighting kerosene, indicating that these substances may be dangerous to use near adjacent susceptible crops.

(vii) *Mistletoe (Loranthus spp.).*—Spray applications to the foliage have proved ineffective but liquid injections of copper sulphate are promising. Further tests with other poisons are in progress and radioactive tracer methods are being developed for following the movements of such poisons.

(viii) *Mint Weed (Salvia reflexa).*—Experiments have been conducted to assess the agricultural importance of this weed. Summer-growing crops can be grown on heavily infested land with little or no reduction in yield. Mint weed is of little importance in winter crops and should be regarded rather as a weed of stock-routes and over-grazed native pastures. Chemical sprays are of doubtful practicability because of their high cost relative to the value of the effective grazing lands.

(ix) *Trees.*—Preliminary trials in Queensland with plant growth-regulating substances for the control of regrowth and suckering have shown that partly they are, at least, as effective as commercial tree-poisons when applied to "frilled trees".

(x) *Pre-emergence Tests with Plant Growth-regulating Substances.*—Pre-emergence applications of phenoxyacetic acid compounds proved toxic to all dicotyledons tested and, in addition, showed varying degrees of toxicity to monocotyledons, including cereals. No differences were found between the sodium, amine, and ester formulations. The results showed that while many weed species were almost completely inhibited by 1 lb. per acre applications of phenoxyacetic acid compounds, the establishment and yield of cereals was not affected. Higher rates of application, however, markedly reduced the yield of wheat. Carbamates had no effect on the establishment or subsequent growth of any of the dicotyledons tested, excepting linseed, *Linum usitatissimum.* All of the monocotyledonous species were inhibited to a high degree by carbamates; 1 lb. per acre applications of isopropyl-N-phenyl-carbamate reducing the number of fertile tillers and grain yield of wheat by approximately 63 per cent.

(xi) *Differential Effects of Phenoxyacetic Acid Compounds and Phenyl Carbamates applied to Wheat at Different Growth-stages.*—Wheat proved most sensitive to phenoxyacetic acid compounds in the seedling and early tillering stages of growth. The butyl ester of 2, 4-dichlorophenoxyacetic acid was more toxic than the sodium salt and the triethanolamine salt was intermediate in effect. On the other hand, isopropyl-N-phenyl-carbamate was most toxic at flowering and pre-shooting and had no effect at the earlier growth stages.

(xii) *State Weeds Co-ordination Committees.*—With the formation of a committee in Tasmania, there is a Weeds Co-ordination Committee in each Australian State. The Committees have been effective in maintaining a close liaison between the various organizations undertaking research on weed problems in Australia.

4. Plant Introduction.

(i) *General.*—During the year, the Senior Plant Introduction Officer had the opportunity of participating in a plant collecting expedition to South America, organized by the U.S. Department of Agriculture. About six months were spent in parts of Argentina, Brazil, Uruguay, and Paraguay, the main objectives being the collection of seeds and plants of wild species of peanuts, grasses, and pasture legumes. The area visited is one of particular interest, as several of the more promising introductions which have been noted in previous annual reports originated in this part of South America, and it was desired to obtain further strains in order to assess fully the value of the plants in Australia. Many samples were obtained, and are being sent forward to Australia through the Division of Plant Exploration and Introduction of the U.S. Department of Agriculture. In addition, the personal contacts established with botanists and research workers in the countries visited will be of great value for the future work of the Section.

Other than the initiation of active plant exploration, referred to above, the principal developments in the work of the Plant Introduction Section during the past year include: (*a*) expansion of the work of the newer field stations, especially in the Northern Territory and Western Australia, (*b*) further development of regional trials of promising introductions, and (*c*) closer contact with the plant quarantine organization of the Commonwealth Health Department to minimize the risk of introduction of diseases and pests. The Section is the only agency authorized to introduce living plant material for the Council, and additional field stations have been gazetted as quarantine areas during the year.

(ii) *Introduction and Exchange of Plants and Seeds.*—This has continued actively during the year, though on a slightly reduced scale. Some 726 samples were received from overseas countries, including large collections from the Union of Soviet Socialist Republics, Bulgaria, United States of America and Canada. Samples sent abroad in exchange numbered 676, the principal recipients being some of the Balkan countries. The opportunity of establishing exchanges with these countries is particularly welcome, as they are similar climatically to parts of Australia and contacts have been very restricted in previous years.

Pasture and forage plants continue to form the largest class of introductions, followed by vegetables, oilseeds, and cereals. Included in these groups are many varieties of French and broad beans and peas for use by the Vegetable Section, rye varieties for soil erosion control, and collections of soybeans, sunflowers, linseed, and castor beans for trial as vegetable oil plants.

As in previous years, many samples have been supplied to State Departments of Agriculture and other organizations for trial. Many of these trials are on a co-operative basis, and are of great assistance in evaluating the introductions. Exchanges have been assisted by the distribution of quarterly lists of plants introduced, and an annual seed list.

(iii) *Pasture and Forage Plant Trials.*—The 269 new introductions of pasture and forage plants are being tested at the introduction field stations at Canberra (Australian Capital Territory), Lawes and Redland Bay (Queensland), Katherine (Northern Territory), and Perth (Western Australia), together with many of those which have shown promise in previous years.

Several strains of Bahia grass (*Paspalum notatum*) are showing promise in nursery trials at Redland Bay, and work with this species will be intensified when the South American collections become available. It is one of the most important pasture grasses in regions of similar climate to south-eastern Queensland. Other pasture plants of promise for this area include Dryland Napier grass (*Pennisetum* sp.), species of *Stylosanthes* and *Desmodium*, and kudzu (*Pueraria thunbergiana*).

Studies of vetches and other annual legumes for grain and hay have continued at several centres in Western Australia and for green manure at Griffith (New South Wales), and a trial has also been begun at Canberra. The results to date generally confirm the

value of auburn woolly pod vetch (*Vicia dasycarpa*), Monala vetch (*Vicia monantha*), and a variety of *Lathyrus ochrus* from Palestine. Chemical tests made on these plants have shown that they are free from toxicity and of high nutritive value. Many varieties of cowpeas (*Vigna unguiculata*) have been under trial at Katherine, Lawes, and Griffith. Some upright strains developed in South Africa appear to be outstanding hay types, and others are being tested for suitability for green manure, grain production, and as vegetables.

The encouraging results obtained in trials of varieties of bulrush millet (*Pennisetum typhoideum*) have been confirmed in a further trial at Katherine, and they showed promise in a preliminary trial at Lawes. Some of the strains are also under trial at "Gilruth Plains" in south-western Queensland.

(iv) *Trials of Vegetable Oil Plants.*—Experimental work in this group includes trials of several species at Katherine, Lawes, Redland Bay, Westbrook (Queensland), Red Cliffs (Victoria), and Perth.

Results of soybean trials continue to be conflicting and difficulties are experienced in obtaining satisfactory establishment and growth. Six varieties which have shown promise at Redland Bay have been selected for multiplication and further testing, and some varieties recently introduced from China have made good growth in nursery trials at Lawes. At Merbein, early-maturing varieties were most successful in a trial under irrigation.

Sixteen varieties of castor beans have been tested at Katherine and five in Western Australia. They were unsuccessful in the west, but two American varieties showed promise at Katherine. These are low-growing, thin-stemmed, evenly-maturing types, suited to mechanical harvesting.

Sunflower trials have been conducted at Katherine, Lawes, and Westbrook. Growth was fairly good at all centres, but full yield data are not yet available. In view of the promise shown by the Canadian hybrid variety "Advance", seeds of the parent lines have been introduced so that hybrid seed may be produced here for more extensive trials.

Trials with linseed must extend over several seasons to enable reliable results to be obtained, as the crop is inherently a variable one. The potential importance of the crop in south-eastern Queensland appears to warrant such trials, and they are in progress at Lawes, Westbrook, and on the Darling Downs. Results from the first three years' trials at Lawes show that the yields of the best varieties—mostly of Indian origin—are at least equal to those obtained in other linseed-growing countries.

Other oilseeds under trial include sesame, niger seed, peanuts, safflower, and rapeseed. Sesame and niger seed made good growth at Katherine and were well suited to the seasonal length, but further information on yields must be obtained before their value can be assessed in relation to that of alternative oil crops.

(v) *Trials of Technical and Miscellaneous Plants.*—Varieties of yam bean (*Pachyrrhizus* spp.) are under trial at Katherine and Redland Bay, and good seed yields have been obtained at both centres. Growth is less rampant at Katherine, and the seed is more easily harvested. Further tests are required on the insecticidal value of the seeds. As the plants produce a great bulk of foliage, they may be useful as forage plants if not toxic to stock. Preliminary feeding tests with rats, made at the University of Queensland, were inconclusive, and further tests are to be made.

Trials of guar (*Cyamopsis tetragonoloba*) were a failure at Lawes and Red Cliffs owing to poor germination, but an early-maturing strain made good growth and yielded well at Katherine. Technological trials with the seeds of this plant have so far failed to provide a clear picture of its value as a source of mucilage.

Several fibre plants have been tested at Katherine, particular attention being given to ramie in view of the current interest in the plant. The results show conclusively that the length of the wet season at Katherine is too short for the satisfactory growth of ramie, the yields being low and only one cut being obtained.

(vi) *Herbarium.*—The work of the Herbarium has extended considerably during the year, though semi-routine identifications for members of the Agrostology Section and other Divisional officers continue to make heavy claims upon the time of the systematic botanist to the detriment of taxonomic research work.

Extensive collections have been made in Western Australia and the Australian Capital Territory, and the Herbarium has been enriched by collections made by officers of the Division of Economic Entomology on a trip across the Nullabor Plain, by the Commonwealth Nutrition Survey Party in New Guinea, and by officers of the Northern Australia Regional Survey. Donations have also been received from the Brisbane and Melbourne Herbaria. The specimens in the Herbarium now total 15,203.

During the year, an inventory was made of the Lucas collection of marine algae prior to its removal to Sydney on loan to the Division of Fisheries. Visits were made to the Perth, Melbourne, and Brisbane Herbaria for critical checking of material.

5. Take-all of Wheat.

The results of an experiment in which wheat was grown in drums out of doors and continued during the years 1944 to 1947, were analysed. The effect of the disease on plants grown in partially sterilized soil contaminated with the organism at sowing time was significantly less than in the unsterilized controls. The yield of grain in limed soil in the first year was also better than in the unlimed soil. Fertilizing throughout the season by adding solutions of only five elements of plant food consistently gave the best results throughout the period of the experiment. In all but one year the use of a full nutrient solution containing the trace elements significantly reduced yield. The addition of superphosphate alone was without effect on yield.

Contaminating the soil with the organism did not produce adverse effects on yield except in one series in which it was applied to seed sown two months before the usual sowing time. The yield of the crop in those drums that were replanted at the normal time after eradicating the first crop of seedlings, was significantly less than that of the controls.

6. Fruit Investigations.

(i) *At Stanthorpe, Queensland.*—A general account of the scope and purpose of the apple and pear rootstock investigations at Stanthorpe was published in the Council's *Journal* for May, 1938, and results obtained during the first ten-year period summarized in the 18th Annual Report.

The propagation and multiplication of those apple rootstocks which gave the best performances during the first ten-year period in nursery trials have proceeded satisfactorily, and supplies of these selected stocks are being made available to nurserymen. About 2,000 of these stocks are being made available to establish layer beds in a nursery being established by local orchardists.

The two trials in which the trees are planted on an orchard basis of a 20 feet by 20 feet spacing, are in their tenth year. In the first of these, Jonathan and Granny Smith are budded to stocks Malling I., XII., and XVI., Northern Spy, and Pomme de Neige seedlings. Both scion varieties cropped most heavily on Northern Spy during the early years of bearing; by the tenth year the yield of Granny Smith on this rootstock was still greater than on the other stocks, but the lead enjoyed by Jonathan on this stock during

earlier years has been lost. The largest trees are those on Malling XII. and XVI., Pomme de Neige, the smallest on Spy and Malling I. The largest crop fruit in the tenth year was from scions on Malling XII. in the case of Jonathan, and Spy in the case of Granny Smith. Jonathan trees on Malling XII. suffer from a heavy pre-harvest drop of fruit. No appreciable drop has occurred on the other stocks.

In the second orchard trial Jonathan scions are budded on three stocks—Malling XII., S4, and Ivory's Double Vigor. Upon this trial is superimposed a pruning experiment in which severe, standard, and light pruning (Wicken's method) are compared. The lightly pruned trees have grown into the largest trees, and have borne crops about twice the size of those of the hard-pruned trees. The heaviest crops have been borne by trees on Malling XII. From both these trials good crops of marketable fruit are being produced. Preparations are well in hand for the establishment of a field or orchard planting of woolly aphis immune stocks which have been selected on their performance in nursery trials, the results of which were reported last year. Sufficient quantities of further types of woolly aphis immune rootstocks have been propagated to allow their testing on nursery trials which will be established during the 1949 season.

The nursery trial of pear rootstocks has given the following results. William Bon Chretien on *Pyrus Calleryana* are the largest trees but have not been the heaviest croppers. The largest crops have been taken from trees on Malling D.3 and performance on other stocks has been in the order *Pyrus Calleryana*, C7, D4 and B1 selections.

(ii) *In Tasmania.*—Investigation of the problems of physiological storage disorders in apples and pears was again in abeyance because the officer engaged in this work was seconded for a further period, to serve with the Department of Commerce and Agriculture as Fruit Officer in London. These investigations will be resumed during the coming season.

7. Drug Plant Investigations.

The general description and purpose of these investigations have been presented in previous reports, and particularly in the Annual Report of the Council for the year 1945-46. Work has been continued along the lines previously indicated on the opium poppy as a source of morphine, and *Duboisia* spp. as sources of hyoscine and atropine. Adverse seasonal conditions were encountered which seriously affected the progress of the poppy breeding programme. Good progress has been made, however, in the survey of native plants for sources of pharmacological substances, and in the special investigation of the occurrence of rutin in *Eucalyptus macrorrhyncha.* A new project has been undertaken which concerns a search for substances which may have inhibiting effects on tumour-growth in animals.

(i) *Opium Poppy (Papaver somniferum).*—The cross material between the so-called English and Shepparton varieties is now in its sixth generation; many of these lines are already homozygous for certain characters, and it is believed that they should be so for all the important characters by the ninth generation. Correlations between successive generations for morphine content are not high.

The yield trial of selected types at Canberra was a failure because of excessive rain during the maturation period, but the duplicate trial at Griffith yielded some assessable data. Five of the English and Shepparton cross lines yielded more morphine per acre than the standard English variety. In these lines a substantial improvement on the English variety in agronomic type has been developed.

The cross between the English and F6 varieies is in the fourth generation but the results have been somewhat disappointing. The combination of the stout straw, large capsule characters of the English variety with the high morphine content of the F6 variety has not been satisfactorily effected. No other crosses have given as promising results as the English by Shepparton cross.

(ii) *Duboisia spp.*—Observations and assays have been continued on the selected progenies, and information and data upon which the most satisfactory types will be selected for production of hyoscine and atropine under cultivation have continued to be collected. At this stage consistent differences in the nature and amount of alkaloids and their extractability have not been demonstrated between seedling progenies of the "northern" type of *D. myoporoides.* The main basis upon which lines or progenies within this general type are being selected is desirable agronomic characters. Some seventeen lines of this type are still being studied.

All progenies of the "southern" type of *D. myoporoides* continue to yield hyoscyamine to the practical exclusion of hyoscine. Several progenies of this type have been selected for further investigation and comparison with the best lines of *D. Leichhardtii,* of which seven have been selected. In addition, material of a cross between *D. myoporoides* and *D. Leichhardtii* is being studied.

(iii) *Rutin.*—The investigation of the occurrence of rutin in the leaf of the red stringybark, *Eucalyptus macrorrhyncha,* which was mentioned in last year's report, has been commenced. Results have shown that young leaf may have three to four times the content of old and mature leaf. The very youngest red tip leaves may contain 20 per cent. rutin on a dry weight basis. The rutin content of mature leaf has been rather constant at 5-6 per cent. irrespective of time of season or weather conditions. The examination of other species of eucalypts has been begun but so far rutin has not been identified in any of them.

(iv) *Survey of Native Plants for Sources of Substances of Pharmacological Value or Chemical Interest.*—This survey aims to search the native flora systematically for substances of pharmacological value, or other chemical interest (alkaloids, saponins, cyanogenetic and cardiac glycosides, pigments and oils). A preliminary selection of plants is made by means of chemical spot tests in the field. Further examination is made by the Division of Industrial Chemistry of this Council and by the Departments of Chemistry in the Universities of Sydney, Melbourne, and Queensland. The pharmacology of substances found in the plants is investigated by the Department of Physiology, University of Queensland. The results of these collaborative investigations are published as reports to their own institutions and in appropriate journals. Approximately 200 samples were supplied to these collaborators during the war. A compilation of all published and reported references to the poisonous and medicinal properties of Queensland plants is in press, as is also the first report on the results of the field spot tests.

About 700 spot tests for alkaloids and certain other substances were made during the year. Over 100 of these appeared worthwhile subjecting to detailed analysis for alkaloids, and some of them for other constituents. Systematic and complete spot testing of several families has been done. In the Rutaceae, for example, 30 species out of a total of 96 available in Queensland were found to contain substantial amounts of alkaloidal substances.

As part of the general project a search has been commenced for plants which contain substances which may have anti-tumour properties. It has been discovered

recently in the United States that podophyllin (extracted from *Podophyllum peltatum*) has a marked action on tumour growth. Because of a toxic action to certain brain cells it is not a suitable anti-cancer agent. An extensive screening project which is in progress in the United States aims to discover a substance with similar depressant effect on cancer cells without the disability of podophyllin as a therapeutic agent. Among the characteristics of podophyllin is its action on cell division or mitosis; it inhibits mitosis by preventing spindle formation. This character is being taken as the main basis in the search for comparable substances in Australian plants.

8. Tobacco Investigations.

(i) *General.*—Following the recession in tobacco work during the war years and the recent visit of the Officer in Charge to North America and New Zealand, an extended programme of research has now begun. The objective is to determine the conditions under which good quality tobacco can be produced in areas where suitable soil and water for irrigation are available and where other factors are not limiting. The work is being done in co-operation with State Departments of Agriculture.

(ii) *Field Experiments.*—(*a*) At Ayr, North Queensland, in co-operation with the Queensland Department of Agriculture and Stock, variety and fertilizer trails were conducted on the property of Pioneer Mills Pty. Ltd. Yield per acre of graded, cured leaf from the sixteen varieties tested, varied from 1,350 to 1,850 lb. In the fertilizer plots, cultural methods did not permit the maintenance of sufficient soil moisture for normal growth. The work is being continued and extended to include a study of irrigation requirements for tobacco soils. In this area tobacco is in the field during the September-December period, the latter end of the dry season, and the crop is grown under irrigation.

(*b*) At Katherine, Northern Territory, exploratory plots to determine the best period of the year for growth, and the nitrogen and phosphoric acid requirements, were planted at the beginning of August and at the end of February. The first planting was affected adversely by high temperatures experienced during November and December. Harvesting of the second planting commenced in June.

(iii) *Disease Investigations.*—Investigations into yellow dwarf and big bud viruses have continued at Canberra, the work being directed toward the determination of host plants acting as sources of infection. Dodder is being used as a means of transmission of the virus. The Division of Economic Entomology has a similar objective, but is using the insect vector as the agent for transmission. A combined cultural and spray programme using insecticides for the control of the vector, *Orosius argentata* (Evans), was undertaken at Canberra.

(iv) *Physiological Investigations.*—At Canberra, the effect of different water levels and drought treatments on the development and growth of the tobacco plant is being studied in pot cultures. This work is complementary to field investigations on water requirements during growth. A study is also being made of synthetic growth regulators which have been suggested as a means by which growth from axillary buds, following topping, may be controlled. Normally such growth is removed during the operation of "suckering", at a considerable expense.

9. Vegetable Investigations.

(i) *Potatoes.*—(*a*) *Virus Resistance.*—Twelve hybrids which combine immunity to virus X, field immunity to virus A, near field immunity to virus Y, and high resistance to the leaf-roll virus, and possess satisfactory yielding ability as well as good agronomic characters, have been developed. At present the easiest way to develop leaf-roll resistance is to select from hybrid progenies those seedlings showing sensitivity to this virus. Sensitive seedlings are more resistant than tolerant ones, and furthermore when infected are easily rogued from commercial crops as they do not exhibit masking of symptoms which occurs in more tolerant varieties like Factor. It appears that the development of resistance to the major potato viruses is now possible in new commercial varieties for Australian conditions.

Co-operation with the potato agronomists of the Victorian, Tasmanian and Western Australian Departments of Agriculture in the development and testing of the more promising virus resistant hybrids has been continued.

(*b*) *Common Scab* (*Actinomyces scabies*).—Field trials of resistance of potato varieties to scab were continued and extended to include plots at Canberra, Koowee-rup (Victoria), Mowbray Swamp (Tasmania), Rendelsham and Woodside (South Australia). The amount of scab varied considerably, the plot at Koowee-rup being least affected, and that at Mowbray Swamp being far more affected than any of the others, though with a relatively superficial type of scab. Of fifteen varieties subjected to replicated tests, four averaged less than one-tenth the amount of scab that occurred in the susceptible Late Carman controls (measured as proportion of surface area of tubers covered with scab lesions), and four averaged less than a quarter of the rating assigned to Late Carman for severity of scab lesions, irrespective of the surface area covered. These two methods of rating gave somewhat different results; only two varieties were in the most resistant four as judged by each method. These were Ontario and Cayuga, recently introduced from America. They were tested only in one experiment (at Canberra) owing to shortage of seed. A Canadian seedling, 1537-12, was the most consistently resistant of the varieties tested in four or five experiments. The order of susceptibility varied in different localities, for example, King Edward, which appeared one of the most resistant at Canberra, was one of the most susceptible in Tasmania. No variety was immune.

Twenty-one cultures of *Actinomyces* from Canberra, Victoria, and South Australia were tested for pathogenicity on Katahdin potatoes in pots of sterilized soil. They fell into three roughly equal groups, causing severe, moderate, and very little scab respectively. They were also tested for chromogenesis in skim milk and nutrient broth. There was a definite but incomplete correlation between pathogenicity and the production of a dark discoloration in these media.

(*c*) *Rhizoctonia solani.*—In the 1946-47 season, 54 potato varieties were subjected to a preliminary field test for resistance to *R. solani*. In the 1947-48 season, ten of the varieties least injured by *R. solani* in 1946-47 were again tested, together with four of those most injured. The order of apparent susceptibility to stem and stolon lesions varied considerably in the two seasons, but in each season Brownell, Smooth Rural, Potomac, and S-2 were amongst the six least susceptible, while Warba, Red Warba, Russet Burbank, and Arran Banner were amongst the five most susceptible. The development of sclerotia on the tubers bore no apparent relationship to the above results, and there was little sign of any consistent differences between varieties in this respect.

In the 1947-48 season only, 25 lines from the Commonwealth (formerly Empire) Potato Collection, including seven species, were similarly tested. Nine lines of *Solanum andigenum*, six of *S. curtilobum*, three of *S. juzepczukii*, and one of *S. tenuifilamentum* showed no definite resistance. One line each of *S. stenotomum* and *S. Rybinii* were the least affected, but further work is

necessary before it can be concluded that they or any of the varieties of *S. tuberosum* mentioned above are resistant to *R. solani*.

(*d*) *Late Blight* (*Phytophthora infestans*).—Advantage was taken of outbreaks of late blight in New South Wales and Victoria to make collections of the blight fungus for use in tests of resistance. Eight cultures have been isolated from three localities in New South Wales and one in Victoria. These are being maintained in potato tubers and efforts are being made to find a satisfactory medium on which to keep them in artificial culture.

(ii) *Tomatoes.*—Field immune tomato hybrids for both outdoor and glasshouse conditions are being developed. A study of the nature of the host-parasite relationship between the organism *Fusarium bulbigenum* var. *lycopersici* and these field immune hybrids, has been made. The most promising advanced hybrids have been submitted to the tomato experts of the State Departments of Agriculture for selection and development. As a result of this co-operative work the Queensland Department of Agriculture and Stock has selected four hybrids for further work, the New South Wales Department of Agriculture, twelve hybrids, and the Victorian Department of Agriculture, twenty hybrids.

Investigations on early blight of tomatoes caused by the organism *Alternaria solani* have been continued. Pathogenicity differences have been shown in various isolates of the pathogen. The search for tomatoes immune to the disease has been continued. A testing method has been developed and 104 varieties of *Lycopersicon esculentum* together with various lines of *L. pimpinellifolium, L. hirsutum,* and *L. peruvianum* have been tested. None of the lines tested has shown complete immunity to the disease.

Work on the development of hybrids resistant to the spotted wilt virus has been continued. Hybrids between Bounty and *L. pimpinellifolium* possessing a much higher degree of resistance under greenhouse conditions than Pearl Harbour, have been produced. These are now ready for trials under field conditions.

(iii) *Peas.*—An agronomic survey of 300 varieties for plant type, maturity, pod type, and general yielding ability has been completed and is to be published.

In the Ascochyta group of diseases most progress has been made with *A. pisi* resistance. The variety Austrian Winter exhibits a very high resistance to *A. pisi* and this has been crossed and back-crossed with varieties like Greenfeast and William Massey to produce commercial types. The Victorian Department of Agriculture is co-operating in this project. No variety has been found so far with high resistance to either *Mycosphaerella pinodes* or *Ascochyta pinodella*.

A large number of varieties have also been examined for resistance to bacterial blight (*Pseudomonas pisi*) and to powdery mildew (*Erysiphe poltyoni*), both by artificial inoculation and by observation of natural infections. One variety appears to be highly resistant to powdery mildew but all varieties tested were susceptible to bacterial blight. However, with bacterial blight some varieties like Greenfeast are less susceptible than others.

Field observations on frost resistance in peas have been made. A technique of artificial frosting has been developed. Smooth seeded types are, in general, more frost resistant than wrinkled.

(iv) *Beans.*—(*a*) *Resistance to bacterial blights.*—Two hundred varieties, both bush and pole, have been examined for resistance to halo blight (*Pseudomonas medicaginis* var. *phaseolus*) and American blight (*Xanthomonas phaseoli*). Both bush and pod tests have been made and some strains of Red Mexican are the most resistant to halo blight encountered so far. Two varieties exhibited a high degree of resistance to American blight. In co-operation with the New South Wales Department of Agriculture crosses have been made to develop commercial French beans field resistant to the two bacterial blights.

(*b*) *Root rot.*—In recent seasons, certain lines of French beans (*Phaseolus vulgaris*) have been severely affected, even in the seedling stage, by root and basal stalk rot following very hot weather. As previously reported, greenhouse pathogenicity tests of Fusaria and *Macrophomina phaseoli* isolated from affected plants failed to reproduce the early and severe symptoms seen in the field. To ascertain whether differences in resistance to root and stalk rot were related to differences in resistance to excessively high soil temperatures in the absence of pathogenic soil fungi, three lines resistant to root and basal stalk rot and three highly susceptible lines were grown in sterilized soil at soil temperatures averaging about 38° and 42° C. No such relation was found, all varieties suffering about the same injury from the high soil temperatures. The experiment was not carried beyond the seedling stage.

10. Virus Investigations.

(i) *Tomato Spotted Wilt.*—A series of field plots was grown at Dickson Experiment Station to study further the effect of triple planting on incidence of spotted wilt. Combined with the triple planting was an experiment in which plots were surrounded by a zone of tick beans kept sprayed with DDT to act as a trap for thrips. Incidence of spotted wilt was very light during the season, and it was possible at thinning time to eliminate spotted wilt completely from the triple planted plots. Results of these plots have not been statistically analysed at the time of writing, but it is apparent that the border of tick beans has exercised a considerable protective effect.

(ii) *Potato Spotted Wilt.*—Observations on spotted wilt in potatoes have been continued. During the 1947-48 season this disease virtually disappeared from potatoes, reverting to the situation current in 1944-45. This reversion after two epidemic seasons appeared to be correlated with low thrips populations. A study of the thrips population has been made throughout the season and is to be continued.

(iii) *Witches' Broom of Lucerne.*—To determine the incidence of witches' broom disease of lucerne, regular surveys of lucerne-growing areas in the Lachlan Valley have been instituted. It has been found that the percentage of recognizably diseased plants varies throughout the year, reaching a maximum in the summer months and a minimum in the winter. Field plots have been established to study the course of the disease in individual plants of different ages.

It seems likely that water supply may play an important part in the expression of symptoms of the disease, and preparations have been made for a greenhouse controlled watering experiment. A general study of the virus has been undertaken in the greenhouse. Attempts have been made to transmit the disease by grafting, by means of various dodder species, and by mechanical inoculation. Graft transmission is the only method which has been successful. Studies are also being made to determine the host range of the virus.

11. Investigations in Northern Australia.

(i) *Katherine Experiment Station, Northern Territory.*—Investigations at the Katherine Experiment Station during 1947-48 have been confined to experiments on the river levee soil of the Station. Negotiations are taking place for the acquisition of two areas situated about 4 and 20 miles respectively from the Station, which will sample the more extensive soils away from the river levees. The experiments at the Station during 1947-48 concerned various crops, fodder, and pasture

species, and numerous miscellaneous plant introductions. In addition a number of tropical fruits and other plantings have been maintained.

Cotton, peanuts, grain sorghum, and millet have been tested under dryland conditions. The application of fungicidal dusts to peanut seed gave a significant improvement in the establishment of peanuts under wet conditions. A comparison of two varieties of peanuts under several fertilizer treatments is in progress.

Six varieties of grain sorghums have been compared, and in spite of a relatively dry season, these crops have grown exceptionally well, and good yields are anticipated.

Three varieties of cotton are being examined under several fertilizer treatments. Satisfactory growth has been made. Disease and insect pests have not been severe this season, but heat wave conditions towards the latter part of the growth period caused premature bursting of the bolls. In spite of this, exceptionally high yields were obtained from the first picking. However, it will be necessary to repeat this experiment over several seasons before a true estimate of probable production can be gained.

Plantings of broom millet at four different times during the season have not given promising results this year. Some of the tobacco which has already been harvested and air-cured is of fair quality.

Tobacco, cowpeas, bananas, pineapples, and papaws are being grown with supplementary irrigation. A series of tobacco plantings has been made to determine the optimum planting time and responses to fertilizers. Observations on four varieties of bananas over a period of several years indicate that the William hybrid variety is the best type examined. It grows to a height of 8 feet and bears large bunches of good fruit. The bunches are open and the plants do not lodge. Other tropical fruits under observation include pineapples and papaws. The cowpea has been shown to be an excellent cover crop to be sown between these fruits. It is well adapted to the conditions and re-seeds freely under cultivation.

(ii) *Kimberley Research Station, Western Australia.*—A research programme has been commenced at the Kimberley Research Station near Wyndham, Western Australia, jointly with the Western Australian Department of Agriculture The major objective of these investigations is to determine whether or not irrigation water can be economically used for crop or pasture production on the heavy soils of the lower Ord River region.

Investigations during the wet season of 1947-48 have been concerned with rice and pastures under irrigation, and various crop species under both irrigated and natural rainfall conditions. Rice, peanuts, and certain pasture species have made promising growth under irrigation. All experiments, however, have been seriously affected by natural pests such as locusts and the white cockatoo. The experiments with these crop species are being repeated under irrigation during the current dry season.

(iii) *Northern Australia Regional Survey.*—During 1947 and 1948 the Northern Australia Regional Survey party has been examining the Barkly Tableland and adjacent areas Field operations commenced in April, 1947; during that winter a total of 4,000 miles of land traverses were made in the region bounded by the North-South Stuart Highway in the west, Camooweal in the east, the desert areas adjoining the Tennant's Creek-Mount Isa Highway in the south, and the watershed between the Gulf and inland draining systems in the north The survey includes studies in the geology of the area, its geomorphology, soils, vegetation, climate, land use, and potentialities.

As a result of the range of climatic conditions and the occurrence of varying types of geological parent material, a considerable range of soils and vegetation types occurs. The most productive areas are restricted to the broad belt of heavy clay soils which extends from Newcastle Waters to Camooweal and then southward down the Georgina basin. The region is used exclusively for cattle raising, the main product being store cattle which are sent into Queensland or South Australia. Some fat cattle are produced, but under the existing organization of the industry only a small proportion can be directly marketed. The number of fats could be increased if adequate transport or local marketing and killing facilities were available.

Apart from the survey of the Barkly Tableland, further work has been done in the Katherine-Darwin region which was surveyed in 1946. A more detailed examination of the area within a 25-mile radius of Katherine has been completed with the specific objective of selecting sites suitable as experiment areas supplementary to the Katherine Experiment Station.

12. Other Investigations.

(i) *Fertilizer Experiments in Pine Plantations.*—Annual measurements were continued in the fertilizer plots already established, as previously reported; they showed no important change from previous results. Soil samples taken from plots of *Pinus radiata* in the Moss Vale district that gave a relatively poor response to phosphate, showed that these soils possessed a very high phosphate-fixing capacity. This, together with the comparatively high phosphate requirement of *P. radiata,* may account for the poor response of this species to phosphate as compared with *P. caribea* and *P. taeda* in coastal plantations. Further treatments were applied to young self-grown *P. radiata* at Penrose plantation, using heavier dressings of phosphatic fertilizer than any applied previously in these experiments, viz. 8 and 16 cwt. per acre of superphosphate, or equivalent dressings of ground rock phosphate. Some of these plots were also sprayed with zinc sulphate solution. No response is yet apparent.

(ii) *Peas.*—With William Massey peas it was found that seed of good green colour gave a better stand of plants in glasshouse and small plot trials than did pale-yellow seed from the same sample. The reason for the better brairding of the green peas over the yellow is being sought in further trials and field observations.

III. ENTOMOLOGICAL INVESTIGATIONS.

1. General.

Steady progress has been made in the main fields being investigated by the Division of Economic Entomology.

The control of St. John's wort by introduced insect enemies has continued to fulfil its early promise, and a special team of investigators has been assigned to study the progress of the eradication and the pasture changes that result from it. Work will be continued until the two insects chiefly concerned, the weed, and the competing pasture species, have settled down to a natural balance.

Tests of DDT dusts against the red-legged earth mite have shown that the toxic effect of dusting treatments persists for several months, and it is hoped that this will enable DDT to be applied along with the usual superphosphate dressing in the late summer months. A similar prolonged persistency of DDT dusted on to pasture has been demonstrated in experiments on the control of the pasture cockchafer *Aphodius howitti.* Almost complete control of this pest has been obtained in the first larval stage, although the later stages are markedly resistant.

In investigations of the transmission of the virus disease of lucerne known as witches' broom, strong evidence has been found for regarding the jassid *Orosius*

argentata as the probable vector. Confirmatory experiments, in which this insect will be used in an attempt to transmit the disease to healthy lucerne plants, are in progress.

Trials of new insecticides for use in preserving timber from termite attack have demonstrated the great value of pentachlorphenol for this purpose, and the same substance is now being tested as a soil poison against termites. Biological studies on timber borers have been commenced to link up with the work on these insects that has been proceeding for some years in the Division of Forest Products.

The comprehensive investigations on the insecticidal control of cabbage pests, commenced in 1943, were successfully completed this year. The main practical conclusion to be drawn from this work is that the most effective means of control is an all-purposes combination dust or spray containing DDT and an aphicide. Several such combinations have been found satisfactory, and all are much superior to rotenone and pyrethrum products.

Staff difficulties have necessitated a temporary interruption in the investigations on the blowfly, buffalo fly, and sandfly problems, but these will be taken up again shortly.

With the steady expansion in the scope of the Division's investigations, the need for basic taxonomic studies on a number of major groups of insects has come to be increasingly felt. This need has been met, partly by officers primarily concerned with other matters devoting a part of their time to taxonomic work, partly by the appointment of specialist taxonomists, and partly by enlisting the co-operation of overseas bodies to carry out revisions of difficult groups. Taxonomic work is now proceeding on various groups of flies, cockchafers, parasitic wasps, termites, grasshoppers, and ants.

Two major expeditions were organized during the year to study the distribution of various injurious insects and to collect material for taxonomic study.

2. Cattle Tick.

(i) *Testing of Dipping Fluids.*—During the year a dispersible DDT paste, a DDT powder, and a paste of benzene hexachloride (BHC), were tested against the cattle tick. Since the publication of the previous report methods of analysis of DDT and BHC have been developed, and used in the examination of over 1,100 dip samples. The results have helped considerably in assessing the value of the medicaments.

At a concentration of 0.5 per cent., pp′-DDT neither the DDT paste nor the DDT powder was as toxic or persistent as certain other DDT formulations tested earlier. The BHC preparation was first tested at a concentration of 0.25 per cent. gamma isomer. At first a remarkably efficient kill of ticks was obtained, and the cattle were afforded about eight days' protection from reinfestation after dipping. With continued use and normal replenishment, the toxicity deteriorated and the protective period fell to three to four days. Increasing the concentration to 0.05 per cent. gamma isomer restored the killing efficiency to a high level, but the protective period was usually only about five days. The shorter protective period necessitated more frequent dipping than with satisfactory DDT preparations, but in spite of this the material controls ticks efficiently.

The concentration of DDT or BHC in the above preparations drops to a very low level between dippings, because most of the particles sink rapidly. For instance, surface concentration may drop 50 per cent. after 45 minutes' standing. Re-suspension of the bottom deposit by stirring with paddles is difficult when the dip is clean, and almost impossible when the vat is contaminated with much dung and soil. The practical method of stirring is to pass a number of cattle through the dip. These animals must then be re-dipped to ensure their immersion in a wash of reasonable concentration. Analyses have shown that frequently-used dips of the above formulations require stirring by about 25 head; infrequently-used dips may require 100 head or more.

(ii) *Other Toxicological Investigations.*—(*a*) *Bio-assay Tests.*—To simplify the preliminary selection of promising acaricides, bio-assay tests are now being undertaken. Engorged female ticks are dipped in 1 per cent. alcoholic solutions of the materials to be tested, and their efficacy is judged chiefly by their effect on oviposition. Of thirteen toxicants tested by this method "Toxaphene" and "Chlordane" proved outstanding, inhibiting egg-laying to the extent of 100 per cent. and 98 per cent., respectively, compared with the controls dipped in alcohol alone. A bio-assay technique employing larval ticks is also being developed.

(*b*) *Toxicity of DDT to Cattle.*—This experiment has now been in progress for 27 months. The mean weight of the animals treated weekly with a solution of DDT in peanut oil now approaches that of the control animals. No post-mortem evidence of poisoning was detected in one animal slaughtered after 24 months' treatment with DDT.

(*c*) *Arsenic Resistance.*—Experiments were performed to investigate the possibility that arsenic resistance of ticks is correlated with high fluorine intake by the cattle. Stalled cattle were drenched daily with sodium fluoride, and the susceptibility of their ticks to treatment with arsenic was compared with that of ticks from untreated animals. Results to date are inconclusive.

(iii) *Biological and Ecological Investigations.*—Distinct advances have been made in methods of culturing and studying ticks. Experiments on the influence of temperature and humidity on the fertility of female ticks have shown that between 30° and 39° C. fertility decreases with rising temperature; at these temperatures variation of relative humidity between 45 per cent. and saturation has no effect on fertility.

Investigations have been made into the measurement of populations of larval ticks in pastures, a subject on which information is needed in the study of cleansing pastures by different dipping practices. Satisfactory methods have not yet been developed, but the work is being continued along with field studies of the behaviour and survival of larval and adult ticks.

3. Insect Physiology and Toxicology.

(i) *Digestion.*—Some general problems of insect digestion have been studied as a preliminary to more detailed investigations of the digestion of keratin by wool pests. It has been found that the crop and midgut of starved cockroaches (*Blattella germanica*) are filled with food within ten minutes of commencement of feeding. Absorption takes place either from the midgut (e.g. ascorbic acid) or from the hindgut. The histological distribution of alkaline phosphatase, glycogen, ascorbic acid, the golgi substance, and previously undescribed argentophile inclusions show some interesting relationships in the cells of the midgut epithelium of *Blattella*.

The mechanism of initiation of secretory activity has been investigated in the adult mealworm (*Tenebrio molitor*) by a method involving the determination of the number of mitoses in the regenerative cells of the midgut. The bulk of the evidence is against neural control and the possibility of humoral control is under investigation.

(ii) *Insect Muscle Respiration.*—An extensive series of experiments on the purification of adenyl pyrophosphatase of locust (*Locusta migratoria*) muscle was undertaken. A crude extract of this enzyme remained in the supernatant solution from which myosin had been precipitated. Very recent work on mammalian muscle has demonstrated an enzyme which can be easily

removed from myosin and is activated by magnesium, as is the insect enzyme under investigation. The latter may, therefore, have a closer counterpart in mammalian muscle than was originally thought.

Some studies have been made of the pH and temperature optima, and of activation and inhibition, of insect adenyl pyrophosphatase. Glutathione and cysteine activate slightly; iodoacetate does not inhibit, but ninhydrin inhibits strongly, a fact not previously recorded for this type of enzyme.

(iii) *Excretion.*—Certain aspects of excretion in larvae of the Australian sheep blowfly have been studied. Particular attention has been paid to the accumulations of granules in the lumen of certain modified regions of the malpighian tubules. The amount of granular deposit formed depends upon the diet: calcium and non-toxic magnesium salts produce very large deposits, while excess phosphate markedly depresses granule formation. These studies have a bearing on the accumulation or elimination of potentially toxic materials from the insect body.

(iv) *Toxicity of Materials to the Housefly.*—New apparatus and testing techniques have been developed to evaluate insecticides possessing residual toxic properties when applied in spray form. By applying to individual flies measured doses of poison in solution, it has been shown that the gamma isomer of BHC is about three to five times as toxic at DDT, which in turn is about seven times as toxic as pyrethrins. Males are killed far more readily than females by each of these poisons, this probably being largely due to their different body weights.

The importance of activity of flying insects in determining the dosages which they acquire during exposure to space sprays became apparent in previous work. A study of the flight activity of the housefly has now been initiated. Already there are strong indications that females are capable of flying continuously for longer periods than males, some females having been induced to fly for more than 30 minutes.

4. Biological Control.

Further progress has been made with the attempted biological control of St. John's wort (*Hypericum perforatum*), of the potato tuber moth (*Gnorimoschema operculella*), and of the cabbage moth (*Plutella maculipennis*). Plans are being made for the introduction of parasites of other major insect pests, and during the year *Comperiella bifasciata* consignments were received from the Commonwealth Bureau of Biological Control for liberation against red scale.

(i) *St. John's Wort.*—With the object of facilitating the artificial distribution and natural spread of the introduced Chrysomelids, *Chrysomela hyperici* and *C. gemellata*, more detailed information has been sought on the distribution of St. John's wort in the various States, and this has indicated that the weed occupies a greater area than had been realized, especially in New South Wales and Western Australia. As a result of surveys in the south-west of Western Australia, it was decided, in conjunction with the Department of Agriculture, to liberate *Chrysomela* spp. in that State.

(*a*) *Chrysomela hyperici.*—In Victoria, this species continued to make very satisfactory progress throughout the Bright district, where its control over the weed is increasing. Within the last few years, it has brought under control considerable areas of the weed throughout the pine plantations near Myrtleford, whence considerable numbers of insects were secured for liberation elsewhere. Also, reports from Dargo, Victoria, where *C. hyperici* was liberated in 1940 and 1941, indicate that the insect has increased greatly in numbers. In one area there, the beetles were reported to have practically cleared the weed from a twenty-acre paddock by the end of 1947.

In New South Wales, the colony established at Tumbarumba in 1944 is expanding satisfactorily. The insects are also making good progress at Yankalilla, South Australia, where they are already exercising an appreciable degree of control. In Western Australia, the first liberation of *C. hyperici* was made in November, 1947, at Mornington Mills.

(*b*) *Chrysomela gemellata.*—In the Bright district and along the Ovens Valley this species is very numerous and widespread, occurring over much of the area together with *C. hyperici*. Observations made over the last few years suggest that *C. gemellata* is more effective than *C. hyperici*. As it is no longer possible (except at some points where colonies derived from particular liberations still remain isolated) to collect large numbers of the two species separately, it is necessary to refer to the latest redistributions of adults as "*Chrysomela* spp.".

(*c*) *Chrysomela spp.*—In Victoria, 466,000 adults were released in the Myrtleford district, and 185,000 in other parts of the State, all these redistributions being made by officers of the Victorian Department of Lands and Survey. Approximately 135,000 beetles were liberated in New South Wales, chiefly in the Albury, Tumut and Orange districts; 150,000 were forwarded to South Australia for liberation in the National Park; and 200,000 were released in Western Australia at Mornington Mills, Holyoake, Arumvale, and Alexandra Bridge. Distribution of the insects in Australia during 1947-48 totalled 1,136,000, all of which were collected in the Bright and Myrtleford districts of Victoria.

(*d*) *Agrilus hyperici.*—This root-borer is still recoverable from its areas of establishment, but its effect upon the weed, and its rate of spread, are much less striking than those of the two Chrysomelids.

(*e*) *Overseas consignments.*—Shipments of *Chrysomela* spp. to the United States were made during the year for the control of *Hypericum* (Klamath weed) in the western States. Two air-freight consignments, totalling some 500,000 adults, were successfully forwarded, and were utilized by the United States Department of Agriculture, in collaboration with the University of California, for large-scale liberations over a wide area of California.

(*f*) *Ecological studies.*—In view of the success now attending biological control of St. John's wort, it seemed appropriate to begin a field study of the expansion in the beetle populations and the contraction in host-weed density. Such a study has been started in two infested districts—Bright (Victoria) and Tumbarumba (New South Wales). It aims at recording quantitatively the progress of the beetles until the beetle and weed populations reach a state of balance. It also aims at securing information on the natural regeneration of vegetation following partial or complete destruction of the weed.

(ii) *Potato Tuber Moth.*—Work with the natural enemies of this pest continued along lines similar to those of last year. Breeding methods for *Copidosoma kochleri, Chelonus phthorimaeae*, and *Microbracon gelechiae* were standardized, and a programme of mass liberation in all States planned. However, a number of adverse factors (especially outbreaks of predatory mites) interfered with the breeding programme and kept liberations well below the projected level. Approximately 50,000 *Microbracon* were liberated in the eastern mainland States. A simple technique for mite control has now been evolved and this should allow of considerable expansion in the production of these parasites in the coming season.

The Commonwealth Bureau of Biological Control forwarded numerous consignments of laboratory-bred *Omorgus phthorimaeae*. A moderately satisfactory emergence of adult parasites was secured, allowing

several field liberations to be made in New South Wales and Victoria. Further consignments are expected, and these, together with further large-scale breeding of the other three parasites will, during the coming season, give ample opportunity for the establishment of these natural enemies of potato moth if their establishment is, in fact, possible.

(iii) *Cabbage Moth.*—A number of consignments of *Angitia cerophaga* and *Diadromus collaris* was received from the Cawthron Institute, New Zealand, during the year. Cultures of these Ichneumonids were maintained at Canberra. A new method of rearing *Angitia* in the insectary has been developed, giving practically 100 per cent. parasitism of the hosts and a higher percentage of females in the parasite progeny than other workers have attained with this somewhat intractable insect. On the other hand, difficulty has been experienced in breeding *D. collaris* in satisfactory numbers, a low rate of parasitism of the exposed hosts being normal in the laboratory. There is in fact some reason to question the identity of the species being handled—a matter now being investigated.

Both these parasites have been consigned to the various States, in all of which they have now been liberated. In attempting to establish these species, the greatest difficulty encountered has been the general use of DDT to control *Plutella*. Nevertheless, it is hoped that the parasites will be able to increase in numbers on host populations feeding on cruciferous weeds and undusted root crops.

Some recoveries of both species have been made in Tasmania (according to reports from the Department of Agriculture) and also from New South Wales and the Australian Capital Territory. No information on establishment in other States is as yet available. It is too early to judge whether these recoveries indicate the permanent establishment of the parasites.

From field-collected material of *Plutella*, a number of native parasites have been reared. In Australia, unlike so many other countries, there do not appear to be any native species of *Angitia* or *Diadromus* attacking this insect. Instead, the place of *Angitia* is taken by the very common *Hymenobosmina rapi*, while the pupa is attacked by *Brachymeria* spp.

(iv) *Red Scale.*—Some years ago *Comperiella bifasciata* (Chinese race) was imported from California, and bred at Canberra, whence it was distributed to the interested States. Subsequently it has been bred at the Waite Institute. While some recoveries have been recorded, its establishment is improbable—though possible in South Australia.

Recently, two additional consignments of *C. bifasciata* were received from the Commonwealth Bureau of Biological Control, and red scale exposed to the parasites have been despatched to the New South Wales Department of Agriculture. A culture of this parasite is being maintained temporarily at Canberra.

5. Population Dynamics.

Following earlier theoretical investigations on the part played by competition in regulating the abundance of animals, experimental work in this field initiated last year was continued in the period under review. The investigations have been concerned mainly with the study of intraspecific competition for food amongst muscid larvae, the species used being *Musca domestica, Chrysomyia rufifacies*, and *Lucilia cuprina*. The last species was used for most of the detailed work.

In all three species it was found that the relation between larval density and the number of emerging adults per gram of food fell into two distinct phases. In the first there was little mortality, the number of adults increasing progressively with larval density, while their size progressively fell. At a particular critical density, however, the second phase began, in which mortality increased rapidly with larval density, and the number of adults emerging per gram of food decreased. Examination of the curve representing these relations clearly indicated that a muscid population limited solely by food supplied at a constant rate should oscillate violently in density, unless the reproductive rate were excessively low. Direct experiments to study this situation are only in their early stages, but they already clearly indicate that the expected violent oscillations do in fact occur in a constant environment to which food is added at a constant rate.

Many other aspects of this type of competition are being studied. A particularly interesting conclusion, which is also to be derived from the curve already mentioned, is that the greater the percentage of eggs or young larvae destroyed (up to a point not far short of the complete destruction of all eggs and larvae) the greater should be the average density of adults. This conclusion is also being tested directly.

6. Locusts and Grasshoppers.

Experimental work on the ecological control of *Chortoicetes terminifera* has now been continued from the Trangie Field Station. Old man saltbush (*Atriplex nummularia*) has now grown to considerable size in the barriers planted between oviposition and food-shelter habitats of the test outbreak centres, and in places is forming the continuous hedge required, to a height of 6-7 feet. The search for suitable tree species, to give greater height to the barrier, was continued with test plantings of coobah (*Acacia salicina*) and belah (*Casuarina lepidophloia*) but these proved no more successful than the species tried earlier. It appears now that *A. nummularia* is the only species that can be used in this work and, reviewing the ecological control work as a whole, may prove to be the answer to most of the problems involved. However, it has yet to be seen how this plant will stand up to grazing of normal intensity; its efficacy as a means of reducing the locust population of the outbreak centres has also to be tested.

The work on the relation of locust abundance to tree density has been completed and prepared for publication. The analysis of recent outbreaks of *Chortoicetes* in relation to climatic and other factors has been continued, along with the taxonomic and phase studies mentioned in earlier reports.

Rather more attention than usual has been given to broad distributional and ecological studies on *Chortoicetes*, species of *Austroicetes*, and other Acrididae with which these are associated. In this connexion two major collecting expeditions were undertaken, one to Western Australia, across the Nullarbor Plain and returning along the shore of the Bight, and the other to Tasmania. Much new information was provided by these trips, including the discovery for the first time of *Chortoicetes* in north-western Tasmania. The evidence indicated that the specimens found had invaded Tasmania by flying across from a point 400-500 miles away on the mainland.

7. Pasture Cockchafers.

Investigations have been continued on *Aphodius howitti*, and on other species of economic importance belonging to the sub-families Melolothinae and Dynastinae.

The distribution of economic infestations of *A. howitti* has been studied, by means of questionnaires and field surveys, as a co-operative project with the Victorian and Tasmanian Departments of Agriculture and the Waite Institute. In this work the Council has been primarily responsible for New South Wales, in which serious infestation appears to be confined to the

Southern Tablelands. The susceptible region has been provisionally mapped with a view to a climatological analysis.

Investigations at the Dickson Experiment Farm have yielded information on the seasonal life-cycle in the Canberra area, and on the general biology and behaviour of the insect.

Some preliminary work has been done on the ecology of *Aphodius*. A striking feature of all infestations is the patchy distribution of the grubs. This appears to be due chiefly to the fact that the adult beetles are gregarious and fly about, and lay, in discrete swarms. The swarms exercise considerable discrimination in their selection of oviposition sites, avoiding dense and tall pasture, and where possible choosing improved pastures with a legume component, or sheep camps. However, swarms that find themselves over natural pasture remote from any improved pastures will lay very densely in this, and thus produce dense grub infestations in atypical situations. Quite minor obstructions such as fences or isolated posts, and still more trees and hedges, seem to induce settling and oviposition.

Methods have been devised for the quantitative study of populations of both larvae and adults, and the distribution of larvae over a plot devoted to a fertilizer and grazing trial at Dickson Farm has been examined for correlation with pasture condition, fertilizer treatment, &c. Two types of light traps have been used successfully for estimating the relative numbers of adults in flight on different days, and could no doubt be applied to the comparison of adult numbers in different seasons.

Experiments in the control of *Aphodius* by means of DDT dusts applied to the pasture have shown that almost 100 per cent. mortality of young larvae results from an application of 3.3 lb. of pp[1]-isomer per acre, and a single application may remain effective for up to 18 months. Full-grown larvae are not affected.

A detailed description of the immature stages of *A. howitti* has been prepared to permit of certain identification of this species in the larval stage.

Work on the taxonomy of cockchafers other than *Aphodius* is proceeding satisfactorily with the assistance of the British Natural History Museum. Larvae of a number of species found in pastures are being bred through to the adult stage to permit of larval-adult correlation, and the larvae described. Preliminary ecological observations have been made on species of *Sericesthis, Adoryphorus,* and other genera of the Melolonthinae and Dynastinae.

8. Red-legged Earth Mite.

During the past year considerable attention has been devoted to the determination of the minimum concentration of DDT dust required to produce an efficient kill of the earth mite in subterranean clover pastures. The lowest dosage applied was 1 cwt. of 0.1 per cent. DDT per acre (less than 2 oz. DDT per acre). This produced a high initial kill and such residual effect that the mite population on treated land remained very low for three months. On land treated with 1 cwt. of 0.5 per cent. DDT per acre the mite population was negligible even six months after treatment.

Methods of application suitable for large-scale treatment of pastures are being examined, and tests are being made to reduce the cost of DDT treatment by incorporating the toxicant in superphosphate.

It has been found that mites from untreated land can penetrate into pasture cleared of mites by means of DDT at the rate of about ½ chain in two months. Re-infestation of large paddocks treated with DDT by mites migrating from outside is therefore likely to be a slow process.

In preliminary investigations with benzene hexachloride, a high initial kill of earth mites was obtained, but the persistency of this insecticide was not comparable with that of DDT. Intensive work with this material is therefore not contemplated at present.

A preliminary study of the influence of temperature on aestivating eggs indicated that under favorable moisture conditions the eggs will not hatch at temperatures higher than about 65° F. This figure agrees fairly well with average air temperatures prevailing at the time of hatching in the autumn. Other biological investigations on eggs and mites were carried out, including a study of the internal anatomy of the mite.

9. Insect Vectors of Plant Viruses.

(i) *Tobacco Yellow Dwarf.*—The investigation on the yellow dwarf virus disease of tobacco was continued and expanded in co-operation with the Division of Plant Industry at Canberra, Australian Capital Territory, during 1947-48. Aspects of the problem on which progress was made were the determination of alternative host plants of the disease, the stage of the life-cycle in which the insect vector (the jassid *Orosius argentata*) becomes infective, the incubation period of the virus in the insect, the minimum feeding period required by the vector to become infective, the persistence of virus in the insect, and a determination of the role of the insect in the continuity of the disease from year to year.

Six species of plants were artificially infected with the virus by infected jassids. Three of these were found to be naturally infected in the field, namely *Datura stramonium* (thornapple), *D. tatula* (thornapple) and *Lycopersicon esculentum* (tomato). Laboratory experiments showed that the minimum period of feeding by an infected insect necessary for transmission of the disease to a healthy plant is less than two days, and that infected insects can continue transmission of the disease for at least sixteen days after removal from diseased plants.

(ii) *Potato Virus Disease.*—The survey, begun in 1941, of the abundance at Canberra of the green peach aphid (*Myzus persicae*) and the potato aphid (*Macrosiphum solanifolii*), vectors of leaf roll and mosaic diseases of potatoes, was concluded.

(iii) *Witches' Broom Virus Disease of Lucerne.*—A study of witches' broom virus disease of lucerne was begun in 1947 to determine the insect vector, any alternative host plants of the virus, and its method of dissemination from these to the lucerne crops. Evidence already available suggested the disease was insect-borne, and that a jassid was possibly the vector. In the spring of 1947, a survey was begun of lucerne stands in the Lachlan Valley, New South Wales, to find which jassids occurred on diseased and healthy lucerne fields, and to obtain information on their distribution and abundance. *Orosius argentata* was the most abundant of nine species collected. Preliminary transmission experiments have shown that this species will transmit the virus from lucerne plants to *Datura stramonium, Malva parviflora,* and *Beta vulgaris*. Back-transmission experiments to lucerne are still in progress.

Using a new method of fixation, virus inclusions have been demonstrated in the xylem vessels of diseased plants. Attempts are being made to trace the passage of the virus through the insect vector by the same method.

10. Field Crop and Vegetable Pests.

(i) *Cabbage Moth and Cabbage Butterfly.*—Dusts containing 1 per cent. DDT, diluted with pyrophyllite, or sprays containing 0.1 per cent. DDT, gave ample control of these pests when applied every 14

days. It was again found that, providing complete control could be effected before hearting, it was not necessary to treat the cabbages again during the marketing period.

New insecticides tested against infestations of the cabbage moth and cabbage butterfly were 0.1 per cent. "Chlordane" (octochloromethanotetrahydroindane), 0.1 per cent. "Rhothane D3" (dichlordiphenyldichlorethane), 0.48 per cent. rotenone-pyrenone (a mixture of piperonyl cyclonene, rotenone, and pyrethrins), 0.1 per cent. DDT as "Guesarol BW40", a "Toxaphene" spray containing 0.1 per cent. chlorinated camphene, and a "Toxaphene" dust containing 1 per cent. chlorinated camphene. These were tested against 0.1 per cent. DDT plus 0.05 per cent. nicotine sulphate (1-800 "Black Leaf 40") and untreated controls. All insecticides were significantly superior to the untreated control. There was no difference between the DDT plus nicotine sulphate, the "Rhothane D3" and "Guesarol BW40" sprays. The "Chlordane" and "Toxaphene" sprays were significantly inferior to the DDT, while the "Toxaphene" dust was inferior to the "Toxaphene" spray. The rotenone-pyrenone mixture was the poorest of these insecticides and confirmed previous results.

The 1947-48 experiments complete the programme of investigations on cabbage pests, extending over the past five years and involving 30 field trials and 100,000 cabbage and cauliflower plants. The most important findings are that the insecticide has yet to be found that will satisfactorily control all cabbage pests, but that DDT at high concentrations is the nearest approach to this ideal. The comparative ineffectiveness of all rotenone and pyrethrum products tested indicates that they are of little use to the commercial grower. The most efficient combined dust tested was a mixture of 1 per cent. DDT and 2.4 per cent. nicotine sulphate (5 per cent. v/w "Black Leaf 40"). In the absence of nicotine sulphate, 0.5 per cent. DDT and 1 per cent. crude BHC, although slightly less effective, could be used. The most effective spray was a mixture of 0.1 per cent. DDT and 0.125 per cent. HETP, applied freshly mixed, the latter insecticide deteriorating fairly rapidly in aqueous solution. An alternative spray, 0.1 per cent. DDT and 1 per cent. soft soap, was very effective, while DDT and nicotine sulphate or BHC was slightly inferior.

Experience has shown that it is advisable to use combined insecticides, even when aphids are not numerous, in order to prevent a build up of aphid populations.

(ii) *Cabbage Aphid.*—Freshly mixed sprays containing 0.125 and 0.0625 per cent. HETP gave excellent protection, and were more effective against cabbage aphid (*Brevicoryne brassicae*) than 5 and 2½ per cent. dusts. There was a marked decline in the toxicity of sprays stored for 24 hours, although they remained more effective than dusts stored for a similar period. DDT (0.1 per cent.), dissolved in solvent naphtha and emulsified with "Wetsit", was more effective than 0.1 per cent. DDT applied as a redispersible powder.

In addition to the five-year summary of cabbage pest work given above, one important result relating specifically to cabbage aphid was obtained, namely that nicotine sulphate dust, when applied under conditions of high temperature, was far more effective in controlling extremely high infestations than any of the newer insecticides.

11. Termites.

The most important aspect of the research on termites has been laboratory testing with standard colonies of *Coptotermes lacteus* and *Eutermes exitiosus,* 120 test colonies of the former and 370 of the latter having been installed. The materials studied include native timbers, synthetic building boards, improved woods (densified and resin-impregnated), and anti-termitic chemicals. These tests, which have been a part of the work of the Division for a number of years, are arousing increasing interest in other parts of the world, and several requests have been received from overseas for tests to be conducted on the termite resistance of a number of different materials. The results obtained this year have shown the high protective value of pentachlorphenol, and the superiority of phenol-formaldehyde resins over urea-formaldehyde resins in conferring resistance against termite attack. The following commercial hardwoods have been tested; *Eucalyptus pilularis, E. microcorys, E. maculata, E. acmeniodes,* and *Tristania conferta.*

Field tests of timbers and preservative materials have been continued. A report on the condition of samples used for the International Termite Exposure Test was forwarded to the United States authorities who originated the project.

An attempt is also being made to evaluate the efficacy of certain soil poisons in the prevention of termite attack. The materials being studied are: creosote and 5 per cent. pentachlorphenol, each applied at 0.5 gallon/cu. ft. of soil; and white arsenic and lead arsenate, each at 2 oz./cu. ft.

12. Miscellaneous Pests.

(i) *Meat Ants.*—The campaign to eradicate meat ants (*Iridomyrmex detectus*) from city areas in Canberra was continued with the co-operation of the Department of the Interior. More than 4,000 nests were treated, including 446 located beyond the built up area. Treatment of the latter was necessary to prevent re-population of treated nests within the built-up area, of which a number of instances were observed following the treatments of the previous season.

(ii) *Timber Borer.*—The increasing amount of *Lyctus* damage associated with the more widespread use in recent years of *Lyctus*-susceptible woods has resulted in a co-operative programme of research formulated by the Division of Economic Entomology, the Division of Forest Products, and the Forest Services of New South Wales and Queensland. Biological studies being carried out by the Council include: the effects of temperature and moisture-content of wood on the length of the life cycle in *L. brunneus,* the depth of oviposition in various timbers, the incubation period of the eggs, and the length of adult life.

13. Taxonomy.

During the past year work on the taxonomic revision of certain families of flies has been actively pursued. Reviews of the Mydaidae, Apioceridae, and Nemestrinidae are well under way, and progress has also been made on certain groups of the Tachinidae and Bombyliidae. These studies have been greatly assisted by visits to Melbourne, Sydney, and Brisbane, where material in the State Museums, and in the collections of other institutions and private individuals, was examined.

Arrangements have been made for a comprehensive revision of the ants of Australia to be undertaken by a Melbourne specialist working on a C.S.I.R. grant; the first part of what will be a large monograph is now ready for publication, and work on the succeeding parts is in progress. An officer of the British Museum is undertaking a similar revision of two groups of cockchafer beetles to which a number of important pests of pastures and crops belong, and will be visiting Australia during the coming year to continue his studies here on behalf of the Council.

The Division's collection of locusts and grasshoppers is being sent in sections to a specialist working at the Academy of Natural Sciences, Philadelphia, U.S.A., for a general taxonomic revision of this group, and

manuscripts covering the first two sections are in an advanced stage of preparation. Other work, on the same group of insects, and on termites, is proceeding in Canberra.

In the last years of his life, A. A. Girault was enabled by a C.S.I.R. grant to produce in manuscript form a revision of the Australian Chalcidoid wasps, which include a large number of valuable parasites. The enormous manuscript so produced remained in the keeping of the Queensland Museum, and now, with the Museum's co-operation, an officer of the Council is revising the group on the general basis of Girault's manuscript and material, supplemented by material from other sources. The manuscript as left by Girault was not suitable for publication, but the improvement and expansion now being undertaken should eventually provide a most valuable revision of this extremely difficult taxonomic group.

All this taxonomic research is being supplemented by field collecting in various parts of the Commonwealth, including areas difficult of access, whose insect fauna is very little known.

Many insects have been identified for institutions and individual entomologists both in Australia and overseas. The C.S.I.R. collection of insects has been increased by the acquisition of the Turner collection of moths, generally considered to be the best collection of Australian moths in existence. Other smaller accessions, involving, however, several thousand insects altogether, have also been received.

IV. ANIMAL HEALTH AND PRODUCTION INVESTIGATIONS.

1. General.

During the year progress with new investigations has been most difficult. Supply of trained personnel and of essential materials has become worse. Work well established and in progress for several years has suffered severely, and it has been impossible to start new work planned a year or two earlier. Although an area of 115 acres at Prospect Hill, near Parramatta, was purchased in August, 1946, for the purpose of providing space for the establishment of a sheep and wool research laboratory, no progress has been made towards this objective. Some progress was made in the establishment of the Regional Pastoral Centre and Laboratory at Armidale, New South Wales.

In the following paragraphs brief mention is made of the main investigational activities of the Division. Some of the work mentioned is being carried out in co-operation with other Divisions of the Council and some with Departments of Agriculture and Universities in the several States.

2. Animal Health Research Laboratory, Melbourne.

(i) *Pleuropneumonia of Cattle.*—The experiment designed to determine the influence of nutritional stresses on the maintenance of immunity against pleuropneumonia was concluded. An attempt was made to maintain a low plane of nutrition by gross overstocking, but under the conditions of the experiment this attempt was not as successful as could be desired. Nevertheless, valuable results accrued.

All the animals had been vaccinated at least once, three years earlier, and half of them had been vaccinated in addition on two occasions subsequently at yearly intervals. Resistance was challenged by exposure to nebulized culture, the experiment being completed in two stages. It was again found that animals vaccinated once only have a high degree of resistance after three years. There was no significant difference between groups vaccinated once or thrice, whether on the high or the relatively low plane of nutrition. It is of interest that both local and serological responses became less at each yearly vaccination. Observations carried out in other experiments have shown a similar loss or failure of response on reinoculation into the tip of the tail. It appears that this may be explained by a local modification of the tissue brought about by a previous inflammatory reaction.

In view of the occasional serious sequelae to pleuropneumonia vaccination with living culture, investigations have been begun to determine whether a satisfactory resistance to infection might be obtained by the use of dead vaccines.

During the year 376,500 doses of vaccine were distributed. Antigen for the complement-fixation test was supplied to State Departments of Agriculture, and to Kenya, as in the past.

(ii) *Caseous Lymphadenitis of Sheep.*—The experiments, mentioned previously, on the protective value of animal vaccination one month before shearing, and of placing sheep directly "off shears" into a clean, rested paddock, were continued. Each year a new batch of sheep is added to the experiment, but the results will not become available until each batch is slaughtered about four years after the commencement.

(iii) *Tuberculosis of Cattle.*—The eradication of bovine tuberculosis from an infected herd by the routine application of the intradermal tuberculin test, may be considerably delayed because some extensively infected animals do not react, and therefore remain as spreaders of infection. Experiments to determine the value of the complement-fixation test for the detection of such animals have been continued. With the antigens and methods so far tried, the complement-fixation test has not provided a practical means of solving this problem. Other approaches to the problem have been tried, and encouraging results have been obtained by the application of a modified subcutaneous tuberculin test. Work at the laboratory has been supplemented by tests in the field conducted by veterinary officers of State Departments of Agriculture. The route of infection with tuberculosis in the Australian environment, as compared with overseas countries, is being studied, as well as some of the difficulties associated with the occurrence of non-specific reactions to the intradermal tuberculin test.

(iv) *Mastitis in Dairy Cattle.*—The original experimental herd at Werribee, which is now being maintained as a producer unit, is still under supervision. Streptococcal infection has almost completely disappeared from this herd over a number of years. Further observations on the possibility of calfhood infection by *Str. agalactiae* by means of infected milk, have been carried out on animals which were removed from their mothers at birth, one group being fed on infected milk, and another on sterilized milk.

In the last report the attempt to eliminate *Str. agalactiae* injection in two "closed" herds by intensive treatment with penicillin was mentioned. It was not possible to eliminate infection in one herd and only temporary freedom was obtained in the smaller herd. Treatment was then discontinued and both herds re-examined after six and twelve months. In the small herd infection had returned to its pre-treatment level within six months, and in the large herd within twelve months.

During the year extensive trials were carried out on two new preparations of penicillin which greatly simplify its use in mastitis by avoiding the use of special infusing apparatus, namely, (*a*) an oily suspension in small collapsible tubes with a sterile tapered nozzle, and (*b*) a small sterile wax bougie ("mastics"). Both proved non-irritating and of the same efficiency against *Str. agalactiae* infections as the aqueous

solutions. As a result of these trials, the Commonwealth Serum Laboratories have adopted the collapsible tube preparation as the standard pack for mastitis treatment, and a commercial firm intends to manufacture "mastics".

Staphylococcal mastitis continues to present a difficult problem. Standard dosages of penicillin having proved to be ineffective in only a very small proportion of cases, very large doses were tried with very little success. Even poorer results were obtained with 4,4-diaminodiphenylsulphone ("Sulphone") in spite of the encouraging preliminary reports from abroad. Combined treatment with "Sulphone" and penicillin gave better, but still unsatisfactory results.

An interesting but rare case of udder infection by an *Actinomyces* was found in a herd that was under penicillin therapy. The results of the studies carried out are being prepared for publication.

(v) *Toxaemic Jaundice in Sheep.*—The investigation has been continued with the active co-operation of officers of the Veterinary Research Station, Glenfield (New South Wales), and of officers of the Divisions of Soils and Plant Industry. The intensive study of the experimental flock at the Field Station, Barooga, has shown that the summer annual plant, *Heliotropium europaeum*, contains a substance which is damaging to the liver of sheep and that the plant is therefore a poison plant.

Systematic studies were continued on the pasture and on the soils. Further studies on copper assimilation and storage by sheep have confined the importance of molybdenum in restricting the uptake and storage of copper in the liver. A report on the co-operative investigations has been prepared by the Investigation Committee.

(vi) *Haematuria Vesicalis of Cattle.*—Work has been mainly confined to the improvement of analytical methods for estimating groups of urinary-phenolic bodies referred to in the last report, and considerable progress has been made.

(vii) *Toxicity of Wheat for Stock.*—Earlier observations suggested that excessive production of lactic acid in the bowel might be an important factor in the illness produced in horses and sheep through consuming excessive quantities of wheat. This aspect is being investigated from the pathological and biochemical aspects.

(viii) *Anaplasma Centrale and Haemobartonella bovis.*—The strains have been propagated in calves. *A. centrale* in heavily infected blood was found to be capable of causing infection after preservation for 486 days at the temperature of solid carbon dioxide.

(ix) *Effect of Long-continued Cutaneous Application of DDT Oily Solutions to Cattle.*—The experiment referred to in the last report is being continued. The animals have developed normally and do not show signs of intoxication. All have been through one lactation and several are in their second. Calves from the first pregnancy were sold in excellent condition when between 5 and 6 months old and had not shown signs of intoxication.

(x) *Bacterial Oxidation of Arsenical Cattle-dipping Fluids.*—Five distinct types among 15 strains of Gram-negative bacteria capable of oxidizing arsenite to arsenate in the presence of oxygen, have been isolated. They are best classified as belonging to the genus *Pseudomonas*. It appears likely that oxidation is mediated by the cytochrome cytochrome-oxidase system, but since oxidation is a strictly adaptive process, there is evidence for a specific enzyme also. It has not been possible yet to demonstrate this directly. These studies support the findings by the Division of Entomology, described in the 19th Report, that physical exclusion of oxygen, by rafts or oil films, prevents oxidation, as does acidification. Since growth in the presence of lactose, sucrose, or glucose does not depress arsenite oxidation it is likely that the known effect of these carbohydrates in preventing oxidation in dipping fluids is via stimulation of arsenite-reducing bacteria. Copper sulphate (1/2500) does not depress growth or oxidation of arsenite and up to 4 per cent. of sodium chloride has only a slight effect.

(xi) *Physiology of Reproduction in Sheep.*—(*a*) *Reproduction in the Ewe and Ram.*—The study on cyclical activity of the reproductive tract in the Merino ewe showed that regular cyclical changes occurred in the vaginal contents in some animals while they were experiencing regular oestrous cycles, but in others these changes were not so apparent. There was no evidence of cyclical variation in the macroscopic appearance of the cervix. Observations on the isolated guinea-pig uterus did not reveal evidence of cyclical variation in spontaneous activity or in re-activity to adrenalin in this animal. Observations have been made on the development of sexual activity in the young Merino ewe. Anatomical and histological observational studies are also being made on the development of sexual organs and activity in the young ram.

(*b*) *Assay of Oestrogen in Subterranean Clover.*—The change in weight of the uterus in the ovariectomized virgin guinea-pig following consumption of clover shows promise of providing a satisfactory method of assay.

(*c*) *Relationship of Male Hormone to Penile Development and to Posthitis.*—In two normal wethers treated with 100 mg. a marked degree of development of the *processus urethrae* persisted for 32½ weeks, but the effect was no longer obvious 13 weeks later. Observations over a period of 2½ months on wether sheep suggest that implantation of testosterone propionate increases resistance to the so-called "pizzle rot" (posthitis).

3. McMaster Animal Health Laboratory.

(i) *Parasitological Investigations—Internal Parasites.*—(*a*) *Studies on Phenothiazine as Anthelmintic.*—Small daily doses of phenothiazine (5 grams) were equally effective against the nodule worm (*O. columbianum*) whether injected into the rumen or into the abomasum. The anthelmintic effect occurred earlier and was of shorter duration when the drug was injected into the abomasum. From the other trials it appears that phenothiazine is just as effective when a low concentration in the vicinity of the parasite is maintained by repeated small doses, as when a high concentration for a short period is induced by a single large dose. Phenothiazine sulphoxide was found to have similar anthelmintic properties to phenothiazine itself when given in comparable doses and to be equally safe. Phenothiazine in flake form was less effective than the usual fine powder, but when used in tablet form was not significantly less efficient against nodule worm than the powder, provided the tablet was retained by the sheep. Further trials have been carried out concerning the most effective dose rate of phenothiazine against trichostrongylosis in young sheep and in adult sheep respectively

(*b*) *Anthelmintic Effect of Phenothiazone in Salt Licks.*—Trials during recent years, referred to in previous reports, showed that in the seasonal conditions then existing, this method held little promise. They were continued nevertheless, hoping that a wet summer which would favour worm infestation might also cause the sheep to consume more of the lick. These circumstances did arise during the past summer, and clear evidence was obtained that phenothiazine/salt mixtures available to the sheep in the form of licks, can prevent losses from haemonchosis. Despite this favorable result, no reliance can be placed on this method of worm-parasite control at present. The consumption of phenothiazine/salt varies from season to season and

from sheep to sheep. Moreover, the cost in phenothiazine is considerably greater than that of single massive doses given at strategic intervals during the year.

(*c*) *Other Anthelmintic Investigations.*—Several anthelmintics were tested for efficiency against *Paramphistomum* spp. in sheep. Hexachlorethane and carbon tetrachloride were effective when dosed into the rumen. Tetrachlorethylene, orthodichlorbenzene, paratertiary-butyl phenol, nicotine sulphate, and phenothiazine, were all ineffective. Hexaethyltetraphosphate, used as a substitute for nicotine in insect control, caused mild intoxication resembling nicotine poisoning when administered to sheep in doses of 1 ml. and 2 ml., and these doses were without effect upon *H. contortus*. Wheat germ oil being claimed to be effective against *Enterobius* in man, was tested at several dose rates and by abomasal and ruminal injections in sheep, but appeared to have no anthelmintic value whatever.

(*d*) *Observations on Nodule Worms of Sheep.*—In young sheep the period from administration of nodule worm larvae to the first appearance of eggs in the faeces ranged from 39 to 58 days, and maximum egg output was reached in 50 to 80 days. In two to three year old sheep, the periods were 40 to 150 days, and 77 to 230 days. These long latent periods increase the difficulty of controlling nodule worm by allowing the parasite to carry over from season to season in the bowel nodules where they are protected from anthelmintic treatment.

(*e*) *Effect of Plane of Nutrition on Haemonchosis.*—Results obtained in a previous trial have been confirmed. Sheep on the better ration threw off their *H. contortus* infestations in 3 to 39 days (mean 18.9 days). Of 10 sheep on the lower plane of nutrition, four threw off their infestation in 44 to 78 days (mean 57.7). The other six sheep on the low plane of nutrition showed no loss of infestation during a period of 110 days. When subsequently dosed with *H. contortus* larvae, those on the poorer diet developed heavy infestations, whilst those on the better ration proved relatively resistant. These results serve to stress the importance of maintaining sheep on a high nutritive plane as part of the campaign against internal parasites, as well as to ensure maximum production.

(*f*) *Resistance to Internal Parasites—"Self Cure".*—Observations on the "self cure" have been continued, both in the laboratory and in the field, in collaboration with the Regional Pastoral Laboratory at Armidale. In several experiments, sheep which were infested with *H. contortus* were given fairly heavy doses of the infective larvae of that species. The majority threw off the existing infestation within a few days and developed a fresh infestation from the larvae about three weeks later; some threw off the old infestation, but the larvae failed to establish a new one, whilst others retained the old infestation and the larvae also established themselves. The throwing off of the existing infestations was accomplished by an increase in red cells and eosinophiles in the blood, but as the new infestation from the larvae developed, the red cell count fell again, and the eosinophilia disappeared. That the existing infestation was actually lost was confirmed by post mortem examination of several of the sheep concerned. These observations on penned sheep offer an explanation of "self cure" as it has been observed to occur in the field. It seems probable that the rains favour the development of larvae from eggs on the pasture and that the sheep consume large numbers of larvae in a short period. This is an important and hitherto unsuspected aspect of host-parasite relationship and the study will be continued.

(*g*) *Immunity and Resistance Phenomenon in Nematode Infestations.*—Studies on the measurement and interpretation of antibody formation in sheep infested with nematodes have been continued and brought into relation with observations on "self cure". Satisfactory antigens for the complement-fixation test can now be prepared regularly from third stage infective larvae. Antigen can also be prepared from adult worms, but those from adult *H. contortus* vary greatly in potency. In sheep carrying *H. contortus* the titre of complement-fixing antibody is enhanced by dosing with larvae. Weekly complement-fixation tests over a period of nine months, on sheep in a flock used for epidemiological studies, has given remarkably consistent results. It has now been established that the alcohol-soluble lipid material of nematodes is an essential constituent of the antigen used to detect complement-fixing antibodies. The evidence so far suggests that the active antigenic principle is an unsaturated fatty acid which may be associated with a phospholipid such as lecithin.

(*h*) *Studies on Simlimnea brazieri, Intermediate Host of the Liver Fluke.*—This work has been carried out by the holder of an Ian McMaster Scholarship. Its purpose was to provide further information on the bionomics of the snail, but it has also included detailed anatomic and taxonomic research. Studies on the local distribution of *S. brazieri* have shown some of the probable reasons for its occurrence in some habitats, and absence from others which appear equally suitable. Laboratory studies on the toxicity of various chemicals to *S. brazieri* showed that copper sulphate could be relied upon in concentrations up to one part per 1,000,000, and that toxicity depended on the free copper ions in the solution. Several other inorganic and organic substances were tested for toxicity, including DDT and BHC, but all were less toxic than copper sulphate. Extracts of tea-tree (*Leptospermum scoparium*) were toxic to *S. brazieri* under laboratory conditions, but its use in the field was not promising.

(ii) *External Parasites of Sheep.*—(*a*) *Bionomics of the Body-louse of Sheep* (*Damalinia ovis*).—This work has been continued to obtain confirmation of some previous findings. It will now be terminated and the results submitted for publication.

(*b*) *Bionomics of the Foot-louse of Sheep* (*Linognathus pedalis*).—Periodic observations on a naturally infested flock have been continued throughout the year. There is marked seasonal fluctuation in population density, it being heaviest through the late winter to early summer, and lightest in late summer and autumn. Sheep vary greatly in individual susceptibility but, in general, the younger sheep are the more heavily infested. Lambs were found naturally infested within 48 hours of birth, and observations commenced recently have shown that lambs can become infested on pasture plots from which infested sheep were removed at least 48 hours previously. Small-scale trials concerning the toxicity of insecticides for this species showed that arsenic rotenone, DDT, and BHC were all toxic to the nymphal and adult forms, but none of them were ovicidal. BHC was the only one which showed effective residual toxicity. These findings still await confirmation under field conditions.

(*c*) *Studies on Sheep Dipping.*—Most attention during the year was given to field trials concerning "stripping", i.e., decline in insecticide concentration in the dip bath as dipping proceeds. A proprietary DDT preparation, "Rucide", showed considerably less "stripping" than dispersible DDT powders or proprietary BHC preparations. "Stripping" occurred much more slowly from plunge dips than from power sprays, particularly if the plunge dip was of large dimensions. The effect of staple length on the dipped sheep is not to increase the rate of stripping directly but to increase the quantity of dip removed from the bath, per sheep, and hence to necessitate more frequent replenishments. This applied also when the period for which sheep were exposed to power sprays was increased, wetting was more complete, and hence more

dip was taken out by the sheep. With power sprays the rate of stripping increased as the volume of fluid in the sump diminished, and was greater if the sump was of small capacity. The rate of stripping was found to vary greatly with different formulations. In none of these trials, however, was the rate of stripping such as to reduce the insecticide concentration below effective levels, provided the prescribed initial concentrations were used and replenishments were made as directed.

(iii) *Blowfly-strike Problem.*—(*a*) *Control of Body-strike.*—Seasonal conditions in some areas resulted in an extremely high incidence of body-strike. A series of "strike waves" occurred after heavy falls of rain at intervals through the late summer and autumn. In one flock, despite successful treatment later in the season, deaths were 16.7 per cent. After several methods were used in an attempt to control the strikes, a BHC preparation was tried at two strengths. One group of sheep was sprayed and the other dipped. This preparation brought the strike under control and the good effect lasted for a period of five weeks. These results tend to confirm findings overseas, namely that BHC can be used effectively against body-strike, but that its effects pass off rapidly after about four weeks. This product, therefore, offers great promise under Australian conditions where outbreaks of body-strike are usually of short duration, and one treatment would suffice. In unusual seasons such as that just past, when body-strikes occurred over a period of two to four months in different localities, two or more treatments would be required.

(*b*) *Crutch-strike.*—A small trial was carried out to compare the efficacy of jetting the crutch with BHC preparations. The results were not clear-cut but tended to confirm results obtained by the New South Wales Department of Agriculture, that BHC gave a shorter period of protection than arsenic, and at considerably greater cost.

(*c*) *Head-strike.*—Three groups of rams were treated by jetting about the poll and base of the horns. The preparations used were a proprietary calcium arsenite preparation, BHC dispersible powder containing 0.1 per cent. gamma isomer, and BHC dispersible powder containing 0.2 per cent. gamma isomer. During the next four weeks there were approximately 10 per cent. of head-strikes among rams jetted with calcium arsenite and none among those jetted with BHC. Similar results have been obtained by the New South Wales Department of Agriculture, and there seems little doubt that BHC is highly effective for prevention of head-strike in rams.

(iv) *Parasite Physiology and Toxicology.*—The work of this section concerning helminth antigens has already been dealt with under 3 (i) (*g*).

(*a*) *Aerobic Metabolism in Adult Intestinal Nematodes.*—By measuring electrometrically the oxygen tensions at different sites within the gut of living animals, it was found, contrary to the general idea, that appreciable amounts of oxygen were present (about 0.2 to 0.05 mg. per cent.) in the contents of the rat small intestine near the mucosa. Some low concentrations of oxygen were also found in the sheep's abomasum and small gut. Preliminary experiments indicated that intact parasites can maintain their haemoglobin in the oxygenated form at very low oxygen tensions.

(*b*) *Physical Characters of Haemoglobins isolated from Nematodes.*—Haemoglobin from *N. muris*, and *Nematodirus* spp. purified by ammonium sulphate fractionation showed the following characteristics: HbO_2 band (542 mμ) lower and narrower than the β band (578 mμ); Met. Hb, rounded peaks at 630 mμ and 503 mμ; Hb, a broad band with a peak at 56 mμ. The efficiency of nematode haemoglobins as oxygen carriers at the oxygen tensions found in the host's gut is being investigated.

(*c*) *Ability of Nematode Parasites to Utilize Oxygen.*—The respiratory metabolism of *H. contortus, Ostertagia, Syphacia, Heterakis,* and *Paramphistomum* spp. have been examined, and in particular, interesting differences in RQ figures were obtained. With *Paramphistomum* oxygen uptake was stimulated in some cases by CN, instead of being more or less markedly depressed.

(*d*) *Mode of Action of Phenothiazine as an Anthelmintic.*—Some phenothiazine was synthesized with radioactive sulphur and it was then determined what proportion of the "labelled" drug must be included in an anthelmintic dose of phenothiazine to permit estimation of the rate of uptake of the drug in the biological systems: (*a*) *Syphacia* spp.—mouse host, and (*b*) *N. muris*—rat host. It was found that a much higher proportion of the labelled drug was necessary in such work than is required for *in vitro* experiments. The rate of uptake from the two parasites was approximately in proportion to their relative body-surface areas. This work on the mode of action of phenothiazine is continuing as material is available.

(*e*) *The Feeding Activities of N. muris.*—It was hoped to estimate the numbers of *N. muris* destroyed and removed by anthelmintic treatment, by estimating faecal haematin in treated rats. However, the faeces of infested rats contained variable amounts of haematin, much in excess of that present in the parasites themselves. From various estimations of the quantity of haematin in *N. muris* and in the faeces of infested rats, it was considered that this parasite feeds largely on the solid tissues of the host's gut, ingesting host blood incidentally, but causing no appreciable haemorrhage.

(*f*) *Immediate Sources of Energy of Nematode Parasites.*—This work is being carried out by a recently appointed Ian McMaster scholar, using buffered breis prepared from *Nematodirus* spp. and *Ascaridia galli.* These preparations evinced marked oxygen concentration and the presence of enzyme systems which in mammals are concerned in the Krebs cycle of aerobic metabolism. More detailed investigations in relation to succinic dehydrogenase, however, suggest that although the Krebs cycle accounts for some of the aerobic metabolism of these parasites, it cannot be of major importance. This work is proceeding and results to date suggest that acetate is an important immediate source of energy.

(*g*) *Nutrition of Parasitism.*—Some preliminary observations have shown that rats fed on rations high in protein are much less susceptible to *N. muris* infestation than others on rations of similar energy value but low in protein content.

(v) *Biochemical Studies.*—(*a*) *Vitamin D Supplements for Sheep in Southern Latitudes.*—Trials were commenced in April-May, 1947, and continued throughout the winter on the effect of massive doses of vitamin D administered to weaners. In New England and in the Riverina no beneficial effect was expected and none occurred. At Frodsley in Tasmania, where the treated and control weaners were on ryegrass-clover pastures, with a supplement of hay, no marked difference occurred between treated and untreated groups. At Vaucluse, Tasmania, however, where the experimental groups were run on Algerian oats through the trial, there was a marked response to the vitamin D supplement. A further series of trials was commenced in Tasmania in 1948.

(*b*) *Drought-feeding Experiment.*—Experiments to be carried out with the aid of a grant from the Burdekin Bequest were planned in conjunction with the N.S.W. Department of Agriculture. These experiments aim to determine the optimal proportion of roughage and concentrates for weekly and bi-weekly feeding of sheep, and the effect of calcium supplement to cereal rations on the conception rate of ewes. The first year has been

fully occupied in procuring material for fencing, water supply, feed shed, and other facilities for a site at Glenfield where the work will be carried out.

(*c*) *Dental Abnormalities in Sheep.*—Flocks were encountered in the field during the year with incisor and molar abnormalities similar to those occurring in experimental sheep fed on unsupplemented cereal rations during their developmental stages. These field occurrences were among sheep which had suffered severely from drought and had been hand-fed as weaners.

(vi) *Physiology of Reproduction.*—(*a*) *Studies on gonadotrophins.*—Considerable progress has been made during the year. The effect of a number of enzymes on the activity of gonadotrophins has been determined. Mucin stains are being applied to sections of the pituitary gland to see if, in this way, the content and distribution of gonadotrophins can be estimated.

(vii) *Studies on Spermatogenesis in Rams.*—This investigation is about to terminate. The results of the past year's work on the effect of season, of carotene intake, and of plane of nutrition on the quantity and quality of semen are being prepared for publication. It was found that there is a seasonal variation in the seminal characters of rams. There is a degradation in the summer except in those rams on a high plane of nutrition with adequate carotene intake. On the carotene-deficient diet, the semen does not completely return to normal in the winter. Severe vitamin A deficiency resulted in a completely abnormal semen in rams at any time of the year.

(viii) *Studies on Cattle Parasites at Yeerongpilly, Queensland.*—(*a*) *Onchocerca gibsoni (Beef-nodule Worm).*—The parasite was found to be endemic in the Brisbane area although the incidence is not high. At least two, and possibly three species of *Onchocerca* occur in Queensland cattle, viz. *O. gibsoni, O. gutturosa,* and *O. lienalis.* Larvae can be found in the skin almost anywhere on the beast's body, but as yet the larvae of these three species cannot be clearly distinguished from each other, and until this can be done, the difficulty of working out the life history of the parasite will remain great. Two filarlid larvae were found in some 250 specimens of the pest *Austrosimulium pestilens* but they could not be identified.

(*b*) *Epidemiology of Parasitic "Gastro-enteritis" of Calves.*—Outbreaks are not uncommon in the coastal and sub-coastal regions of Queensland in both beef and dairy cattle. Losses are confined mainly to young stock during the late winter and early spring when pastures are poor. The species concerned are *Haemonchus contortus, Bosicola radiatum, Bunostomum phlebotomum,* and to a lesser extent *Cooperia punctata* and *C. pectinata.* Groups of calves at Beaudesert, Pinpana, and Oonoonba are being examined monthly to check the seasonal fluctuation in parasite populations. Infestations appeared to reach a peak during the first four-six months of exposure and then to decline. Adult cattle appear to be relatively highly resistant to infestation. Permanent calf paddocks appear to be a bad feature of calf husbandry in Queensland and elsewhere, and are associated with heavier worm infestations than where calves are grazed in rotation ahead of, or even with, the milking herd.

4. The F. D. McMaster Field Station.

(i) *General.*—Approximately 29.11 inches of rain were recorded during the year ending June, 1948. The year was characterized by summer rain and 62 per cent. fell in November, December and January. During the year 100 acres of oats, 46 acres of millet, 12 acres of sudan grass, and 33 acres of sorghum were sown.

The sheep numbers were reduced to make way for new experimental flocks. At 30th June there were 70 rams, 170 wethers, and 570 ewes. The cattle numbers increased to 31.

(ii) *Inheritance of Skin Wrinkles in Sheep.*—The investigation has been concluded and the experimental sheep have been dispersed. The results of the investigation have been prepared for publication. Observations on skin wrinkles are being continued on sheep in other investigations.

(iii) *Inbred Flocks of Australian Merinos.*—Five inbred families are being developed from three original "lines of blood", as described in earlier reports. They now comprise (*a*) a flock of 34 females with an average coefficient of inbreeding of 20 per cent., (*b*) two subgroups, one consisting of 56 females which have an average coefficient of inbreeding of 11.7 per cent., and the other of 54 females with an average coefficient of inbreeding of 5.7 per cent., (*c*) two families, one consisting of 55 females having an average coefficient of inbreeding of 7.3 per cent., and the other of 48 females with an average coefficient of 3.7 per cent.

On occasions a lamb with pigmented wool has been born in the flocks and there have been malformed progeny, and some with undershot lower jaws. These observations have been recorded and their incidence related to genetic possibilities. Broadly, however, no gross occurrence of defects has been observed. Nevertheless, as the degree of inbreeding increases, so do birth weights, survival rates, and final body size decrease.

(iv) *Investigations of Heterosis.*—A series of six inbred and three non-inbred but related rams has been sent to "Gilruth Plains" to be mated in the exploration of usefulness of the phenomenon of heterosis. Two rams were 12.5 per cent. inbred, and four were 25 per cent. Together with non-inbred controls they are being mated with randomized groups of ewes which total 365, and are drawn from the "Gilruth Plains" station flock.

(v) *Polledness.*—The investigation of polledness in sheep has been concluded, and a provisional hypothesis put forward to explain the genetic situation. The conclusions are that hornedness and polledness are characters, paired in the Mendelian sense, but at extremes of a range within which there is continuous variation. The range has been described, and for convenience, four points in it have been selected, as horns, scurs, knobs and depressions, upon which to base classifications of groups. It is suggested that horns and depressions, together with intermediate forms, are demonstrations of particular gene frequencies which have been isolated as breeds, strains, or breeding groups of sheep, and that the whole situation is controlled by a quantitative genetic series common to all such animals. This quantitative series provides the substratum of inheritance within which polledness is completely dominant to hornedness. Oftentimes characterization is unlike in males and females which are full sib. This is not due to sex linkage of hornedness but it is possible that the sex chromosome may carry some factor which excites appropriate male hormonal secretions, and so horn growth, when, and only when, factors for hornedness are also present.

(vi) *Studies on the Inheritance of "Hollowback", "Hairiness" and "Parrot Mouth".*—(*a*) *"Hollow Back".*—The "hollow-backed" Merino ram critical for this investigation has died. He was being mated with his own daughters to examine the possibility of the character being a recessive condition. The investigation is therefore in abeyance.

(*b*) *"Hairiness".*—A breeding group was developed by mating a "hairy" ram (synonym "fluffy tip") with ewes which were not of that nature. The first cross progeny were not "hairy". Females in this generation were mated with their sire until he died and was replaced by another "hairy" ram. As stated earlier, data are accumulating but are still inadequate for proper interpretation.

(*c*) *"Parrot Mouth".*—No further examples of "parrot mouth" have occurred in the inbred group. However, the Merino ram with the condition was mated with six "parrot-mouthed" Southdown ewes in April and their progeny will be examined at a later date.

(vii) *Development of Hybrid Dairy Cattle.*—The experimental herd now consists of 31 animals, thirteen of which have Zebu "blood". It includes two half-bred bulls and one quarter-bred. The remainder are females. The herd is under Government test and has six females in milk. The two quarter-Zebu heifers have satisfactory dairy temperament. Present figures indicate that production by the quarter-Zebus is within the range of possibility for what may be regarded as highly selective breeding applied to uplift dairy production.

5. Wool Biology Section.

(i) *Nutrition of the Ewe in Relation to Growth of Skin and Fleece of the Lamb.*—A study of the effects of the nutritional state of the ewe on the pre-natal growth and development of the skin and of the fleece of the lamb was started during the year. A group of ewes is being kept continuously during pregnancy on a high level, and another group on a relatively low level of food intake. Periodic observations on fleece production and general behaviour are being made on the ewes. Growth studies will be made during the first twelve months of life of the lambs.

(ii) *The Rate of Wool Production in Relation to Food Intake.*—In the last report it was mentioned that studies were being made on the production factors in two contrasting types of sheep, fine-wool Camden Park Merinos and Corriedales. These studies were made in association with the Walter and Eliza Hall Fellow in Veterinary Science in the University of Sydney. Data were collected systematically and these have been examined in an attempt to find the answer to several specific questions. By taking the rate of wool growth and the nitrogen intake, the productive capacity of the two types of sheep has been determined. The results suggest that a reliable constant may be found for intermediate types of wool-producing sheep which could be applied to standard conditions of type of feed and temperature.

(iii) *The Influence on Fleece Growth of Non-nutritional Factors.*—In the examination of the data mentioned in paragraph (ii), it was found that neither the total wool-production rate nor the individual fleece characters remain unchanged when the food intake is kept constant. The most striking of the fluctuations in the total wool-production rate was found to be associated with change in atmospheric temperature. The fluctuation appears to be due mainly to changes in fibre length growth rate. A significant rise in suint production, and a decline in wax with rising temperatures was noted in the Corriedales, and to a less extent in the Merinos. Another type of variation noted was in the cross-sectional area of the fibre associated with the progressively increasing weight of the fleece.

(iv) *The Influence of Changes in Cutaneous Blood Circulation on Growth-rate of Wool.*—Experiments were started to investigate the effect of increase in the flow and volume of blood through the vessels of the skin on the growth-rate of the wool fibre. This increase was produced by the removal of control by the sympathetic nerves. Preliminary observations have shown a very significant increase in the growth-rate of the wool fibre.

(v) *Some Reactions of Sheep to High Temperature and Varying Humidities.*—Experiments were carried out in co-operation with the School of Physiology in the University of Queensland. Sheep were given (*a*) seven-hour periods of exposure to a series of predetermined temperatures and humidities, and (*b*) continuous exposure for 28-day periods to three different conditions of temperature and humidity. Careful observations were made on the reactions of the animals and, in the second series, on the fleece growth. The importance of the plane of nutrition in the heat-regulating system of the sheep was confirmed. At the highest temperatures (37.5° C.), and especially at the highest humidity, the production of suint was significantly increased.

(vi) *Statistical Records on Distribution of Breeds of Sheep in New South Wales.*—During the year the available statistics for sheep and wool production in New South Wales according to breeds were examined for two yearly periods at an interval of ten years, viz. 1936-37 period and 1946-47 period. A series of 22 maps for each period was prepared to show the regional variation, over the State, in the numbers of Merino and pure British breeds, in density of sheep population, in average weight of adult fleece shorn, in average weight of fleece produced per acre, in the proportion of Merinos and crossbreds in the sheep population, in the proportion of cultivated land, and in the percentage of lambs marked from ewes mated. These maps with the companion tables provide information necessary in the planning of surveys. In addition, information from stud books, particularly regarding flock size, was summarized. All this information in the summarized form as well as being of value in the planning of research and survey projects should have a wider interest and value to the industry. The work will gradually be extended to include a study of information from the other States, and this will be done in association with the Wool Section of the Division of Agricultural Economics.

6. Regional Pastoral Centre and Laboratory, Armidale, New South Wales.

(i) *General.*—During the year the Regional Pastoral Laboratory and Field Station became definitely established in the New England District of New South Wales. This regional centre has developed from the section established by the Division some years ago and made possible by the help given by the University College at Armidale in granting space and certain facilities. The University College granted more space to enable the erection of laboratory buildings and the establishment of culture plots for work on pasture plants. An area of 4,496 acres was acquired in September, 1947, for the establishment of a Field Station. This is situated about eight miles from the town of Armidale and is known as the Chiswick Field Station. During the year the development of the property has been restricted by shortage of materials and labour, but within the limits imposed, the development has been satisfactory.

Plans have been prepared for the laboratory to be erected in the grounds of the University College. A start was made in the construction of an annex to the laboratory and when the building is completed it will provide temporary laboratory accommodation.

The Regional Centre has been established for co-operative work between the several Divisions of the Council and the Department of Agriculture of New South Wales. Up to the present the Division of Plant Industry has been the principal co-operator in the venture. The Division is carrying out a programme of work on natural and improved pastures, and this is described in the section of the report dealing with the activities of the Division of Plant Industry. The whole of the work of the centre is co-ordinated by a Technical Committee consisting of the Divisions concerned. The co-operation and support of the graziers of the New England district has been very encouraging. Formal discussion with graziers and with representatives of agricultural bodies has been provided for by the establishment of a Consultative Committee which met once during the war.

A brief outline of the work which was carried out at Armidale during the year by the Division of Animal Health and Production is given in the following paragraphs.

(ii) *Blowfly Strike of Sheep—Lamb Marking Dressings.*—The work on the prevention of flystrikes associated with lamb marking, commenced in 1945, was rounded off in October 1947, and the results are now in the course of preparation for publication. In these trials excellent results have been obtained consistently with a dressing comprised of citronella, boric acid, and bentonite. Many other agents have been tested and the method of application, including the quantities of dressing required, the concentration of the repellent in the dressing, the effects on healing of marking wounds, and the modifications in procedure according to the prevalence of blowflies at the time, have been considered. For general purposes a dressing containing 10 per cent. of citronella oil has been found most satisfactory.

The work has shown that during a severe fly wave under extensive field conditions where shortage of labour and difficulties in handling large numbers prevail, if marking of lambs is carried out, different protective measures are indicated. Under these circumstances normal crutch-strike in the lambs during the period following marking becomes the primary consideration and jetting with benzene hexachloride (not less than 0.75 per cent. BHC) can be expected to give three to four weeks complete protection to the lambs.

(iii) *The "Elastrator" Techique for Marking Lambs.*—The "Elastrator" technique for castration and tailing was tested under conditions of fly activity. For castration the method appeared to be a satisfactory alternative to the use of the knife. For docking, the "Elastrator" could be regarded as an "alternative procedure" to be used only when it is safe to assume that flies are not active or will not become active. The technique has no obvious virtues and many disadvantages.

(iv) *Udder-strike in Ewes.*—Ewes protected against crutch-strike by the modified Mules operation have been observed to show strikes in the region of the udder. The strikes have occurred under "fly wave" conditions persisting during, and for several weeks subsequent to, lambing. The incidence observed has been from 10 to 15 per cent. of the flock.

(v) *Internal Parasites of Sheep.*—(*a*) *Epidemiological observations.*—Systematic work has continued on the collection and examination of material and information in the studies on the epidemiology of the common internal parasites of sheep. This work has depended mainly on finding the correlations between variation in climatic conditions and changes in the intensity of infestation (worm burden). These observations were extended to include the collection of blood from the sheep under systematic observation in order to determine the rise or fall in the circulating antibodies. The phenomenon of "self cure" has been under study as part of these investigations.

(vi) *Winter Feeding of Weaners.*—The spectacular results obtained in the New England district of New South Wales in the use of oat crops for winter grazing were mentioned in previous reports. Further experiments were carried out in the winter of 1947, and with the use of a crop of turnips and Wimmera ryegrass. The sheep at first showed a preference for the ryegrass and later for the turnips. By September the sheep showed a weight gain of 13.5 lb., whereas the natural pasture group lost 3.6 lb. The result does not compare very favorably with the weight gain of 26.4 lb. in the previous year with weaners grazing on an oat crop. Further, the control of nodule worm infestation which had been observed in sheep grazing the oat crop was absent in those on the turnips and ryegrass.

(vii) *Neo-natal Mortality in Lambs.*—One of the problems in sheep-breeding in the region is the occurrence of death in lambs soon after birth, and the incidence may be very high. Preliminary observations were made during the year. It was found that most of the losses occur within the first two or three days of life. The absence of milk in the stomach of the dead lambs suggests that they have not sucked. Plans were prepared for a systematic investigation of the problem.

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

(i) *General.*—The rainfall for 1947-48 was above average, but the summer rains were delayed and the response of the pasture was not very satisfactory. Established Mitchell grass which was in good order from the previous year responded reasonably well, but few seedlings appeared. Button and Flinders grasses made a poor response on the plain country but fairly good response on the timbered country. The general pasture position at June, 1948, is good, and ample feed is available, which should last for about four months. Growth of young Mulga was good.

The stock numbers at shearing in April, 1948, were 3,558 ewes, of which 1,427 are on the main breeding experiments, 360 in the top-crossing experiments, 1,000 for cross breeding, 174 blowfly strike control, and 597 in the flock. There were also 1,147 lambs in the main breeding experiment and 1,234 in the flock. With the rams, the total sheep numbers were 6,327.

At shearing in April 1948, the ewes and rams gave a cut per head of 10 lb. 13 oz. of greasy wool, and the lambs 3 lb. 9 oz. The total number of bales was 161. Tender fleeces were obtained from about 20 per cent. of the ewes which had suckled lambs but none from the unmated ewes.

The health of the sheep was reasonably good. "Scabby mouth" occurred in a small group, 48 of 1,300 flock lambs, but was of a mild character. There was an outbreak of "pink-eye" after shearing and during mating, but few or no losses occurred.

All the ewes on the property, except for a small control group, have been protected against flystrike by the use of the modified Mules operation. There were 24 strikes recorded in 3,886 ewes, which represents 0.6 per cent. In the control group the strike incidence was 13 per cent. The strike incidence in untreated flocks in the district was high.

(ii) *Animal Breeding Trials.*—Investigation of methods of breeding as applied to Merino sheep now forms the main animal experimental work. In the main breeding trial, mating and lambing are carried out in small yards so that essential observations can be made for the records. A satisfactory technique for feeding and husbandry was developed and the sheep reacted very well to the close confinement of the yards.

(*a*) *Main Breeding Trial.*—The broad objects and methods of this investigation were given in the previous report. Conclusive results from this experiment cannot be expected for many years, but a series of observations on progeny testing, wool sampling and wool production will be made, and results of these will prove valuable.

(*b*) *Top-crossing Experiment.*—This breeding trial was commenced in May 1948. The object of this trial is to compare the progeny of inbred rams with those of related but not inbred rams. The nine rams in the trial were bred in a special flock at the McMaster Field Station, and were transferred to "Gilruth Plains," for testing. They represent three levels of inbreeding, viz. 0, 12½, and 25 per cent. Each ram was mated in the breeding yards to a group of 40 ewes selected at random from an even line. The ewes are not inbred and are not related to the rams. The nine sires will be assessed by the performance of their progeny from

matings in two successive years. For this purpose, ewe and wether progeny will be held until 18 months of age, for measurement of wool-production characters.

8. Other Activities.

(i) *Fleece Analysis Laboratory.*—(*a*) *Routine Measurements.*—During the year the laboratory continued to carry out routine measurements of samples of fleece collected in experimental work, and in this way acted as a central measurement laboratory for most of the large-scale experiments conducted by this and other Divisions of the Council. Experiments from which wool samples were examined during the year include the breeding trials at "Gilruth Plains," genetical studies at the McMaster Field Station, studies of the Wool Biology Section, co-operative grazing trials at the Experimental Farm of the New South Wales Department of Agriculture, Trangie, and co-operative grazing trials at Wongan Hills, Western Australia. In addition, many samples which were collected in the conduct of the survey of Merino wool production were examined.

(*b*) *Development and Investigational Work.*—Work was continued on the improvement of the speed and accuracy of the several measurement techniques. A new method of measuring mean fibre diameter, and the total number of fibres in a bundle (for determining the density of the follicle population) by making casts of cross sections, was brought into routine use. Devices for measuring percentage medulation, and for analysing fibre length distribution, were taken to an advanced stage of development. The loss factors to be used for various vegetable burrs when determining the vegetable content of wools by dissolving the wool in boiling caustic soda were investigated. In conjunction with the Sydney Technical College, part of the physical and chemical significance of some of the common trade terms were investigated.

(ii) *Investigation of Beef Production in Australia.*—The survey of beef production in Australia has been continued. The field work during the year was carried out exclusively in Queensland. The coastal fattening districts and the breeding areas of the eastern Gulf country were visited by the surveyor during the period June-November 1947, and, after the wet season, the Queensland section of the survey was completed in May-June 1948, by an examination of the south-western Channel country and the cattle-producing areas of the western and north-western districts. The surveyor then proceeded to the Northern Territory. During the wet season, whole time was given to collating the data collected in the earlier survey work. Preliminary outlines of the survey of beef production in Tasmania and in Victoria were prepared.

(iii) *Poultry Breeding Investigations.*—Satisfactory progress was made during the year in the provision of the necessary facilities and staff for the poultry breeding research unit on the Council's field station at Werribee, Victoria. An outline of the first project to be undertaken—a comparison of breeding systems, was given in the previous report. Pullets reared from the foundation stock numbered 1,550, and came into production in the autumn of 1948. To define the mating programme for the year, their records of performance from date of first egg to May 31, were analysed for the characters, early maturity, intensity of laying, freedom from broodiness, and weight of egg. The results of these analyses have permitted the formation of 46 mating groups involving 40 sires and 330 dams. All matings in connexion with these investigations are by means of artificial insemination after the method of Burrows and Quin. This technique gave very satisfactory results during the breeding season of 1947, and will be used on a larger scale in the coming year. The facilities provided for the poultry-breeding unit will permit a comparison of three methods of obtaining individual records of performance, namely, trap-nesting the single test pen, and the laying battery. By June 30, 1948, 270 birds were housed in single test pens, and 360 in individual laying battery cages. Subsidiary investigations include studies on the physiology of fowl semen, cockerel fattening with orally administered synthetic oestrogen, and the genetics and mode of expression of sex-linked factors controlling colour of shank and plumage in the cross between the White Leghorn and the Australorp.

V. BIOCHEMISTRY AND GENERAL NUTRITION.

1. General.

During the period under review, researches into various aspects of the nutritional physiology of the sheep have been continued and the findings have been translated into terms of practical application in the pastoral industry.

The fact that obvious symptoms of copper deficiency are very widespread in flocks depastured in South Australia has focussed attention on the limitations imposed on plant growth by the copper status of the soils, and led to the recognition that the productivity of large tracts is seriously limited by the low concentration of copper, zinc, molybdenum, &c., within the soils. The light sandy soils of the so-called Ninety-Mile Desert of the upper south-east of South Australia are typical of the most deficient terrain. Five years of experimental work conducted by this Division on some of the least promising areas has now proven conclusively that appropriate manurial treatment with superphosphate containing zinc and copper will allow good permanent pastures to be established on these deficient tracts. The response is dramatic and the costs involved in converting these areas to good grazing lands are relatively small. A conservative estimate indicates that at least 3,000 square miles of practically useless terrain may be developed in this way.

Supplies of radioactive isotopes have been obtained through the generosity of the United States Atomic Energy Commission. The laboratory has been equipped for the critical estimation of these isotopes and metabolic investigations in which Co^{60}, Fe^{59} and C^{14} are being used as tracers are in progress.

The laboratory facilities for the Division are being extended with the construction of a four-story building immediately adjacent to the existing Council for Scientific and Industrial Research Nutrition Laboratory and its annexes in the grounds of the University of Adelaide. This is nearing completion. The annexe at Hackney approximately three-quarters of a mile from the central laboratory has been erected and is in the course of being fitted to house animals and apparatus for metabolism studies.

The property of 600 acres at O'Halloran Hill about 10 miles distant is being developed as a main site for field and pen-feeding experiments with sheep.

2. Nutrition and Wool Production.

During the period under review researches into the factors involved in wool production have developed along two main lines: the nutritional factors which provide the raw materials, and the physiological processes which determine their utilization have both been studied further.

The state of the energy and nitrogen balances and the rate of wool growth of several merino sheep were studied at five levels of fodder intake, and from the results it is clear that the rate of wool growth depends ultimately on the concentration and the composition of the assemblage of amino acids in the tissue fluids which surround the wool follicles, and that the quota of amino acids which eventually becomes available in this way to serve as a substrate for wool production

depends not only on the protein in the diet but also to a great extent on the nutritional state of the animal. If the protein in the diet is to be utilized efficiently for wool growth, the animal must be in strongly positive energy balance, and even then the efficiency of utilization of the absorbed amino acids is small. From the amino acid constitutions of the proteins in the diet and in the main products of the nutritional transactions (wool and flesh) it was estimated that the cystine and methionine contents of the former would limit its efficiency for wool production to 35 per cent. under ideal nutritive conditions. Under the conditions of these experiments the efficiency of utilization was highest, 15 per cent., when the best wool producers were in strongly positive energy balance, and lowest, 5 per cent., when the poorest producers were in a nutritional condition close to maintenance level, under which circumstances the substrate of amino acids is depleted materially to provide fuel for the living processes.

The rate of wool production increased approximately 500 per cent. from the lowest to the highest level of feeding, the difference in the rate (weight per unit time) being due to changes both in the length and the mean diameter of the fibres. A study of the variance of the fibre diameter distributions revealed that, with a change in nutritional level, the finer classes vary over a more restricted range than the stronger classes and that each fibre is influenced up to the limit of its capacity in proportion to the area of its cross section.

From these experiments it is clear that a merino sheep grazing on natural pastures would rarely, if ever, exhibit its full wool producing propensity, and as a corollary, that the rate of wool production by a grazing sheep would vary considerably with the seasonal changes in its nutritional environment and that this would be reflected in its wool staple.

3. Metabolic Studies.

(i) *Processes of Rumination.*—(*a*) *Utilization of Urea.*—The first of the experiments designed to determine whether urea may be substituted for protein when supplementing the fodder available to the sheep from poor dry pastures, indicated that if urea is fed at a level of ½ oz. a day and is accompanied by a rather large amount of starch, its nitrogen is converted to wool protein with an efficiency of approximately half that of the nitrogen and wheat gluten.

A series of experiments to determine the minimum quantity of starch necessary to provide for an economically feasible conversion has been started.

(*b*) *Digestion of Refractory Carbohydrates.*—During the past year critical micro-methods for the analysis of mixtures of the lower fatty acids have been developed and these have rendered possible the further investigation of the fermentation of cellulose and of the hemicelluloses by the microorganisms of the rumen. A series of *in vitro* fermentations of natural fodders has been completed and attention has been given to the early and late phases of these fermentations—in the early stages hemicelluloses are rapidly broken down and in the later stages the more refractory cellulose is attacked. The products of the first phase consist essentially of acetic acid while in the later phase propionic acid predominates.

(*c*) *Absorption of Fatty Acids from the Rumen.*—Selective absorption of the fatty acids through the rumen wall has complicated greatly the study of *in vivo* digestion of carbohydrates by the ruminant. Preliminary experiments which involve the precise measurement of the e.m.f. set up between the blood stream and the rumen contents have been completed and the results indicate that on the alkaline side of neutrality there is no selective absorption of fatty acid anions. The necessary apparatus has been assembled to study this phenomenon further.

(*d*) *Intermediary Metabolism of Fatty Acids and of Carbohydrates.*—The sheep's capacity to obtain useful energy from the digestion products of its fodder apparently differs from that of other animals. The following series of investigations aims to illuminate the intermediary processes involved.

(1) *Experiments with Phloridzinized Sheep.*—An adequate supply of phloridzin which was separated from fresh apple bark rendered it possible to continue the investigation of the relationship between the carbohydrate and fatty acid metabolism in the phloridzinized sheep. Difficulties encountered in earlier experiments have been overcome by introducing the fatty acids slowly into the jugular vein. The observations so far leave no doubt that propionic acid is predominantly glucogenic in the sheep as in other animals. The fasting sheep apparently differs from other animals in that it converts to glucose part (c. 30 per cent.) of the acetic acid administered in this way.

(2) *Ketone Production by the Sheep.*—The preliminary studies of the mechanisms involved in ketone formation by the sheep have been extended. Injected acetate rapidly disappears from the circulation. Analyses of blood for acetoacetic and β-hydroxybutyric acids after injection of acetate have failed to indicate any increase in these acids. This work will be extended with the use of radioactive C^{14} tagged acetic acid.

(3) *Blood Sugar in Lambs and Respiration of Erythrocytes.*—Whereas the intermediary metabolism of the adult sheep is apparently distinct in some respects from that of other animals, it is possible that the metabolic processes of the very young lamb are more like those of mixed feeders and carnivores. Investigations carried out with the young lambs from the Division's breeding flock at Glenthorne indicate that the blood-sugar of the new-born lamb is approximately that of its dam; subsequent to suckling it rises rapidly to a high level for about two weeks, after which the concentration gradually falls to the level found in the adult.

The respiration of the washed red blood cells of the lamb has been investigated and the results indicate that this is increased materially after the addition of methylene blue and glucose. The rate of respiration under the latter conditions decreases after the first two or three weeks of life.

(ii) *Energy Metabolism.*—The study of various aspects of the energy metabolism of the sheep has been continued as an integral part of the comprehensive programme of nutrition and wool production. The two calorimeters and the apparatus for maintaining sheep under strictly controlled conditions have been in constant use. The basis of knowledge of the energy transactions involved in the utilization of fodder by the sheep has been strengthened by conclusions drawn from the results of a series of experiments designed to investigate the origin of the extra heat evolved by the sheep after it has fed. This heat increment represents the quota of the potential energy in the absorbed nutrients which is dissipated without providing directly for the energy demands of the animal. The findings have an important bearing on the theoretical background of energy metabolism and have simplified the assessment of the relative values of different fodders. According to the nature of its fodder, the sheep dissipates in this way between 35 and 50 per cent. of the potential energy of the digested and absorbed nutrients.

4. Vitamin A Requirements of the Sheep.

The results of the first series of investigations of the vitamin A requirements of the Merino sheep have been published. The experiment designed to determine the minimum carotene intake necessary for successful

reproduction was continued throughout the year. Following the first lambing the ewes were again fed a basal diet low in carotene, and after the vitamin A reserves had been depleted over a period of eight months they were mated. After a month they were supplemented with carotene in olive oil to provide the individuals of the four groups with 25, 50, 75, and 100γ carotene/kg. body wt./day, respectively. The effects of this treatment on the vitamin A in the blood indicated that carotene administered in this way was poorly utilized. Lambing was unsatisfactory in all groups. Another experiment has been started to extend these observations.

5. Physiological and Tissue Metabolism Studies.

The investigations of the effect of cyanide on tissue respiration have been continued. Further proof of the combination of ferri-cytochrome with cyanide was obtained. Evidence apparently in conflict with this hypothesis resulted from experiments in which the cytochrome c concentration was varied in systems containing the oxidase and KCN. The observations may be reconciled, however, by assuming that the cyanide may combine with the oxidase-cytochrome complex to render it more stable. This phenomenon is being investigated further.

(i) *Cytochrome Oxidase in Copper Deficiency.*—The cytochrome oxidase activity of tissue suspensions prepared from the livers, brains and kidneys of rats that had been rendered seriously copper-deficient has been estimated and contrasted with the activity of tissue preparations from control rats fed adequate quantities of copper. These assays revealed that the cytochrome oxidase in the liver reflected closely the copper status of the animals. In extreme cases of copper deficiency the cytochrome c oxidase activities of the kidney and brain tissues were similarly depressed.

(ii) *Arginase.*—A manometric method for the estimation of arginase activity in dispersed tissue suspensions from liver has been adopted in preference to those previously employed. This allows precise assays to be made with ease and rapidity. Partially purified arginase was found to be activated by manganese, cobalt, and nickel, the degree of response being in that order. This confirms previous observations. Copper in similar concentration was found to inhibit arginase completely. Preliminary assays have been made on the arginase activity of liver tissue from rats that had been maintained for three generations on rations very low in cobalt.

6. Chronic Fluorosis.

The experiment in which five groups each of six sheep have been provided with drinking water containing 0, 2.5, 5, 10 and 20 parts of fluorine per million respectively has now been in progress for over three years. Although there is some indication that the permanent incisors of the individuals which have been confined to water containing 10 and 20 p.p.m. fluorine erupted earlier than those of the other groups, the differences only just reached an acceptable level of statistical significance.

No lesions were discernible on the incisors of the control sheep. Slight roughening of the enamel was observed on the 4th pair of incisors of three of the group which received 2.5 p.p.m. fluorine, and on the 3rd and 4th pairs of incisors of individuals in the 5 p.p.m. group. All sheep in the 10 p.p.m. group erupted 3rd and 4th incisors which bore evidence of the mottled enamel characteristic of chronic fluorosis, and all the sheep in the 20 p.p.m. fluorine group had well-defined lesions on the 3rd and 4th incisors, and the 2nd pair of incisors of all except one individual were affected.

For the third year in succession there were no significant differences between the mean wool productions of any of the groups. It is evident that this range of intakes of fluorine in the drinking water will not very seriously affect the health and productivity of sheep in the course of three years. The experiment is being continued.

7. Minor Elements and Animal Nutrition.

The study of the functions of the trace elements cobalt, copper, and molybdenum in animal nutrition and of the limitations imposed on the health and productivity of animals and plants by soil conditions which lead to deficiencies of cobalt, copper, molybdenum, zinc, &c., has been continued in the laboratory and in the field.

(i) *Experiments in the Laboratory.*—(*a*) *Cobalt in the Nutrition of the Rat.*—Three filial generations of rats have been bred while confined to a diet containing a concentration of cobalt, $<0.03\gamma$ Co/g. dry wt., which would lead to the fatal consequences of cobalt deficiency in a sheep within a year. No signs of deficiency have appeared in the rats nor has their behaviour been in any way different from that of the control rats which have received generous supplements of cobalt. This experiment is being continued.

(*b*) *Copper Deficiency in the Rat.*—A diet on which young rats will develop the syndrome of extreme copper deficiency within six weeks has been evolved and a comprehensive series of experiments is being carried out to study various aspects of the role played by copper in the physiological economy of the animal. The mechanism of the interaction between copper and molybdenum is also being studied in the rat.

(*c*) *Analytical Procedures.*—A considerable amount of attention has been given to the chelate complexes which are formed between cobalt and certain organic structures, and to the microchemical estimation of cobalt. From these investigations the method of cobalt estimation previously evolved in this laboratory, which was capable of estimating 1γ Co in up to 100 g. of plant or animal tissue with an accuracy of 1 per cent., has been greatly simplified without loss of precision.

(*d*) *Copper and Molybdenum in the Nutrition of Ruminants.*—In the course of a study of the physiology of copper absorption and elimination a series of critical balance experiments have been conducted to investigate the influence of molybdenum on the retention of copper by the sheep.

(ii) *Experiments in the Field.*—(*a*) *At Robe Field Station.*—(1) *Cobalt Deficiency and Interaction of Copper and Molybdenum.*—A new series of experiments with 120 evenly matched Merino ewe weaners was started in December, 1947, to investigate (*a*) the part played by cobalt in the physiology economy of ruminants, and (*b*) various aspects of the interaction of copper and molybdenum in ruminant nutrition. These are proceeding.

(2) *Copper Deficiency and Wool Production.*—The experiment designed to study the effects of various degrees of copper deficiency on wool production by Merino sheep was completed after weaning the lambs in December, 1947. The profound effects of the copper supplements previously reported were maintained at shearing in October, 1947. The fleeces from the adequately supplemented groups (those which received 10 mg. Cu/day or more) had an appraisal value approximately double that of the fleeces from the unsupplemented animals. The values of the fleeces from the groups which received less than 10 mg. Cu/day ranged between these extremes according to the amount of copper in the supplement. The effects of the graded states of copper deficiency induced by the treatments on the capacity of the ewes to produce and support lambs and on the capacity of the ewes and lambs to store copper were studied in detail.

(3) *Grazing on Copper-dressed Pastures.*—Copper-deficient pastures at Robe which were top-dressed with copper in 1940 have supported normal lambings over

three generations but do not provide sufficient copper to prevent completely the copper-deficient lesion in the wool.

(4) *Grazing on Cobalt-dressed Pastures.*—Cobalt-deficient pastures at Robe top-dressed in 1940 with 1 lb. cobalt sulphate per acre continue to support mature ewes but do not provide sufficient cobalt to permit satisfactory growth of their lambs.

(5) *Copper Deficiency and Pigmentation.*—The failure of pigmentation in black sheep which have been rendered copper-deficient has been discussed in previous reports. The experiments to determine whether this function fails before the ability to impart crimp is affected are continuing. It is probable from the rather restricted range of observations that these functions are closely linked and possibly have a common origin.

(6) *Dried Liver Supplements and Cobalt Deficiency.*—It has been confirmed that supplements of 40 g. dried liver per day do not prevent either the course of the cobalt deficiency syndrome or its fatal termination in sheep on cobalt-deficient pastures.

(7) *The Mode of Action of Cobalt.*—The experiments to determine whether cobalt administered direct into the abomasum of sheep is as effective as cobalt administered *per os* have been continued. The results imply that cobalt exerts its effect equally in all compartments of the stomach. Experiments are being carried out to investigate this phenomenon.

(8) *Experiments to Illuminate the Effects of Various Treatments on the Storage of Copper and of Iron in the Liver.*—The liver biopsy technique has been applied in a series of experiments. Preliminary observations indicate that the massive stores of iron accumulated in the livers of sheep which have suffered profound copper deficiency for a long period are not readily dispersed by subsequent copper therapy. These observations are being continued.

Doses of sodium fluoride sufficient to induce symptoms of chronic fluorosis were shown to be without influence on the level of copper in the livers of mature sheep—they exerted no effect whether the sheep were or were not receiving supplements of copper.

It has been demonstrated by this technique that more than 90 per cent. of copper (10-40 mg. Cu) injected intravenously as copper sulphate is stored in the liver of normal sheep within 24 hours. A smaller proportion of the copper injected intravenously into copper-deficient sheep is stored in the liver—apparently under these conditions the remainder is taken up by other tissues.

(*b*) *Field Stations Other than Robe.*—(1) *Keith.*—A fresh flock of young Merino ewe weaners was introduced on to the copper-dressed pastures at Keith in March, 1948, and the copper status of these is being determined periodically.

(2) *Borrika.*—This station is typical of the areas where the symptoms of profound copper deficiency appear in the flocks only in certain seasons. During 1947-48, practically no signs of deficiency became apparent in the individuals of the experimental flock depastured there on untreated pastures.

(3) *Glenroy.*—This station is typical of the areas where symptoms of profound cobalt deficiency appear in flocks only in certain seasons. During 1947-48, the experimental flocks under observation there behaved normally.

(4) *Kybybolite.*—No signs of copper or of cobalt deficiency have appeared in the experimental flocks depastured in this area.

(iii) *The Distribution of Cobalt and of Copper Deficiency in South Australia.*—The experimental work and the collection of data necessary for mapping deficient areas in South Australia have both been completed and the maps are in the course of preparation. The publication of another information circular on this and other aspects of the practical application of the findings that was requested by the State Department of Agriculture of South Australia has been delayed pending the completion of the maps. This brochure, which will incorporate a précis of the knowledge obtained from the experimental studies and suggest the procedure by which this may best be applied, is being prepared for distribution by the State Department. It is a pleasure to record the close co-operation and help afforded by the officers of that department.

8. Minor Elements and Plant Nutrition.

The experiments which have led to the recognition that the productivity of very large areas of South Australia is limited by trace element deficiencies have been discussed in previous reports. The continued observation and quantitative assessment of the productivity of experimental plots sown in 1944 and in subsequent years have proved unequivocally that if appropriate dressings of superphosphate containing copper and zinc are applied, high-yielding mixed pastures may be established on the singularly deficient Laffer sands of the Ninety-Mile Desert. It is now clear that approximately 3,000 square miles of terrain which hitherto have been considered either worthless or very seriously limited in value may be brought into profitable bearing. The cost of development of this terrain is comparatively small. Initial dressings of zinc sulphate and copper sulphate costing approximately 5s. per acre have been proved to correct the zinc and copper deficiency for at least four years and probably these will suffice for much longer. These constituents are added to the superphosphate when sowing. The responses have been dramatic and the development of subterranean clover (Bacchus Marsh var.) and of other species has been extraordinary. The value of the Ninety-Mile Desert for the extension of agriculture is now obvious and development of this area which has always been a barrier between the rich lower south-east and the rest of the State will enhance very materially the productivity of South Australia.

Experimental Work on the Mineral Nutrition of Plants in the Ninety-Mile Desert.—A detailed report has been published (Bulletin No. 234) discussing the experiments that have proven that high-yielding pastures consisting of subterranean clover (Bacchus Marsh var.), lucerne, and Phalaris may be established and maintained successfully on the Laffer sands by addition of zinc sulphate and copper sulphate to the dressing of superphosphate applied at seeding.

An extension of these investigations has demonstrated that high-yielding mixed pastures can be established on the poor Laffer sands under a cover crop of wheat or oats—crops which produce payable yields of grain which contribute materially towards the initial costs of clearing and sowing the land. The initial dressings of zinc sulphate and copper sulphate each applied at 7 lb. per acre have been found to correct the deficiencies for the period of observation which at this juncture is four years. Further addition of zinc and copper is unnecessary for at least this period whether or not a cover crop has been grown.

The findings from experimental investigations which are proceeding render it more and more apparent that a deficiency of zinc and copper is general in the sandy soils of the Ninety-Mile Desert, and that the correction of these deficiencies will enable valuable mixed pastures to be established on soils which were formerly considered almost worthless. Reports concerning various aspects of these investigations have been submitted for publication.

9. Accessory Food Factors and Food Composition.

During the year the investigation of the methods for the determination of thiamine in cereals and bread was completed. A critical method was evolved and it has been applied to a survey of the thiamine content of the bread available in Adelaide. The results of these investigations have been submitted for publication.

At the invitation of the Editors of Nutrition Abstracts and Reviews a review on the influence of the milling process upon the nutritional value of wheaten flour and bread has been prepared and sent to the United Kingdom for publication.

10. Analytical Chemistry.

An analytical section has been organized to deal with the very large number of chemical estimations involved in the various research activities of this Division. The duties of this section will be twofold: to evolve analytical techniques suitable for the problems, and to conduct the major bulk of the semi-routine analyses.

11. Equipment.

The laboratory has been equipped with the apparatus necessary for the critical quantitative estimation of radioactive isotopes. Supplies of Co^{60}, C^{14}, &c., have been procured from the Atomic Energy Commission of the United States of America and are at present being used as tracers in a number of investigations. A modern quartz spectrophotometer and the latest type of polarograph were installed during the year to facilitate analytical procedures.

VI. SOILS INVESTIGATIONS.

1. General.

For the past four years a considerable portion of the activities of the Division of Soils has been occupied in the examination of areas for land settlement under post-war conditions. It appears now that the demand is diminishing and that an increasing amount of time will be available for studies in pedology and soil problems of a physical, chemical, or microbiological nature rather than those directed to land-use values. The selection of land for more intensive settlement has extended the information on many areas of Crown land of relatively low fertility which advancing knowledge has shown to be satisfactory for large area farms, particularly for sheep grazing purposes. One result which has been particularly valuable has been the development of techniques of reconnaissance soil survey and their application over large areas.

The year has seen solid advances in the work of the Soil Chemistry and Soil Physics Sections in the following up of problems brought forward by the Soil Survey Section or by other Divisions of the Council, or State agencies. Of these the relation of soils to building foundations, the structural characteristics of soils in the field, the relation of soil to plant growth and animal health arising from the research on toxaemic jaundice of sheep, are good examples. Close collaboration is sought between the field and laboratory workers and as a policy the latter now spend periods with the soil survey teams to become acquainted with the problem they are investigating in the laboratory.

Close liaison has been maintained with a number of State Departments of Agriculture, Irrigation Commissions, Lands Departments, and War Service Land Settlement agencies, both State and Commonwealth. In New South Wales and Western Australia a beginning has been made in co-ordinating soil survey investigations in the respective States by the setting up of an Advisory Committee on which the Division of Soils is represented, and it is hoped this policy will become general in all States.

The survey work of the Division has very largely been occupied in "service" work on behalf of various State and Commonwealth bodies requiring evaluation of land quality for the forming of opinions on its suitability for closer settlement and the better statement of the problems confronting development. Such work has constituted a large part of the survey activities since the initial organization in 1927. It is earnestly desired to reduce the amount of this type of survey work and set free a proportion of the pedological staff for scientific study of problems in soil genesis and morphology and the mapping of broader groupings of soils over the whole of Australia. The aim is to produce a soil map of Australia of both academic and practical value employing broad mapping units but of considerably more detailed form than the zonal groups used in the map published in 1944 by the Council. The work has been limited only by the shortage of skilled pedologists and it is true to say that soil science is heavily handicapped by lack of suitable research personnel.

Following the policy of decentralization, a regional unit has been formed for Queensland and northern New South Wales centred at Brisbane. The head-quarters are at the laboratories occupied by the Council at St Lucia within the University. This makes the fifth of a chain of regional centres in southern and eastern Australia linking Perth, Hobart, Deniliquin, Canberra, and Brisbane to head-quarters at Adelaide. North Australia is still served from Adelaide.

The activities of the Division are divided between four Sections—Soil Survey and Pedology, Soil Chemistry, Soil Physics and Mechanics, Soil Microbiology.

2. Soil Survey and Pedology.

Surveys have proceeded in all States of the Commonwealth and in the Northern Territory. These have varied from highly detailed surveys to very broad reconnaissances, the type being suited to the objective of the work and the staff and time available. In aggregate 2,600 square miles have been covered by mapping in 1947-48, of which 410 square miles were in moderate detail, and 185 square miles in intensive form; the balance was mapped in broader categories. These figures exclude the traverses made on the Barkly Tableland of North Australia of which no soil map was issued pending further investigations in 1948.

(i) *New South Wales.*—Survey proceeded on the Hunter Valley unit of 200 square miles between Scone and Denman, some 75 square miles being completed in the northern end. The objective is a pedological study of the soils of the country bordering the Hunter River flats which were intensively mapped in 1946. The land formation is of considerable interest from the diversity of soils represented, their relation to parent geological material, and the effects of erosion now very evident from overgrazing. Mineralogical studies have proceeded on soils collected from the survey to ascertain the process of weathering and the correlation of soil occurrences with parent material. Relatively little work of this type has been done in Australia as a means of studying soil genesis, and the investigation in field and laboratory is an experimental approach as far as the Division is concerned.

The problem of fertility status of the basaltic soils in the Lismore District was followed up intensively in the field by survey of limited areas and a parallel study in a mobile laboratory on certain soil characteristics, particularly pH, nitrogen, and organic content. The field work was recently resumed for the current year. The original project dealing with the red soils has been expanded to cover black, brown, and transported basaltic soils also. It is hoped to map the district occurrences accurately and make full examination of their field

characteristics in 1948. The suggested decline in fertility is also under review. Collaboration of the Division of Plant Industry in pot experimental work and the New South Wales Department of Agriculture in chemical work and general liaison has been maintained.

At the instance of the Irrigation Commission of New South Wales and the Closer Settlement Board, a highly detailed survey was made of 20,000 acres of high ground adjoining the Coomealla Irrigation Area near Wentworth. There is a considerable area of superior quality land for horticultural development in the unit and the survey defined the types of soil and their pattern of distribution so that any development could be soundly based. An extension of the existing settled area is proposed but there is a much larger area of suitable land available if engineering design and market possibilities prove economic.

The Deniboota Irrigation Area near Deniliquin was further mapped and about 140,000 acres have now been covered. This area is a potential new unit for irrigation and the survey has shown the quality of the soils and their problems and the complex occurrences of types and phases. The question of such soil variability over short distances has been studied, particularly as it relates to irrigability affecting land use and to the manner in which soils may best be classified and mapped in this region.

A small unit of 15,000 acres at Woodstock on the south-western slopes was surveyed in connexion with toxaemic jaundice investigations. The significant feature is the relation of the soils to copper-bearing rocks which could affect the mineral composition of pastures causing the disease. Experimental work with sheep on selected portions decided by the survey is now under way by the Division of Animal Health and Production.

Land settlement of ex-servicemen on resumed estates in the Riverina irrigation areas has called for the survey and evaluation of further areas on the basis of which suitable subdivision may be ensured.

Regional surveys on a broad scale have been undertaken in the south-west of New South Wales and in the Macquarie and Bogan River areas comprising the Macquarie Region in the central part of the State. This work is regarded as of considerable importance, but, owing to the demands for service work, progress has been relatively slow until recently.

(ii) *Victoria.*—The field study of the local area of 70 square miles near Coleraine has now been completed. This is a joint investigation of the problem of land slips, gullying and deposition which have characterized erosion in the district. The Victorian Department of Agriculture and the Victorian Soil Conservation Board have co-operated in the work. Erosion control must be concerned with the two separate problems of gullying and siltation, and of land slips; the former is related to the usual factors of land use and uncontrolled run-off and the latter to wider causes probably connected to water intake on adjacent tableland country at higher levels, which is a difficult feature to deal with.

(iii) *South Australia.*—The survey of a unit of 350 square miles in the Northern Marginal Lands region in the Wilmington-Willochra district was continued in collaboration with the Department of Agriculture. This work which is confined to cooler months of the year was carried forward over 200 square miles and the remainder will be completed in the forthcoming year. The object is twofold; to study the pedology of the soils in a region of wide climatic range where the desert loam soils are typically developed, and to study the incidence of erosion on the landscape with its implications of land use. The ecology of the area is also being worked out.

The new Loxton Irrigation Area has been examined in very close detail in an attempt to define the actual planting design of farms and the subdivisional plan. This is a joint project with the Department of Agriculture undertaken in an endeavour to plan the whole settlement on the soundest lines to ensure profitable occupation by settlers. Time alone will show how effective this work has been.

Surveys of some estates in Adelaide proposed for mass building of houses by State authorities have been made. This ties in with the study of soil and foundations mentioned below. (*See* Soil Physics Section.)

(iv) *Tasmania.*—The large swamp areas in the north-west of the island have been under examination for four years, the delay being chiefly due to adverse weather conditions preventing access and maintaining the swamps in a wet state. A reconnaissance survey of the 50,000 acres of Montagu Swamp has now been completed and samples collected. There is a very much larger total swamp area in the region and the major task of drainage, clearing, and development turns on the results of the survey as to type and suitability of the soils. Confirmation of opinions is required from the laboratory examination of collected soil samples before the evaluation is made.

(v) *Western Australia.*—The principle of examining large areas by making close surveys of selected units and linking these together by wider traverses has been well developed in this State. The region dealt with recently was the Tone River district in which several older and two new "spot" surveys were used to characterize the soil pattern. Reconnaissance mapping has advanced over 1800 square miles in the region, mainly using broader groups of soil types known as "associations". This compilation has proved extremely valuable to the War Service Land Settlement authorities in selecting to good advantage units of country for closer examination and subdivision. The great advantage is the perspective obtained of soil distribution in broad mapping units in a relatively short period of work. The policy is to extend this type of mapping over all the wetter south-west of the State.

(vi) *Queensland.*—The first project undertaken by the Division commenced recently in the Burdekin Valley. It has been proposed to dam the river and make use of the water for extended irrigation in the valley and delta. As a first step the soils are to be classified and mapped and this is expected to occupy about three working seasons in the valley. The field unit is operating from the new regional centre set up at Brisbane.

(vii) *North Australia.*—The reconnaissance survey of the Barkly Tableland and adjacent coastal belt proceeded during the winter of 1947 and has been resumed in 1948. The party includes a soils officer from the Division, who has prepared a report on last year's preliminary traverses. The present soil reconnaissance deals with the area of the Barkly Tableland proper, the desert fringe to the south, and the coastal region from Burketown to Borrooloola; the western boundary is the north-south road between Tennant Creek and Daly waters.

3. Soil Chemistry Section.

Co-operative investigations designed to elucidate some of the soil factors associated with the occurrence of toxaemic jaundice, have been continued to assist the Division of Animal Health in its study of this problem. A more detailed study of the Barooga Field Station and an adjoining property confirmed the wide variability in soil reaction noted in an earlier survey. On one soil type at the field station the reaction of the surface soil varied by over 3 pH units. Consecutive samples, taken on a 4-chain grid spacing sometimes differed by 2.5 pH units. Variability was still very marked when

samples were taken on a closely spaced grid within an area of a few square feet. The data obtained were used to design a system of sampling for the study of seasonal variations in soil reaction. For comparative purposes similar work is being carried out on a small area at the Waite Institute, Adelaide.

A large series of subterranean clover samples, representative of the Adelaide Hills and part of the south-east of South Australia were collected and analysed for copper and molybdenum, for comparison with a similar series collected in Victoria by the Division of Animal Health and Production. During the course of this survey several samples of extremely low molybdenum status were noted but there was no field indication that, even at these low levels, molybdenum was a limiting factor in the growth or yield of the clover. The survey did not include samples from areas known to give responses to molybdenum. A spectro-chemical survey is also being made of these and other samples to ascertain the normal amounts of the different trace elements present. Further work is in progress on some of the factors controlling the availability of copper and other trace elements in the soil.

During the soil and fertility survey of the basaltic red loams of northern New South Wales the mobile laboratory was stationed at Wellongbar for some months. Over 2,500 soil samples were collected and examined for pH. In addition to reconnaissance samples, eighteen selected areas, each of about 20 acres, were sampled on a systematic grid pattern and maps and graphs prepared to show the normal range of variation in soil reaction. Variability from spot to spot in each area sampled was considerable. This variability was greater in two areas of virgin scrub than in the adjoining areas of developed pasture. About 500 samples have been brought back to the laboratories for more detailed examination.

A series of soils from the Moss Vale pine plantations was examined for their phosphorus status. It was found that these soils were low in available phosphorus and had an extremely high phosphate fixation capacity. This probably accounted for their lack of response to ordinary applications of superphosphate.

Spectrograms have been taken of samples representing a number of typical soil profiles to obtain the distribution and amount of the more important trace elements present. This information, when complete, will give a useful geochemical background to certain major soil types. The flame spectrographic method has been in continuous use throughout the year for the determination of exchangeable cations in soils and has given very satisfactory results. Several spectrochemical analyses have also been carried out for other organizations to assist them in investigations in progress.

Much progress has been made in developing quantitative spectrochemical techniques for use with soil and plant samples. Success has been achieved in the use of suitable methods of background correction to enable the quantitative determination of elements such as molybdenum when present in plants in amounts of the order of 0.01 to 2 p.p.m. Comparison of chemical and spectrochemical values on a large series of samples showed that the spectrochemical technique could now be relied upon to give results of a good order of accuracy.

Routine descriptive analyses of the large number of soil samples collected by the survey parties continued to occupy much time. In addition to the very large number of samples taken in connexion with the various soil reaction surveys already mentioned, more than 1,500 soil samples were received during the year. Soils from some of the northern Australia surveys presented new difficulties, requiring modifications in some of the methods in use. Analytical methods have continued to receive close attention. The introduction of the plummet balance and the automatic sand-washing equipment has considerably speeded up the process of mechanical analysis.

4. Soil Microbiology Section.

The principal work has centred on studies of the genus *Rhizobium* and the symbiotic fixation of nitrogen by it in association with leguminous plants. Inoculation commercially of bulk seed of leguminous crops before sowing is made with pure cultures of the specific strain required. Glasshouse experiments under controlled conditions were made with *Rhizobium meliloti, Rh. trifolii* and *Rh. leguminosarum* to determine whether better inoculation was achieved using an inoculum of mixed effective strains or one derived from a single effective strain. The data do not indicate any significant advantage when using a uniform seed sample of a single species of plant. It is known that a given bacterial strain varies in effectiveness of nitrogen fixation over the range of host plants in the group it is capable of infecting, and, in addition, there is considerable heterogeneity in various commercial seed samples of legumes of agricultural importance. It is therefore thought that the glass house results may not apply to field conditions and that cultures of mixed strains of the specific organism may be more effective than a pure strain in actual practice. Before any recommendations could be made it would be necessary to test out the hypothesis with field trials.

A large culture collection of various strains of *Rhizobium* is maintained, and cultures have been supplied on request to overseas and interstate distribution services. In addition to these there has been a consistently heavy demand for commercial cultures from growers in South Australia, and some 1,700 such cultures for seed inoculation purposes have been supplied this year in comparison with 1,500 in the previous year. The growing demand for commercial cultures has necessitated improved methods of handling and distributing them since the heavy demand is mostly restricted to periods of autumnal and spring seedings. In this direction experiments have been conducted which have led to a rapid method of inoculation of bottled sterile media using a specially designed atomizer spray activated by compressed air.

Organisms similar in character to *Bacillus polymyxa* have been isolated from a number of clay subsoils, some, but not all, of which have shown mottling or a tendency to glei formation. These organisms are capable of reducing ferric oxide both fixed and free in the clay crystal lattice to the soluble ferrous form with accompanying decolorization from various shades of reds and browns to modifications of greys and whites. These organisms have been isolated in pure culture, but under such conditions the reduction is not nearly as vigorous as in mixed cultures. The physiology of the organisms concerned is being studied with a view to determining the factors controlling reduction, and of these the amount and nature of organic matter is believed to be the principal limiting factor governing the participation of iron in their metabolism.

5. Soil Physics and Mechanics Section.

(i) *Infiltration of Water into Soil.*—Small sprayed and flooded plots are commonly used to determine the infiltration characteristics of soils. They provide useful comparative data but, because of the lateral movement of water by seepage beyond the limits of the plots, infiltration rates obtained in this way are not representative of large areas wetted by rain or irrigation water. It has been found that relatively large plots are required, greater than 10 feet in diameter in most soils, before this lateral spread is reduced to negligible proportions. It is not always practicable to use such

large plots as these and methods for preventing or correcting for lateral movement have been investigated. Wetted buffer zones surrounding the test plot were found to be effective with spray applications but not with flood applications. A correction factor was worked out which when applied to results from small unbuffered plots made most of them virtually independent of size of plot and the results more applicable to large wetted areas. This factor is based empirically on the fraction of the total applied water found immediately below the test plot at the conclusion of the application.

The above experimental work was conducted on the sandy types of soils in certain irrigation areas in South Australia. A further point raised was the possibility of changes in the rate of infiltration after a prolonged period of irrigation. Tests made at Berri, Barmera, and Loxton showed that after 25 years of irrigated culture there was no serious decline in the rate of absorption such as had been reported with heavier soils in New South Wales. This does not cover the whole texture range of "mallee" soils but should apply to light or moderately light and sandy types.

Expressions to show the relation between the period of application of water to a soil surface and the quantity entering the profile have been worked out. The relationship can best be represented by an equation based on the rate of entry approaching a constant value after the initial period of high absorption.

(ii) *Electrical Measurement of Water Content and Temperature of Soils.*—The electrical resistance of small blocks of gypsum can be used as an index of the water content of soils in which they are embedded. The conductivity of the blocks is related to temperature and a special electrolyte thermometer which has been designed by the Division can be buried *in situ* with the block and be used to measure temperature and conductivity at the same time. These instruments are now being used extensively in the investigation of moisture fluctuations under house foundations. Other installations have also been made in co-operation with the Highways and Local Government Department, South Australia, at various positions under a paved road. The method is also of considerable interest in regard to agricultural problems and co-operative work has been carried out with the Department of Agronomy at the Waite Institute on the construction, calibration, and characteristics of the gypsum blocks. A nomogram has been prepared to permit easy correction of observed resistances to a standard temperature of 20° C. An officer has now been located temporarily in the Building Research Section for research on the composition and improved design of blocks similar to the gypsum type now in use.

(iii) *Retention of Water in Soils.*—Investigations have continued into the forces operating in soils affecting water entry and water availability to plants. Evidence has been accumulated from field and laboratory experiments on the low tension to be found in soil water at field capacity. Apparatus has been set up for measuring the water retained at various tensions created by subjecting the soil sample to variable conditions of pressure by the application of gas under pressure to the system. It is expected that this will facilitate various measurements including the indirect measurement of field capacity and wilting point of soils.

(iv) *Evaporation of Water.*—In co-operative work with the University of Adelaide at the Waite Institute, a series of daily observations has been made with a Piche evaporimeter over a period of four months. These observations have been compared with those obtained from a standard tank evaporimeter. The Piche evaporimeter consists essentially of a graduated glass tube with one end closed, and the open end covered with a filter paper disc which is clamped on. The amount of evaporation from the paper surface is given by the change in water level in the tube. Very high correlations were found to exist between the Piche readings and daily mean "wet bulb" saturation deficit which was continuously measured by a recording hygrograph. The close inter-relation of these two quantities suggests the possible use of the Piche evaporimeter as an instrument for giving accurate estimates of daily mean saturation deficit.

(v) *Soil Colloids.*—X-ray studies have continued on the clay minerals present in soils. The group of solonized ("mallee") soils was selected for the initial project and the research is approaching completion. It has been found from X-ray diffraction and associated investigations that illite is consistently present in mallee soils and in fact represents about 75 per cent. of the clay minerals of these soils. Illite has not been recognized as a major clay mineral in many soils by overseas workers and its consistent presence in mallee soils in high amounts is a matter of some interest. The samples being used in these X-ray studies came from representative solonized mallee soils in Victoria, South Australia and Western Australia.

In this work a method is being used which permits the approximate determination of the relative proportions of each mineral occurring in a sample. The technique is empirical and consists in preparing various mixtures of standard clay minerals the patterns of which are compared with those of the soil colloids. Since size and degree of perfection of the crystals are unknown factors that also affect intensity of line development, the method is only semi-quantitative. The samples of soil colloid are treated with glycerol to intensify the diffraction lines of one of the common minerals—montmorillonite. Without this treatment the lines may vary in intensity depending on the water content of the colloid. Additional information regarding identification of the colloids from mallee soils is being obtained by measurement of the absorption of water vapour and the dehydration of the colloids upon heating.

(vi) *Soil Structure.*—There appears to be a widespread awareness of the importance of soil structure in relation to maintenance of fertility and the establishment of pastures as well as its effect on permeability to water. The Division has been engaged on aspects of this research for the past two years.

Some difficulty is found in establishing pastures under irrigation on certain soils in the Riverina district of New South Wales. Experiments are being conducted by the Division of Plant Industry to find what effect prior cropping of the land has on establishment of subsequent pastures. At the same time the possible effect of such pretreatments on soil structure has been examined by the Division of Soils, since it is considered that the difficulties of establishments are associated with unfavorable soil structure. It has been found by examination of collected samples that no improvement in the stability of the soil structure resulted from prior cropping to wheat, oats or rice for one year. Structure measurements are also being made in relation to long-term horticultural and agronomic experiments. In the Murrumbidgee Irrigation Area changes in structure are being followed in a soil reconditioning experiment being conducted by the Council's Irrigation Research Station at Griffith, New South Wales. Similarly on the Wagga Experimental Farm of the Department of Agriculture, New South Wales, the initial conditions of soil structure have been established prior to the commencement of a rotation experiment to be conducted during the next twelve years by the Council's Division of Plant Industry, in co-operation with that department.

(vii) *House Foundations.*—Further reports have been made for the State housing authorities in Melbourne and Adelaide on the soils of acquired estates on which they have been planning to build large numbers of houses. Soil maps have been provided together

with a description of the physical properties of the soil affecting the design of foundations. Altogether in the past three years 4,000 acres have been covered in these surveys including 1,400 acres during the past year.

The programme for measuring moisture and volume change under house foundations has been greatly expanded following the erection for this purpose of six huts in the suburbs of Adelaide by the Housing Trust of South Australia and four huts in the suburbs of Melbourne by the Housing Commission of Victoria. In addition three further sites are being used for these measurements, one of these being in Sydney, where co-operative work on moisture measurement is being done with the Commonwealth Experimental Building Station. Readings associated with the Melbourne installations are being undertaken by the Council's Building Research Section. At all these sites, devices for measuring seasonal and progressive changes in moisture and temperature have been installed. In addition, a start has been made on the installation of apparatus for measuring actual soil movement at various depths which is directly concerned with the stability of walls and possible cracking. It is hoped in this way to obtain information on the behaviour of various types of soil accompanying changes in water content which it is presumed occur during the wet and dry seasons of the year. Information will be obtained in each case on the depth to which significant changes occur in water content and soil movement, which should assist in determining the design of foundations.

6. Overseas Research.

Three officers of the Division have been overseas in the past year and are still abroad. One is studying the pedology of the zonal soil groups in America and Europe, particularly their characteristic morphology and genesis in comparison with similar or specifically Australian groups already defined here. One officer is engaged on research at Rothamsted Experimental Station on the comparative longevity and effectiveness of pure strains of *Rhizobium* inoculated into soils under field conditions whereby they come into active competition with other strains in a natural environment. The third officer is engaged on research in soil mechanics, principally at the Building Research Station, Watford, England, in continuation of studies on soil changes under varying moisture conditions associated with building foundation.

VII. IRRIGATION SETTLEMENT INVESTIGATIONS.

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

1. General.

The staff of the Merbein Station, depleted during the war, has now been built up to a number greater than in pre-war years, an additional six officers having now been appointed. The chief activity in the past year has been the initiation of a range of investigations relating to the major problems of the irrigated lands of the middle and lower Murray lands, to the economic plants grown in these areas, and to the processing and care of the products.

The dried fruit industry, after three successive years of low production, had a favorable season in 1947-48. The productivity potential though not high, was fully realized at a yield about 15 per cent. below that of peak years.

The Advisory Committee of the Station, which held two meetings during the year, stressed that the maintenance of productivity has always been the greatest problem of irrigated lands and asked for increased concentration by the Station on investigations relevant to the usage of water, the maintenance of fertility of the soil, and the reclamation of land exhibiting soil wastage resulting from irrigation. During the year an examination of the chief areas affected in this district has shown that in most cases the decline is due to well-known causes, mainly excessive irrigation causing salt and seepage. The problem of reclamation has been a major project of the Station for many years and considerable success has been achieved by agricultural drainage, following investigations in regard to the depth and spacing of the drains. A residual problem of early settlement is the establishment of horticulture on major soil types of heavy texture not now considered suitable for certain horticultural plants. These areas are relatively of minor extent, and where, following investigation, it has not been possible to envisage any methods by which the yield of plants on such soils can approach the average of the light-textured soils, abandonment of the units with replacement areas for the settlers concerned has been carried out over past years. The lands abandoned for horticulture have a definite research interest, and preliminary investigations include a study of the physical and chemical soil changes.

The irrigation areas in which investigations are proceeding include Renmark (South Australia), which presents special difficulties in that the responses of major soil types to agricultural drainage are too feeble to warrant the expense. A similar problem exists in portions of the settlements of Lyrup and Berri (South Australia) and in Curlwaa (New South Wales). The Station is also examining, in co-operation with State officers, the reclamation problems of the Tyntynder and Cohuna districts (Victoria), and the Wakool district (New South Wales). These districts are used for pasture production, and present a special problem in that the value of the produce is not considered sufficient to warrant the expense of reclamation works.

Advancement has been made in the development of methods for the more precise measurement of irrigation waters, and a gauging unit for the standardization of water meters is being assembled.

In the soils and land-use section long-term investigations have commenced on nitrate fluctuations, field fertilizers, and the relationship of the health of citrus trees to the soil types on which the trees are established. Studies of the entry of irrigation water into soils of various types, the soil moisture changes, and soil treatment in relation to physical properties are also in progress.

Investigations for industry have included a soil survey of small areas for irrigation expansion and the examination of sultana buds for estimate of potential yield and for pruning modifications.

Fruit processing requisites, particularly oils, are still in short supply, and methods of processing need annual examination and revision.

A biology section, recently organized, is continuing the collection and study of insects of economic interest and control methods. Plant work includes weed control, field trials with synthetic growth regulators, and the study of the hormone physiology of the grape vine. The mineral deficiencies have in general proved difficult to diagnose by examination of the plant, but certain deficiencies have been disclosed by field trials in specific soil-plant environments.

An organized field trial on citrus trees, including the use of compost, has been commenced in co-operation with the Victorian Department of Agriculture, and on this plot precise data are being obtained in regard to the mode of growth of citrus branches and fruit. The Station is a unit in the vegetable investigations organized by the Vegetable Problems Committee of the Division of Plant Industry, and has undertaken variety trials, plant breeding and selection, irrigation requirements of tomatoes, and glasshouse culture.

2. Irrigation and Reclamation.

Reclamation investigations in the Swan Hill district have taken the form of surveys in which the association of a high water-table and pasture decline has been noted. The survey is now being extended to the sub-soil horizons in order to determine the relation of underground water to the River Murray. A salted area of land in the Wakool district has also been examined; and it is noted that, where subsoil aquifers of sand exist, salt damage has occurred to distances up to seven chains from the irrigated lands and the adjacent channel.

Investigations in regard to a method of draining sand beds which underly the surface of the Curlwaa and Renmark irrigation areas are in progress.

Lines of test wells have been established at Renmark to determine the nature of the general water-table of that district. It has been found that the general subsoil water level tends to recede to river level during winter, whilst no irrigation water is being applied to the land, but tends to rise towards the surface during spring and summer while irrigation is proceeding. This rise and fall of the water-table suggests an appreciable amount of natural drainage throughout the area, and careful control of the quantities of irrigation water applied should considerably lessen the height of rise of the general water-table and thus lessen the deleterious effects on the soil of a high water-table. At Curlwaa a site has been chosen where a well was previously sunk into the sand to a total depth of 12 feet. Test well lines extending 10 chains away from the well have been read at weekly intervals to establish the normal water-table level prior to pumping from the well.

An investigation of the water distribution of movable and fixed spray installations has been conducted. The trials on the movable type spray were made in the open while those on the fixed type were made amongst established citrus trees. The distribution patterns in practically all cases examined were considered satisfactory, and on this account the capital cost of installation and the cost of maintenance and operation are more important in assessing value.

A meter consisting of a rotor operating in a length of 15 inch diameter pipe has been used to measure water on to the Station vineyard throughout the last irrigation season. The performance of the meter has been found satisfactory for the measurement of water in channels in experimental plots. A gauging station for the calibration of meters is nearing completion; it consists of a diversion from a main drain outfall to a length of channel fitted with a Parshall flume, and other necessary structures.

No standard apparatus or method for the determination of infiltration rate has yet been adopted by various workers. The widely used Mariotte tube principle has been adopted for supplying the water to the soil, and investigations have been made of the effect of the area of wetted surface, buffering, and depth of the guard ring on the infiltration rate and the variability of results. It has been found that normal statistical methods are not applicable to the analysis of results where the method employed greatly affects the magnitude of these results. An unbuffered ring 100 sq. inches in area has proved suitable for the determination of infiltration rates over a wide range of soil types. It has been used in a comparative study of adjacent irrigated and non-irrigated soils. It has also been used in a study of the irrigation potentialities of a range of typical mallee soil types.

Investigations of the water requirements of tomato plants have been continued and the results obtained are being statistically examined. The trend is that less frequent watering of tomatoes is beneficial.

3. Land Use.

Further soil survey work has been carried out on minor areas, on account of urgency for irrigation settlement and to relieve the Division of Soils. Detailed survey of 750 acres in this district and in the Nyah-Woorinen district and a preliminary survey of 1,600 acres for the First Mildura Irrigation Trust have been completed and reported on to the appropriate authorities.

For the work on relationship of citrus growth to management and soil type, air photographs taken in 1933 and in 1945 have now come to hand and soil maps have been transferred on to them as the first step in the analysis of the data. It is established that the health of citrus trees is associated with minor variations of soil type, and the investigation is planned to examine this association more precisely.

In the Wakool district, Riverina, New South Wales, pasture plots including standard pasture mixtures have been established on each of the five major soil types. The results during each of the first two years indicate wide differences in production value associated with the soil classifications.

At Woorinen the vine health survey was continued in order to gauge the effectiveness of drainage and again indicates that only one of the four major soil types shows a significant response to drainage. This confirms previous physical measurements in reference to movement of water to the drain.

Two areas on difficult types are being prepared for experiment in "renovating" land which has failed under sultana vines. Flood irrigation and the growth of pasture and forage crops are the main "renovating" agents to be tried, and the land is being graded for this purpose. Preliminary soil samplings are being carried out.

A similar problem in its earlier stages is being defined at Bungunyah, where high chloride content in vine leaf samples indicates a salt problem.

In order to examine the irrigation of pastures by drainage water containing injurious salts, an area at Karadoc (south-east of Red Cliffs) on river flat country has been suitably laid out. A series of soil samples has now been analysed to give a picture of salt status before irrigation begins, and the percentage of soluble salts in the water used for irrigation is recorded.

4. Horticulture.

The three general manurial trials—one at the Station, one at Red Cliffs, and one at Woorinen—have been maintained, the Woorinen trial having been harvested this year for the first time since 1941. Results from the last two harvests are all now being analysed by the Mathematical Statistics Section, but it is obvious that in the Woorinen trial a reduction of yield with ammonium sulphate, first noticed in 1941, has continued. This will be a special subject for investigation next year.

A new manurial trial was laid out at the Station in autumn, to compare various times of application of nitrogen as ammonium sulphate, namely, dressings in autumn, early spring, and late spring, respectively, and split dressings.

In preparation for more extensive nitrate work on vines, the nitrate status of tomatoes in the frequency of irrigation trials was examined throughout the summer, but, in the layout adopted no differences in nitrate due to watering were found.

The tendency of non-setting of the grapes of the Gordo Blanco vine (Muscat of Alexandria) has been further examined. The individual grapes of small size are invariably seedless, in contrast to larger berries with normal seeds. This feature is acknowledged internationally to be an inherent characteristic of the variety, and field experiments have shown the disability

to be less evident when the nutrition of the vine, including trace elements in some environments, is maintained at a high level.

Iron chlorosis investigations have been continued. A study is being made of the relationship between soil pH and seasonal changes in the pH of the sap of different portions of both healthy and chlorotic currant vines, with a view to gaining information which may have some bearing on the availability of iron within the vine. Further evidence has been obtained to show that chlorotic currant vines can be considerably improved by restricting cultivation to a minimum, and allowing a cover crop or weed growth to remain during the spring and early summer. The swabbing of pruning cuts with a 20 per cent. ferrous sulphate solution was also beneficial. In the case of chlorotic fruit trees, a marked improvement of the health of the trees occurred on one site, following the planting of lucerne as a permanent cover crop, once again showing the beneficial effect on chlorotic plants of the presence of other species.

Tests were carried out on a fan designed by the Division of Aeronautics to give protection against frost damage by air disturbance over the area to be protected. The Division of Radiophysics provided temperature-measuring equipment consisting of Sanborn elements made up to resemble young vine tendrils to record air temperatures, and balloon gear to obtain the inversion temperature pattern was also used. The trend was for the area of protection given by the fan to be strictly limited, but further tests of the equipment will be made.

5. Plant Work.

In May of each year the buds of 100 sultana canes from the Mildura district are microscopically examined to determine whether they contain potential bunches. The figures for May, 1948, revealed a further decrease in fruitful buds to 33 per cent., compared with 44 per cent. in 1947, and 52 per cent. in 1946. In view of this low result, a further sample of canes from the Mildura district was examined and gave a comparable result, as did also canes from the Nyah-Woorinen and Renmark districts.

Special pruning methods have been advocated to leave more potential bunches on the vine than would be left by the normal pruning practices. Trials have been laid out at the Research Station and at Woorinen to determine the effect of these pruning methods on bud burst, bunch count, and yield of fruit.

Small-scale weed control trials on some of the most important weeds in the irrigation area were continued using various types of weedicides. Hardhead (*Centaurea picris*) has not been controlled. The above-ground portion of the plants has been killed by power kerosene, also by an oil product containing phenol and mineral oil, and by "Atlacide", but regrowth occurs with all treatments. "Methoxone" to date has not shown much promise on this species, but there is every indication that a properly timed application will eradicate hoary cress (*Lepidium draba*). The other weedicides mentioned above will kill the aerial part of the plant, but regrowth occurs. Bindweed (*Convolvulus arvensis*) has been controlled but not eradicated by "Methoxone".

For vitamin C determinations of tomatoes, grown at the Red Cliffs vegetable plot, different methods of preparation of the sample have been used in each of three seasons, namely (*a*) expression of the juice and decolorization by filtering, (*b*) grinding with acid washed sand, and (*c*) dispersion with a Waring Blendor. Conflicting results were obtained, and for the 1947-48 season the three methods were compared on one sample of tomatoes. Method (*a*) gave a significantly higher ascorbic acid content than (*c*) at the 1 per cent. level, and (*c*) gave a significantly higher result than (*b*) at the 2 per cent. level.

One year's observations on the growth of one branch from each of 115 citrus trees on a block in Merbein have now been completed. The plot includes Navel oranges and Valencias. The shoots of spring growth have been classified into several types on the basis of flowering habit. Increases in the length of shoots and areas of leaves have been measured. Leaves produced by summer and autumn growth proved considerably larger than those produced in the spring and it was on the former that symptoms of iron chlorosis appeared most marked. Counts of flowers and fruit were made at several stages during the season to determine the percentage of flowers which set and to investigate possible linkage between shoot type and fruit production.

Studies of the chloride content of citrus leaves have been carried out by the method of electrometric titration with silver nitrate solution of a suspension of dried, ground leaves. Indications are that the chloride content of the general run of trees investigated varies between 0.1 and 1.0 per cent. chloride as sodium chloride on a dry weight basis. Values of over 4 per cent. chloride as sodium chloride have been recorded for old leaves on trees in salty patches. Monthly determinations of chloride content on leaves produced in spring 1947 have so far failed to show any significant variation in chloride content with age.

The influence of manganese and zinc sprays on Valencia oranges, Marsh grapefruit, and Eureka lemons is being investigated. Present indications are that manganese may give a definite improvement in tree appearance, and the benefit of zinc application has long been known.

Swabbing trials with minor elements have been continued on the Zante currant and the Gordo blanco. In these all pruning cuts were swabbed immediately after pruning with a concentrated solution of a salt containing boron, copper, iron, manganese, molybdenum, and zinc. With Gordos a significant increase in dried fruit yield, amounting to 20 per cent. in one instance, has been obtained by swabbing with 20 per cent. zinc sulphate. The increase in yield in this case was associated with improved setting and some increase in berry size. It is evident that zinc deficiency in Gordos does occur in the Mildura district, but possibly only on some soil types.

In connexion with the study of the hormone physiology of the grape vine, the methods and problems of hormone work were studied in the plant physiology department at the Waite Institute. Preliminary investigations have been carried out on methods of hormone extraction suitable for grape berries.

Preliminary spot trials were conducted with three synthetic growth regulators as sprays on currants, sultanas, and Gordos before, at, and after flowering. The results were mostly inconclusive, but were of value in suggesting lines to be followed up in larger trials during the coming season. However, α-naphthalene acetic acid at 30 p.p.m. applied to the inflorescences about flowering time definitely prevented fruit from setting on all varieties.

6. Pests and Diseases.

Two pests have been observed in the vineyards to a greater extent than usual, namely, the grape vine moth (*Phalaenoides glycine*) which does not usually appear in the vineyards, and the vine leaf blister mite (*Eriophyes vitis*). Red scale (*Aonidiella aurantii*) occurred in greater numbers than usual in citrus orchards. Although the light brown apple moth (*Tortrix postvittana*) did not make its appearance in the vineyard, it was found damaging citrus orchards, causing fruit drop.

Three fungus diseases again made their appearance: Oidium (*Oidium tuckeri*) and black spot (*Gloeosporium ampelophagum*) fairly generally, and downy mildew

(*Plasmopara viticola*) in a few vineyards late in the season. Oidium and black spot developed sufficiently to cause commercial damage but fortunately the advent of dry weather prevented harmful development of downy mildew.

7. Fruit Processing.

Investigations on the dipping and drying of sultanas were continued, further work being carried out on the use of special sulphonated oils and wetting agents. It has been shown that suitable grades of sulphonated oleic acid are superior to vegetable oil emulsions in the dipping of sultanas by the cold dip process, and that wetting agents such as "Teepol" make dipping easier, and slightly improve the drying rate in certain cases, when incorporated in the dipping solution.

Investigations were also carried out on the effect of heating the potassium carbonate—oil emulsion mixture used in the cold dip process. These showed that the temperature of the cold dip mixture as with caustic dips has a marked effect on the drying rate of dipped sultanas. In one trial the drying period was reduced by three days when the dip was heated to 120° F. and by approximately six days when it was heated to 160° F. A disability of the mixed dip is that only a few tins of grapes can be dipped simultaneously, in contrast to the bulk dip used in cold dipping. By lowering temperature and increasing concentration in the mixed dip, bulk dipping appears to be practicable.

Trials were also carried out at Woorinen and the Research Station with a temperature dip containing potassium sulphite and potassium hydroxide instead of the usual potassium carbonate and sodium hydroxide. The new dip gave dried sultanas which were lighter and more uniform in colour than with either "mixed" or "cold" dips.

Further investigations were carried out on mould control during the drying of the fruit on the racks. It has been shown that where 1 per cent. potassium propionate was added to the cold dip mixture, very considerable protection against mould growth resulted, while the drying rate of the fruit was unchanged. The propionates appear to be effective as fungicides, while being perfectly harmless from the health aspect.

In dipping trials on Gordos, fruit dipped by the caustic soda dip heated to 200° F. dried 2-3 days faster than fruit processed by the mixed dip. Investigations were also carried out on the effect of the pH of the cold dip mixture on the drying rate of dipped sultanas, and on the amount and composition of sultana "bloom".

Investigations on the packing-house treatment of dried fruits included further work on the salvaging of rain-damaged currants. A washing process has been evolved which proved very successful commercially, and enabled the salvaging of some 82 per cent. of the 1947 currant crop in the Mildura district, a much higher figure than was at first expected. The process consisted essentially of washing the fruit by means of two Walker-type washing machines suitably arranged in series, with a 4 per cent. paraffin oil emulsion in water plus a small amount of a harmless detergent such as potassium linoleate or "Teepol" followed by dehydration for a short period. From 90 to 95 per cent. of the mould spores originally present were removed in this way, and storage trials have shown that less than 10 per cent. of the remainder survived storage in Mildura for 150 to 200 days during the summer period.

It has also been shown that mould spores may be readily destroyed by treating the fruit with small amounts of ethylene oxide. The most effective treatment for rain-damaged currants was to wash the fruit thoroughly with an oil emulsion—detergent wash, followed by dehydration for a short period, and treatment with ethylene oxide to destroy any remaining mould spores.

Investigations are also being carried out on the use of vegetable oils to replace paraffin in the packing-house treatment of dried fruits, and on the use of N.D.G.A. as an antioxidant in retarding the development of rancidity in peanut oil applied to dried fruits.

8. Vegetables.

Vegetable investigations have been continued at Red Cliffs (Victoria) and Buronga (New South Wales) during the 1947-48 season. The work was mainly confined to field-grown and glasshouse tomatoes, irrigation of tomato plants, and a replicated variety trial of soybeans. In addition, small observational plots of safflower and guar were established for the purpose of obtaining agronomic notes as to the suitability of these plants to district irrigation conditions.

With tomatoes, the aim of the investigation is to determine the most suitable varieties for the district and to develop fusarium wilt resistant hybrids that possess desirable agronomic characteristics. The trials were first commenced in the 1943-44 season at Red Cliffs and have been conducted in close co-operation with officers of the Division of Plant Industry. In all, 36 varieties of tomatoes were tested, and it has been found that no one variety had all the qualities favoured by growers and consumers, but that parent material is available for plant breeding with a view to obtaining a variety of good bush type and producing a high yield of good quality medium sized fruit when grown under unstaked cultural conditions and watered by furrow irrigation. Until more suitable varieties are available, Pearson 29-17 appears to be one of the most desirable ones to grow in the Mildura district.

For the past three seasons several hybrids have been tested at Red Cliffs. It has been found that Pan America is a suitable parent for introducing field immunity to fusarium wilt and that the use of this variety in some crosses leads to an improvement in vitamin C content; however, further work is necessary to improve the agronomic characteristics of these hybrids, particularly with regard to bush type.

In view of the greatly increased use of glasshouses for tomatoes in the Mildura district, a glasshouse of commercial size (100 feet by 15 feet) was erected in 1947 and investigations were commenced. The aim of the work is to develop, if possible, more suitable varieties than South Australian Dwarf, the one most commonly grown in glasshouses at present. Several new hybrids and some imported varieties have been included in the trials and single plant selection will be carried out.

From a preliminary trial of 40 soybean varieties grown in 1946-47, twelve of the most promising for this district were included in a replicated trial in 1947-48. Data obtained included the germination percentage of each variety, agronomic notes as to the suitability for irrigation conditions in the Mildura district, yield, and maturity studies. The work is being carried out in co-operation with plant introduction officers, Division of Plant Industry. It is already apparent that selection of variety for each district is important.

9. Finance.

Contributions to the work of the station have been continuous for many years, and increases have been made for special investigations. Contributing bodies include the Australian Dried Fruits Control Board (£1,600) and the Mildura Packers' Association (£1,000). Other contributions have been received from the Water Conservation and Irrigation Commission of New South Wales, State Rivers and Water Supply Commission of Victoria, the Rural Bank of New South Wales, and from producers' organizations in a number of districts for examination of problems of their districts.

B. IRRIGATION RESEARCH STATION (MURRUMBIDGEE IRRIGATION AREA), 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. New buildings officially opened during the year provide excellent facilities for research.

The Officer-in-Charge of the station left in February on a six months' trip to the United States of America to visit agricultural institutions and to meet research workers studying problems similar to those of the Murrumbidgee Irrigation Area.

2. Field Experiment with Orange Trees.

The complex field experiment with orange trees, involving many cultural and irrigation treatments, has been maintained and some preliminary work has been done on root distribution and on the nitrogen and organic matter status of the various plots. During midsummer some difficulty was experienced in keeping to the schedule of watering, as the high rates of evaporation and transpiration shortened the interval between irrigations so much that weed control became difficult on the "no-wilting" plots. The first crop of fruit will be picked from the experiment this year. A brochure has been published describing the treatments and the statistical design of the experiment.

3. Irrigation Investigations.

Field experiments were continued with short sections of furrows bounded by buffer furrows, in order to elucidate the principles underlying the movement of water from furrows of different shapes and containing different depths of water.

Two principles have now emerged. The infiltration rate is, in general, proportional to the wetted perimeter; but the lateral movement of water is independent of it. Infiltration rates did not follow Kostiakov's equation strictly, probably due to the union of the soakage profiles beneath the surface, especially with the larger sized furrows. Smaller furrows tended to have a higher absorption of water per unit of wetted perimeter. Where lateral soakage is desirable, as in watering up to a row of seedlings, a greater spread of water is obtained, for any given quantity used, by having small furrows. When a fixed spacing is being considered, water usage is more economical if the furrows are large, because the greater wetted perimeter results in closer proximity of free water to the plant row.

In the hydraulics laboratory, depth of water and wetted perimeter are being further investigated in relation to flow rate, grades, and surface resistance in the furrow. Field trials have shown the importance of uniformity of grade, particularly in the flatter ranges.

4. Rice Field Investigations.

The data on the usage of water in rice fields have been collated and a report issued. This shows that, as was expected, the amount of water used on farms overlying sand-drifts may far exceed that used on other farms. On farms over sand-drifts the water lost by infiltration may be twice that required for the normal demands of transpiration and evaporation.

5. Drainage Investigations.

Drainability studies to determine best depths and spacings of tile drains have been continued, and the technique is being examined with a view to reducing the size of the experimental area, thus allowing a greater number of sites to be investigated simultaneously. Information supplied by these studies is being used as a basis for the installation of two farm-size tile drainage trials. Records of tree health and yields, together with changes in soil salinity and drainage effluent, will be kept to determine the efficiency of the tile drainage system.

Exploratory trials with the mole plough have shown that satisfactory drainage channels can be made with this implement. The scope for mole drainage is being investigated.

Methods of establishing and maintaining pastures on salted land are being worked out: such factors as width of bay, length of run, and pasture mixtures are being considered. Results so far show the necessity for well-graded land and correct irrigation facilities, especially on light sandy loam soil. What were previously four abandoned horticultural farms have now been combined into one successful dairy farm.

6. Soil Reconditioning Investigations.

Before old orchard land can be successfully replanted on the M.I.A. it is necessary to rectify the deteriorated soil structure and thus restore the fertility of the soil. This problem is being investigated on a former peach block now laid down to the following: no treatment; lucerne; vegetables; pastures. Tests on the initial physical condition of the soil were made in 1945 by the Council's Division of Soils and have been repeated subsequently. One outstanding feature has been the dense nature of the soil, especially in the plough sole layer, where the apparent density reached values as high as 1.70.

7. Salt Investigations.

The work on salt damage to soils and plants has been continued and a new and accurate method of estimating sulphate ions has been evolved which is much quicker than the standard gravimetric method. This method can be used directly on soil extracts and subsoil waters; leaf analyses always involve a preliminary destruction of the organic matter, without loss of sulphur, and it is clear that there is room for a simplification of the existing methods for carrying out this long and tedious step.

The effect of salt upon orchards is only partially described by a study of the direct evidence in the trees themselves. The soil also suffers damage by puddling, or loss of structure, and this has then an indirect effect on the health of the trees. It is planned that the aspect of salting as well as the general question of deterioration of soil structure by the formation of hard pans will be more actively studied in the future as it is of first importance to the Murrumbidgee Irrigation Area.

8. Vegetable Investigations.

Having established that applications of superphosphate over a number of years lead to the building-up of a reserve of available phosphate in M.I.A. soils, investigations are now in progress to determine the rate of accumulation and the effectiveness of the "reserve" phosphate. Chemical analyses of the soil and the plant are used to supplement measurements of crop growth in the field.

An irrigated and cultivated summer fallow has been shown capable of supplying the whole of a crop's requirement of nitrogen, and trials in progress are designed to determine the length of fallow period necessary to achieve this accumulation of nitrates. The long-term effects of intensive fallowing practices on soil fertility are the subject of trials just beginning.

Minor elements play an important role in the nutrition of vegetable crops in many parts of the world and exploratory trials have begun to determine whether one or more of these minor elements are lacking under M.I.A. conditions.

In practice, difficulty has been experienced in obtaining a satisfactory setting of grain in sweet corn during the summer months. A small experiment, carried out to determine sowing dates which would avoid flowering

during the hot dry winds in January, indicated that sowings during November were likely to be unsatisfactory in this respect, and that October, December, January and early February sowings were safe and equal in merit.

9. Plant Physiology.

The study of methods for the accurate measurement of plant growth is now at an advanced stage. With field-grown tomatoes, the procedure adopted has resulted, on an average, in a twenty-fold increase in precision over that obtainable with simple random sampling. Moreover the relative benefits are greater the greater the variation in size of the experimental plants. This work is being prepared for publication.

The sampling procedure is being applied to a study of the problem of soil fertility as affected by organic manuring. Most of the work is being done with rice hulls—a by-product of the local rice mill—and has included a detailed study of the early growth of the tomato plant, and a field trial to test the residual effect of rice hulls using cabbages in the second season.

The positive effect of rice hulls on the yield of tomato fruit even without additional nitrogen, was confirmed; and a residual effect amounting to a 15 per cent. increase in yield was established by the cabbage experiment. Both these effects are to be investigated in terms of the nutrient intake of the experimental plants.

A second general problem being investigated by the established methods of plant growth analysis is that of the water relations of plants. The initial project was a study of the effects of light and of severe wilting on the subsequent growth of individual leaves and petioles, and of the stem and roots of the tomato plant at the eight-leaf stage. The light wilt treatment consisted in allowing the plants to reduce their soil water to a level at which the leaves showed obvious signs of water stress. This occurred twice within a period of six days. Over the same period, plants of the serious wilt treatment were not watered at all; their soil-water level was in the vicinity of the permanent wilting percentage for several days before the level was restored to the moisture equivalent. The immediate effects of treatment on growth were as expected, but, immediately after the period of treatment, relative growth rates tended to be greater in the wilt-treated plants than they were in the control plants. Analyses for total and protein nitrogen and for total phosphorus are being undertaken, and the results will be studied in relation to the dry-weight changes of the individual plant parts. It is believed that this type of experiment will supply some of the necessary interpretative background for the phenomena of wilting, and for less academic studies relating to correct irrigation practice.

10. Frost Investigations.

Frost can be the cause of considerable loss in citrus orchards on the M.I.A. When heavy frosts occur early in the winter before the young autumn growth has had time to mature the tree receives a setback by the loss of the new growth and, in addition, much of the fruit may be wasted owing to frost damage. Deciduous plantings may also be injured by late frosts destroying the young buds. Often these losses are particularly great on certain farms which prove to be frost liable. The results of a study on frost liability in a section of the mallee country have now been reported.

In the winter of 1947 the extent of the phenomenon of atmospheric temperature inversion was investigated. It was found that there is at Griffith on calm frosty nights a reservoir of warmer air at only about 50 feet above the trees. Experiments are now being carried out on the practicability of protecting orchards on frosty nights by drawing down this comparatively warm air by means of a 21-ft. propeller blade, or fan, mounted horizontally on a tower and driven by a 10 h.p. electric motor. The propeller was designed by the Council's Division of Aeronautics. On present indications such an installation may be sufficient to protect about one and a half acres of mature citrus trees.

A similar experiment in a block of almond trees has been planned and will be carried out in the early spring of this year. More work is necessary before the economic value of the system can be clearly stated.

11. M.I.A. Agricultural Extension Service.

In September the extension service associated with the Station was placed on an entirely new basis. The work will now be carried on under the aegis of the New South Wales Department of Agriculture, and the Council for Scientific and Industrial Research officers of the original service have been seconded to the Department to form part of the staff of the new M.I.A. Agricultural Extension Service under the leadership of Mr. R. R. Pennefather as Extension Organizer.

The work will be expanded to cover "large-area" (rice) farms and to deal with all aspects of agricultural extension work. The head-quarters of the Service remain at the Research Station, Griffith.

12. Publications.

A new series termed "Internal Reports" has been started. These are, in the main, short papers dealing with research work which in its present form is of too limited a scope to appear in a regular research journal.

Those published during the year dealt with tomato irrigation, interplanting of tomato varieties, survey of frost liability of northern Lakeview, and atmospheric temperature inversion. Reports were also issued on a citrus culture experiment, and on water in rice growing.

VIII. FOREST PRODUCTS INVESTIGATIONS.

1. Introduction.

At the Fifth British Empire Forestry Conference held in London during June and July, 1947, at which the Division was represented, forest products delegates gave considerable attention to ways and means of developing co-operative forest products research work within the Empire. It was felt that this field of research was too large for wasteful duplication of effort and it was therefore agreed that the laboratories concerned should keep each other more fully informed of work in hand and work planned. Discussion centred on several fields of investigation from which better results might be obtained more quickly if the work were carried out on a co-operative basis and duplication avoided. To this end a number of corresponding committees were set up within the framework of the Forest Products Committee of the Conference and were charged with the responsibility of co-ordinating work which has a wide application. Further, a conference of Empire specialists in timber mechanics has been arranged for September, 1948, to meet initially in Canada and later it is hoped to continue the discussions at the United States Forest Products Laboratory, Madison, Wisconsin. Mr. K. L. Cooper, Officer-in-Charge of the Timber Mechanics Section of this Division, has left Australia for the purpose of attending this Conference and has already attended the Geneva meetings of the F.A.O. sub-committee dealing with mechanical wood technology.

The idea of co-ordinated forest products research has been extended within Australia and, at the Second Annual Forest Products Conference held in Melbourne in November, 1947, the machinery for co-operative research on certain projects was improved and it was further agreed that in certain instances co-operative publications could well be prepared. This conference, which was attended by delegates from the six State Forest Services, from the Forests Department of New Guinea, from the Forestry and Timber Bureau, and from the Munitions Supply Laboratories, as well as

by officers of this Division, proved most successful in that it laid the foundation for greater co-operation between this Division and all the bodies represented. It was agreed that certain applied problems could well be taken over by those State Forest Services which had staff and equipment for dealing adequately with them; on the other hand the representatives of the State forestry authorities requested the Division to handle a number of problems of common interest. Representatives of the Division of Economic Entomology, the New Zealand Department of Scientific and Industrial Research, and the Standards Association of Australia were invited to be present for certain sessions of the Conference. The Division was also represented at the Annual Eastern States Timber Industry Stabilization Conference held in March, 1948, at Toowoomba, Queensland, and at the Conference of the Australian Pulp and Paper Industry Technical Association, Hobart. The Ninth Annual Pulp and Paper Co-operative Research Conference was held in April, 1948, at Burnie, Tasmania, and this again proved to be most interesting and effective in that the programme of work of the Division relating to fundamental studies in wood chemistry, pulp and paper problems, and fibre investigations was fully discussed with the representatives of the Australian pulp and paper companies and the New Zealand company, N.Z. Forest Products Limited. It is by means of such conferences that the Division is able to put before interested bodies the results of its own research and to discuss the many technical problems that are brought forward both by industry and forestry authorities.

One particular example of the assistance given by the Division to industry may be quoted here. During the early part of 1947 representatives of the Red Gum Section of the Victorian Sawmillers' Association asked the Division for help, particularly in regard to (1) the avoidance of seasoning degrade during the drying of 1-inch red gum, so that satisfactory processing could be subsequently accomplished and a useful product obtained, and (ii) the effective conversion to a usable product of the stocks of waste material now held by the millers but of no value owing to the extent of warping and collapse present. As a result of the work carried out by several sections of the Division, it appears that almost complete utilization of this waste material can be obtained in the form of 2-in. to 6-in. wide T. & G. flooring. Demonstrations of this were carried out at the Division and at a co-operating commercial plant for the benefit of a well-attended gathering of the representatives of the Red Gum Sawmillers. Early estimates place the quantity of additional material which, as a result, should be made available to the building industry from this field as over 1,000,000 super. feet per year in Victoria alone.

It is recorded with pleasure that early in 1948 two graduate members of the staff of the National Forestry Research Bureau, Nanking, China, arrived in Australia to study techniques of forest products research in the laboratories of the Division. It is recalled that in the early history of the Division many members of the staff were trained in a similar way at the United States Forest Products Laboratory, Madison, Wisconsin, and the Division is only too happy to be offering similar training facilities to research workers from other parts of the world.

Throughout the year the results of the work carried out in the Division have been made known to the trade and the public generally through the medium of the monthly *News Letter* (of which over 3,000 copies per issue are now distributed), lectures, visits to the laboratories and personal interviews. The number of inquiries has, if anything, increased and over 3,500, in addition to those covered by correspondence, have been handled during the year. Results of work on certain projects have been published in scientific journals and a list of publications by officers is attached to this report. There has been a definite improvement in the staff position during the year, although some vacancies still remain to be filled.

The Division records its appreciation of the co-operation received during the year, particularly from the State Forest Services, the Commonwealth Forestry and Timber Bureau, and the Forests Department of New Guinea. The taking over of applied and extension work by some of the States has considerably relieved the Division and has enabled greater concentration on more fundamental projects and those best handled by one authority for all States.

2. Wood Structure.

(i) *Cell Wall and Fibre Studies.*—(*a*) *Tension Wood Fibres.*—The chemical and physical properties of these fibres have been compared with those of normal wood fibres using material from several Australian hardwoods. It has been demonstrated that the so-called tertiary or gelatinous layers of the tension wood fibres in the species investigated are unlignified and consist almost entirely of a highly oriented form of wood cellulose. The evidence obtained has indicated that the secondary wall of the tension wood fibres of mountain ash (*Eucalyptus regnans* F.v.M.) consists of three layers of different micellar orientation: the outer layer in which the micelles are oriented at 40° to the longitudinal fibre axis; the middle layer in which the orientation is 18°; the unlignified inner layer (or gelatinous layer) in which the micelles are oriented at approximately 5° to the longitudinal fibre axis. The possible relationship between this cell wall structure and the abnormal properties of tension wood has been considered.

(*b*) *Fibre Shrinkage.*—The behaviour on drying of fibres isolated from both the normal and reaction wood of softwoods and hardwoods has been examined in detail. None of the fibres changed in length on transfer from water to alcohol or from water to alcohol to benzene. However, on the evaporation of the liquid present nearly all the fibres, if free from restraint, twisted appreciably and this twisting was accompanied by some small contraction in length. Twisting was of the order of one complete revolution per mm. of length. The actual longitudinal shrinkage of both normal wood fibres and tension wood fibres was on the average 0.5 per cent., allowance having been made for the contraction due to twisting. Certain compression wood tracheids showed a longitudinal shrinkage of over 3 per cent. (excluding contraction due to twisting); on the other hand, tracheids from normal wood shrank longitudinally over 1 per cent. It was considered that the results obtained do not explain in any way the high longitudinal shrinkage observed in reaction wood.

(*c*) *Cell Wall Lignin.*—A recently published German method for revealing the distribution of lignin in the cell wall has been examined. This involved the use of liquid nitrogen peroxide on cross sections of wood followed by treatment of the sections with triethanolamine. Using a number of species in which cell wall lignin is comparatively well marked, the method was tried in comparison with other methods employed in this laboratory. While it is effective as showing general distribution of lignin there was no indication of cell wall lignin pattern.

(ii) *Wood Anatomical Investigations.*—(*a*) *Family Studies.*—Considerable progress has been made during the year. Examination of the timber species of the Proteaceae, which family is very widely represented in Australia, has been completed and two papers for publication prepared. In this work it was observed that in the large modullary rays of two of the Australian

genera, namely *Dryandra* and *Banksia*, radially aligned vascular tissue was present. The elements of this tissue consisted of vessels and tracheids which always appeared to have some lateral connexion with the vertical water-conducting tissues of the stem. The suggestion has been put forward that such tissue might function as an accessory water-conducting system in these genera, although no reasons for this can be advanced. In the investigations of the wood anatomy of various families, the need for extending the scope of the work to cover a geographical zone wider than just Australia has been becoming apparent and, therefore, in the study of a number of these families the timber species from the south-west Pacific area have been included. On this basis work has been completed on the Anacardiaceae and Apocynaceae; the anatomical features of the timbers in the various genera have been compared and methods for separating the genera on anatomical grounds discussed. Other families at present being investigated include the Anonaceae and the Myrtaceae.

(*b*) *Timbers of the South-West Pacific Area.*—In addition to the family investigations referred to above it has been necessary to carry out numerous examinations of a variety of timbers from this area because of this importation into Australia. Such timbers have come from New Guinea, New Caledonia, New Hebrides, Borneo, and Malaya. The closest co-operation with the Forests Department of the New Guinea-Papua Administration has been maintained and many authentic specimens have been received from this source. Authentic specimens have also come to hand from British North Borneo.

(*c*) *Tyloses.*—A correlation has been observed between the presence of tyloses in timber and the type of vessel-ray or vessel-parenchyma pitting. Where the pits are large, tyloses invariably occur in the truewood; where pits are small tyloses are not present although the vessels are often filled with deposits of gum. The limit of pit size for the development of tyloses is in the region of 8-10 μ. It has been observed further that wherever tyloses occur, whether in sapwood, wound tissue, or truewood, they are formed because a living parenchyma cell borders on an air-filled vessel. The very marked growth into the vessel cavity which results from the stimulation of a single living cell has been observed.

(iii) *Identification and Identification Methods.*—(*a*) *General.*—The number of identifications of wood and fibre products completed during the year has totalled 900. As in the previous year most of the timber specimens submitted have been derived from the Pacific area north of Australia.

(*b*) *Methods.*—The card sorting identification key for the Australian commercial timbers has now been completed and a number of trial sets put into service. The indications are, that with some minor modifications, this key should prove effective and arrangements have been made to send the first sets to the Australian Forestry School, Canberra, for use by the forestry students.

(iv) *Structure in Relation to Properties.*—(*a*) *Sapwood-Truewood.*—Although a simple chemical test has been developed for the differentiation of sapwood from truewood in eucalypts, this test has not been successful when applied to other species. It appears clear that the development of truewood is connected with the length of life of the ray and vertical parenchyma cells (which cells are involved in the formation of tyloses and the deposition of gum in the vessels, features which are criteria of truewood) and in those species without apparent truewood or with very little truewood this question of the living parenchyma cells becomes important. Work has therefore commenced with the object of determining how long these parenchyma cells live in trees of various species. The correlation of truewood formation with the crown in young material of mountain ash has been continued and the results obtained suggest that, in this material, all the sapwood growth rings are in direct contact with the living leaves. Pruning of *Pinus radiata* D. Don. causes some increase in the amount of truewood formation but the differences from control unpruned trees are not marked and further material needs to be examined.

(*b*) *Collapse.*—The structure of the wood in veneers cut from logs of mountain ash has been investigated in relation to the development of collapse during drying. Sections cut from the veneer have revealed that collapse occurs more severely on the "tight" side but that there was no apparent structural reason for this extra collapse. The location of the collapse appears to be mainly in the zone between the early wood and late wood of any one growth ring.

(*c*) *Longitudinal Shrinkage of Reaction Wood.*—Experiments have been carried out in an attempt to explain the high longitudinal shrinkage observed in specimens of reaction wood from both hardwoods and softwoods. It was considered that in compression wood at least, the greater percentage of lignin might have some influence. Therefore radial longitudinal sections cut at various thicknesses were used for the measurement of longitudinal shrinkage both before and after controlled delignification. The shrinkage was not reduced by the delignification and, if anything, there was a slight increase as the delignification proceeded. These results appear to eliminate lignin as a cause of this abnormal shrinkage. The investigations of the reasons for such high longitudinal shrinkage are being continued.

(*d*) *Brittle Heart.*—In experiments designed to investigate possible reasons for brittle heart in the living tree, green specimens of mountain ash were subjected to compression parallel tests in the steamed condition. The idea was to keep the wood hot and plastic as far as possible during the time the load was being applied. In many of the specimens minute compression failures, as revealed by the isolation of broken fibres on acid maceration, were developed in areas far removed from the macroscopic failure. Green unsteamed control specimens subjected to the same test did not develop minute compression failures except in the areas immediately adjacent to the macroscopic failure. These experiments indicate that under certain conditions minute compression failures which are indicative of brittle heart can be formed over a wide area and may be some assistance in explaining the development of brittle heart in the living tree.

(v) *Growth Studies.*—(*a*) *Eucalyptus regnans.*—A project involving the investigation of the development of woody cells from the cambium of this species has been carried out in co-operation with the Section of Wood Chemistry. For the chemical analyses the material collected was separated into six groups, namely: outer bark, inner bark, cambial zone, newly differentiated wood, sapwood, and true wood. The monthly variations in moisture content and mineral constituents from pith to sap were also determined. Tissues differentiated from the cambial zone apparently dropped in moisture content fairly rapidly by virtue of secondary thickening; a further drop was noted at the change-over from sapwood to truewood. It is possible that at such a time a certain amount of gas replaces water in the cell cavities and some suggestions have been put forward regarding the possible origin of this and on the function of the wood rays in sap movement in the living tree. The cambial zone apparently contains a high percentage of uronic acid anhydride and a low percentage of true lignin. Microscopic examination of the lignin distribution in the cell walls of the cambial zone supported the results of chemical analysis in this regard.

(*b*) *Eucalyptus gigantea.*—A comprehensive study on the growth of young alpine ash (*Eucalyptus gigantea* Hook. f.) from the Australian Capital Territory, based on microscopic examination of transverse sections taken at various heights at monthly intervals over a period of two years, has been completed. From the determination of cambial activity at various times as measured by the number of cells produced in a radial direction, the general characteristics of growth have been determined and a working expression derived for the estimation of cambial activity at any time of the year. Particular attention has been paid to the time of the year in which growth commences, the early stages of growth, the relation of structure to environment, identification characteristics of the material examined, maximum growth rate, formation of late wood, and the radial diameters of fibres.

(*c*) *North Queensland Species.*—Work on selected species from this region has been continued although it has been necessary to alter the basis of the experiment so that the material for examination cut at monthly intervals is taken from one side of each tree only.

(vi) *Crystals and Siliceous Inclusions in Parenchyma Cells.*—A survey of timbers occurring in the south-west Pacific area has been commenced with the object of determining the nature and extent of crystal deposits and certain siliceous inclusions in ray and vertical parenchyma cells. Siliceous inclusions have been considered important because of their reputed correlation with blunting of saws and with marine borer resistance of certain timbers. In the latter connexion it is of interest to record that samples of turpentine (*Syncarpia laurifolia* Ten.) grown in Hawaii have been reported not to be resistant to marine borer attack in comparison with the Australian grown specimens of the same species. Examinations of sections and determinations of silica in the wood showed that the Australian specimens all contained a relatively high percentage of silica which occurred in the form of concretions in the ray cells whereas the material grown in Hawaii showed few, if any, of such concretions and possessed very small amounts of silica. The work was extended to the examination of timbers of known marine borer resistance from both Australian and New Guinea sources and all such timbers showed abundant deposits of siliceous inclusions in the ray cells. On the other hand, timbers known to lack marine borer resistance showed no inclusions.

(vii) *Photography.*—The photographic work of the Division has involved the preparation of 71,000 photographic prints and enlargements.

3. Wood Chemistry.

(i) *Lignin.*—(*a*) *Syringyl and Guaicyl Radicals in Australian Wood Lignins.*—Various Australian woods and isolated lignins have been subjected to alkaline nitrobenzene oxidation and the resulting aldehydes separated by means of vacuum sublimation. The molar ratio of syringaldehyde of vanillin for eucalypts of the "ash" group has thus been shown to be 4:1 whereas for jarrah it is only 1.5:1. The aldehyde resulting from oxidation of *Pinus radiata* is mainly vanillin, and two softwoods indigenous to the Southern Hemisphere, viz., hoop pine (*Araucaria cunninghamii* Ait.) and celery-top pine (*Phyllocladus rhomboidalis* L. C. Rich.) yielded only vanillin sublimation. These results substantiate those of Hibbert, who discovered that angiosperm lignin yields both syringaldehyde and vanillin whereas gymnosperm lignin yields only vanillin on oxidation with nitrobenzene. However, the ratio of 4:1, as found for some eucalypts, is higher than that found by Hibbert for North American deciduous woods.

Five different isolated lignins have also been subjected to alkaline nitrobenzene oxidation. Klason lignin, wood hydrolysis lignin, kraft lignin, and soda lignin all yielded 5 per cent. or less of aldehyde, but methanol lignin from mountain ash yielded 26 per. cent. This is taken as further strong evidence that methanol lignin, in its properties, is closer to "native" lignin than are any of the four other lignins examined.

(*b*) *Fractionation of Methanol Lignin.*—The fractionation of methanol lignin into aldehydes, acids, and phenols has been attempted by extraction of its solution in chloroform with sodium bisulphite, carbonate, and hydroxide respectively. Although there was an appreciable yield of aldehydes, the bulk of the lignin was retained in the phenol fraction, the yield of acids being negligible. A similar separation has been effected by precipitating the concentrated methanol extract of wood into sodium bisulphite solution. Under these conditions, the phenolic fraction is precipitated and the bisulphite extract may be processed to yield an aldehyde fraction, which, if isolated in an atmosphere of carbon dioxide, is a viscous liquid. This gives the characteristic lignin colour reactions but, on exposure to air, changes to a dark solid.

(*c*) *Molecular Weight of Methanol Lignin Fractions.*—Both cryoscopic and viscometric methods have been employed in attempts to determine the molecular weight of the phenolic fraction of methanol lignin. The results from cryoscopic measurements, using acetophenone and dioxane as solvents, have been somewhat unsatisfactory because of their wide scatter, but almost without exception they fall below 2000, and consequently it may be concluded that this lignin is not a high polymer. This conclusion has been substantiated by viscosity measurements in which the limiting value of sp/c has, in every case, been of the order of 0.1.

(*d*) *Mechanism of Methanol Extraction.*—Previous reports have discussed the important hydrolytic role which organic acids from the wood might play during the methanol extraction of lignin. It has been assumed that these acids consist mainly of acetic acid formed from constituent acetyl groups of the wood. It has now been shown that, when applied to mountain ash (*Eucalyptus regnans*) which has been de-acetylated by treatment with cold dilute alkali, the usual course of the methanol extraction is not completely inhibited although the yield of lignin is lower and a smaller proportion of it may be recovered as a precipitate. In other words, a smaller yield of a more degraded product results from the previous de-acetylation of the wood.

(ii) *Carbohydrates.*—(*a*) *Alkaline Degradation of Holocellulose.*—The Ekenstam phosphoric acid fractionation technique has been used for further investigations into the breakdown of holocellulose when treated with dilute alkali. The theory that this alkali-sensitivity is due to the hydrolysis of a xylo-glucosan bond has been tested by treating holocellulose with dilute acid instead of with alkali. Although a xylo-glucosan bond should be much more easily hydrolysed by acid, no breakdown has been observed. It has also been suggested that the marked decrease in chain length could be due to the rupture of alkali-sensitive links formed by oxidation of cellulose by chlorine. Cotton linters which had been subjected to holocellulose and alkali treatments have not shown this form of breakdown. Since it was possible that the greater degree of crystallinity of the cotton might have restricted the reaction, these treatments have also been applied to cotton which had been previously swollen in phosphoric acid. Although the accessibility of the cellulose to the reagents had thus been increased, no breakdown has been revealed. The easily-hydrolysable links thus seem to be peculiar to wood cellulose.

(*b*) *Fractionation of Wood and Holocellulose Nitrates.*—In an endeavour to determine the chain length distribution in wood carbohydrates, mountain ash wood meal and mountain ash holocellulose have been nitrated in an anhydrous medium containing excess phosphoric acid. Some difficulty has been experienced in finding methods for stabilizing the nitrates and for removing the nitro-lignin. The nitrates have been fractionated by partial solution in successively richer mixtures of ethyl acetate and alcohol, to give approximately 20 fractions from each sample. The molecular weight of each fraction has been determined through its intrinsic viscosity in acetone solution. Molecular weight frequency distribution curves, so derived, have been interpreted as being the result of an acid hydrolysis at a periodic acid-sensitive weak link. This hypothesis is being checked by repeating the work under more carefully controlled conditions.

A more rapid method (*Pulp & Paper Mag. Canad.* 48 (3) : 166) for the fractionation of wood nitrates is under investigation. Various solvent-precipitant systems have been tried in an endeavour to find one in which the precipitate settles easily and with which the fractions will be evenly distributed.

(*c*) *Water-soluble Polyuronide.*—Wood from mountain ash which has been exhaustively extracted with methanol at 150° C. has been found to yield, on extraction with hot water, at least 5 per cent. of a polyuronide material. This material has been separated on the basis of solubility, into two chemically similar fractions, the acetates of which, through viscosity determinations, gave molecular weights which could account for the physical difference between the two fractions.

(*d*) *Hemicelluloses from Mountain Ash.*—Extraction of wood with 5 per cent. sodium hydroxide at room temperature has yielded four crude fractions. A small amount of pectin has, in addition, been isolated from the residual wood. The weight of hemicellulose which has been recovered has corresponded to about 53 per cent. of the weight lost by the wood during the alkali extraction. Preliminary analysis of the four fractions has indicated that the uronic anhydride content varies inversely with the average molecular weight.

(iii) *Wood Chemistry.*—(*a*) *Chemical Investigations of the Cambial and Neighbouring Zones of Eucalypts.*—Samples of the cambium, and young differentiating wood tissues, young sapwood, sapwood, truewood, inner bark, and outer bark have been collected from young mountain ash trees felled after the renewal of spring growth. It is proposed to compare the chemical composition of the various zones with the object of obtaining some insight into the general chemical changes which occur during secondary growth, in both the xylem and phloem areas, of a normal eucalypt tree. Precautions have had to be taken to arrest enzyme activity in those zones where such activity would be harmful. A comparison of the effects of different methods of drying these materials has been made. During uronic acid determinations it has been observed that the phloem elements and the cambium evolve greater amounts of carbon dioxide than do the xylem elements. Similarly the phloem elements and the cambium have been found to contain greater amounts of free acids, soluble in 80 per cent. ethanol. Lignin contents, determined indirectly, have been shown to be about 1 per cent. for the cambium zone, 11 per cent. for the outer bark and 24 per cent. for the truewood. Preliminary estimations have revealed that sucrose is present to the extent of 10-15 per cent. in the dry cambium material.

(*b*) *Relationship between Chemical Composition and Grinding Properties of Eucalypt Wood.*—Samples of good and poor grinding mountain ash have shown marked differences between some of their carbohydrate constituents, particularly in respect to water-soluble hemicellulose. It is anticipated that the analytical data, when completed, will offer a tangible explanation of the suitability of a eucalypt wood for grinding.

(iv) *Wood Hydrolysis.*—A comparison of the removal, by dilute sulphuric acid, of pentosan and uronic acid constituents of immature mountain ash has shown that the former is removed at a faster rate during the initial stages of hydrolysis. An estimation of the amount of non-accessible pentosan has been made. A new percolation apparatus for investigating the mechanism of wood hydrolysis and the nature of its products has recently been completed. During attempts to characterize the simple carbohydrates resulting from the hydrolysis of wood hemicelluloses, the barium salt of what appears to be xylono-methylaldobionic acid has been isolated. It was, however, somewhat contaminated with lignin, probably in the form of a chemical complex. Apparatus for two-dimensional paper chromatography has been constructed and the separation of xylose from other sugars has been fairly satisfactory.

(v) *Pulp Evaluation Studies.*—(*a*) *Suitability of "Unit" Sheets for the Study of Fundamental Sheet Properties.*—The properties of "unit" sheets have been related to those of standard laboratory hand sheets. "Unit" sheets have been laminated to produce sheets of standard "basis" weight. These have been found to differ significantly from standard sheets except in tensile strength. This has fundamental significance because partition of those factors which affect tensile strength from those which affect other properties, such as bursting strength, appears to be feasible. The properties of "unit" sheets may be related to those of sheets of greater basis weight by straight lines representing the regression of a property on basis weight. For sheets made from pulps which have been beaten to different degrees, these regressions have different slopes but all intersect at a basis weight of 10 g./M^2 in the case of long-fibred krafts. Hence the basis weight of "unit" sheets, arbitrarily chosen as 10 g./M^2 from trial and error methods, appears to have significance. The point of intersection of eucalypt pulps has still to be determined, but it is anticipated that it will also be in the vicinity of 10 g./M^2 because it is impossible to form a homogeneous continuous sheet at lower basis weights.

(*b*) *Additive and Antagonistic Effect of Cations on Pulp and Paper Properties.*—Cations in process water may enhance or decrease sheet properties or may be without any measurable effect, depending on their valency. Combinations of cations may be additive or antagonistic, within limits of concentration, in their effects on sheet properties. The reduction in strength caused by 50 p.p.m. of cerous chloride has been largely counteracted by the addition of 100 p.p.m. of sodium chloride.

(*c*) *Systematic Survey of Cation Effects.*—A systematic study has been in progress of the effect of increasing concentrations of cations on pulp and paper properties. All cations have been found to increase freeness but their effects on sheet properties vary both with valency and with concentration, the latter within limits. Univalent cations, up to a certain limiting molarity, increase strength properties. Divalent cations, with the exception of zinc, have no effect. Zinc ion, up to a limiting concentration, reduces strength. Trivalent and tetravalent cations, within very low limiting concentrations, cause very marked reduction of sheet properties.

(*d*) *Application of Amino-Resins to Eucalypt Pulps.*—Preliminary investigations have been made into the use of ureaformaldehyde resin for increasing the wet strength of paper. Optimum conditions of pulp concentration and time of treatment have been sought with the object of using these to study fundamental factors influencing resin retention and wet strength. Various phases of technique have also been investigated. There

are indications that resin retention is susceptible to anions and that water-soluble inorganic material introduced during the pulping process is detrimental to wet strength development.

(*e*) *Modification of the Valley Iron Works 1½ lb. Niagara Beater.*—Pulp stock will only circulate in the Niagara beater at concentrations not exceeding 2 per cent. The beater has been fitted with an auxiliary circulating device which facilitates the handling of stock up to 4 per cent. concentration. Under these conditions, greater bed plate weights may be used without endangering the tackle.

(*f*) *Inspection and Service-Testing of Laboratory Pulp Evaluation Apparatus.*—British standard laboratory pulp evaluation apparatus is now being manufactured in Melbourne under licence from the Technical Section of the Papermakers' Association of Great Britain and Ireland. Six sets have been inspected and tested by this Division.

(vi) *Paper Testing.*—(*a*) *Correlation of paper-testing instruments.*—In co-operation with the Australian pulp and paper industry, inter-company correlation of paper testing instruments has been undertaken at regular intervals. These surveys have revealed occasional disagreement between the instruments and action has been taken to determine the reasons for these differences and to eliminate them.

(*b*) *Calibration and Inspection of Tear-Testing Instruments.*—Australian-made dynamic tear testers, of improved design, for use in Australia and for export to Britain, have been inspected and calibrated prior to despatch to the purchasers.

4. Timber Physics.

(i) *Physical Properties of Wood.*—The density and shrinkage of a number of New Guinea timbers have been studied and additional material from some of the secondary eucalypts of the south-eastern part of Australia has been tested in view of their increasing importance. Work has been carried out to obtain corrections for veneer of various thicknesses for use with electrical moisture meters. Trial tests have been completed on the compression of wood at temperatures up to 200° C. over the range of moisture content, 5 to 20 per cent. The apparatus for the determination of thermal diffusivity and conductivity of wood has been further modified and in a room conditioned to ± 1.5° C. the test cabinet can be maintained within ± 0.05° C. More uniform heating is now obtained from a steel shim 0.002 inch thick, heated by alternating current, the power being measured by a watt meter with the voltage coil operated through a calibrated feedback amplifier. To reduce losses along the heater strip, guard piles have been incorporated with gaps of only a few hundredths of an inch. For the measurement of temperature, thermocouples are used with a photoelectric amplifier in conjunction with a stable galvanometer of moderate sensitivity in the null method adopted to overcome lag in galvanometer response. Trial tests have been carried out on the determination of the dielectric constant and power factor of wood. The effects of temperature, moisture content, frequency and species on these properties are being studied. Tests on the effect of temperature on the electrical conductivity of southern blue gum have also been made.

(ii) *Studies of Creep in Wood.*—The tests on initially green beams subjected to prolonged loading have been continued and tests on beams initially at 14 per cent. moisture content commenced. Of the initially green beams, three more have failed during the year, two loaded to a maximum stress in the extreme fibre of approximately 45 per cent. of the ultimate strength as determined in standard tests and one at just over 20 per cent. of the ultimate strength. Several initially air-dry beams have been under test for periods of over six months. Two have already failed in 24 and 77 days under load, at stresses of a little over 40 per cent. of the short time ultimate strength. The total deflection of initially air-dry beams after five months under load was about twice the initial value, whereas in this time in initially green beams stressed to the same percentage of ultimate strength, namely, between 40 and 50 per cent., the deflection increased about fourfold. Beams initially green observed for variation of stiffness, as determined by vibration methods, whilst under load for well over a year, have shown no change. This was found to be accounted for to within a few per cent. by changes in the moment of inertia of the section due to shrinkage. Thus the modulus of elasticity is apparently unaffected by prolonged loading, at least to stresses of half the ultimate strength.

Beams loaded to produce extreme fibre stresses of 3 to 6 per cent. of ultimate strength showed an increase in deflection with time of about 210 per cent. in a period of nine months under load but it is not yet known how much of this is elastic after-effect and how much plastic flow. In two months, the beams loaded to the lower stress have recovered by 13 per cent. of the total time increment of stress and that at the higher by 39 per cent. Preliminary tests on creep in tensile specimens have yielded rather variable results, and owing to the small number so far tested, no very definite conclusions can be drawn. The general impression, however, resulting from these trials is that creep in tension is considerably smaller than creep in bending. The extensometers designed for these tests have been checked on a testing machine by comparison with electrical resistance strain gauges and found to give the required accuracy and precision.

(iii) *Electrical Strain Gauge.*—The 48-channel unit for the Timber Mechanics Section has now been completed in its final form except for a few minor adjustments of a routine nature. Further improvements have been made in the drying of gauges and the best procedure has been found to be two days at ambient temperature followed by four hours at 80° C., this temperature rise being obtained by passing a current through the gauge. A winding machine has been constructed for making ¼-in. gauges and has proved very satisfactory. Also ⅛-in. gauges are now being manufactured and although these will probably vary by as much as ± 5 per cent., they will be satisfactory for work on stress concentrations in test specimens.

The behaviour of electrical resistance strain gauges under prolonged loading is being studied in the hope that these gauges may be utilized in creep tests on timber. An attempt has been made to develop an unbonded gauge, with a mercury cup connector, for use on green timber. Preliminary tests, however, have shown that these gauges are not satisfactory for large strains (more than 0.1 per cent.). The effect of initial strain in the wire on gauge factor is being studied.

(iv) *Battery Separators.*—Owing to the reduction of imports from dollar countries, and the consequent almost complete cessation of supplies of Port Orford cedar and Douglas fir to this country from North America, there has been increasing demand on the limited supplies of high quality kauri for the manufacture of battery separators. It has therefore been necessary to intensify the search for substitute timbers. Tests on klinki pine, yellow sassafras, white cheesewood, red tulip oak, yellow walnut, rose alder, grey satinash, rose satinash, northern silky oak, negrohead beech, and Queensland maple have been carried out to assess their suitability for use as battery separator veneer. These tests include inspection for defects, chemical treatment for removal of deleterious substances, flexibility and bending tests, the measurement of electrical resistance, and hardness. At present, the value of the last test as a means of assessing wearing resistance is open to question but no satisfactory test for this purpose

has been developed. Only klinki pine and sassafras proved satisfactory in all properties. Life and maximum discharge tests have been carried out on klinki pine in comparison with Port Orford cedar, kauri, and Douglas fir. As far as can be seen at present, klinki pine compares favorably with any of these and may be superior to Douglas fir as regards life. Additional klinki pine logs have been obtained and separators have been made for further confirmatory tests including life tests on a vibrating table. The life tests carried out to date are difficult to interpret owing to the positive plates having a shorter life than the separators. In future, test batteries will be made using thicker positive plates in the hope that the separators will fail first.

As a result of a survey of the storage battery industry and of tests carried out during the year for various separator and battery manufacturers, a recommendation was made to the Standards Association of Australia that the emergency standards prepared during the war to cover wooden separators for automobile and aircraft batteries should be replaced by a standard specification covering wooden separators for all types of accumulators. A draft specification has now been prepared for submission to the Standards Association.

(v) *Dielectric Heating.*—A study has been made of the temperature distribution in mountain ash specimens subjected to dielectric heating under various conditions and of the moisture changes which occur. Preliminary tests have been carried out using red gum blocks to develop the necessary technique to maintain moisture content gradient in the wood. Comparison tests were then commenced on matched samples of wood with and without temperature gradients, but with the same average temperature or heat input to assess the effect of the gradient on the movement of moisture. The gradient has in all cases been present in one direction only and moisture and heat losses on the lateral faces have been minimized.

(vi) *Miscellaneous.*—Tests have been carried out during the year to determine the sorption characteristics of "flong", a paper-pulp board used in the printing trade. A number of instruments and pieces of apparatus have been calibrated for other Sections, these included dial gauges, micrometers, balances, weights, thermometers, thermocouple wires, and electrical moisture meters. Tests have been carried out on electrical equipment and instruments such as apparatus for hydrogen ion determination, temperature controllers for furnaces, and air conditioning equipment.

A high voltage power supply and photoelectric turbidity measuring apparatus were made for the Wood Chemistry Section, and various instruments have been constructed for internal use including one for measuring the dielectric properties of wood. A cycling equipment for batteries to the standards laid down by the Society of Automotive Engineers (U.S.A.) has also been constructed. In addition, temperature controlling gear, giving closer control than that available commercially, has been constructed for various purposes, including a thermometer calibrating bath and an air-conditioned cabinet.

5. Timber Mechanics.

(i) *Design of Containers.*—As in past years, assistance has been rendered to various State and Commonwealth Departments and to private firms with respect to improvements in the design of packages. Tests on potato crates, fibre boxes for gelignite, and boxes for the transport of bottles of patent medicine illustrate the range of investigations. As a result of a recommendation placed before the Second Forest Products Conference, at least one of the State Forest Services has indicated its willingness to undertake box testing. It is considered that a box testing authority should be located in each State to ensure a greater coverage of the problems of box design throughout Australia. Although the Division will gradually vacate this field, the various State authorities taking up the work will be given assistance not only in the training of staff but also in those technical matters relating to box testing with which the Division is better equipped to deal.

(ii) *Standard Tests.*—Apart from the routine testing of silver-top ash and white and brown stringybarks, attention has been mainly devoted to the analysis of the results of previous tests. The strength grouping of Australian timbers is one aspect of the analysis which has received a great amount of attention and the correlations between bending strength and other properties used in structural design are still being studied. Also the question of the number of results required to group correctly a particular species has been investigated. It has been determined that the testing of approximately 30 trees is necessary for correct grouping unless the species mean falls at or close to the middle of the range for a particular group. This applies if only one property in one seasoning condition is used for grouping; the number of trees required if both dry and green results are taken into account and if other properties are also considered, is being investigated. The tabulation of data on some 400 Australian species have revealed many instances of inadequate information and in order to obtain, in the shortest time, sufficient data to satisfy the majority of inquiries, an analysis is being carried out to determine the minimum number of specimens required to determine the species average for any property within certain reasonable limits of accuracy.

(iii) *Silvicultural Treatment and Strength.*—The analysis of results of strength tests on species subjected to silvicultural treatment has not yielded any significant correlations between strength properties and treatment. This negative result has been attributed in large part to the use of standard or near-standard size test specimens in which were included in many cases more growth rings than those laid down subsequent to a particular treatment. Efforts have been made to discover a better testing technique and initially the problem of laminating green specimens to near-standard size from slivers of wood cut from a restricted area of the cross section of a log was studied. Although some good results were obtained in the gluing of the green material, difficulties have been met and the investigation has been temporarily suspended.

Low capacity machines for testing very small specimens are being investigated. So far the investigations have been restricted to a low capacity Izod machine and to specimens cut from within the growth rings of young fast-grown mountain ash.

(iv) *Fundamental Studies of the Properties of Wood and Investigations of Testing Methods.*—Arising out of proposals to standardize internationally the mechanical tests on timber, a number of problems have been reviewed. Although about half the world's timber testing laboratories carry out standard tests with specimens of 2-in. by 2-in. cross section the remainder favour a 2-cm. by 2-cm. cross section. To study the effect of specimen size on such properties as bending strength, stiffness, and compressing strength, a series of tests have been commenced covering several species and various combinations of specimen length and cross section. A knowledge of the effect of specimen size is obviously of importance in making comparisons between the properties of local and overseas timbers. Another interesting experiment connected with this series was conducted on a specimen laminated from myrtle beech and balsa, the first-mentioned species representing the late wood and the latter the early wood of a piece of timber. It was demonstrated that the variation in stiffness with decrease in size of the

model specimen could be predicted quite well from the known properties and the relative numbers of bands of the two species. The variation of stiffness with size of specimen has been determined mathematically for laminations of unequal thickness.

The standardization of the speed of testing is of considerable importance particularly as there are two techniques at present employed and a third has been suggested. Testing at a constant rate of strain or at a constant rate of machine-head movement has been specified for many years by the recognized British and American specifications. However, modern machines are usually provided with a device which allows the load to be applied at a constant rate. The results of tests carried out using these two procedures differ significantly; for spruce it has been shown that the average values for compression strength may differ as much as 10 to 15 per cent. On the basis of investigations made in this laboratory, a method has been suggested whereby it is possible for a laboratory to select either of the two procedures and ensure that the results obtained will be comparable with the alternative procedure. The third technique which involved maintaining a constant duration of test irrespective of whether rate of strain or rate of stress is used has been shown to be of little value from the point of view of obtaining directly comparable results.

Investigations on impact hardness using a ball-drop impact machine have indicated high correlations between the impact hardness values and density and between impact and static (Janka) hardness values. The range of this machine is virtually unlimited compared with the Janka test, and it may be used not only for the complete range of hardness values from the softest to the hardest woods but also from low-density fibre boards on one hand to sawdust-cement slabs on the other.

As a result of investigations carried out some time ago on the variation of compression strength and density in short lengths of boards, a report has been prepared in which are discussed the methods to be used in estimating the strength properties of a specimen with a knowledge of the properties for matched control specimens and with partial or no knowledge of the method of variation of the properties between specimens.

Further studies have been conducted on a variety of subjects including the effect of moisture content on the impact values of wood, the lateral stability of deep beams, the effect of non-axial loading in compression strength parallel to the grain, the variation in compression strength perpendicular to the grain with size of specimen, area of loading plate and orientation of growth rings, and the effect of radius of loading head on the centre-point static bending test.

(v) *Flooring.*—The study of the strength and stiffness characteristics of flooring of all eight species and plywood for which the tests were originally planned has been completed and several reports prepared. Recommendations have been made in several instances to reduce the thickness of the flooring or alternatively to widen the joist spacing thus providing more economical utilization. Local housing authorities have co-operated by laying trial $^{9}/_{16}$ in. flooring in place of the standard $\frac{3}{4}$ in. flooring, and preliminary observations suggest that adequate serviceability as far as strength and stiffness will be given by the thinner material. Some minor investigations have also been carried out to study the effect on the stiffness and strength of the flooring with varying joist spacing and flooring thickness. Analysis of the results of these tests indicates that the theoretical relationships are likely to be conservative and therefore safe for design purposes. Factors involved in end matching have also been investigated.

(vi) *Fibre Building Boards.*—With the exception of the test for nail-holding power, the mechanical testing of "Caneite" has been completed and the results are being analysed. A minor series of tests designed to determine correction factors for adjusting the various strength results of "Caneite" to a standard moisture content has been completed, and has yielded results comparable to those obtained from wood. The decrease in strength for an increase of 1 per cent. in moisture content proved to be approximately 3 per cent. of the average air-dry value. Since the preparation of the working plan, equipment has been acquired to enable the puncture resistance of this and other materials to be measured. Creep in "Caneite" is also being studied with a view to determining the best spacing of ceiling joists and nogging to prevent undue sag of ceilings after being in position for a considerable period. The material required for the tests on "Masonite" was selected according to plan and the mechanical testing is well under way. At the request of the Masonite Corporation tests were conducted to find a method of bending "Masonite" which would not affect the appearance and strength of the material nor require a lengthy and expensive pre-treatment. The results of these tests enabled recommendations to be made for the bending of this material without affecting its characteristic properties and with a pre-treatment period of less than 1 minute.

(vii) *Long-time Loading Tests.*—Short-time compression tests on matched specimens of the species used in the main investigation on the effect of long-time loading on connector joints have been completed. Although nine more connector joints have failed under long-time loading during the past year there still appears to be little correlation between the time to failure and either the load applied or the joint detail. As practically all the failures to date have been by bending of the outside legs of the three-member joints instead of longitudinal splitting of the centre piece as occurred in practice, it was thought that the shape of the members used in the experiment might be responsible. Six specimen joints, using a greater ratio of width to thickness of members were assembled and heavily loaded, and in every case splitting of the central member occurred. As two effects, the shape of specimen and long-time loading were confounded in this short experiment, further work is necessary before the apparent effect of shape on the method of failure can be checked.

(viii) *Miscellaneous.*—At the request of the Australian Wool Realization Commission, tests were carried out on a composite fabric of cotton twine and twisted paper yarn, a South African substitute for the jute wool pack. A report on the investigations covering the strength properties of the fabric, both wet and dry, and the resistance of a wool pack made of this material to the ramming of wool into it, has been prepared.

Extensions to the tables given in C.S.I.R. Pamphlet No. 112 on Building Frames have been completed for incorporation in the Australian Standards Association specification 0.56.

6. Timber Seasoning.

(i) *Fields of Work.*—Over the past year several projects of significance to the timber industry, but of a nature somewhat removed from timber seasoning investigations, were continued. Greatest emphasis was given to (*a*) studies in sawmill performance, recovery and efficiency, and (*b*) the development of wall board and flooring materials, using wood waste as the basic material. In the specific field of seasoning, a number of projects were investigated. In addition, because of the under-supply of seasoned timbers in Australia, many of the timber-using industries have needed help in planning and establishment of seasoning

and associated plant involving new equipment, as well as the redesigning of old established plants of low efficiency. In this sphere, the technical services of the Section have been fully utilized and satisfactory co-operation with industry maintained.

(ii) *Studies in Sawmill Performance.*—In co-operation with the States Forests Services and industry, work has been carried out on the milling of the "ash" type eucalypts in Victoria, and on jarrah in Western Australia. The initial study undertaken last year at the request of the Victorian Sawmillers' Association comprised an examination of mills operating on green "ash" timber only; this year fire-killed timber was studied. An examination was made of the effects of variation of size of sawn product on mill production rate and percentage recovery obtained from the mill log, the composite effect of these relationships on manufacturing margin; the mill time occupied in operational and non-operational duties; the lost production time; and the sawn production, quantity of waste wood, and sawdust loss. Reports on this work have been issued.

The studies undertaken in the mills operating in the jarrah forests of Western Australia were carried out at the request of, and in co-operation with, the Western Australian Forests Department. The object of the studies was to determine the extent of and reasons for poor efficiency at these mills and to indicate methods of improving performance.

(iii) *Building Materials.*—Work on a sawdust-synthetic-resin building board has been commenced, and encouraging results are being obtained. The principal variables studied so far include particle size, resin concentration, resin grading, and temperature of pressing. To date, mountain ash has been used as a standard species, although some minor scout tests have been made with other species. The results obtained indicate that a finely ground resin is desirable irrespective of the sawdust grade, and that a coarse resin produces a variable board of low strength. The strongest boards gave a modulus of rupture of 6,500 lb. per square inch and were made from a coarse sawdust and a fine resin. Present indications are that a resin concentration as low as 10 per cent. is satisfactory, but that there are likely to be a number of problems in production technique. Work on sawdust-cement and wood wool-cement boards was limited almost entirely to the handling of a considerable volume of inquiries, particularly with regard to methods of preparation and application and suitability for housing.

(iv) *Veneer Drying.*—The "ash" type eucalypts of south-eastern Victoria could be important species for the manufacture of plywood but for the difficulty in seasoning the peeled veneer. An examination of the seasoning characteristics of these eucalypt veneers has, therefore, been commenced. Interim indications are that the major part of the seasoning degrade develops prior to the moisture content falling to 50 per cent., showing the influence of collapse; that face checking occurs primarily on and through checks developing from the tight side of the veneer; that tight $^1/_{16}$ in. thick veneer dries with less checking than looser cut veneer; that the use of a chemical dip (saturated sodium chloride solution) of 10 seconds is of advantage; and that reconditioning is of considerable value in reducing buckling. Recovery in size following reconditioning averaged 8 per cent. of the dry width prior to reconditioning.

(v) *Moisture Equilibrium Studies.*—Work on this project has been carried out as two allied but separate studies, namely, (*a*) a determination of the equilibrium moisture content of Australian timbers when exposed to specific conditions of temperature and humidity, and (*b*) an examination of the inter-relationship between locality in Australia and equilibrium moisture content.

For the former of these studies material from six Australian species has been prepared (some 2,300 samples) in thickness of $\frac{1}{8}$ in., $\frac{1}{4}$ in., $\frac{1}{2}$ in., and 1 in., the following variables being included in each parcel: (*a*) tangential and radial sawn material, (*b*) material air-dried from the green condition and material kiln-dried under controlled conditions, and (*c*) reconditioned and non-reconditioned material. The effect of some of the above variables on rate of change of equilibrium moisture content will also be studied.

From the second of the studies mentioned above it is anticipated that data obtained will permit the preparation of maps showing lines of uniform equilibrium moisture content, plotted as monthly and seasonal means. Meteorological data from some 217 stations throughout Australia are being used.

(vi) *The Seasoning and Processing of Red Gum for Flooring.*—For many years considerable quantities of 1-in. thick red gum have been unavoidably produced by red gum sawmillers during the milling of the larger structural sections into which this species is normally converted. Despite Australia-wide shortages of seasoned 1-in. material for housing and general building purposes, the industry has not been able to use the 1-in. red gum because of its very refractory seasoning characteristics. It has, therefore, been regarded almost completely as a waste product of little use and low value. Results of the successful attack on this problem have been referred to earlier in this report.

(vii) *Kiln Design and Plant Layout.*—Performance tests were carried out on a timber pre-drier designed by the Section from an idea submitted from industry. The unit is intended for use in areas with poor air-drying conditions. The design provides for air-drying on a progressive principle without the necessity for periodic movement of all timber stacks within the drier, as is normal with progressive units. This is achieved by means of a damper system through which points of entry and discharge of the circulating air can be changed at will. The tests made indicate that the prototype, which has a charge capacity of some 100,000 super. feet of timber, is operating satisfactorily both aerodynamically and thermodynamically; some nine months' operation on 1-in. thick Tasmanian messmate stringybark has indicated that drying from the green condition to a mean value of about 25 per cent. moisture content requires approximately three weeks, whereas air-drying over the same moisture content range, in the locality in which the pre-drier has been installed, has required up to eight months. The final drying in kilns of the pre-dried material does not appear to be less satisfactory than that of partly air-dried stock and, under certain operating conditions, the use of the pre-drier shows considerable economy over the more orthodox technique of preliminary air-drying and final kiln-drying usually adopted for this species. The Section has undertaken to design two pre-driers, each of 150,000 super. feet charge capacity and steam heated; and four pre-driers each having an approximate charge capacity of 240,000 super. feet and heated by means of gases from the burning of wood waste.

Drawings, specifications, and material lists to cover the construction of timber seasoning kilns, drying rooms, plywood re-driers, and progressive and compartment type veneer driers to suit a wide range of requirements were prepared on request for 36 companies. Some 300 drawings were issued, including plans covering modifications required for the modernizing of obsolete units.

(viii) *Kiln-Drying.*—Kiln schedule studies on 2-in. thick satinay and brush box from Queensland were completed, and reports covering recommended schedules for backsawn and quartersawn stock of the latter

species were prepared. An examination of the drying characteristics of timber from three secondary species now being milled in increasing quantities in south-east Australia, namely, 1-in. quartersawn white stringybark and silver top ash was completed and reported. Scout runs completed on the white stringybark indicated that chemical seasoning will be of value. Work on the development of schedules for 2-in. backsawn and quartersawn stock of white stringybark and brown stringybark and silvertop ash was commenced.

(ix) *Miscellaneous Seasoning Investigations.*—A considerable number of minor miscellaneous inquiries (some 1200) was received from the timber and allied industries during the year. Subjects on which information was required included collapse and reconditioning, kiln maintenance, temperature and humidity equipment, wood waste disposal, the drying of speciality items, timber conditioning, the testing of refrigerator insulation, moisture meters and moisture content control, air seasoning practice, the drying of veneer and plywood, timber handling, the rating of steam boilers, boiler fuel requirements, kiln-drying schedules for numerous species, the utilization of veneer waste, chemical seasoning, moisture resistant coatings, kiln testing technique, the design of vat heaters, peg drying, drying costs, &c.

(x) *Correspondence Courses in Timber Seasoning.*—Interest in the correspondence courses in timber seasoning and kiln operation conducted by the Section was maintained by industry throughout the year. Since the inception of the correspondence courses in 1932 some 600 inquiries have been received, and 240 students have completed either one or both of the courses offered. Some 30 students are at present active.

7. Timber Preservation.

(i) *General.*—In the current year the Section has faced the problem of maintaining progress in the many and varied research projects now under way and at the same time of coping with the large volume of applied work. This applied work has included the answering of requests for assistance or technical advice from Government timber-using departments, industry, and the public. In addition, considerable time has been spent inspecting field tests in three States and preparing the necessary reports. To some extent, this has limited progress in research projects, but in the coming year it is hoped to adjust the balance. To this end, staff has been augmented recently by the appointment of a technical officer for applied work and a research officer to strengthen work on aspects of timber mycology. During the year, the officer-in-charge of the Section visited New Zealand to attend the Dominion Federated Sawmillers Conference at Rotorua and to spend some time inquiring into various aspects of wood preservation in New Zealand. Officers have also visited New South Wales and Western Australia.

(ii) *Field Tests.*—Inspection of field tests has represented an important part of the year's work as five major tests have been examined in eleven localities in Western Australia, Victoria, and New South Wales. In Western Australia, the final inspection was made of tests installed in 1938-39 to determine the extent to which various heart rots of jarrah, occurring in the living tree, are capable of continued progress in converted timber in contact with the ground. This test has shown that most heart rots of jarrah do not extend during service and that the previous practice of rejecting this timber for small areas of decay was a needless waste. This is an important result which has been incorporated already in revised standard specifications for jarrah. Tests of preservative-treated fence posts were also inspected in Western Australia. Results after approximately seventeen years' service have continued to demonstrate that round posts of non-durable timbers may be treated simply, effectively, and cheaply with a number of different preservatives.

In Victoria, field tests of preservative-treated poles of lower durability timbers were inspected in three localities and demonstrated to many visitors representing the main pole-using authorities. As the value of preservative treatment for poles is now clearly evident in these tests, the policy during all recent inspections has been to publicize the interim results, both by demonstration during inspections and by wide circulation (over 200 copies) of inspection reports. The interest taken may be judged from the fact that during the New South Wales and Victorian inspections 65 engineers and technical representatives visited the pole test sites, many of them remaining throughout inspections which lasted for several days.

(iii) *The Preservative Treatment of Eucalypt Truewood.*—This project, referred to in the last report, has continued steadily. Results have now demonstrated beyond doubt that many eucalypt timbers, the truewood of which was previously considered untreatable with oil preservatives, may be penetrated satisfactorily at high pressures. Penetration tests have now been completed using specimens from a number of different trees for the following ten eucalypts—southern blue gum, brown stringybark, marri, yertchuk, karri, white stringybark, jarrah, messmate stringybark, silver-top ash, and manna gum. Using creosote oil at pressures of 1000 lb./sq. in., average absorptions of over 6 lb. per cubic foot have been obtained for all the above species with the exception of yertchuk. The main and urgent application of this work is in the preservative oil treatment of eucalypt rail sleepers, but before its practical value can be finally assessed, it will be necessary to demonstrate that commercial treatment at high pressure is economically possible. A high pressure cylinder capable of treating five broad gauge sleepers at each charge has been designed and will be installed as soon as possible. It is planned to treat several hundred sleepers for service test.

(iv) *Diffusion Studies.*—The correlation of diffusion rate of salts with wood structure has been the principal study made during the year, the Wood Structure Section co-operating in this work. Results have indicated that for transverse diffusion the most important structural feature was the ray cell area and on this basis a local explanation may be offered for the very significant difference in diffusion rate in the radial and tangential grain directions. There was also evidence that abundance of parenchyma reduced the difference between radial and tangential diffusion rates and that transverse diffusion was correlated with orientation and distribution of vessels rather than with total vessel area. This work is continuing.

(v) *Lyctus Borer Investigations.*—In the review for 1946-47, the preliminary investigation was reported of two methods designed to simplify the present commercial boric acid process for the Lyctus proofing of green veneer. The first method under test involves only the momentary immersion of green veneer in cold boric acid solution followed by block stacking of the treated sheets to permit diffusion. Very promising results from the testing of this method are now being obtained, the first inoculation with mated pairs of Lyctus beetles having produced no attack in treated plywood exposed in compulsion tests. This result has been confirmed by chemical analysis of several hundred sheets of treated veneer, the boric acid content of which has been consistently above the level for theoretical immunity. Re-inoculation with beetles in all the 312 cages in which the experiment is housed is now being made and if results are confirmed the method will be recommended to industry. This simplified method should prove of considerable

economic advantage to the plywood industry abroad as well as in Australia. Local industry has followed the progress of the tests with considerable interest and the method has been adopted already by at least one commercial plant though its formal recommendation must await the confirmatory tests.

In the second method under test, the effect of adding various toxic chemicals to glues used for bonding plywood is being determined. Results from the first beetle inoculations of the 1440 test plywood panels have now been obtained and indicate that with some chemicals complete or substantially complete protection has been afforded. For various reasons, however, any apparently promising results from this test must be viewed with considerable caution until retests have been made—particularly for preservatives such as DDT and "Gammexane", the permanence of which is in doubt.

For the above experiments and for others projected, the need for large quantities of Lyctus beetles hatching throughout the year has necessitated careful attention to laboratory breeding technique. Also difficulty in obtaining uniformly satisfactory results with naturally collected beetles has resulted in the raising of Lyctus breeding work to the status of a project. Experimental work is at present aimed at developing a uniform high yielding laboratory strain by repeated selection.

(vi) *The Toxicity of Metallic Naphthenate Preservatives.*—A satisfactory laboratory technique has been developed for formation of copper naphthenate from fractioned naphthenic acid crudes. The method requires the formation of the sodium soap by titration to neutrality with sodium hydroxide followed by simultaneous addition of copper sulphate and sodium naphthenate to ice-cold water. The flocculent copper naphthenate precipitate is then dissolved in benzene, the benzene phase washed to remove any unreacted copper sulphate, and the metallic naphthenate isolated by distilling off the benzene. Preliminary toxicity tests have been made using the agar culture method. No difficulty was experienced in obtaining a uniform dispersion of the copper naphthenate in the agar medium and dosage-response results when plotted on double log paper gave a close approximation to the theoretical linear relationship.

(vii) *External Coatings for Wood Stave Pipe in Western Australia.*—During the year a second inspection was made of the karri wood stave pipe on the main Goldfields water supply system between Kellerberrin and Kalgoorlie in Western Australia. The purpose of this inspection was to determine the extent to which deterioration of the wood had progressed since the first inspection in May, 1946, and to discuss the practical application of protective coatings developed by the Division. During the year, a further 53 coating formulations were prepared and subjected to solar exposure tests. An experimental length of wood pipe under a pressure of approximately 100 lb./sq. in. has been installed for further test of selected coatings.

It has now been recommended that test sections of the pipe line in Western Australia be coated with a 3-coat system employing a tar-creosote priming coat, a horizontal tar-asphalt intermediate coat and a light-reflecting aluminium shield coat, the latter coating being applied only on the northern quadrant where solar effect is intense.

(viii) *General Survey Work.*—The survey of marine borer damage to wooden ships and harbour installations in Australian waters has been completed. Review of the data collected has indicated the need for long-term research in this problem and a marine biologist will be appointed.

During the year inspection of recovered cross arms was commenced in connexion with the project to survey the causes of service failure of cross arms throughout Australia. Inspection was commenced in Western Australia where data were obtained from five areas previously selected as representative of a range of service conditions. Arms were examined and classified under twelve main headings for defects now visible and particularly for prime causes of failure. End splitting, decay, and termite attack proved to be the main causes of failure in Western Australia. The survey is continuing in Victoria and will be extended to other States as opportunity permits.

(ix) *Timber Mycology.*—Preliminary testing of various methods for accelerated laboratory decay tests, reported previously, was completed. The results showed that improvement in accepted techniques is necessary before adopting a method for long-term investigation of the natural durability of Australian timbers to decay. A research officer has been appointed to continue and expand this work.

8. Veneer and Gluing.

(i) *Peeling.*—(*a*) *Plantation-grown pines.*—An investigation has been made of the suitability for plywood manufacture of slash pine and loblolly pine. Although both species could be peeled and dried without difficulty, appreciable warping was displayed in three-ply panels made from $^1/_{16}$ in. veneers. This effect was ascribed to the differential shrinkage of late and early wood, as the presence of compression wood could not be detected, and very large differences in density and shrinkage were observed between material selected visually from late and early wood bands. Preliminary tests have indicated that the warping may be eliminated by multi-ply construction, even five plies yielding good results. The economic importance of this study lies in determining silvicultural policy towards plantations which may become a major source of veneer. The experiments carried out have been on material from young thinnings, and comparable results may not be obtained with pruned, mature trees.

(*b*) *New Guinea Klinki Pine.*—The experiments carried out on klinki pine, and referred to in the last report, have been extended to include an examination of this species for the manufacture of matches, and the results have been satisfactory.

(*c*) *Ash Eucalypts.*—Investigations have been continued into the possibility of producing veneer from the ash eucalypts. Logs of mountain ash have been peeled under different degrees of compression for the Seasoning Section, which has studied the effect on drying characteristics.

(*d*) *Heating Veneer Logs.*—Several advantages accrue from heating logs before peeling into veneer, and studies have been made of the temperature distribution within the log under various conditions, and the results compared with those to be expected from the work of MacLean (U.S. Forest Products Laboratory). The effects of peeling temperature on glue shear strength of plywood made from the veneer and on tensile strength of the veneer along the grain have been investigated, but do not appear to be critical.

(ii) *Gluing Investigations.*—(*a*) *Survey of Species.*—Gluing tests with a range of adhesives were carried out on a number of Australian species.

(*b*) *Casein Glues of Low Alkali Content.*—Because of the shortage of caustic soda, wet-mix casein glue formulae with reduced proportions of sodium salts have been investigated. Considerable economies can be effected without adversely affecting dry strength or working life, but some deterioration in water resistance is indicated.

(*c*) *Substitutes for Casein.*—In view of the shortage of casein for use in cold-setting adhesives, the use of other natural adhesive bases, such as potato starch, peanut meal, and soya bean protein has been studied. Cold-mixed potato starch-casein blends produced adhesives satisfactory in most respects, but of fairly low

water-resistance. Dry-mixed starch adhesives have been prepared. Peanut residues obtained during oil extraction in Australia, have been found to be unsatisfactory in adhesive properties. In combination with casein, however, fairly good results can be achieved. Particle size is important, finer material producing stronger bonds. Optimum proportions of lime, caustic soda, and tetrasulphide for incorporation in soya bean glues have been determined. The properties have also been studied of soya bean glues containing varying proportions of casein.

(*d*) *Lignin Adhesives.*—The condensation of phenol, lignin, and formaldehyde did not yield very encouraging results. Reaction products of lignin and furfural, however, showed promise, when the condensation was carried out under alkaline conditions. Best results have been obtained with glued joints made in the hot press. An encouraging feature of the tests has been the high water-resistance obtained with some bonds; on the other hand a relatively large proportion of acid has been required to effect setting. Soda lignin was used.

(iii) *Rheological Properties of Adhesives.*—(*a*) *Stormer Viscometer Studies.*—As a basis for the rheological study of adhesives, data were obtained on a series of Newtonian liquids in the Stormer rotational viscometer. Functions were derived for viscosity, and their range of applicability delimited. A method of obtaining the fundamental flow curve for Newtonian liquids from the experimental data obtained in the Stormer viscometer has been developed and applied to the determination of the true yield values of non-Newtonian materials.

(*b*) *Thickening Colloidal Systems.*—Following on from the above calibration studies, a method has been evolved for determining the experimental consistency curve at any instant during the setting of an adhesive. It is thus possible to trace the changes in rheological characteristics with time, and examine the relation to adhesive qualities. Various aqueous systems with casein as the principal constituent have been examined, and an increase in yield value with degree of denaturation has been generally observed. Several synthetic resins, including urea-formaldehyde, phenol-formaldehyde and resorcinol-formaldehyde, were also prepared in the laboratory and their flow properties studied. Of particular interest were the results obtained with the resorcinol-formaldehyde resin upon the addition of further formaldehyde as a hardener. This system exhibited practically Newtonian behaviour until the abrupt transition to the gel stage, and on the basis of these observations a rheological category may be distinguished in which rate of shear is instantaneously proportional to shear stress at any arbitrary time, but in which, at constant stress, shear strain is not proportional to time.

(*c*) *Physical Study of the Phenol-Formaldehyde Molecule.*—The Hoppler viscometer has been used to determine the intrinsic viscosity of an A stage phenol-formaldehyde resin in ethyl alcohol. From the examination of solutions of higher concentration than those necessary for the calculation of intrinsic viscosity a linear relation between concentration and the logarithm of relative viscosity has been established, which suggests that the particles conform neither to a linear nor a spherical model, but probably have an intermediate configuration.

(*d*) *Reduction of Viscosity of Starch Glues.*—A recognized disadvantage of starch glues is their high viscosity at concentrations which give adequate joint strength. It has been reported that dilute potato starch pastes exhibit lowered viscosity upon the addition of small amounts of salts. This effect has been studied at concentrations approaching those used in wood adhesives and has been amply confirmed, even 1 per cent. of added salt reducing the viscosity to about one-tenth of its original value.

(iv) *The Nature of Adhesion.*—Experiments on the chemical nature of the bonds between glue and wood indicate that the mechanism of adhesion probably varies considerably with the type of adhesive. Evidence was found that the hydroxyl groups in the wood substance play an important role in the bonding of wood with urea-formaldehyde resins, as acetylation of any considerable proportion of these groups caused a marked decrease in the strength of the bond. On the other hand replacement of a proportion of the hydroxyl groups by methoxyl had no appreciable effect on the strength of joints made with casein glue.

(v) *Testing Methods.*—With the object of improving current methods of testing glues and plywood, a statistical analysis was made of an experiment designed to examine the frequency distribution of glue shear failing loads of plywood test specimens. The distribution was found to differ significantly from the normal but not to such a degree as to invalidate analyses of variance based on the assumption of normality. The precautions necessary for avoiding subjective errors have been determined. The number of test specimens required to establish the significance of a given difference between means has been studied.

(vi) *Durability of Plywood.*—(*a*) *Deterioration of Glue Lines.*—The effects of micro-organisms on the breakdown of casein glues at various periods after mixing were examined. With glues of low alkalinity rapid deterioration was evident, but at higher alkalinity there were no indications of spoilage over a period of about four weeks, indicating that bacteria are unable to multiply in such a medium, although sporing forms may survive.

(*b*) *Face Checking.*—The principal factors in plywood manufacture responsible for face checking of exposed panels have now been evaluated and are in agreement with results obtained independently by Knight (Forest Products Research Laboratory, Great Britain). In particular the use of thin face veneers can considerably improve the suitability of plywood for external use, and it is hoped that this may lead to a greater acceptance of plywood for the external sheathing of houses. Accelerated exposure tests in a weatherometer have been made and results are in accordance with those obtained under conditions of outdoor exposure. Further external confirmatory tests are in progress on a larger scale.

9. Utilization.

(i) *Timber Uses.*—Numerous requests for assistance with problems connected with timber utilization were received during the year from members of the timber industry, from Federal, State and Municipal authorities, and from the general public. Those directly related to specific uses called for advice on timbers suitable for artists' panels, axe handles (laminated), barrel staves, bearings (wringer), benches (butchers'), butter churns, caravans, clothes pegs, coffins, cooperage, cricket bats, croquet mallets, doors, dowels, drum handles, electric meter boards, electrical fittings, feeding troughs, fishing rods, flooring, foundry vats, furniture, golf club heads, handles, ice cream spoons, ice hockey sticks, instruments, joinery, log cabins, mouse traps, musical instruments, pattern making, picking sticks, pipes, pressing boards, printers' backing blocks, shipbuilding, skis, slide rules, spokes and felloes, telephone booths, textile equipment, tool boxes, turnery, veneers, violin bows, water cooling towers, weatherboards, wharf decking, wood floor, wooden vise jaws. Inquiries concerning the characteristics and uses of species required the preparation of notes on some 30

species, chiefly from Australia and the Pacific area. Six species descriptions and four articles on various aspects of timber utilization were prepared for publication in the Forest Products News Letter. A mimeographed list of timbers used for various purposes is being revised. Over 100 copies of Notes on Log Cabin Construction were distributed in response to enquiries. A survey of the timbers used in wooden tanks was begun during the year.

(ii) *Manufacturing Processes.*—The Officer-in-Charge of the Section was seconded to an Australian paper company to study American practices for storing and handling wood at pulp mills, and performance of equipment for unloading, storing, conveying, barking, sawing, shipping and screening and to assist in integrating wood handling operations in the company's programme of development in Australia. Inquiries on handling were dealt with for other companies. Sawmilling practices and equipment were compared and discussed with sawmillers and Government authorities contemplating reorganization of the layouts of plant, particularly to convert thinnings and immature timbers. The requirements for manufacturing wood flour were set out in detail for several enquirers. Details on manufacturing to promote more efficient production or improvement in quality were given in regard to a number of products.

(iii) *Waste Utilization.*—The survey of sawdust production in the Australian sawmilling industry revealed that 58,000 tons of sawdust per month are produced, of which 18 per cent. is used for power production, 0.5 per cent. used for other purposes at the centre of production and 10 per cent. despatched for various industrial uses. The location of the 42,000 tons per month not utilized at present is indicated from the survey, and it is possible to show quantities available in proximity to selected centres. A report on the survey is ready for distribution. A working plan was completed outlining investigations to be undertaken in the laboratory to establish the composition and properties of Australian sawdusts. Information on calorific values of sawdust and other wood waste and on types of burners and furnaces suitable for industrial heating or steam raising from waste wood was supplied. Attempts to produce a briquette from sawdust and a cheap binder were made. Results of research into the production of building materials from sawdust and notes on various industrial uses of wood waste were distributed.

(iv) *Sawing Studies.*—Two different methods of sharpening hand saws were compared, a machine for studying the action of circular saws was designed and, at the request of a manufacturer intending to adapt an overseas power chain saw to Australian requirements, preliminary tests on chain saws were made.

(v) *Standards.*—Assistance was given to the Standards Association of Australia in the work of its Timber Sectional Committee, Committee on Dimensions of Timber in Buildings, and Committee on Household Furniture. The activities of grading committees in various States were revived to review existing standards or to draft others for timber products whose grading has not yet been standardized. In March a meeting of the Timber Sectional Committee in Sydney, attended by the Chief of Division as Chairman and two officers as Joint Honorary Secretaries, reviewed timber standards work and recommended that a Timber Industry Committee be set up to bring all work on timber standards under unified direction. Attention was devoted to the revision of standard grading rules for Western Australian timbers, and the Officer-in-Charge of the Section visited Western Australia to collaborate with the Forest Department and the Grading Committee in that State in finalizing drafts and preparing for publication 28 revised specifications for a comprehensive range of sawn and milled products of jarrah, karri, and wandoo. A grading study on radiata pine milled flooring was made to provide a basis for the development of grades for Victoria, and questions affecting these grades have been referred to a South Australian sub-committee. Field studies at sawmills cutting ash eucalypts, at depots of some master builders and on housing estates were undertaken to gather information basic to the revision of standard grading rules for structural timber and building scantling; for the development of joinery grades; and for revision of grades for flooring, lining and weatherboards. Scantling was selected and forwarded to Tasmania to demonstrate marketable qualities and a covering report prepared to assist in the preparation of Tasmanian grading rules for this product. Quality characteristics of red gum flooring produced from sawmill waste were examined, and grading rules were prepared for flooring of this timber as part of the project aimed at improving utilization of this species.

The Food and Agriculture Organization of the United Nations was furnished with replies to a questionnaire on technical standards in the field of wood utilization, together with copies of all relevant publications. A study of Australian practices of calculating the cubic content of standing timber was made to provide information to the Association Francaise de Normalisation. Action was taken to prepare an Australian list of standard terms and definitions for use in forest products research as part of an Empire activity.

(vi) *Miscellaneous.*—(*a*) Mountain ash for the large scale storage and maturing of wine was tested using experimental tanks, but taint developed after two months. Small scout tests were then commenced on alternative species.

(*b*) Laboratory work was undertaken to find fillings suitable for the repair of wooden stave pipe sections of the Western Australian goldfields water supply. A report has been prepared describing the tests and recommending several caulking compounds for field trial.

(*c*) The use of secondary species for butter box manufacture was investigated in co-operation with appropriate State and Commonwealth authorities.

(*d*) Tests to determine the efficacy of sealing compounds in protecting milled flooring during house construction were made, and floors were laid down to establish the best conditions of preparation and laying of boards over sub-floor heating systems.

(*e*) Investigations were carried out on packaging of timber and the loading of packages into railway trucks with mechanical devices, such as fork lift trucks, cranes, &c. The most successful system promised to effect up to 50 per cent. increase of loading with air-dried material in rail trucks.

(*f*) Assistance was given to a sporting goods manufacturer in splitting and gluing lawyer cane for use in cricket bat handles.

(*g*) The causes and prevention of stain of yeast when packed in hardwood boxes was investigated. Treatment with mineral wax emulsion was recommended when parchment paper is not available.

(vii) *Liaison and Educational Work.*—Apart from individuals, parties visiting the Division included students from several Technical Schools and the Australian Forestry school, instructors from the Education Department, trainees from rehabilitation courses, and representatives of the building trades. A Divisional exhibit was installed at the Royal Agricultural Show, Melbourne. Strip films on forestry and forest products were prepared for State Education Departments.

IX. FOOD PRESERVATION INVESTIGATIONS.

1. General.

The investigations described in last year's report have been continued and few additional projects have been started. At the request of the New South Wales Government Railways, officers of the Physics Section co-operated with railways engineers in studies of a new type of louvred van for the long-distance transport of fruit and vegetables. It is planned to extend these studies in an endeavour to obtain coefficients of performance of ventilated railway vehicles carrying the major types of perishable foods. In collaboration with the New South Wales Department of Agriculture, preliminary work has been carried out on a new, major investigation of the freezing of fruit and vegetables.

It is planned to extend the fish preservation investigations by opening a small branch laboratory at Eden (N.S.W.). This laboratory should be ready for occupation towards the end of 1948. Further extensions of the Division's Brisbane laboratory are about to be made; such additional space is essential for the resumption of meat preservation investigations on a scale at least equal to that before the outbreak of the last war.

Two senior officers of the Division recently returned to Australia after visits overseas to gain further experience. Refrigerated transport was a major subject of inquiry by one of these officers who has submitted detailed reports on the physical and engineering aspects of such transport by railway and by fishing vessels.

Encouraging financial support of the investigations has continued to be given by various public bodies and several industrial organizations.

2. Physical Investigations.

(i) *Cold-store Survey.*—The detailed study of the performance of representative commercial fruit stores, referred to last year, is being continued. Measurements are in progress in six stores this season. A progress report on this work was read at the annual conference of the Commonwealth Cold Storage Association.

The measurements carried out so far reveal some substantial differences in the degree of uniformity of temperature between stores of different types. In the best type studied the extremes of temperature in different parts of the store were generally within 1½°F. of the average; in the worst a temperature range from 5°F. below the average value to 2°F. above was typical. Further work is needed to see whether a satisfactory correlation of the degree of uniformity of temperature with the relevant design and operation factors can be established.

Studies of the humidity and the weight loss from fruit in storage and the factors affecting them are in progress. Measurements of the rate of initial cooling of fruit have been carried out in a number of stores. This is of particular importance with pears since their storage life may be substantially reduced by slow cooling to the storage temperature.

(ii) *Gas Stores.*—A note on the gas-proofing of stores has been published. The performance of a commercial store gas-proofed in an unusual way was checked and found satisfactory. Further measurements will be necessary to tell whether the proofing retains its efficiency well enough.

(iii) *Measurement and Control of Relative Humidity.*—Consideration has been given to the design of equipment for holding high humidities in cabinets and storage rooms. One storage room was fitted to maintain 20°C., 90 per cent. R.H. A cabinet in which it is hoped to be able to maintain the humidity constant at any desired value over a fairly wide range at low temperatures is being constructed. Some types of instrument which might be adapted to measure humidities in narrow spaces inside stacks of fruit have been studied in the laboratory, and further work is in progress.

(iv) *Rail Transport.*—In co-operation with the New South Wales Government Railways two detailed comparisons of cargo temperatures in a new type of louvred van with those in a car of the present standard type on the same train have been carried out. An attempt was made to deduce from the test results valid coefficients of performance for the cars which could be used to estimate cargo temperature histories for different weather conditions. Further measurements will be needed to check these estimates. If the method proves successful a great deal of time may be saved in future investigations of ventilated transport problems.

(v) *Evaporation of Water from Foodstuffs.*—Some determinations of the ratio of rate of evaporation of a fruit to rate of evaporation of a geometrically identical wet body under the same conditions, have been made with bananas, beans, and pears, in order to obtain data needed for the interpretation of the results of transport and storage investigations.

(vi) *Cooling of a Wet Body.*—Calculations have been continued at intervals during the year. Several possible alternatives to the numerical methods previously used for solving the equations have been tested but all had to be rejected.

(vii) *Vapour Pressure of Dried Foods.*—Further measurements have been made with dried egg and dried peas. A report on this work is being prepared.

(viii) *Canned Fruit Processing.*—A numerical analysis was made of some of the heat transfer problems involved in estimating the advantages of rapid rotation of cans of fruit during processing.

(ix) *Colour Measurement.*—It has not yet been possible to construct a photoelectric tricolorimeter for which complete plans and specifications have been prepared by the Council's Physics Division.

(x) *Freeze Drying.*—A freeze drying unit obtained from the Australian Red Cross and originally designed for blood drying has been installed for the drying of certain heat-sensitive, biological material. It will be a valuable "tool" for chemists studying the nature of the changes taking place in foodstuffs during processing and storage.

3. General Chemistry.

(i) *Polarography.*—Polarography has many applications in food analysis, but its use is limited by inadequate knowledge of the effect of various factors such as viscosity, capillary constant, and time of standing, on polarographic diffusion currents. The effect of these factors has been investigated systematically. It has been shown that changes in viscosity produced by substances in true solution have considerable influence, while viscosity changes due to the presence of lyophilic colloids have little influence in the absence of secondary effects. A paper on the effect of viscosity has been prepared.

An investigation of the operating characteristics of a commercial recording polarograph has been carried out and a report prepared. The accuracy of the measurement of half-wave potential and diffusion current was determined, and an equation for calculating the error in the measured half-wave potential was obtained.

Investigations on the polarographic determination of ascorbic acid have been initiated.

(ii) *Catalytic Oxidation of Ascorbic Acid (Vitamin C).*—Preliminary investigations have been made of the mechanism of the copper-catalysed and iron-catalysed

oxidations of ascorbic acid. Evidence has been obtained that the limiting factor in the latter reaction is the oxidation of ferrous iron by oxygen.

(iii) *Dehydroascorbic Acid.*—Investigations have been carried out on the stability and determination of dehydroascorbic acid and a paper has been prepared for publication. This substance is produced from ascorbic acid by oxidation, and has some vitamin C activity. The destruction of dehydroascorbic acid was studied from pH 0 to pH 7 at 0°–100° C. Maximum stability was found at approximately pH 2. The temperature coefficient of the rate of destruction was found to increase with increasing pH. Borate considerably accelerates the destruction of dehydroascorbic acid. Dehydroascorbic acid could not be prepared pure, but a preparation of about 75 per cent. purity was obtained. Some tests were made on solutions of "diketogulonic acid" which is produced from dehydroascorbic acid on standing. This substance was found to be comparatively stable at pH 1–5 but less stable at pH 6–7. Its stability was considerably increased by borate. These data were used to develop a method of more specific determination of dehydroascorbic acid.

(iv) *Natural Coating of Apples.*—Investigations on the natural coating of Granny Smith apples have been continued and a progress report on last season's work has been prepared. The results obtained in 1947 show an increase in all fractions during storage. The most striking increase was in the concentration and degree of unsaturation of the oil fraction. This confirms previous results. These changes were considerably reduced by "gas" storage in approximately 5 per cent. of carbon dioxide. They were not significantly affected by source or maturity of fruit. Changes during storage are also being determined in the 1948 season.

The fraction insoluble in light petroleum but soluble in ether or carbon tetrachloride ("resinous" fraction) was further examined. Recrystallization from ethanol showed that it consisted predominantly of ursolic acid, but small amounts of other material were obtained. A sample of fatty material was obtained by extraction of dried flesh with light petroleum. Both the fatty acids and "unsaponifiable" fraction of this material were found to differ from those of the skin lipoid. Samples of the three main fractions of the natural coating material have been prepared for further examination.

(v) *Production of Volatiles by Apples.*—These investigations have been concerned mainly with the determination of volatile esters. A colorimetric method depending on their conversion to the corresponding hydroxamic acids has been studied in detail.

It is desirable that the colorimetric procedure should be standardized with the ester which corresponds most closely to the predominant volatile esters of apples. With the object of identifying these esters, samples of apple volatiles were condensed in a liquid oxygen trap and analysed in the mass spectrometer of the Division of Industrial Chemistry. Samples of pure esters were prepared for comparative purposes. This investigation is still in progress.

4. Microbiology.

(i) *Egg Investigations.*—Experiments on the storage of shell eggs have been continued, with particular reference to the pasteurizing and oiling treatments mentioned last year. The results obtained previously with various pasteurizing schedules have been fully confirmed, both in respect of the control of rotting and on other aspects of internal quality. The effects of oiling were studied in some detail in relation to the age of the egg when oiled and to treatment with carbon dioxide. Results have shown that oiling leads to a significant improvement in the flavour of the stored eggs, but for other measures of internal quality the results have been inconsistent. Some of the observations have indicated that the reasons for the beneficial effects of oiling are more complicated than was first expected, and some more detailed studies of the physicochemical effects of the process have been commenced.

Some investigations have been made of a "pink-white" disorder which has been occurring in some consignments of Australian eggs. The condition has been reported in North America where it has been found to be due to the ingestion of substances contained in the seeds of malvaceous plants. The New South Wales Department of Agriculture has cooperated by feeding rations containing cotton and mallow seed and the development of abnormalities is being followed in the stored eggs.

Experiments carried out in South Australia, with eggs subjected to various prior treatments, showed that egg pulp produced in a mechanical pulping device compared favorably in bacteriological quality with pulp produced by hand-breaking. The feasibility of effective pasteurization of egg-pulp in a plate-type heat exchanger was shown in a trial run carried out in New South Wales.

(ii) *Clostridium botulinum Investigations.*—Studies of the growth of this organism in relation to the concentration of dissolved metals have been continued. Experiments on the destruction of type A botulinum toxin by heat have shown that its stability in vegetable liquors is determined mainly by the inorganic salts and other small molecules in solution. The protective effects of various inorganic anions and cations, and of some organic anions, have been demonstrated at concentrations in which they occur in vegetables.

(iii) *Heat Resistance of Bacterial Spores.*—Progress has been limited by the lack of a full-time investigator, but some aspects of the previous investigations were continued. A re-examination of the pH requirements of some *Bacillus* and *Clostridium* strains has shown that the differences between heated and unheated spores of the same strain were previously overestimated. For some strains at least, it has now been shown that such differences in pH requirements are small and of doubtful significance. This aspect of the work has therefore been discontinued. Some further experiments on the possible role of starch in promoting spore germination have all yielded negative results.

(iv) *Disinfection by Cationic Detergents.*—The bactericidal properties of two compounds were tested against an additional series of bacteria at various levels of pH. Depending on the bacterial species, susceptibility of the cells to disinfection was found to be decreased with decreasing pH, decreased with increasing pH, or to be virtually independent of pH. With two organisms detailed studies have been made of both the adsorption of the detergent by the cells and of the inhibition of their respiration. Each has been studied in relation to pH, but in neither case has a relationship with bactericidal efficiency been revealed. The experiments are being continued.

(v) *Mould Growth Studies.*—The study of the water relations of mould adapted to growth in a dry environment has been continued. Growth has been observed with the activity of the water as low as 0.62.

(vi) *Bacteriology of Prawns.*—A special investigation of the bacteriology of prawns and the changes which occur during handling and marketing was carried out during the summer. A report was submitted to the Director-General of Public Health in New South Wales, at whose request the investigations were made.

5. Meat Investigations (Brisbane).

(i) *General.*—The difficulty of getting highly-trained scientific workers for key positions has continued throughout the year. Consultation work and other assistance given to industry and other laboratories

continued to occupy a considerable amount of time, on occasion necessitating appreciable laboratory and plant-survey work, as well as help in the design of equipment.

(ii) *Plant and Equipment.*—In connexion with the work on the sterilization of air, and meatworks and cold-storage hygiene, the laboratory built a Bourdillon slit sampler with a very wide range of speed variation for securing adequate estimations of the microbial content of air. This machine has afforded a useful tool for the making of far more accurate, repeatable, and reliable estimations of the microbial content of air than had been obtained by any method previously used.

An especially sensitive hydrometer for work connected with the quick density method for the determination of the moisture content of meat extract, reading density in g./ml. at 20 °C. from 1.0300 to 1.0450, was designed and built. A first experimental model from the glass blower, built to our specifications, and left open for adjustment, was calibrated and later used as a standard for similar hydrometers. Several of these are now used by industry.

(iii) *Investigations on Ozone.*—Work on the estimation of very low concentrations of ozone was continued. This carried the level at which stable concentrations could be obtained to at least as low as 0.2 p.p.m., with a daily variation of approximately ±0.05 p.p.m. Since this variation was probably due to slight voltage change, owing to hand control of voltage being employed, work is under way to use constant voltage control for this purpose.

When using the type of ozone generator commonly employed in commercial equipment, no detectable production of oxides of nitrogen was found in concentrations of ozone up to 20 p.p.m. This is in marked contrast to results obtained when using generators such as the laboratory type consisting of two concentric tubes, between which the air is passed under pressure, and subjected to the high-voltage discharge across the annular space.

In the last annual report it was stated that the reason for the bactericidal effects observed on meat being held for tenderizing, and subject to ultra-violet radiation, was not clear. The possibility that ozone may have been responsible for these effects was investigated. A commercial ultra-violet mercury-vapour lamp used in the tenderizing work was set up in a glass envelope through which air was passed. No ozone or oxides of nitrogen could be detected in the air which had passed the walls of the operating mercury-vapour tube.

(iv) *Aerosols and Storage-room Disinfection.*—Using a commercially-available piece of equipment for the distribution of aerosol materials in storage rooms, their effect on suspensions of bacteria in the air of such rooms has been investigated with, so far, very satisfactory results. This work has included studies at different stabilized levels of relative humidity; results from these are, however, not entirely conclusive but the work will continue. The phenomenon of rapidly decreasing air populations with time, following the atomizing of bacterial suspensions into storage rooms, was studied, and curves obtained showing population decay rates as a function of time, after the organisms had been atomized into the air. Various aspects of this work are continuing, especially since comparatively little work has been done on organisms causing meat spoilage compared with that done on pathogenic organisms.

(v) *Meat Extract and Creatine.*—Studies commenced some years ago on creatine but suspended during the war, which will have a very definite bearing on certain future investigations in this laboratory's programme, have been given further attention. The work has included a thorough examination of the literature on creatine, particularly in regard to its occurrence with other crystalline substances in gritty agglomerates in meat extract. Petrological microscopic determinations of the crystals as an aid to identification were carried out, and an electrometric method of determination of chloride, previously worked out in this laboratory for meat extract, employed. Work is being done in developing satisfactory quantitative methods of assay for several chemical substances in meat extract. Colorimetric methods of the visual type cannot be used satisfactorily for the determination of creatine in meat extract owing to the turbidity of the solutions. However, with the photoelectric type of colorimeter, which is now being used, satisfactory and repeatable results are being obtained.

6. Fish Preservation Investigations.

(i) *Educational Work.*—Staff members gave a series of lectures and practical demonstrations on fish preservation to a group of Commonwealth Reconstruction Training Scheme trainees at the Commonwealth Fisheries School and later conducted a special cannery course for six selected trainees, some of whom intended entering the field of commercial fish canning.

(ii) *Fish Canning.*—A visit was made to a fish cannery at Ulverstone, Tasmania, where an experimental programme on the canning of whitebait was carried out.

Work has been continued on the problems associated with the unattractive colour and the undesirable tough texture found in canned Australian salmon. The tenderizing effect of presoaking the fish in salt solutions for up to sixteen hours before canning has been confirmed and a marked improvement in colour of the brown portions of flesh has been obtained by the addition of sodium nitrite to the salt solutions.

Some preliminary work has been carried out on the canning of edible flesh from the school shark but a satisfactory method of overcoming the partial heat breakdown of urea with accompanying gas production in the can headspace has not yet been developed.

(iii) *Fish Smoking.*—Numerous inquiries have been received from persons interested in the commercial procedure for fish curing and smoking. Some preliminary work has been carried out on the performance of an automatic fish-smoking kiln installed by a fish-processing establishment at Eden, New South Wales.

(iv) *Shark Flesh Investigations.*—Work has proceeded on the problem of the post-mortem development of ammonia in shark flesh. A technique for the preparation of sterile samples of flesh under aseptic conditions has been developed. Comparisons have been made between the rates of production of ammonia in sterile flesh and also in flesh contaminated by various bacterial species capable of decomposing urea.

7. Fresh Fruit and Vegetable Storage.

(In Co-operation with New South Wales Department of Agriculture.)

(i) *Physiology and Biochemistry.*—Considerable progress has been made during the year with the investigations into the nature of the organization of the plant cell and its respiratory behaviour. These two main problems, besides being basic to further developments in storage methods, are of great fundamental interest to plant physiologists and biochemists. As during the previous year, these investigations have been carried out in active co-operation with members of the Botany Departments of the Universities of Sydney and Melbourne.

With the publication of two papers on salt accumulation and salt respiration, the work on investigating the process whereby plant cells achieve and maintain high concentrations of substances in solution, has been temporarily discontinued.

Work on apple tissue has been continued using Granny Smith apples about whose behaviour in storage much is now known. With the assistance of the New South Wales Department of Agriculture, an investigation of the relations between fruit size, cell size, respiration rate, nitrogen fractions, organic acids, and starch-sugar balance is being carried out in developing Granny Smith apples.

On the biochemical side, analyses from the experiment on fruit size, commenced last year, have been completed. It has been found that respiration rate per unit weight is constant for all size ranges for fruit picked from the one tree. Total nitrogen content exhibited large random variations, but the protein nitrogen content was rather constant. Soluble nitrogen compounds (probably mainly asparagine) are considered to exert a mass action effect in promoting protein synthesis, although this is small compared with the effect exerted by the rate of oxidation of carbohydrates in respirations.

Investigations on the metabolism of the apple in storage have been continued and a comprehensive survey of the metabolism of the Granny Smith apple at 0° C., which was commenced last year, has been nearly completed. The respiratory activity shows two major climacteric peaks and a smaller rise early in storage and each of these rises is correlated with a simultaneous change in the concentration of a carbonyl compound; the latter appears to be an intermediate in carbohydrate metabolism and its concentration may govern the level of respiration rate. Respiration measurement conducted with peeled apples, after the wound respiration has ceased, have confirmed the hypothesis that over 90 per cent. of the respiratory activity of the whole fruit is in the flesh. Respiration investigations with *Avena coleoptiles* (var. Victory) using the Warburg technique have been begun. The tissues show a very stable respiration after cutting and a high metabolic turnover making it appear promising for the investigations on organic acid and nitrogen metabolism. By suitable starvation methods, the respiration rate can be doubled by the addition of glucose.

Further studies on the physiology of ripening in stone fruits have been carried out using samples of peaches picked at intervals during development and maturation on the tree. The stability and respiratory behaviour of the tissue has been investigated using the Warburg constant volume respirimeter.

Some further work has been carried out to obtain fundamental information on the physiological basis of cold injury as a manifestation of which characteristic disorders appear in many fruits when stored at low temperature. Most of the work to date on cold injuries has consisted of observations of the effect of various pre-storage and storage factors on the appearance of macroscopic symptoms. Some preliminary studies of the tissue of normal and cold injured rind of oranges have been carried out and this work is being continued.

(ii) *Fresh Fruit Storage.*—(*a*) *Skin Coatings for Apples.*—No further experimental work on this project has been carried out during the year. The results of the experiments carried out in 1946, designed to compare the effects of skin coatings with those of gas storage on physiological behaviour of the fruit and on incidence of storage disorders, have been incorporated in a detailed report. The effects of coatings have been very variable, important factors being maturity of the fruit, temperatures at the time of treatment, and type and thickness of the coating. Under cool storage conditions, storage in artificial atmospheres is likely to be of more practical value than the use of coatings. Despite certain undoubted benefits, it is concluded that the value of skin coatings in the commercial storage of apples is strictly limited and, at this stage, their use cannot be recommended.

(*b*) *Orchard Variability in Relation to Storage of Apples.*—This work is being continued along the lines indicated in the last report. Information so far obtained indicates the existence of considerable variability related mainly to variations in crop size and fruit size. It is likely also that position of the fruit on the tree has a considerable influence on its maturity and behaviour during storage.

(*c*) *Maturity and Storage Studies with Apples.*—Investigations have been commenced to obtain data on the relation between number of days from blossoming and optimum maturity of apples as determined by storage behaviour and the development of quality. The Granny Smith and Delicious varieties from the Orange district are being used.

(*d*) *Cool Storage of Peaches and Nectarines.*—This work, which was temporarily suspended during the war, was resumed during the year, and factorial experiments with Elberta and J. H. Hale peaches and Goldmine nectarines have been carried out. After another season's work, it will be possible to issue authoritative statements on the storage of these fruits.

(*e*) *Cool Storage of Plums.*—Trials of the cool storage behaviour of a number of new varieties have been undertaken with the co-operation of the New South Wales Department of Agriculture and will be continued for several years.

(*f*) *Cool Storage of Pears.*—A report has been published. Further data are being obtained on the effects of delay between picking and storage and of rate of cooling in the store. The work with Bosc pears has shown that there is little, if any, direct effect on storage behaviour of spraying with hormone preparations to control pre-harvest drop. This agrees with the conclusions of American workers.

(*g*) *Maturity and Ripening of Papaws.*—In response to a request from growers in northern New South Wales, an investigation of conditions most satisfactory for ripening were carried out. It was found that maturity at picking is most important and that ripening of this fruit cannot be carried out satisfactorily until the field problems of extreme variability in ripening behaviour and the high degree of latent fungal infections which cause rotting of the fruit before ripening is completed, are overcome.

(iii) *Transport.*—A survey of the interstate and intra-state movement and conditions of vegetables has been completed in co-operation with officers of the Departments of Agriculture. Certain problems have been defined in connexion with ship transport, mainly due to faulty handling and stowage, and in connexion with long distance rail transport of perishable vegetables, especially peas and beans, in which there have frequently been large losses due to "sweating". It was shown that beans carry better in cases than in the usual bags and that methods of stacking and position in the railway van are important in relation to wastage.

8. Dehydrated Foods.

(i) *Vegetable Dehydration.*—The study of the suitability for dehydration of various onion varieties has been continued for the fourth season. All the material used this year was drawn from Victoria and the arrangements for growing and harvesting the onions were made by the Victorian Department of Agriculture. The study of various strains of the Australian Brown variety selected by the Victorian Department, which was started last year, was continued. American strains of this variety were also examined, together with several American varieties not previously tested. All these lines were grown in two districts. In addition, two strains of the Australian Brown variety were grown in other

onion-growing districts and on several different soil types. The chemical analysis of the fresh onions and the processing of all these samples have been completed but the dehydrated samples have not yet been examined.

In studying the dehydration of green peas, attention has been concentrated this year on the relationship between the maturity of the fresh pea and the quality of the dehydrated product. Most of the work was done on peas grown at Picton and maturing in fairly cool weather. The peas were size-graded and determinations of total solids, alcohol-insoluble solids, starch, and ascorbic acid contents were made. It was evident that the maturity had a large effect on the quality of the dehydrated product, but the data so far available are inadequate to define the most suitable maturity in terms of chemical or physical criteria. A semi-commercial run was carried out by an officer of this Division and yielded promising results, but the peas available were rather over-mature. A much larger commercial test, which also gave promising results, has been carried out by a New Zealand factory basing the conditions on the results of laboratory experiments by this Division.

(ii) *Storage of Dehydrated Vegetables.*—Published work from other laboratories and earlier unpublished data from this laboratory have established the greater stability of dehydrated vegetables with lowered moisture content storage temperature, and oxygen supply, but the effect on storage behaviour of variations in processing technique has received less attention. A large experiment, designed to permit statistical evaluation of the significance of observed differences between samples receiving different treatments, was therefore set up as described in previous reports. The design of the experiment also allowed a more precise comparison of the effects of different temperatures on storage in air and in nitrogen. The voluminous data have been analysed in conjunction with the Section of Mathematical Statistics and are now being prepared for publication. Consideration of the results is still in progress, but some interesting points are already clear.

Among these is the higher carotene retention in carrots dehydrated after blanching for three and a half minutes in steam compared with those precooked for 30 minutes in boiling water. This is of theoretical as well as practical interest as suggesting that the long cooking in water may remove soluble antioxidants. The retention of sulphite during the storage of both carrot and potato is shown to be better at the lower moisture and higher sulphite levels; in potato a retarding effect of high sulphite on the development of discoloration can be demonstrated both in tasting test scores and in appearance scores for dry material. Losses of carotene in carrots and of ascorbic acid in cabbage and potato follow an approximately logarithmic course, as do those of colour scores in tasting tests and appearance scores for dry material. Sulphite, however, shows an approximately linear rate of loss.

(iii) *Fruit Dehydration.*—The scope of this work has been widened this year to include investigations of the treatment of fruit with sugar prior to dehydration. The results of the processing and storage experiments now in progress should be of considerable interest to the various commercial processors who have made inquiries about methods of producing sugared (or glacé) fruit. At the same time, since the addition of sugar inhibits some of the deteriorative changes which occur during the hydration and storage of fruit, these processing investigations will provide valuable indications of suitable starting points for fundamental chemical studies. The study of the effect of the drying conditions on the rate of drying and the quality of the product has been continued. This season the main study has been the determination of the effect of varying the wet-bulb temperature when the dry-bulb temperature is controlled to simulate the conditions obtaining in a single-stage counter-flow tunnel. Apricots and clingstone peaches were used for this work and the results are now being analysed.

The investigation of the effect of the maturity and ripening of clingstone peaches on the quality of the dehydrated product was continued. The study of sulphuring of clingstone peaches by means of metabisulphite dips instead of by burning sulphur has been continued. As in the previous season, the dipped products were in general slightly inferior. A storage experiment was started to compare the rate of deterioration of the two types of products.

It was reported last year that very satisfactory dehydrated products were obtained with cool-stored pears of the Josephine, Packham's, Triumph, and Winter Cole varieties. Similar results were obtained this year with Winter Cole pears. It was found that (1) rings were better than halves, quarters or slices, (2) unbalanced samples were better than blanched, and (3) dip-sulphiting was definitely not satisfactory.

In addition to the work done at Homebush, experiments designed to compare sun-dried apricots with blanched and unblanched dehydrated apricots were carried out at the Berri Experiment Farm, South Australia, in co-operation with the South Australian Department of Agriculture. Also detailed temperature and air-flow measurements were carried out in commercial dehydration tunnels at Tongala and Shepparton, Victoria.

(iv) *Meat Dehydration.*—Investigations begun last year to study the effect of the duration and nature of precooking treatments on the quality of the dried product have been completed and analysed. The best results are obtained with steam cooks at, or slightly above, atmospheric pressure.

A study was made of the effects of cooling and storing the cooked meat prior to mincing. The temperature of the meat at mincing was found to have a marked effect on the texture of the finished product.

The cooking conditions necessary for softening the meat sufficiently to remove it from the bone by hand have been studied and the changes in quality of the product investigated. Some aspects of this are still under investigation but it appears that it is possible with low temperature steam cooks to remove the meat from the bone by hand without introducing undesirable texture or flavour.

(v) *Fresh Potato Investigations.*—The interstate variety trials carried out in previous seasons are being continued in co-operation with the Victorian and South Australian Departments of Agriculture. A smaller number of varieties, selected from those previously studied, is being used. Samples of a number of varieties grown in two districts were separated into density groups in a study of the relationship between the solid content of the fresh potato and the texture, grain-size, and form of the cooked potato as determined by tasting tests.

9. Canning and Fruit Products Investigations.

(i) *General.*—Canners and executives from associated industries made full use of the technical assistance available for the solution of their problems. In this connexion visits were paid to canneries when necessary. In addition, general inquiries were received from all parts of the Commonwealth. As was the case in previous years, good co-operation was given by industry in the furtherance of investigations being carried out by the Section. Valuable assistance, also, was rendered by the New South Wales Department of Agriculture in the production and supply of fruit and vegetable varietal material.

(ii) *Vegetable Canning.*—Prediction of maturity and studies of the quality of sweet corn were continued in the field, factory, and laboratory. Confirmation of the value of refractive index as a rapid maturity indicator was shown by correlation with grain moisture. For practical control purposes a sample of ten cobs from ten locations in a reasonably uniform field provides an adequate sample for laboratory determination of refractive index. Ten cobs from each of 23 points is required for the same accuracy in a variable crop.

Line samples were taken from the cannery for refractive index work, and comparable canned material was simultaneously reserved to establish more definitely the true relation between maturity and canning quality. The canned samples have yet to be submitted to tasting tests.

A new type of pea tenderometer was constructed by the National Standards Laboratory for use in pea canning investigations. The machine is portable and hand operated and was designed by the Section as a result of experience gained in earlier work. The tenderometer was used for maturity studies of canning peas at Batlow and Bathurst, New South Wales, and, as in the case of the use of refractive index with sweet corn, it is intended to provide a rapid measure of maturity.

A considerable amount of work has been carried out with the object of developing a suitable firming treatment for a number of canned vegetables. The vegetables being studied are cauliflower, cabbage, silverbeet, beans and broccoli. The most satisfactory method so far used is immersion in water at temperatures from 100° to 140° F. for a period of 30 minutes. No firming was apparent in silverbeet, but in all other vegetables listed, treatment caused a pronounced and permanent firming of the tissues which persisted after processing. Packing raw, cold injection, and normal blanching procedures in steam, water, or citric acid solution all gave products of much softer texture. Work is proceeding in an endeavour to determine the mechanism of the phenomenon.

A varietal canning trial of tomatoes grown at Bathurst, Leeton, and Hawkesbury Agricultural College, New South Wales, was undertaken. Thirty varieties were included in the test, which confirmed the conclusion that maturity at picking is the most important single factor determining the quality of the canned product.

Imported seed of four beetroot varieties was grown at Hawkesbury Agricultural College to provide material for varietal and maturity studies. A statistically planned tasting test showed a significant preference for appearance but no significant differences in texture and flavour. The Asgrow Canner variety was rated first, being followed by the popular Detroit Dark Red.

(iii) *Fruit Canning.*—In co-operation with the New South Wales Department of Agriculture eighteen varieties of rockmelon were subjected to a canning trial. In addition to the straight pack, it was canned with passionfruit and also as a constituent of fruit salad. All packs were found acceptable with a general preference for yellow over the green varieties.

The examination of a large number of freestone peaches canned during the early part of 1947 was completed and the results subjected to statistical analysis. Those trials indicated that high quality freestone packs, comparable with American packs, may be prepared from the varieties J. H. Hale and Dripstone. Creditable packs may also be prepared from Elberta Late and Elberta Cling. A number of these freestone varieties were canned again this season and will be examined for quality differences.

Some 24 varieties of clingstone peaches packed at Leeton during the 1947 fruit season were tested for canning quality. The results of these examinations were submitted to a conference consisting of growers' representatives and members of the Department of Agriculture and canning organizations. The conference concluded that a number of varieties tested have good canning qualities. By the use of suitable early maturing varieties it should be possible to expand the peach canning season in the M.I.A. by almost a month.

Work on clingstone peach variety trials was expanded during the 1948 peach season at Shepparton, Victoria. With the co-operation of the Shepparton Preserving Company and the Victorian Department of Agriculture, 53 varieties were canned. These varieties included all those previously canned at Leeton, and, in addition, a number of parents and seedlings developed at the Tatura Research Station. Examination of these packs will be completed during 1948.

Examination of apricots packed at Leeton during the 1946-47 season in connexion with maturity studies demonstrates the optimum maturity as that at which the fruit shows full colour development but is still firm. Tree-ripened fruit appears to be superior in quality to store-ripened material, although the differences are not marked.

Studies in the pre-processing browning of pears show that dilute solutions of sulphur-dioxide give good protection, particularly in preventing oxidation during the period between packing the fruit into cans and the actual syruping and exhausting step. The film of sulphur-dioxide solution on the surface of the fruit prevents the rapid browning which frequently occurs at this stage.

(iv) *Fruit Juices.*—The citrus juice investigations recommenced in 1945 and continued in 1946 were carried a step further during the 1947 season. Again, the existence of an association between the use of Bordeaux sprays and the appearance of bitterness in the processed juice of mature Valencia oranges was confirmed. It is thought that Bordeaux sprays have the effect of delaying rind maturity so that the normal mechanism of disappearance of bitter principles from the orange rind does not operate. This hypothesis is in line with the views of plant pathologists of the New South Wales Department of Agriculture on the probable mechanism of the control of the fungal disease "black spot" by Bordeaux sprays.

The bitter principles present in greatest amount in the rind and juice of Navel, Valencia, and Parramatta oranges have been proved to be identical with each other and with limonin isolated from Navel and Valencia oranges in California. In addition to limonin both Navel and Valencia oranges contain at least one other bitter principle which has been isolated in pure-crystalline form but not yet identified.

(v) *Lacquer Investigations.*—Australian canners have indicated that there is an immediate need for a sulphur-resisting, internal lacquer for food cans which combines dependable protection against sulphur-staining with an attractive appearance. A project has therefore been commenced, in co-operation with two lacquer manufacturers, directed towards improving the performance of sulphur-resisting lacquers manufactured in Australia. More fundamental knowledge of the phenomenon of sulphur-staining and of the mechanism of the protection provided by lacquers containing zinc-oxide is being sought, and a comprehensive series of tests has been undertaken involving a variety of oleo-resinous varnishes containing different types and different levels of zinc-oxide.

(vi) *Meat Canning.*—A number of curry packs of beef and lamb were prepared with the object of producing an Indian style curry which would prove acceptable to the Australian public. A satisfactory blend of spices was obtained and formulae suitable for commercial use were developed.

(vii) *Equipment.*—The need for a relatively inexpensive type of vacuum, can-closing machine prompted an investigation into the method of vacuumizing by

steam flow pressure. Steam jets were designed and fitted to an automatic can closer and connected to a permanent supply of steam at reduced pressure. Satisfactory vacua have been obtained with six types of canned vegetables, and steam flow closure is now used as a routine practice for all laboratory canning trials.

Some time ago this Section investigated the value of "thermo-rotation" for the heat processing of fruit juices. Following this work a continuous roto-cooker has been designed and constructed. Tests with canned fruits show that it is possible to reduce with safety the time required in the standard commercial fruit cooker. There is a need for detailed information on "thermo-rotation", particularly with respect to the nature of the circulation of liquids and solids within the can. Equipment has been constructed that will permit cinephotography of the contents in the transparent can during rotation, and this work will be done shortly.

X. FISHERIES INVESTIGATIONS.

1. General.

In the course of the past year, the work of reorganizing and equipping the Fisheries Division to undertake a comprehensive research programme has largely been completed. Improvements and additions were made to the central marine laboratory at Cronulla, New South Wales, and the branch laboratories in Melbourne, Perth, and Hobart were also in operation. Plans are in hand for the provision of a fully-equipped marine laboratory on the sea-front at Cottesloe. This, when completed, will replace the temporary accommodation being used in Perth, and will serve as a much-needed centre of marine research on the eastern Indian Ocean littoral. It is anticipated that two small field marine stations will be provided by the Queensland Government during the coming year to facilitate the Division's research work. One will be at Dunwich (Stradbroke Island) in the south of the State, and the other on Thursday Island in Torres Strait, where pearl-shell studies will be conducted.

To meet the needs of an expanding programme on exploratory and conservational work, additional arrangements were made for the use of research craft. Hitherto only one full-time research vessel—F.R.V. *Warreen*—has been in operation. This vessel is now operating in Western and South Australian regions and has been refitted to enable trawling and long-lining fishing to be undertaken, in addition to pelagic fishing. The F.R.V. *Liawenee* is shortly to be chartered from the Tasmanian Government to conduct investigations into the chief fisheries in the Tasmanian region—those centred on barracouta, school shark, and crayfish. On the trawling grounds off the south-eastern continental coast, increased use will be made of the 75-ft. trawler, M.V. *H. C. Dannevig* chiefly for further investigations on the condition of the trawling industry. A three-year loan of a 75-ft. General Purposes Vessel has been obtained from the Royal Australian Navy. This vessel will be employed chiefly in pearl-shell investigations in Torres Strait, serving the above-mentioned field marine station. Finally, the Division is conducting the scientific work on board the M.R.V. *Fairwind,* a vessel 125 feet in length, which commenced a survey of the fishery resources of Papua-New Guinea in May, 1948, and which is being operated by the Department of Agriculture, Stock, and Fisheries, Port Moresby. Appointments made to co-ordinate and facilitate the research work of these vessels include those of a scientific officer-in-charge, a marine superintendent, and a gear officer.

Certain localized investigations have been continued in conjunction with operatives in the industry. Mass-catching experiments were continued by the *Eden Star* during the first half of the year, after which the owners entered upon a refitting programme. Using the Division's mackerel purse-seine net, which was enlarged to a length of 288 fathoms, this vessel, which was much hampered by adverse weather, made four successful shots (averaging 17 tons of mackerel) in seven attempts. Crayfish (in Western Australia) and scallops (in Tasmania) were other objects of survey work made possible by the use of small craft, made available respectively by fishermen and the Tasmanian Fisheries Division.

As in previous years the Division has conducted a considerable amount of advisory work. Much of this has been concerned with the operation of the increasing number of fish canneries, particularly with regard to the question of adequate fish supplies.

Research on agar has been suspended, since an industrial potential has now been developed capable of supplying, at an economic price, more than twice Australia's pre-war requirements of this commodity. However, the search for new seaweed beds was continued, as the total sources of raw material supplies must be determined.

2. Operations of Fishing and Research Vessels.

(i) *Fishing Tests in South-Eastern Australia.*—Several more good catches of horse-mackerel (15 to 20 tons each) have been made with the Division's mackerel purse-seine net, operated by local fishermen. There is no longer any doubt about the feasibility of this method for that species in our waters. These more recent catches were all made on the New South Wales coast, whereas the previous ones were in Tasmania. Tasmania still seems the most promising area for the fishery of this type, for geographical and climatic reasons discussed in earlier annual reports. The present demand by canners for these fish, however, is not as great in Tasmania as in New South Wales, because of the availability of barracouta in the former area. It is felt that the Division has now almost completed its task of demonstrating purse-seining for horse-mackerel, but as further series of catches in Tasmania would probably act as a spur to local canners to take up the matter more quickly for themselves, this will probably be attempted in the coming year. A progress report on these tests has been published.

(ii) F.R.V. *Warreen.*—This vessel continued to work in Western Australian waters, completing two cruises (Nos. 29 and 30) and almost concluding a third, No. 31, during the year. Sea time was, however, considerably curtailed in August and September and during the first quarter of 1948, because of a breakdown and the installation of the new winch and line coiler.

Cruise No. 29 (5th July to 30th July) surveyed the area from Esperance to the Western Bight in a search for pelagic fish previously observed from the air. Bad weather proved a handicap and fish shoals were only observed on two occasions in the eastern part of the cruise, but the presence of pilchards was demonstrated by small catches taken in drift nets and from fish stomachs.

Cruise No. 30 (23rd September to 15th December) was planned to investigate pelagic fish and crayfish between North West Cape and Cape Naturaliste. No pilchards were taken except for a very few in drift nets in Geographe Bay and no crayfish, except for a few southern crayfish (*Jasus lalandii*) near Hamelin Bay and Naturaliste Reef. Guano deposits in Shark Bay were investigated, and a routine line of oceanographical stations extending for 100 miles west of Rottnest Island were instituted.

Cruise No. 31 was begun on 15th April, the offshore Rottnest traverse being repeated first. The object was to investigate shoaling pelagic fish, particularly pilchard, south and eastwards, but especially in Naturaliste Bay and in the vicinity of Albany. A few

pilchards were taken in Naturaliste Bay but no shoals were seen. In May, *Warreen* shifted to Albany and there pilchards were taken with the lampara net in Princess Royal Harbour and King George Sound, catches ranging up to 24 cwt. The net was also shot by the *Warreen's* crew from local boats, and catches ranging up to 1,000 lb. were taken in King George Sound. The lampara net used is of small size designed for the purpose of capturing bait of smaller size than pilchards, so a net constructed with special reference to this fish might be expected to give better results. Nevertheless, the *Warreen's* catches of pilchards, totalling all told about 3½ tons, have aroused considerable local interest in this field which occurs in large quantities, and it is hoped that a regular fishery will soon accrue.

A further interesting catch was of more than 500 lb. of bonito, taken in three hours' trolling near Doubtful Island.

A second routine line of oceanographical stations running southwards for 100 miles from Breaksea Island was instituted early in May.

Much of the work planned involving the use of drift nets, long lines and craypots along the southern coast has been completely nullified by the presence of leather jackets in plague-like numbers. The *Warreen's* experience, however, has helped a newly-arrived local vessel to take this fish in payable quantities for the Perth market.

During the October cruise of the F.R.V. *Warreen*, a survey was made of the guano deposits on several islands and on the platforms of navigation beacons in Shark Bay. The main guano producer in this locality is the pied cormorant (*Phalacrocorax varius*), and deposits were extensively worked between 1850 and 1888, by which time most of them had been exhausted. The deposits now being formed on the perforated platforms of navigation beacons erected in 1938 have, in eight years, accumulated to a depth of 3½ feet. The survey indicated about 1,000 tons of guano available on the islands visited and analyses of samples delivered to the State Department of Agriculture revealed values, at present prices, ranging from £4 10s. to £18 10s. per ton.

Work done by *Warreen* on tuna distribution, and on plankton and hydrology, is referred to below under these headings.

3. Fisheries Biology.

(i) *Trawlfish.*—(*a*) *Statistics*—A paper on the effect of the war on the east Australian trawl fishery has been published. This deals with the history of the fishery as revealed by the catch statistics, and demonstrates that the 1946-47 level of fishing intensity (an equivalent of about 4,600 trawler-tons) was very much higher than the optimum; the optimum could not be estimated from the data available, but it was adduced that the trawlfish stocks had not in the past been able to sustain a fishing intensity greater than the equivalent of 3,250-3,500 trawler-tons; this level of fishing intensity was therefore suggested as the maximum to which any possible restrictive legislation should aim. It was estimated that such a fleet would land about 12,000,000 lb. of fish annually from the New South Wales and Bass Strait trawling grounds. The trend of events has been confirmed during 1948. The fall since 1944-45 in rate of catch of flathead is some 300 per cent. or more. The catch of total fish has had to be made up from second and third quality fish—morwong and nannygai, yet even so has fallen, and it may only be a matter of time before these species become equally badly depleted if fishing goes on at the present rate.

It is worth noting that the industry has opened a small extension of the Danish seiner trawling grounds; working from Lakes Entrance (Victoria), between half a dozen and a dozen vessels have been fishing about 30 miles east and west of this port since June, 1947. The catch has been tiger flathead and sand whiting (*Sillago ciliata*) in about equal proportions; relatively large quantities of cod (*Physiculus*) were also being taken and discarded on account of poor carrying qualities. The steam trawlers also appear to have caught by far the bulk of their fish from Eden southwards this year. Both these developments reflect the overfished condition of the main New South Wales grounds.

(*b*) *Biology.*—Routine sampling at the Sydney Fish Market was continued on flathead, morwong, and nannygai. Estimates of the age composition of the flathead catch has not yet been completed for 1947. The possibility of age-determination in the morwong by means of the scales is receiving attention.

Work on the biology of the trawl fishes was greatly assisted this year by two trips with the C.R.T.S. vessel *H. C. Dannevig*, using a small otter trawl with fine mesh codend cover. With this gear, samples of small flathead of the O and I groups, which are normally never seen in the fish markets, were obtained from Flinders Island to Newcastle. It was found that the O-group, and probably also the I-group, rarely occur in water deeper than 40 fathoms, and that there is a concentration of these age groups off Twofold Bay. The presence of a similar nursery ground near Jervis Bay is suspected. The shoreward limit of these age-groups remains to be found, and is being investigated at Twofold Bay with a small otter trawl towed from launches. Whether Twofold Bay is the only large nursery area for the species, or whether there are others, is an important point for future work.

Very large catches of O and I group nannygai were also made inside 40 fathoms throughout the length of coast investigated. The young of the morwong have yet to be found. Enormous catches of small "forage" fish (*Apogonops anomalus*) were made in the winter months, establishing this species as one of the most important sources of fish-food. The work provided evidence of a negative nature on the deep-sea occurrences of prawns.

The large samples of very young flathead were of great assistance in work on age-determination. In general, they confirmed the results obtained from the otoliths. In particular, it was possible to demonstrate that the otolith grows isometrically with the fish-length, at least from a fish-length of 10 cm. This is apparently unique in otolith work, and, of course, greatly strengthens the technique of back-calculations from the otolith rings.

In the coming year, it is hoped to expand this work so that the coast is covered in each month.

The "failure" of a flathead year-group, suggested in last year's annual report, is very evident in the length-frequency data of this year: these show undersized flathead of 25-30 cm. in approximately equal numbers with the 30-35 cm. and 35-40 cm. size groups; normally the length-frequency polygons reach a sharp peak about 35 cm., and the 25-30 cm. fish are barely represented.

From the C.R.T.S. vessel *A. R. McCulloch* some preliminary work has been done on the problem of mesh-size in the codend in relation to escapement of the smaller fish sizes.

(ii) *Australian Salmon.*—(*a*) *Raciation*—A most important development has been the discovery of two genetically distinct races in eastern Australia, the one possessing gillraker counts of 25-29, and the other of 34-38; a total of 315 specimens has been examined so far, and all belong to one or the other. The adult salmon of New South Wales (and probably those of Gippsland) and the fingerling-length fry of Tasmania belong to the latter race: fingerlings and young salmon up to 20 cm. from Port Phillip belong to the former. Young salmon up to 20 cm. in Gippsland Lakes are

apparently mixed. Western Australian salmon (young and adult) belong to the former race.

This establishes one fact—that the New South Wales salmon are virtually independent of the Western Australian stock. This had been suspected, as the growth-rates are very different, but not proved, and in view of reports of salmon shoals from much of the coast of the Great Australian Bight it might well have been disputed. It was quite unsuspected that there were two races in eastern Australia.

(*b*) *Tagging.*—The problem of tagging salmon has received further attention. Previous work had all been with the earclip tag which was known to come off. A thousand salmon at Lakes Entrance were tagged in January, 1948, using four types of tag. Returns from this experiment had ceased to come in by June, 1948, and the four types give the following percentage returns: 2.5, 3.5, 3.7, and 7.3. The lowest return was for the earclip type, and the highest for the Petersen tag fixed through the dorsal moiety of the hypural bone. This result should have been even more clear-cut, for it was found that the latter tags had not been adequately wired up and were coming off; this probably accounts for the absence of returns after April. A further 450 fish were therefore tagged at Pambula (New South Wales) in May, using the Petersen tag only, as a final preliminary before embarking on a planned tagging programme. Returns are coming in satisfactorily from this latter experiment.

The Lakes Entrance returns were from 40 miles west to 20 miles east of Lakes Entrance until late in April, when one came in from Twofold Bay and one from Moruya (New South Wales). The two previous salmon tagging experiments in the east had yielded 6.3 and 3.2 per cent. recoveries.

(*c*) *Biology.*—Routine sampling of the Victorian salmon catch has largely broken down as a result of conditions at Melbourne Fish Market. However, biological sampling is being done at Narooma Fish Cannery, and in the Sydney Market. In the coming year it is hoped to get sampling done at the new cannery at Cattle Bay, Eden, which occasionally draws supplies of salmon from as far south as Lakes Entrance.

A large collection of scales made intermittently since 1938 has been read. The results will be worked up in the coming year along with the collections of length measurements. It can be said that the salmon scale is good for age-determination.

(*d*) *Western Australia.*—During the year there has been considerable expansion in the catch of salmon in Western Australia. Returns show 1,636,194 lb. taken in the Albany area during March, and 652,407 lb. in the Bunbury area during May. Considerable quantities were taken in other months in these and other areas. The fish is assuming a prominent role in the Western Australian fisheries, and will be given a more prominent place in the Division's biological programme in future. Mention is made below of an aerial survey planned primarily to observe the distribution of salmon shoals on the beaches. Such a method of survey is most suitable for this purpose, given good weather conditions, and it is hoped to make a further survey at another season of the year to obtain comparable data. A canning firm at Albany has recently purchased an aeroplane and engaged a pilot to facilitate watching the movements of salmon shoals.

(iii) *School Shark (Notogaleus rhinophanes).*—There are indications that school sharks are being over fished. Fishermen now have to go further afield and use more gear than formerly to maintain the Victorian and Tasmanian catch at approximately 2,000,000 pounds (flesh weight) annually. The flesh is sold on the fresh fish market as "flake", and the liver is processed for its relatively high potency vitamin A oil. This oil averages 18,000 I.U. vitamin A per gram and is the chief Australian source of high potency fish liver oil. Accordingly it has become necessary to ascertain the life cycle of the school shark in order that measures can be introduced to give the most effective protection for maintenance of the stock of these sharks.

Female sharks under 4 ft. 6 in. in length are sexually immature and should be conserved. It is estimated that these fish are then about 5–6 years old. Generally, a sexually mature female gives birth to about 36 young averaging about 13 inches in length. During spring, pregnant females make a spawning migration shorewards into shallow bays and inlets, where they give birth to their young before returning to deep water. Areas such as Pittwater, Blackman's Bay (Dunalley), Port Sorell, and the Hunter Island area (Tasmania), and Corner Inlet and Westernport (Victoria) are known to be nursery grounds for young sharks, whereas Port Phillip (Victoria) is essentially a nursery for second year sharks. At the end of their second year these sharks apparently move out into the deeper waters of Bass Strait. This recruitment for the offshore stock therefore proceeds from the inshore nursery grounds.

(iv) *Tuna.*—Trolling from *Warreen* during cruises off the south-west coast in the past year has not revealed the southern bluefin (*Thunnus maccoyii*) to be present in quantities equivalent to those occurring in the coastal waters of the eastern States. It has been demonstrated that a smaller size (1½–4 lb.) than in the east is to be caught near the coast. The important size group of the New South Wales spring fishery (averaging 17 and 25 lb.) has not been located in any strength, nor have large spawning adults, such as are known to enter King George Sound in summer, been found. Comparatively few of these large individuals were reported this season, but at least one school of 250–300 fish entered Albany Harbour in December, 1947.

Warreen took considerable catches (best more than 500 lb. in three hours) of the Oriental bonito (*Sarda orientalis*) on occasions by trolling and demonstrated that the range of distribution of this species extends to the region of Bremer Bay.

An experiment to test the possible use of the introduced *Gambusia affinis* was made by *Warreen*. The fish survived tolerably well, and when thrown overboard behaved in a manner which suggested that they may be useful as live-bait for tuna pole fishing.

(v) *Pilchards and Anchovies.*—A paper on the growth rate and general life-history of the pilchard in New South Wales is in the press. Further studies on the pilchard, in this and other areas of Australia, are being undertaken. A forecast was made, several months in advance, that the 1947 winter would be a poor season for pilchards in southern New South Wales, and this was confirmed. Probably much more could be done in the way of such forecasting if it is ever warranted by the emergence of a significant fishery. Samples of winter pilchards from Western Australia have been analysed, but the oil content is not high enough for commercial reduction. It has now been shown, for many parts of Australia, that this species has always relatively little oil at the season of maximum abundance, because this season (though it differs from region to region) is always the spawning period.

A study of the growth rate and life history of the anchovy is almost complete. This is predominantly a bay or estuarine species but the older fish move out to sea in the winter, at least in Victoria and Tasmania. The growth rate is much less than that of the related anchovy of Europe. It is now obvious that these fish occur in very large concentrations in Port Phillip Bay in shallow waters, and local fishermen have been making regular catches of several tons each with beach seines.

The demand, however, is very limited, and the Division is attempting to interest canners and other trade operatives. The fish could be used for straight canning, fish paste, or tuna live-bait.

(vi) *Tasmanian Whitebait.*—The 1947 catch was a record at about 1,100,000 lb., but there are still no unmistakable signs of decline in the abundance of fish. The biological research is practically complete and future work will consist merely of a careful watching of catch and fishing effort levels. It has been confirmed that the fish are only one year old when they spawn and die. Those of the southern rivers are definitely distinct in many ways from the fish of the northern streams, but there is no evidence of minor population groupings in either of these main stocks.

(vii) *Barracouta.*—A report on the Division's previous work on this species is in preparation. This work indicates the probable situation as to local populations, growth-rate, the seasonal condition cycle, general life history research, and the condition of the stocks. However, all this will require confirmation in the future. A large programme of field work is planned to begin shortly, utilizing the research vessel *Liawenee,* which is being chartered from the Tasmanian Government. It is now generally recognized that this fish has the greatest potential for future exploitation of any species being fished in Australia. Large quantities are being canned for export. However, barracouta has probably a more lasting future in the trade as a table fish for local consumption, especially in view of the proven or suspected depletion of many of the stocks of "table" species. There is a prejudice against it in many quarters which requires to be met with a strong advertising campaign.

(viii) *Mullet (Western Australia).*—Of a total 4,873 fish tagged in Western Australian estuaries during the year, 4,368 were sea mullet (*Mugil dobula*), and of the latter 44 were recaptured, all in the same estuary in which they were tagged. One mullet which was at liberty for 365 days showed a growth of 3 in., which is in close agreement with that previously estimated for the third year's growth as calculated from scales.

Market sampling of mullet taken in the three important western estuaries shows 97 per cent. to be two years old, at which age they have not spawned. Corresponding figures for South Coast mullet and mullet from the Geraldton, Abrolhos and Shark Bay regions are 80 and 50 per cent. respectively. The developing Shark Bay fishery actually yields only 30 per cent. of the 2-year class. Although there the northern mullet (*Moolgardia pura*) is taken in mid and late summer, *Mugil dobula* remains the dominant species in the catch.

An interesting development along the South Coast is the neglect of mullet and other estuarine fisheries for the intensifying fishery on salmon.

(ix) *Black Bream.*—Further tagging tests, using the opercular type tag, were carried out during the latter half of 1947, including 700 releases in South Queensland estuaries, bringing the total to 3,600 on the east coast. The total returns of these tags since the programme was begun in 1945 is only 22 or 0.6 per cent. Such small returns have indicated the unsuitability of the tag which appears to be lost easily. A new series of tests has begun utilizing the Petersen disc tag fastened through the flesh of the back. During 1948, 717 have been released in Queensland and New South Wales with a return of 13 or 1.8 per cent. within two months. Tagging has now shown movement of bream from one estuary to another. In most cases bream have not moved from the estuary in which they were tagged.

(x) *Schnapper, Sand Whiting, Blackfish, Tailer, Garfish.*—Biology of these fish is now being studied. Market measurements have been carried out throughout the year and other data have been accumulated in the field. Study of eggs, larvae, young, and spawning habits has received greatest attention.

(xi) *Trout (Freshwater).*—The growth rate of trout under natural and hatchery conditions is being studied on marked fish in Tasmanian waters. Preliminary work on selective breeding has been carried out, and this work is being extended.

Culture.—A study is being made on the hydrological and biological changes which result from the addition of artificial fertilizers to ponds and lakes under Australian conditions.

4. Shellfish Investigations.

(i) *Crayfish—Western Australia.*—During the year the 1947 marking programme was completed. 4,936 crayfish (*Panulirus longipes*) were marked in population tests, and 544 (11 per cent.) recovered. To study migration, a further 2,056 were marked; 238 (11.5 per cent.) were recovered, showing a range of movement between 2 and 30 miles. 3,731 immature crayfish were also marked and liberated in an area where they would be free from capture during 1947. Two of them were recovered in April, 1948; they were then mature and their carapace lengths showed increments of 0.7 inch and 1.1 inches in nine months.

Examination of the carapace length frequencies of about 18,000 crayfish from the Abrolhos Islands indicates that three age groups are being fished. These groups have been identified provisionally as being the second, third, and fourth years after the moult into the adult facies. Maturity is considered to occur during the late second and early third year. A continuous fishing test was carried out in the Southern Group, Abrolhos Islands, to determine the rate and nature of the replacement of crayfish in a typical shallow water area. This indicated that the crayfish taken during the season come from three main sources, the accumulation during the closed season, local migration from adjacent areas and, towards the end of the season, a large-scale migration from deep waters to shallow grounds. The catch made during the period of this experiment showed a total population of 65 per acre, of which 57 were of marketable size.

A similar experiment designed to investigate the progressive movement from deep to shallow grounds and the rate of growth during the season is in progress and is proceeding satisfactorily.

Sample measurements of carapace lengths in the Abrolhos commercial catch made during 1947 indicated a progressive decrease of the modal class towards the minimum legal carapace length of $2\frac{3}{4}$ inches. These measurements, resumed in 1948, showed the season opening with a lower modal class than at the opening of the 1947 season. The unit catch for the early part of the 1948 season was also lower than for the corresponding period of 1947.

Estimates of the total crayfish population of the Abrolhos fishing grounds (carapace length $2\frac{3}{4}$ inches and over) lie between 1,300,000 and 2,000,000 crayfish; 400,000 to 700,000 of these would be in the smallest length group of $2\frac{3}{4}$ inches. Flesh weight tests indicate this to be an uneconomic size, the highest proportion of flesh weight to total weight occurring at carapace lengths of 3–$4\frac{1}{2}$ inches.

A number of newly moulted females were measured and examined in both the Abrolhos and Rottnest areas. At the Abrolhos, 670 females with carapace lengths between 2.4 and 3.1 inches were mature but virgin; 80 per cent. of these were above the legal minimum size. The corresponding size range in the cooler Rottnest Island waters was 2.5 to 3.5 inches, 90 per cent. being above the legal minimum size.

The general indication from the work of the past two years is that owing to the extensive larval distribution there is no danger of permanent depletion of the present fishing grounds as the fishery operates at present, but some grounds may be temporarily overfished.

Attention has been given to the skin disease known by the fishermen as "crayfish poisoning". The chief causative organism is *Erysipelothrix rhysiopathiae*, and the infection is a minor erysipeloid, although typical streptococcal and staphylococcal infections occur. Methods of prevention and treatment have been developed.

A general report on the marine crayfishes of Western Australia has been prepared, and a detailed analysis is being made of the results of the field measurements and experiments.

Tasmania.—Studies were confined to ascertaining the period during which the phyllosoma larvae of the common crayfish (*Jasus lalandii*) inhabit the upper surface strata of the sea. They first appear in the plankton about October, and remain until January when, since they can no longer be caught in the plankton hauls, they apparently descend from the surface.

(ii) *Scallops.*—The predicted decline of the Tasmanian scallop fishery (the decline was predicted for either 1947 or 1948) did not occur in 1947, which saw a record total catch of 433 tons of meats, but a catch-per-dredge only very slightly higher than the previous year, and still far below the pre-war level. Early reports suggest that the catch of scallops this year is very poor indeed. Further analysis of the length-frequency data obtained since 1944 confirms the belief that there has been no widespread effective survival of spat for perhaps five or six years, or even longer. The length-frequency data show a steady growth in size by the stocks of scallops on the main beds, with no indication of young scallops entering the fishable stock. Growth in these mature scallops is of the order of 3–5 mm. a year, which agrees with the age-determination from the rings on the shells. These age-rings also indicate an average age on the Main Channel (No. 8) bed of 12 years. Since 1944 there has also been a complete failure by both fishermen and research workers to find young scallops in any numbers—though the presence of "nursery beds" was formerly a well-recognized feature. It is tempting to suggest that an environmental change is causing a prolonged failure of spat which may suspend the fishery for this species (it is to be noted that this species has been very abundant only since 1937); in this event, restriction of the fishery is no solution to the problem.

No fresh tagging has been undertaken this year. It had been hoped to obtain an estimate of the population reduction by fishing from this work, but this appears to have failed for two chief reasons: the unreliability of tag returns, both as regards actually recovering all the tagged shells from the fishermen, and unreliability in respect of date of capture; also the difficulty in determining where to sow the tagged scallops, since the fishery is always highly localized even within the one area, and shifts from season to season and within the one season. As far as they go the returns indicate an average annual recapture of 7–8 per cent. over the whole of the Main Channel (No. 8) bed, rising to 15 and 20 per cent. in places. On one small bed nearly 50 per cent. were recaptured in the first season.

More time will in future be devoted to the life history of the scallop, especially the emission and development of spat, and its settling. Work has already been begun along this line. During the past year further diving operations were conducted. In all, fifteen separate descents in depths to 9 fathoms were made on seven different scallop beds in the D'Entrecasteaux Channel (Tasmania). Considerable information was obtained on the ecology of the scallop in its natural habitat.

The drift bottle programme, instituted in 1946 to study the water currents in the Channel, was completed in 1948. In all, 1,950 bottles were released, 40 per cent. of which have so far been returned. There appears little if any basis for the claim put forward that the Northern Channel scallop beds were depleted because the larval scallops were being carried down the Channel to form the large beds in the Gordon area. The reason for depletion was most probably due to overfishing. The Gordon area beds supported 90 per cent. of the scallop fishing industry in 1947. However, the main centre of this year's scalloping operations has again shifted further south, since it proved to be uneconomical to work last year's areas.

Routine sampling, and planktological and hydrological work associated with the fishery were continued.

(iii) *Oysters.*—(*a*) *Pacific Oyster (Ostrea gigas).*—A total of 54 cases of the spat of this oyster were introduced from Japan, partly to Tasmania and partly to south Western Australian waters. They were transported by sea, and owing to delay at the point of shipping were four weeks *en route*. The cases, each of 4 cubic feet capacity, were kept thoroughly wet during the voyage, and were maintained at a temperature of 50° F. while passing through the tropics. There was naturally considerable mortality among the spat before they were laid out at their destinations, but at Pittwater, Tasmania, there is a sufficiently large quantity of surviving spat to test out the subsequent rate of growth, which so far has been very rapid indeed, and it is hoped, will determine whether the oyster will spawn. Further mortality has, however, occurred at the Western Australian site of the experiment (Oyster Harbour), this being caused chiefly by a thick growth of algae which died off and tended to smother the oysters, which also became heavily encrusted by barnacles and ascidians.

(*b*) *Ostrea angasi.*—Whilst Western Australian estuaries were being examined to estimate their possible use for Pacific oyster culture, the surviving distribution of this native mud-oyster has been mapped. Several specimens of an oyster not yet identified, but which may be an environmental form of *O. angasi*, have been dredged from *Warreen* in King George Sound.

(iv) *Pearl-Shell and Pearl Culture.*—Preparations have been made to carry out work on the biology and distribution of the pearl oyster in connexion with pearl-shell and pearl culture studies in the Torres Strait. This work will commence in the latter half of 1948.

5. Hydrology.

(i) *Oceanic Investigations.*—(*a*) *South-east sector.*—During 1947-48 the evaluation of seasonal cycles of hydrological conditions in the onshore waters of this sector was continued, and 50 m. stations off Port Stephens, Botany Heads, Port Hacking, Ulladulla, Eden and Maria Island were sampled at monthly intervals. From the results to date a number of conclusions can be drawn.

A definite bimodal seasonal cycle of organic production is common to all the onshore waters in this sector. A pronounced vernal and a late summer rise in organic production appear to be the counterparts of similar production peaks in north European waters. Average level of organic production, however, except perhaps in the southern limits of the sector, is much lower than that prevailing in north European waters.

(*b*) *South-West Sector.*—The evaluation of the seasonal cycles of hydrological conditions in the onshore waters of this sector has been continued during 1947-48 by sampling at frequent intervals off Geraldton,

Fremantle, and Albany. In contrast with conditions on the eastern Australian coast, no seasonal cycle of organic production appears to be evident, and it is probable that such organic production as does occur is confined to the lower bounding layer between the water and bottom substrate. The continued absence of key nutrient elements in the upper layers of water must exert a limiting effect on phytoplankton growth.

In order to supplement and possibly explain some of the anomalous production features of these onshore waters, F.R.V. *Warreen* has completed two 100-mile traverses off Rottnest Island and one 100-mile traverse off Albany during 1947-48. From these results it is apparent that nutrient levels in the surface layers, and nutrient reserves in the deep water layers, are lower than those prevailing in similar situations in the eastern Australian area. This fact, combined with the isolation of the onshore waters by the relatively wide and shallow shelf, affords an explanation of production anomalies in these waters and will serve as a working hypothesis for continued work on productivity in the south-west sector.

(*c*) *North-East Sector.*—In June, 1948, a 100 m. station off Port Moresby was sampled and will be continued at monthly intervals by an arrangement with the local Department of Agriculture, Stock and Fisheries. The material thus collected will be air-freighted to Cronulla for analysis and will provide data for the evaluation of the seasonal cycle in this area.

(ii) *Estuarine Investigations.* — (*a*) *South-East Sector.*—The estuarine hydrological work in this area has been directed towards an understanding of the ecological and productivity aspects of the estuarine environments.

On the ecological side the influence of rapid changes or conflicts in the chlorinity, under the influence of run off, tidal movement, and marine penetration, has been extensively studied. An estuarine system in which these influences are in hypothetical equilibrium has been postulated and a classification based on the conformity of the principal estuarine systems in this sector to this equilibrium has been attempted.

On the productivity aspect, the investigations have become focused on the relationship between the mud substrate and the overlying water column in various ecological zones of the estuary. An extensive analysis of a large number of bottom muds from the principal estuarine systems in this area has been carried out in 1947-48.

In order to assess the suitability of the Pacific oyster introduced into Tasmania, monthly sampling of water and bottom mud from the Pittwater area of the Derwent River system has been commenced.

A repetition of overseas pond culture work has been commenced in Lake Dobson in Panna Dam.

(*b*) *South-West Sector.*—The principal estuarine systems of this sector have been extensively sampled since 1946 in order to provide data for their comparison with estuarine systems of the eastern Australian area. The comparatively shallow volume and absence of tidal penetration and mixing in the south-west estuarine systems have contributed in large measure to the hydrological differences between them and those in eastern Australia.

Almost complete isolation of bottom waters in late spring in certain south-west estuaries leads to their rapid deoxygenation. This condition seems to persist during the summer period, and, in combination with absolute cessation of summer run-off renders the upper waters of these estuarine systems ecologically hazardous during the summer period. The onset of winter rains leads to an almost complete freshwater scouring and domination of the system. Ecologically, therefore, these south-west systems appear to be very unstable and environmentally poor, thus inhibiting the permanent establishment, except in restricted areas, of the plankton and fauna and flora associated with the typical eastern Australian estuarine system.

(iii) *Oyster Hydrology.*—(*a*) *Mud Enrichment.*—At Shell Point and Woolooware Bay tests have been made on a semi-commercial scale of the results of the addition of fertilizers to the mud substrate; the effects on the metabolism of the mud, and on the growth of oysters in the enriched area, have been studied. This work has involved the monthly collection, at surface and subsurface levels, of mud samples for analysis; and of oysters taken from ten stations within the area for the purpose of weight and growth measurement. A statistical examination of these data will be carried out towards the end of 1948.

(*b*) *Winter Mortality.*—The 1947 winter results were inconclusive because of the mildness of the winter season, and a repetition of the 1947 programme is now in progress. By holding oysters at low temperatures in air and in seawater in a refrigerator, it has been conclusively demonstrated that sustained low temperatures, especially in seawater, are lethal to oysters.

6. Plankton Investigations.

Plankton collections made from *Warreen* in Western Australian waters have shown considerable resemblance to those hitherto made in eastern Australian waters in that they consist of tropical and sub-tropical organisms.

A paper on the net-plankton volumes of the Cronulla plankton 1943-44 and the B.A.N.Z.A. Research Expedition 1929-31 was published. A paper on the results of the plankton investigations at the Cronulla onshore station 1943-46 was prepared and submitted for publication. The results of the work showed that sampling with the Discovery net 70 indicated only one diatom maximum as occurring during each of the years 1943 and 1944, at a time when falling water temperatures had brought some degree of homogeneity to the water mass. They further indicated that the time of appearance of maximum diatom development, the duration of the subsequent period of crustacean development, and the onset, duration, and intensity of the salp invasion might be expected to vary widely with a consequent effect on the general characteristics of the larval and, later, the adult fish populations of the area.

It was found that *Nyctiphanes australis* breeds in the Cronulla area, that *Nematoscelis difficilis, Thysanoessa gregaria,* and *Evadne nordmanni* are indicative of slope water, while *Euphausia recurva* and *Carolinia unciniata* are indicators of ocean waters.

The distribution of certain species of plankton copepods is being studied.

Sorting of eggs, larvae, and post-larvae from the *Warreen* plankton collections made in eastern Australia during 1938-42 has been almost completed. Material is now organized into families and major genera ready for detailed identification and description. Collections from estuaries have also been sorted into families and species. The Mugilidae-Pseudomugilidae-Atherinidae and the Gobiidae-Eleotridae are in part described and figured ready for publication. Further collections of eggs and larvae have been made by *Warreen* in Western Australia and other material obtained from off-shore and estuarine stations on the east coast.

7. Aerial Work.

A flight, planned for the sole purpose of observing salmon shoals on beaches between Fremantle and Eucla, was made between April 19 and 29, using a chartered Avro-Anson plane. Most of this long stretch of coast was traversed twice and all salmon shoals observed were plotted. Incidental to this, shoals of pelagic fish, considered to be pilchard with possibly some mackerel shoals, were seen at various places from

Point Nuyts eastwards to Israelite Bay. Notable concentrations occurred in King George Sound, "about 20 shoals;" off the 12 and 13 mile beaches, Hopetoun, "very many shoals;" and off Starvation Boat Harbour, where, it was estimated, possibly 250 shoals were seen.

8. Taxonomy.

(i) *Bream.*—A paper dealing with taxonomy and systematic position of *Chrysophrys cuvieri* Day has been accepted for publication in American Journal *Copeia.* A full revision of the Australian silver breams has been accepted for publication in *Mem. Q'land. Museum.*

(ii) *Mackerel.*—A paper dealing with the identity, distribution, and systematic position of the rare fish *Lepidocybium flavobrunneum* has been submitted for publication. An annotated bibliography of Spanish mackerel, for publication at a later date, has been revised and brought up to date from 1941.

(iii) *Deep-sea Fish.*—Taxonomic work has begun on the deep-sea fishes collected by *Warreen* during 1938-1942. Attention has been directed to families Myctophidae, Sternoptychidae, and Gonostomidae. Myctophidae are represented by seven genera and many species, several of which are probably new. A world species index to this family has been prepared.

(iv) *Gobiidae.*—A new group of minute transparent gobiioid fish has been discovered in estuaries of southern Queensland and New South Wales. A paper is in the course of preparation dealing with description of one new genus and four new species of the Sicydiaphiinae section of the family Gobiidae. No minute transparent gobies have hitherto been recorded from Australia. Supplementary collections for the characterization of the species were obtained in April-May.

(v) *Index of Australian Fishes.*—Considerable progress has been made in the compilation of a comprehensive card index of Australian fishes. This index combines references from old and recent works.

(vi) *Seaweeds.*—Taxonomic studies were continued on seaweeds from new areas, members of the agariferous *Gelidium-Pterocladia* group being included. These records are being studied in a series of papers. Identifications of various marine algae have been made for the agar manufacturing firms, and at times, for various institutions.

9. Muttonbirds.

Field work, commenced in 1947 in the Furneaux Group, Bass Strait, at the request of the Tasmanian Government, has been extended and a small temporary field station has been established at Fisher Island, a three-acre islet, off Lady Barron, Flinders Island. Here an endeavour will be made to band the entire population of about 200 pairs of muttonbirds inhabiting the island, to obtain information on longevity, homing, inter-island wandering, and to gain other basic biological data.

During the commercial birding season in 1948, a total of 1847 young birds was banded prior to the opening of the season to ascertain the intensity of the birding operations and the degree of escapement of the young. The results were on the whole consistent with those obtained in the previous season when about one-third of the number of young were banded. They indicate that, in the well-worked islands of Franklin Sound (Great Dog, Little Dog, and Little Green Islands) between 50 and 60 per cent. of young birds are captured during commercial operations, while in the less intensively worked Babel Island, the number caught is only about one-third of the annual crop and, in Chappel Island, only about one-sixth.

Plot censuses were made at various portions of the rookeries to gather data for population densities and to assess the effects of grazing on parts of the islands.

The mortality counts carried out over the past several years at Cronulla Beach, New South Wales, for correlations with pelagic fish (mainly tuna) abundance, have been continued. Again a comparatively low mortality was recorded. In the past several years, there has been nothing approaching the high degree of mortality encountered in the year 1941-42.

10. Other Investigations.

(i) *Microbiology.*—(*a*) *Bacteriology*—Studies are being made in south-eastern Austral an waters on the bacterial content of seawater, estuarine muds, and of submerged surfaces. It has been found that bacteria do not play as large a part in the primary fouling films as they are stated to do in other parts of the world. Gram-positive organisms of the genus *Corynebacterium* appear to be much more numerous than they are elsewhere in a marine environment. A paper has been written on the classification of bacteria at the request of *Chronica Botanica.*

(*b*) *Diatoms.*—A study of Australian diatoms, especially those associated with fouling, has provided a large number of new records of genera and species. Feeding experiments with oysters have shown that diatoms and starch give a better substrate for growth than do flagellates or ciliates with or without starch. The starch provides a substrate for bacteria. The object of this work is to study the possibility of feeding oysters, and of inducing spawning.

(ii) *Fouling by Marine Growths.*—Studies on the fouling of submerged surfaces in south-eastern Australia have continued for over a year. The role of bacteria has been referred to above. Gross fouling depends on the nature of the growth, the succession of organisms as well as their nature being found to vary with locality and season. Account will require to be taken of these facts in the evaluation of the effectiveness of anti-fouling paints.

(iii) *Agar.*—Fresh beds of the seaweed *Gracilaria* were discovered and plotted in Queensland in the Cairns district at Matchem's Beach, San Remo, and the Barron River; and in Victoria at Lake Victoria between Paynesville and Sale.

The chief manufacturers of agar have modified their plant, in line with advice from this Division. This has resulted in a great improvement in the quality of their product, which now compares more than favorably with imported agar, and in reduction of cost production.

XI. METROLOGY.

1. General.

A pleasing feature of this year has been the readiness with which industry has approached the Division for advice and assistance in the calibration of equipment. The attention of senior staff has been directed to the preparations for carrying out the statutory functions that will follow the passage of the Weights and Measures Bill now under consideration.

The staff situation has not improved. Over the past year it has been found very difficult to engage any research staff of University graduate standing.

During the year disturbance due to building operations necessitated evacuation of a large part of the Division's laboratory accommodation. A new air conditioning system was installed and the ducting of the existing system rearranged. The new system, however, is not yet functioning and all precision work on surveying tapes has had to be abandoned. Some months will elapse before work can resume.

Drawings have been received and preliminary consideration given to the foundations of the new 1-metre comparator and the geodetic base.

The Chief of the Division returned to the Laboratory in July after having visited national institutions in Canada, United States of America, England, France, and Switzerland, as well as the leading instrument makers in England and Switzerland. As a result of this visit orders were placed for precision measuring equipment which will enable the Division to carry out its statutory obligation for the maintenance of Commonwealth Standards of Measurement.

During the year numerous visits have been received from representatives of organizations and private firms as well as from members of other Divisions of the Council. It has not been possible for members of the Division to make as many industrial inspections as it would be desired, but it is hoped to rectify this position in the coming year.

One phase of the services rendered to other Divisions has been the manufacture of scientific apparatus in the National Standards Laboratory workshop, through which there has been a considerable flow.

A total of 347 Certificates, Reports, and Statements of Examination of items of equipment for calibration were issued.

2. Measurement of Length and Associated Quantities.

With the exception of surveying tapes, measurements of length have continued to be based on end standards with some control by interferometry. Surveying tape measurements have been based on a set of standard tapes calibrated at the National Physical Laboratory some years ago. Additional equipment is now being obtained.

The equipment on order overseas will place the Division in a more satisfactory position with regard to the basis of all measurements of length. The items ordered include a universal 1-metre comparator which, besides enabling the maintenance of the Division's line standards of length, will permit the accurate determination of the coefficient of expansion of the various standards; and a geodetic base for the standardization of surveying tapes. These will be installed in due course.

With regard to end standards, the normal programme is proceeding, namely the regular comparison of Laboratory reference standards.

During the past three years certain end standards were sent to the National Bureau of Standards, United States of America, and the laboratories of the National Research Council of Canada for measurement in terms of the standards of these laboratories. The values given by these institutions agreed with those obtained by the Division to within two parts in a million. The standards were then sent to the National Physical Laboratory and during the year were returned to the Division. The values given by the National Physical Laboratory also agree with those of this Division to within two parts in a million.

These results indicate that the maintenance of length standards has been very satisfactory in view of the present facilities.

As mentioned above, reference standards have been partly maintained by interferometry. A method has been developed for making photographic records of interference fringes obtained for the calibration of slip gauges. By the use of this technique it is expected to increase the ease and accuracy of measurement. Some anomalies, however, have been found among the results and further investigation is being made. A more compact interferometer has been built for the calibration of slip gauges. It is generally satisfactory, but slight modifications are required.

Among the functions of this section of the Division is the considerable advisory and calibration service which has been given to industrial and other organizations.

The expanding use of photogrammetry in the various States has made it necessary to set up equipment for the calibration of aircraft cameras.

During the earlier part of the year several surveying tapes were calibrated for various organizations. Some preliminary work has been completed for the design of equipment for the determination of coefficient of expansion of short lengths of surveying tape. An investigation has been undertaken into the effect of friction on the length of a tape when used in the field "on the flat". Another investigation has been started to determine the accuracy with which the temperature of a surveying tape can be measured under normal field conditions. The facilities for providing a calibration service to industry have continued to be improved. Improvements have been made to the existing instruments for the measurement of gear elements, a new pantograph is under construction, and additional equipment was ordered from overseas. About to be installed are an end measuring machine and a three-dimensional measuring machine which will enable a quicker and more accurate service to be given.

A sub-committee of the British Medical Association has been considering the quality of blood counting apparatus and has sought assistance to examine and certify such apparatus. Equipment has been designed and constructed to enable this work to be done expeditiously and accurately.

Several projects have been undertaken in support of the activities of other Divisions of the Council. Rulings and graticules have been produced and etched patterns have been made using the pantograph developed in this Division.

A considerable amount of work has been done on integrating units which are to be incorporated in a differential analyser being developed by the Division of Electrotechnology.

Investigation and research have been directed towards the solution of various problems arising in the improvement of facilities and techniques associated with the measurement of length, for example, the determination of standards of surface roughness and abrasive studies.

Standards of surface roughness are required for the calibration of instruments used for the measurement of surface finish. The National Physical Laboratory has produced standards by etching rulings on glass. This technique has been developed and successful standards have been produced on various types of glass. Work has also been done on a surface finish standard based on a technique developed in the Division. It was found possible to produce a step on one face of a slip gauge, the two surfaces of the step being flat and parallel to slip gauge accuracy. The separation for surfaces of slip gauge size is well under control and the use of a ruling produced in this technique is very promising of development. A successful standard has been made having a depth of 50 micro-inches with rulings 0.007 inch apart.

In the field of screw measurement the increasing use of pipes and fittings to A.P.I. Standards has created a demand for a centre in Australia approved for the certification of master gauges used in the manufacture of such pipes and fittings. A survey has been made of methods of measurement and steps taken to arrange for formal approval of the Division for this purpose.

Investigations in the subjects of particle size determinations and abrasives have been continued.

3. Measurement of Mass and Associated Quantities.

The primary standard of mass, the platinum iridium kilogramme No. 44, which was obtained through the Bureau Internationale de Poids et Mesures has not yet arrived in Australia, having been made available to the National Physical Laboratory for the decennial intercomparison of standards.

Investigations into errors of balances and means for the improvement of performance have been continued and have been applied with satisfactory results to the balance which will be used with the primary standard. All the balances for the maintenance of standards have now been received.

A set of weights in nickel chrome and two weights in gold-plated bronze, have been received and are under observation prior to being put into service as working standards. A set of stainless steel weights, presented to the Division by Le Service des Poids et Mesures, Paris, has been received.

The investigation is continuing into materials suitable for the production of standards of mass. A number of experimental weights of stainless steel, nickel chrome, cupro-nickel, and brass, are being kept under observation.

All the equipment used for volumetric standardizations has been delivered and is functioning satisfactorily. The Division is now in a position to meet any demands which may be made in this field. The magnitude of volumetric error has been the subject of further study.

An investigation has been completed into the difference between the volume contained and the volume delivered by graduated measuring cylinders. For water the results show that the difference is of the same order as the tolerance on high-grade glassware.

The Division has been represented on the Laboratory Glassware Committee of the Standards Association of Australia and has taken an active part in the work of the Committee.

There is a steadily increasing demand for accurate determinations of the densities of solids and liquids and for the calibration of hydrometers. A hydrostatic balance and a temperature-controlled bath are being installed to meet this demand.

Some difficulty was experienced in obtaining consistent readings of sensitive hydrometers in distilled water. This was found to be due to minute traces of foreign material on the hydrometer stems, which reduced the surface tension of the water. This difficulty was overcome by adding a trace of oleic acid to the water, so reducing the surface tension to a low, constant value. In the course of this work a method was developed for comparing rapidly the surface tensions of liquids with an accuracy quite adequate to permit the calculation of the corrections to sensitive hydrometers.

There has been a number of inquiries for calibration of aneroid type instruments and special equipment is being designed and built for this work.

4. Applied Mechanics.

War-time experience in mechanical testing clearly established that much benefit is to be derived from the regular examination of testing machines and associated equipment. As a result of the demand made on this Laboratory for the calibration of testing machines, some members of the staff are continuously engaged in the verification of testing machines and equipment.

The Division is collaborating in the work of the National Association of Testing Authorities which has recently been established under the aegis of the Commonwealth and State Governments. This has brought about a change in the nature of the demand made on the Laboratory. The change emphasizes the need for extension of the range of proving facilities and for equipment to verify the proving devices themselves.

Attention has been given to the measurement of such quantities as pressure and angular speed involved in the examination of instruments such as pressure gauges and tachometers. Although pressure gauges are still accepted for examination owing to the limited facilities in industry for such examination, greater attention has been called for in the verification of pressure gauge testing devices. This is the object of an investigation at present in progress.

To meet the need for the calibration of angular speed measuring devices such as tachometers, permanent equipment has been provided for the calibration of such instruments.

Vibration studies have been continued and here again a change is noticeable. Previously the demand has been almost entirely for the measurement of vibration and reference has been made in a previous report to a novel yet simple and robust form of vibration pick-up developed for such work. It is now felt that the establishment of facilities for the calibration of vibrometers is even more important.

Although attention has been mainly directed towards the measurement of force, pressure, angular speed, and vibration, assistance has been given in the devising of techniques for special tests and the making of tests and measurements in circumstances where facilities are not available outside the Laboratory. Three typical examples of such work are given below.

A technique was devised for making diamond pyramid indentation tests to determine the hardness of very small steel balls. Measurements were made of a rotational speed approaching 200,000 revolutions per minute, the measurements being required as a guide in the development of a special-purpose centrifuge made in the Laboratory Workshop. The method of stress analysis by photo-elasticity was employed to check the stress concentration in a loading shackle of unusual shape.

XII. ELECTROTECHNOLOGY.

1. General.

Considerable progress has been made by the Division in establishing further electrical standards and extending the scope of its measuring facilities. The more precise derivation of some of the standards, however, is still awaiting the completion of the air-conditioning installation.

The Section dealing with dielectrics research is now well established. Several chemically pure hydrocarbons and a number of polar compounds necessary for the immediate programme of dielectrics research have been manufactured. Measurements taken to date indicate that this should prove to be a fertile field of investigation.

The first units of the differential analyser for the Mathematical Instrument Section have been manufactured and have given a very good account of themselves in performance tests. Arrangements are now being made for the manufacture of the remaining units.

The Chief of the Division went abroad in March to spend approximately six months in England and America, principally to investigate modern trends in the fields of dielectrics research and mathematical computing machines.

2. Direct Current.

Equipment has been completed for the measurement of insulation resistance by an electrometer method which extends the upper limit to which resistance can be measured to 10^{17} ohms.

High-value precision resistance coils, constructed according to the usual methods, have been found to suffer from "dielectric absorption" in the insulation, the effect of which is to make the resistance value indefinite under normal conditions of measurement. This effect is being investigated particularly with regard to the choice of insulation necessary to produce a coil of high stability with freedom from absorption effects.

3. Alternating Current.

Temporary equipment has been completed for automatically controlling the sine wave alternator set at any frequency within the range 20 to 60 cycles per second. Over a period of several minutes, a stability of better than 0.01 per cent. has been obtained. Experimental work on the control of alternator voltage has reached an advanced stage.

Modifications have been made to the electrostatic voltmeter transfer instrument in order to reduce its sensitivity to vibration and to ambient temperature changes.

The construction of a null-indicating dynamometer-type transfer voltmeter has been completed. This instrument will enable R.M.S. alternating voltage to be established in terms of the D.C. standard by a method alternative to that provided by the electrostatic voltmeter. Preliminary tests have shown agreement within 1 in 10^4 between the two instruments, but there is evidence of a definite discrepancy of this order.

In the method adopted at the Laboratory for current transformer testing, highly precise current transformers are used as reference standards and, up to the present, it has been necessary to rely on standards laboratories abroad for the calibration of the standards. In an attempt to overcome the necessity of sending the standards abroad periodically, with consequent long periods out of service, attention has been given to the development of a new method of calibrating the standard transformers, using simple and inexpensive auxiliary equipment. Promising results have been obtained in preliminary tests of the method.

Equipment for voltage transformer testing is still being developed, although the principle of the method adopted has been thoroughly tested. In this method the ratio of the transformer is found in terms of the ratio of two capacitors. A great deal of the work has been in connexion with the development of a suitable precise capacitor for high voltage use. The immediate intention is to set up equipment capable of testing transformers with primary voltages up to 132 kV.

4. Audio Frequency.

With the air-conditioning plant not yet in operation, little of the precise work necessary for the derivation of standards of capacitance and inductance has been attempted. However, sufficient intercomparisons of standards have been made to enable this Section to meet all demands on it for precision measurements.

A wide variety of impedance measurements at frequencies ranging from 50 c/s to 50 Mc/s have been made. The majority were to determine dielectric properties for the Materials Section. To extend the frequency range to 100 Mc/s and to facilitate these measurements, a special test instrument for dielectric measurements is being developed.

In collaboration with the Division of Plant Industry, a considerable number of measurements have been made of the equivalent impedance of potatoes with and without virus infection. It was hoped to establish an electrical method for the rapid selection of seed potatoes. Sufficient discrimination has been obtained to warrant further work. To enable rapid measurements to be obtained on a large number of samples, the design of direct-reading impedance motors is being investigated. A prototype of one method involving manual balance for magnitude and phase has been completed. Another type, in which impedance and phase are read directly from meters, should be completed shortly.

The frequency standard produced by the British Post Office was received in May and has been installed in a ground floor laboratory. Adjustments are almost complete and it should be in continuous operation shortly. In due course, the oscillator rack will be housed in a temperature controlled and screened room in the basement, and the whole installation will run from float-charged batteries.

In developing a counter type frequency-motor, some time has been spent in investigating the mode of operation of electronic counters with a view to increasing their upper frequency limit. During this work the possibility of developing a new electron tube which would itself count up to ten cycles was considered. Several possible modes of operation were considered and much theoretical and experimental work has been carried out in co-operation with the Radiophysics Division. The first experimental counter tube, a scale of five, was successful in showing five stable states although it was not satisfactory as a counter. This work is being continued as it shows every prospect of producing a successful tube which would be of value in electronic computing equipment and many other fields.

5. Radio Frequency.

The development of measuring techniques in this field has been carried out by a Section staffed jointly by the Divisions of Radiophysics and Electrotechnology and has, in the main, been conducted in lines of direct assistance to the research work of both Divisions.

Thermal noise generators have been designed and built to operate at 600 Mc/s and 1200 Mc/s. The noise-producing element in each case is a specially constructed straight-filament tungsten lamp mounted as part of the inner conductor of a concentric transmission line. As well as providing an independent check on the attenuated power output of standard signal generators at these frequencies, the noise generators have proved very suitable for the calibration of receivers used in the study of solar radiation.

The dielectrometer for permittivity and power factor measurements in the range 100-300 Mc/s has been completed. Preliminary tests indicate that its performance will be satisfactory. A more powerful and stable oscillator will be necessary, however, before the instrument can be used for routine dielectric measurements.

Two standard piston attenuators have been designed for use in a band of frequencies centred at 1200 Mc/s. The attenuating tube is excited by means of a resonant cavity to ensure mode purity.

A general purpose thermistor bridge has been developed to accommodate all the values of thermistor resistance likely to be encountered in practice.

Some experimental bolometers have been constructed with a view to using them as detectors of electromagnetic radiation in the millimetre wavelength region. They consist of nickel films evaporated on to a thin sheet of dielectric material. Following the concept that the characteristic impedance of free space is 377 ohms for a plane wave, the films are evaporated to have a resistance per square of this order so as to present a matched load to the radiation. No millimetre-wave oscillator was available for test purposes, but with a standard lamp as a source of radiated power the sensitivity of the bolometers was estimated to be 10^{-8} watt per square cm.

6. Properties of Materials.

(i) *Preparation of Chemicals for the Dielectrics Programme.*—The study of the relationship of molecular structure and the dielectric properties of

materials has involved the preparation of a series of long-chain organic compounds in a very pure state. Considerable effort has been concentrated on the preparation of polar compounds such as symmetrical ketones, secondary alcohols, esters, and ethers, and of several non-polar long-chain hydrocarbons of various chain-lengths. For the purpose of measurement of dielectric properties, specimens are made of solid mixtures of the polar compounds in a non-polar hydrocarbon base.

(ii) *The Relationship between Dielectric Properties and Molecular Structure.*—The study of the dielectric properties of solid solutions of aliphatic long-chain esters in paraffin wax, initiated by Jackson, Sillars, and Pelmore, has been extended in this Laboratory to cover a wider range of polar solutes and hydrocarbon solvents. The variation of tan δ with frequency has been obtained for solid solutions of the ketones laurone ($C_{23}H_{46}O$) and myristone ($C_{27}H_{54}O$) and esters and ethers of corresponding chain-lengths. The results provide useful information regarding the environment of the polar molecules in these solutions. The programme is being extended to the ketones 11-heneicosanone ($C_{21}H_{42}O$) and 13-pentacosanone ($C_{25}H_{50}O$), and esters, ethers, and other polar compounds of corresponding chain-length. Dielectric measurements are also being made with discs of pure polar compounds.

(iii) *Dielectric Constants of Protein Solutions.*—An electrodialysis apparatus has been constructed and used for the elimination of ionic impurities from egg albumen. A dielectric test cell, having electrodes consisting of two concentric rhodium-plated copper cups, was tested and found to be unsatisfactory as a result of errors due to polarization. The use of platinum cups coated with platinum-black gave good results, and trial measurements of the dielectric constant of solutions have been made over the frequency range from 10 kc/s to 4 Mc/s.

7. Applied Electronics.

An aided-laying attachment for a "Shoran" aircraft radar equipment has been designed and constructed. Under operational conditions with rapidly changing ranges this attachment facilitates the following of the radar echoes and reduces the strain on the operator.

The construction of a plotter mechanism to enable a Shoran-controlled aircraft to follow a series of straight parallel courses is being continued.

In addition to the development of electronic equipment for the Division's internal needs, assistance has been given to other Divisions in the design and construction of special apparatus.

8. Mathematical Instruments.

(i) *Differential Analyser.*—Progress has been made on the design and construction of the differential analyser. Two integrators have been completed by Commonwealth Aircraft Corporation Proprietary Limited, and the National Standards Laboratory workshops have built up one gear box, one differential unit, and a plotting table. With these units, a number of performance tests have been made. These indicate that an accuracy of 0.1 per cent. may be expected in any integrator under the worst conditions of operation, i.e. low integration constant and high speed of operation.

Attention is at present being given to the design of the control board for the setting up of the problem to be solved by the analyser. The present intention is to design the control board in two separate units each capable of separately handling ten integrators and associated equipment. The two boards may be readily paralleled for a problem requiring the use of more than ten integrators. A displacement velocity servo for controlling the independent variable drive is being developed. Some work has also been carried out on a recording unit for printing the output in tabular form.

(ii) *Course Plotter.*—Work has been carried out on designing and building a course plotter for mounting in a trailer towed by a vehicle. The machine is essentially a mechanical computing instrument. It is fed with speed and bearing to plot automatically and continuously the course of the vehicle on a map.

(iii) *Digital Computors.*—The Section has continued its activities in the application of electronic techniques to high-speed digital computation. A considerable amount of basic work has been done in developing electronic circuits for counting in both the decimal and the binary systems, and experience has been gained in assembling and controlling these circuits for transmitting, adding, and multiplying numbers. Reliable and consistent operation of ring counters has been achieved up to a frequency of 500 kc/s. Further work is being continued on the development of gating and control circuits.

With existing electronic techniques, binary arithmetic appears to have distinct advantages in the operation of high-speed electronic machines. However, this raises the problem of the conversion of decimal numbers to and from binary numbers, as it is generally considered that it is impracticable for data to be given to and taken from the machine in any but the decimal form. A scheme has been worked out for this conversion which shows promise of success.

XIII. PHYSICS.

1. General.

The Division's post-war policy of increasing the amount of fundamental research, as compared with short-term technical investigations, has been continued with very satisfactory results.

The researches begun in the previous year on certain of the processes associated with the formation of rain are being continued and extended in a number of directions.

Satisfactory progress has been made in the construction of the apparatus necessary for researches at very low temperatures, and the equipment is expected shortly to be in operation.

Some theoretical investigations of certain solar phenomena were mentioned in last year's report. The new theory of solar flares resulting from these studies has been very well received by astrophysicists abroad. Further theoretical investigations aimed at finding explanations of other solar phenomena and at extending our knowledge of the physical conditions in the sun's atmosphere have now been made with considerable success.

In all these researches the difficulty of obtaining physicists to fill staff vacancies has been a severe handicap. This has been accentuated by the loss of two senior members.

The Division is responsible for the maintenance of the Commonwealth Standards of Measurement in light and heat and certain fundamental electrical standards. The adoption by international agreement of the so-called absolute system of electrical units based on the units of length, mass, and time, in place of the international electrical units agreed upon several decades ago, will result in slight changes in the values to be assigned to the standards by means of which the electrical units of resistance and voltage are maintained. Small changes also are necessary in photometric units owing to the adoption of the so-called New Candle in place of the international candle. The maintenance of accurate standards of candle-power has always proved of great difficulty to standards Laboratories, and steps are being taken by the Division to improve its own standards and those of testing laboratories in

the country. It is appropriate to mention here that the Division has taken an active part in the initial steps by which Australia has become affiliated with the International Commission on Illumination.

The Division has taken an important part in the work of the committees advising the National Association of Testing Authorities in the fields of pyrometry, photometry, and illumination. It is expected that the Division will be called upon in the near future to calibrate equipment used in test work in these fields by laboratories affiliated with this Association.

The Division has been represented in the work of several committees of the Standards Association of Australia and the Australian National Committee on Illumination. Assistance has been given to many manufacturing firms and to national and State organizations.

During the year, 183 Reports, Certificates, and Statements of Examination were issued.

In May, 1947, the chief of the Division went abroad for a second time at the request of the Department of External Affairs to act as scientific adviser to the Australian delegate on the Atomic Energy Commission of the United Nations organization, and was absent for a period of five months.

2. Heat.

The main effort of the Heat Section during the year has been concentrated on two research projects: studies of the phenomena of ice crystal formation and the development of facilities for the attainment of very low temperatures. The work on ice crystal formation is being actively pursued along several lines, particular attention being given to the forms of crystals and the numbers produced under various conditions. Good progress has been made with the helium cryostat, with which it is hoped to be able to maintain temperatures down to 2°K; this equipment will be ready for trial as a unit in the near future. When it is completed the Division will have facilities unique in this country for research at low temperatures.

In addition to the above projects, work similar to that recorded in previous reports has continued, particularly on matters associated with the development and maintenance of standards, tests in terms of these standards, studies in hygrometry, the measurement of moisture content, and the development of specialized instruments for use in these fields.

The development and research work of the Section has been retarded to some extent by difficulty in obtaining scientific staff.

(i) *International Temperature Scale and Temperature Measurement.*—The maintenance of the International Temperature Scale, improvements in the accuracy with which it is realized, the calibration of temperature measuring equipment of many types in terms of it, and investigations into means of measuring and controlling temperatures, have all continued to receive attention in the Section. Some new lines of work have been commenced in these fields and steady progress has been made in others.

New equipment has been constructed for the more accurate realization of the lowest of the fixed points on the International Temperature Scale, the boiling point of liquid oxygen (— 190° C.).

Another of the fixed points on the International Temperature Scale, the steam point (100° C.), has the disadvantage that its value depends materially on the pressure under which boiling occurs. A freezing point would be in many ways more convenient, and the National Bureau of Standards, Washington, U.S.A., has recently suggested as a convenient sub-standard the use of special cells of benzoic acid (melting point 122° C.) The National Bureau of Standards has given this Laboratory one such cell for trial and report on its behaviour.

Further experiments on diphenyl ether have confirmed its suitability for use as a thermocouple "cold junction" point. Its freezing point is approximately 27° C., and at ordinary ambient temperatures special cells containing the substance will maintain a reference junction temperature steady to ±0.02° C. for one or two days. The principal advantages of the units over an ice reference point are the ease with which they can be regenerated (by warming) and the reduced temperature difference when thermocouples are used for ambient temperature measurements.

Arising out of tests on the extent to which subsidiary thermal e.m.f.'s could be removed from thermocouple wires by careful annealing, an investigation has been commenced of the electro-thermal inhomogeneities of thermocouple wires.

A high frequency induction furnace of 4.5 kW. capacity and of approximately 1 Mc/s. frequency has recently been purchased. With this equipment it will be possible to set up equipment for the realization of the platinum melting point. This will serve as a useful secondary fixed point for thermocouple and optical pyrometric work and as the standard blackbody source of brightness for the realization of the New Candle.

The Section has continued to undertake, on a limited scale, the calibration of industrial pyrometric equipment and furnaces.

(ii) *Special Devices for Temperature Measurement and Control.*—The Section continues to receive numerous requests for advice on special problems of temperature measurement or control. Problems to which particular attention has been given include the measurement of temperatures in studies of vapour-liquid equilibria, the measurement of the temperatures of estuarine muds and waters, the measurement of skin temperatures of sheep, the precise control of temperature in a viscometer bath, the control of temperature to ±0.01° C. in a water-bath for specific gravity measurements, and the control of the temperature of the Grayson ruling machine.

In several of the above cases use has been made of the electronic proportioning controller designed in the Division, to which reference has been made in previous reports. Numerous requests have been received for details of this equipment, and it would seem to have filled a need for an apparatus capable of giving very accurate temperature (or humidity) control, which is not subject to "hunting".

There have been many inquiries for the details of the design of the photoelectric galvanometer amplifier referred to in the last report. This instrument finds useful application in the recording of very small e.m.f.'s, such as are met with in the measurement of small temperature differences with thermocouples. A new design of the apparatus has been completed, which it is hoped will give an instrument of improved stability.

(iii) *Hygrometry.*—A theoretical and experimental examination of the relationships between the temperature depression of a psychrometer (wet and dry bulb hygrometer) and both the diameter of the wet element and the air velocity has been completed. This investigation gives new information on the errors likely to be encountered in humidity measurements with psychrometers, and quantitative results have been obtained for the accuracy of which such instruments are capable, particularly at low air speeds.

An automatic dewpoint hygrometer accurate to 0.1° C. with a time constant of 30 seconds has been constructed, in which the formation of dew on the test surface is detected photoelectrically and the current from the photocell is used to control the temperature of the surface. For certain purposes an instrument having an even smaller time constant would be very

convenient. Preliminary designs have been prepared for a photoelectric instrument which it is hoped will have a time constant of less than a second.

A theoretical investigation has been made of the errors inherent in the assumption that an air, water vapour system obeys the simple gas laws. This is a common assumption in hygrometric work, and it has been shown that an inaccuracy of up to 0.5 per cent. can occur in the calculation of relative from absolute humidities, and, in fact, that hygrometric quantities, as usually defined, are uncertain to this extent.

(iv) *Moisture Content.*—The measurement of moisture content is a matter of considerable industrial and scientific importance; examples of some materials for which such measurements are important are wheat, wool, tobacco, wood, paper, soil, sand (for concrete), and foundry sands. Methods of drying to constant weight are usually tedious and it is usually more convenient to measure some property of the material which varies with moisture content. Measurements of electrical resistivity are used in a number of commercial moisture meters but these are in many cases severely limited in their application and accuracy.

A moisture meter, rather similar to one developed by the National Physical Laboratory, Teddington, England, has been constructed in the Section; it measures the dielectric, rather than the resistive properties of the specimen and has been used particularly for measurements on wool. The value of the instrument for routine wool measurements has not yet been adequately tested.

For measurements of the moisture content of sands and such-like materials an instrument measuring the electrical properties of the sample is not very satisfactory because the moisture in the sample is likely to behave as an electrolyte. Explanatory tests have been made on a method depending on the change in the thermal properties of the material with moisture content.

(v) *Heat Transfer.*—The assistance which had been given to the Building Research Section in the design of equipment for measurements of the thermal conductivity of insulating and other materials was mentioned in last year's report. The Building Research Section is proceeding with the construction of the apparatus designed for the measurement of the thermal transmission of wall sections; and equipment for tests on 12 in. by 12 in. specimens, which has been designed and constructed in the Laboratory, is now practically ready for transfer to the Building Research Section.

The thermal properties of a layer of volcanic dust if present on the surface of the moon, have been calculated for Dr. J. C. Jaeger, of the University of Tasmania. The result is of interest, since it is quite different from previously accepted values, and is consistent with a new interpretation by Dr. Jaeger of observations of the moon's surface temperature.

(vi) *Precipitation and Ice Crystal Formation.*—Investigations into the physical phenomena involved in ice crystal and, to a lesser extent, droplet formation in air, have been actively continued. This work is immediately related to the experiments of the Division of Radiophysics on methods of artificially inducing the precipitation of rain or snow in the atmosphere, but is concerned with laboratory investigations on the basic processes involved in the large scale phenomena. The studies have been along the following main lines:—(*a*) the examination of the phenomena of the formation and growth of ice crystals in a supercooled fog in which local lowering of the temperature has been produced by such means as the dropping of small pieces of solid carbon dioxide through the fog; (*b*) the examination of the formation of ice crystals in a supercooled fog when suitable foreign nuclei are introduced; and (*c*) a study of certain phenomena associated with droplet formation.

The types of ice crystals obtained under various conditions have been studied directly by observing them microscopically, and techniques for obtaining plastic replicas of them have been extensively applied, permitting the crystal forms to be preserved and examined.

Investigations are in progress on the highest temperature at which ice crystals, when present in a supercooled fog, will continue to grow; a temperature which has been observed to vary between approximately −2° and −0.5° C. Determinations are also being made of the number of ice crystals which result from a given loss of solid carbon dioxide under a wide variety of conditions. Both are problems of practical importance in rain-making field work.

While making some experiments in an expansion chamber it was observed that the formation and subsequent evaporation of water droplets in the chamber seemed to leave invisible centres on which droplets would subsequently form if the air was only very slightly supersaturated. Such a phenomenon has been observed by other experimenters but a study of it does not seem to have been previously undertaken. It would seem that phenomenon might be of considerable meteorological significance.

Some work has been done on (*a*) the design of equipment suitable for the measurement of fog densities in the experimental chambers; (*b*) the application of the automatic dew point hygrometer, referred to above, to measurements of the water content of fogs; and (*c*) the efficiency of various pyrotechnic mixtures, with which silver oxide has been combined, in inducing ice crystal formation in supercooled clouds, with a view to the use of such mixtures in atmospheric tests.

(vii) *Low Temperature Physics.*—Considerable progress has been made with the construction of equipment for the attainment of very low temperatures. The basic equipment is a unit for compressing pure helium gas to about 200 p.s.i. and a sealed chamber inside which the helium gas is cooled by allowing it to do mechanical work and by a Joule-Thompson expansion. Within the chamber, known as the cryostat, there will be a working space of approximately 1 cubic foot in which experiments at low temperatures will be performed. It is anticipated that the temperature of this space will be capable of being held at any desired figure between room temperature and 2° K. The design of the equipment is such that it may also be used for the production of liquefied gases, for experiments outside the cryostat. It is anticipated that the facilities provided by this equipment will be such as to permit of an extensive programme of research at low temperatures being undertaken.

The cryostat itself has been almost wholly constructed in the National Standards Laboratory workshops; particular mention should be made of the excellent service and co-operation of the workshop staff on this undertaking. The cryostat has now been assembled and subjected to its preliminary tests. The compressor is expected from the manufacturer in the immediate future and the whole equipment will then be ready for assembly and test. It is anticipated that the cryostat will be in operation by October, 1948.

The oxygen generator which was acquired as ancillary equipment for the low temperature project has been extensively reconditioned and has been used to produce small quantities of liquid air.

3. Light.

The main work of the Section falls into two subgroups, general optics and photometry. In addition, officers in the Section are undertaking the maintenance of the Division's X-ray equipment and are carrying out research in solar physics.

(i) *Photometric Standards.*—Following the introduction, by international agreement, of the black-body standard of luminous intensity, conversion factors have been obtained for the Division's standard lamps so that calibrations may be undertaken in terms of the new units of candle-power and luminous flux. An induction furnace, which has been acquired by the Division, is a major step towards the establishment of the new standard of luminous intensity in the Laboratory, so that ultimately the use of lamp transfer standards will be unnecessary.

(ii) *Spectrophotometry.*—The recording spectrophotometer has again been put into good use during the year. In all, some 800 spectrophotometric curves have been produced. Typical of the work carried out are the following: measurements of reflectance and colour of papers and paints; transmissions of thin metallic and dielectric films produced in the Section; transmissions and colours of glass filters (several of which have been constructed to reproduce high colour temperatures for controlling the quality of fluorescent lamps in manufacture). Considerable assistance has been given to research workers in other laboratories in certain chemical and biochemical investigations which could not have been made without these facilities for rapid spectrophotometry.

(iii) *Haemoglobinometry.*—A number of haemoglobinometers (including several made commercially to this Laboratory's design) have been calibrated and this service has been extended by issuing calibrated solutions of haemoglobin, so that pathologists may calibrate their own instruments. This is particularly necessary when the instrument is of the dilution type.

(iv) *Colorimetry.*—Industry is becoming aware of the value of colorimetry. One application of the photoelectric tricolorimeter designed by this Laboratory is its use in the manufacture of fluorescent lighting equipment.

A second type of tricolorimeter, employing a vacuum emission photocell and four colour filters, has been designed after experience with an experimental model, and several of these instruments are being constructed by industrial and research organizations.

(v) *Deep Sea Photometer.*—An omni-directional photometer has been designed and constructed for the measurement of luminous intensity down to depths of 600 feet beneath the level of the sea surface. The photometer has an integrating sphere open to the sea-water and a sealed barrier layer photocell. The response current flows through the supporting cable to an indicating meter on the ship. The instrument is intended for use by the Division of Fisheries.

(vi) *The Measurement of Radiant Energy.*—Evaporated dielectric bolometers for the measurement of radiant energy at millimetre wavelengths have been successfully made, using techniques previously developed in the construction of resistance bolometers. These bolometers have been used by a group of workers in the Divisions of Electrotechnology and Radiophysics who participated in their construction. They are stable over short periods of time, but their long-term stability has not yet been checked.

(vii) *High Vacuum Equipment.*—The vacuum evaporation equipment has been used extensively; for example, for the production of aluminized mirrors, neutral light filters with nickel films, neutral step-wedge filters for spectroscopic photometry, and high efficiency three-layer dielectric semi-reflectors.

The equipment has also been used by the Wool Section for producing, by gold shadowing and silica replica techniques, specimens for electron microscope studies of wool fibres.

Equipment is being assembled for the establishment of extremely high vacua, in the range 10^{-8} to 10^{-10} mm. of mercury.

(viii) *Tests on Retro-reflectors, and Investigations on the Light Distribution from Optical Systems.*—An investigation of the optical characteristics of reflector buttons such as are used in highway signs has led to the development of a general theory of the light distribution in optical systems whose spherical aberration is known, when the source is of small but finite angular size. The intensity distribution of the reflected light from a model reflector button of variable thickness is being measured and compared with theory. An experimental investigation of the reflection properties of beaded plastic sheets is also in progress.

(ix) *Film Projector Tests.*—The production of 16 mm. sound-film projectors is still being improved and expanded by Australian secondary industry. As new types become available advantage is taken of this Laboratory's testing facilities by manufacturers in collaboration with the National Films Board. Importers of British machines are also submitting machines for test.

A specification for 35 mm. strip film projectors has been drawn up and the necessary resolution test slides and films have been prepared.

(x) *Studies in the Diffraction of Light.*—The analysis of the diffraction pattern in the plane of an image of an extended object is being continued. This has required a review of the mathematical theory of the diffraction of light, and satisfactory progress has been made in the development of a mathematical theory free from the approximations usually introduced.

(xi) *X-ray Equipment.*—Owing to the departure abroad of a member of the staff there has been some delay in the assembly of the X-ray diffraction equipment. A leak detector of the mass spectrometer type, developed by an officer of this Division, is being found of great value in this type of work.

(xii) *Solar Physics.*—Now that it is realized that the temperature of the sun's atmosphere increases outwards from the photosphere, there is a major difficulty in interpreting spectroscopic observations of the sun's atmosphere, since no theoretical study has been made of the emission and observation of radiation in a case in which the kinetic temperature exceeds the radiation temperature. An attack has been made on this problem by a theoretical examination of the distribution of atoms among the excited atomic states for a range of atom concentrations and kinetic temperatures, and for a limited range of radiant energy densities. From this theory the rate of emission and absorption of selected spectral lines has also been computed.

A preliminary application of this theory has been made to one of the strong solar hydrogen absorption lines which originates in an atmosphere much hotter than the background against which it is observed. The results are in general agreement with the observations, but it is necessary to extend the computations to include also the ultra-violet Lyman radiation before the theory can be regarded as complete. In the course of this work it has been found necessary to review all previous investigations on the electron density and its gradient, and the temperature in the sun's chromosphere. All the spectral observations lead to the conclusion that the temperature of the solar atmosphere is of the order of 3×10^4 deg. K. in the range from 500 to 3,000 km. above the photosphere.

An extension of the theory of induction currents in the sun's atmosphere near growing sunspots has shown that, owing to the reduction in electron concentration with height, the current density in any current path is limited by the current in the coronal regions when the electron velocities approach that of light. Thus most of the electromotive force is in the higher regions, and electrons acquire high energies in the corona when sunspots are growing rapidly. It further follows that these electrons emit electromagnetic radiation with frequencies of the order of 100 megacycles per second

and the calculated rate of emission is of the order of that observed in radio noise observations on the disturbed sun.

4. The Physical Properties of Wool Fibres.

An electron microscopic examination of the surface of the wool fibre is being made, particular attention being given to differences between the surface structures of different types of wool, and between normal wools and those subjected to various anti-felting treatments. Work on the frictional properties of the wool fibre has continued, and a programme has been drawn up for a detailed study of the elastic properties of crystalline keratin.

(i) *The Surface Structure of the Wool Fibre.*—By arrangement with the New South Wales Department of Technical Education an officer of this Section has had use of a console model electron microscope for wool fibre studies. Two different two-stage replica techniques are being used: gelatin collodion, sometimes with subsequent gold shadowing, to reveal height variations on the surface; and collodion-silica, to reveal variations in inclination of the surface. Technical difficulties prevent the use of one-stage replicas. An interesting "doubling" of the edges of the surface scales has been observed. The effect of the Freney-Lipson anti-felting treatment on the scales is at present being studied. Some evidence has been obtained that this treatment, which leaves the general appearance of the scales unaffected, actually weakens them, a result which was expected from a consideration of the frictional properties.

(ii) *Frictional Properties of the Wool Fibre.*—The coefficients of kinetic friction of wool fibres rubbed on horn, both with and against the scales, have been shown to vary with the pH of the surrounding medium and the degree of contamination of the surfaces in very much the same way as do the respective coefficients of static friction. It will therefore usually be satisfactory to measure either type of coefficient when attempting to relate the frictional properties of the wool fibre to the felting of wool.

The effect on the frictional properties of some further commercial treatments has been examined. Chlorzymed fibres, from which the scales have been almost completely removed, show no difference between the coefficients of friction towards the root and towards the tip. Fibres treated with "Lanaset" or with anhydrocarboxyglycine have been shown to retain almost all their frictional difference. This invalidates the statements made by some authors that these anti-felting reagents act by "masking" the scale structure and so reducing the frictional difference. They probably act by "gluing" the fibres together so that their migration is prevented.

It has been shown that N/10 sulphuric acid irreversibly decreases both coefficients of friction. This is in marked contrast to the effect of hydrochloric acid at the same pH, which was previously shown to increase both coefficients reversibly, and suggests that sulphuric acid (which is used in carbonizing) damages the wool fibre.

The effect of solvent scouring on the frictional properties is being studied. The effect of the tension in the fibre has been shown to be of importance in determining its frictional properties.

(iii) *The Elastic Properties of Keratin.*—A programme has been drawn up for measuring all the elastic constants of crystalline keratin in the form of African porcupine quill cortex. This work will begin as soon as further research staff can be obtained. In the past, only the longitudinal constants have been studied. On the basis of the longitudinal stress-strain curves of wool, Astbury and others have evolved hypotheses concerning the structure of keratin. Transverse measurements should be of value in testing these hypotheses. They will also be of value in connexion with the swelling of wool.

XIV. AERONAUTICAL INVESTIGATIONS.

1. General.

At the invitation of the Australian Government, the first meeting of the Commonwealth Advisory Aeronautical Research Council (C.A.A.R.C.) was held in Australia in April, 1948. This Council was set up by the Governments of the United Kingdom and various Dominions as the result of recommendations of the British Commonwealth Conference on Aeronautical Research which was held in London in 1946.

Aeronautical research, particularly in the field of gas dynamics, is now so expensive and time-consuming owing to the larger powers and complicated apparatus necessary for the study of high-speed flow, that the greatest degree of co-ordination is essential if solutions to the numerous and most pressing problems are to be obtained in a reasonable time. The primary function of the C.A.A.R.C. therefore is to co-ordinate the research programmes throughout the British Commonwealth and to suggest the lines of work which might most fruitfully be followed. It also acts as a central liaison agency for the dissemination of scientific information on aeronautics and arranges the interchange and secondment of staff.

The Australian Government, as host, nominated Professor A. V. Stephens, Professor of Aeronautical Engineering at the University of Sydney, as Chairman of the meeting. The Australian delegation was led by Mr. L. P. Coombes, Chief of the Division of Aeronautics, C.S.I.R. Delegates from the United Kingdom, Canada, New Zealand, and South Africa attended the meeting.

At the London Conference in 1946, an item of great importance had been suggested to Australia: the flight development of the suction wing. The Division of Aeronautics undertook responsibility for the research side of this project, and the wind tunnel experiments and suction plant development were carried out in its laboratories. The detailed design and construction of the experimental aeroplane are being done by the Government Aircraft Factories, and the R.A.A.F. will conduct the flight trials.

The Council issued a report making recommendations which may have far-reaching effects. One referred to the positive dissemination and co-ordination of research information between the member countries and it was gratifying that Australia was given the leading part in the field of structural research. The United Kingdom sent a particularly strong and well-informed delegation and there is no doubt that local aeronautical research workers benefited very greatly from personal contact and discussion with leaders in their particular fields.

The last annual report mentioned that the Australian Council for Aeronautics had been disbanded and that it would be succeeded by a committee attached to C.S.I.R. The new Aeronautical Research Consultative Committee has now been formed and during the year held six meetings.

2. Structures.

(i) *Theory of Structures.*—(*a*) *Open Sections.*—Channel, angle and zed sections formed from light alloy sheet or strip are extensively used in aircraft construction and a thorough study has been made of their strength and stability under compressive and bending loads. Such sections made from mild steel or low-alloy steel strip would provide an economical material for constructing large, lightly loaded engineering structures. Accordingly a series of experiments were performed on mild steel channel and zed sections to evaluate for this material certain parameters required by the theory. A paper illustrating the use of the data in design has been prepared for publication in an engineering journal.

(*b*) *Grid Panels.*—Grid panels consisting of two thin sheets of aluminium alloy separated and stabilized by a core of wooden slats arranged in the form of a grid have been evolved for the wing and fuselage construction of high speed aircraft where it is desirable to maintain true, unbuckled surfaces up to high loads A theory for the design of these panels has been worked out and indicates that they will compare very favorably in structural efficiency with other forms of construction in current use. Experiments are in hand to verify the theory.

(*c*) *Structural Efficiency of Plates and Shells.*—The highly competitive nature of international air operations, whether civil or military, demands a continuous study of all factors affecting the operational efficiency of aircraft. Not the least of these factors is the structure weight which has a large influence on the payload and general economics of operation.

A study of the ideal efficiency of wing structures was commenced during the year and appreciable progress has been made in estimating the minimum possible weights of structures which will comply with the airworthiness, strength and stiffness requirements. A criterion of wing efficiency has been established taking into account most of the factors which influence the design. A large number of actual wings has been analysed and a reliable basis is now available for comparing designs and for locating causes of excess weight.

The work on the optimum panel size and shape for stiffened cylinders representative of fuselage construction has been extended to include non-circular cylinders and cylinders on which two mutually perpendicular bending moments act simultaneously. Cylinders with skins which buckle at relatively low loads and those with non-buckling skins have been investigated, the latter giving the more efficient structure when it can be used.

Extramural work at the Aeronautics Department of the University of Sydney has included an experimental study of unstiffened curved dural panels under compressive loading. This represents the basic structural element in aircraft construction which has, however, failed to yield to theoretical analysis. The present study will give valuable information on the mode of deformation and buckling loads of such elements.

(*d*) *Shear Panels and Plate Webs.*—Many components of an aircraft structure particularly wing spars and fuselage side panels are subjected to heavy shearing forces which provide the critical design cases for these members. Although over the years a considerable effort has been put into the theory of stiffened panels under shearing forces there are still a number of important points on which theory does not agree with experience, the result being that shear resisting members, designed on theoretical considerations only, are frequently found to be stronger than is necessary. An investigation is in hand to try to obtain closer agreement between theory and experiment and thus to obtain a more economical structure.

(*e*) *Swept-back Wings.*—The drag of aircraft increases rapidly at speeds approaching the speed of sound, owing to the formation of shock waves near the forward surfaces and edges of the aeroplane. The generation of shock waves on the wings and the tail unit can be delayed by sweeping the surfaces backwards in the form of an arrowhead. This, however, introduces a new set of problems concerning the strength and stiffness of the structure—problems which have as yet hardly been explored. For example, with straight wings of normal form the critical speeds at which loss of lateral control occurs or at which flutter might arise are governed largely by the torsional stiffness of the wing, the flexural stiffness playing a relatively insignificant part. In the case of the swept-up wing flexural stiffness is of great importance since deformation in bending causes a change in the effective incidence of the wing. It has not yet been possible to assess the relative importance of these two factors and to lay down precise requirements for the stiffness of swept-back wings.

Also, because each half of the wing makes a large angle with the fuselage, the analysis of the stresses at the wing root is very complex. However, an approximate solution for the stresses in the root "triangle" of a wing in which the ribs are perpendicular to the axis of sweep back has been obtained in terms of a hypergeometric function, and the labour involved in applying the method to actual wings has been reduced considerably by the application of matrices for solving the simultaneous differential equations which arise.

Extramural work on this subject at the University of Sydney has involved the study of a swept tube containing a series of rigid ribs arranged parallel to the central axis of the aircraft, i.e. making a large angle with the axis of sweep. Methods of solution have been obtained for both constant and exponentially varying bending moments and torque.

(ii) *Life of Aircraft Structures.*—(*a*) *Flight Loads.*—The Flight and Ground Loads Panel referred to in the last report has held five meetings during the year and made a report to the Commonwealth Advisory Aeronautical Research Council at its meeting in April. Seventeen papers on various aspects of flight load investigations have been submitted to and discussed by the Panel, and a programme of research is being actively pursued.

To obtain statistical data on the air load fluctuations experienced by aircraft operating on scheduled routes in Australia, arrangements have been made through the Department of Civil Aviation and with the co-operation of the airline operators to have V-g recorders fitted to about twenty aircraft. The recorder slides will be analysed by the Division and it is hoped that valuable information will be gleaned on operating conditions in Australia for contribution to the British Commonwealth pool of data on loads experienced in flight. Analysis of the records obtained on a series of courier flights to Japan by a R.A.A.F. Dakota aircraft have indicated atmospheric conditions significantly different from those obtained on other trans-ocean routes.

Advantage was taken of a glider camp organized in the summer by the Victorian Gliding Club, to investigate the suitability of sailplanes for measuring the vertical velocity components of gusts. The experiments were quite successful and showed that a very wide range of disturbances with vertical velocities up to at least 35 feet per second can occur in clear air conditions.

(*b*) *Dynamics of Structures.*—The theoretical study of the response of an aircraft considered as a resilient body subjected to aerodynamic disturbances has been extended to the calculation of the bending moments at a number of points on the wing of a typical four-engined aircraft, and the effect of gusts of different forms has been determined.

(*c*) *Strength of Wings under Repeated Loading.*—In order to predict the probable safe operating life of a structure subjected to fluctuating loads, it is necessary to know how it responds to such loads. Because of the complexity of an aircraft structure the only feasible method of determining how a complete component will behave under a given system of cyclic loading, is by laboratory experiment under controlled conditions. The Division has pioneered repeated load experiments and has obtained valuable data on the behaviour of wooden and metal wings. The general conclusion drawn from the tests of wooden wings was that the ultimate static strength was not seriously affected by a large number of repetitions of very high load.

The results were quite different for metal wings. On repeated loading these wings failed after relatively few repetitions of the high load range. The general inference from the tests is that wings of this construction which have a large number of stress concentrations in the form of rivetted and bolted joints have a strictly limited life when subjected to the loads likely to be encountered in service. The work is to be continued on wings of a modern type of fighter aircraft.

3. Engineering Materials.

(i) *Fatigue of Metals.*—Further work has been done on the investigation of surface deformation of fatigue specimens arising from the machining and polishing operations. The discrepancies found between the results from surface analysers employing a stylus for exploring the surface and the more accurate method of taper sectioning have been explained and reported.

The study of the soft layer at the surface of carefully finished steel specimens, mentioned in the last annual report, has been extended to an aluminium alloy and to a 70:30 copper-zinc alloy. With the copper-zinc alloy the effects were similar to but of greater depth than those observed with steel, namely there was a cold worked region harder than the undeformed material, overlaid with a relatively shallow layer of softer material at the surface. The evidence suggested that the soft surface layer consists of fine re-crystallized material. The effects on the aluminium alloy were much less pronounced and a further study by a re-crystallization technique is contemplated.

The determination of the notch sensitivity of a high strength aluminium alloy is proceeding satisfactorily. This involves fatigue tests on rotating cantilever specimens incorporating a systematic series of notches ranging in stress concentration factor from $1\frac{1}{2}$ to greater than 5.

The explanation of the very high apparent strengths observed with fatigue specimens with a notch, which are anomalies not as yet exploited nor even recognized in ordinary engineering design, lies in the combined effects of several factors. The most important effects are due to the presence of the notch and the fact that the specimen is under bending load. These explanations throw quite a new light on the behaviour of metals with severe stress concentrations when repeatedly loaded above the elastic limit and provide important fundamental data for the design of components which are subjected to occasional heavy loads much higher than those they are normally required to sustain.

(ii) *Properties of Alloys.*—The profound influence of a finely dispersed second constituent on the properties of a solid solution alloy is by no means fully understood at present. In connexion with the study of these precipitation phenomena in alloys, laboratory samples of the very high-purity iron required as a base material for the strain-aging investigation have been prepared. Some difficulties have been encountered in eliminating phosphorus and manganese impurities, but these have been largely overcome.

An investigation into the effect of cold work on precipitation hardening in light alloys has also been initiated. A high-purity alloy of aluminium containing 4 per cent. copper has been prepared and is undergoing preliminary examination.

(iii) *High Temperature Alloys.*—(*a*) *Alloy Systems*—The two binary systems selected for study—with a view to the extreme temperature requirements of future gas turbines—were chromium-tungsten and chromium-beryllium. Since the electrolytic chromium obtainable commercially was of insufficient purity, a small plant was set up to give an improved product. Of the chromium-tungsten alloys, those about the equiatomic composition have been found to change completely in character on annealing for protracted periods at elevated temperatures. The single solid solution breaks down into two discrete phases, one rich in chromium and the other rich in tungsten. This finding is considered very valuable, as it gives an excellent opportunity for precipitation hardening. The general character of the chromium-rich side of the chromium-beryllium diagram has been determined. It consists of a eutectic between a high-chromium solid solution and the inter-metallic compound $CrBe_2$. This also gives a strong probability of useful precipitation effects.

The investigation of both these systems has called for refractory vessels of exceptional heat-resistance, in which to carry out melting and high-temperature heat treatment. To this end, much useful experience has been gained in the shaping of beryllium oxide, using slip-casting and pressing techniques. Certain modifications to the accepted procedures have resulted in improved refractory ware.

(*b*) *Grain-boundaries.*—Considerable attention has been devoted to the difficult matter of elucidating the nature of the grain boundary in metals; this is of particular importance in high-temperature alloys, which usually fail along the boundaries. Theoretically, there should be a small change in electrical resistivity at the boundary and efforts have been made to determine the magnitude of this variation. However, accurate measurements were made difficult by certain extraneous factors, notably parasitic thermal potentials in the measuring instrument. This work is proceeding with refined apparatus and test specimens.

Another attack on the grain boundary problem is being made in collaboration with the Division of Tribophysics, with the aid of the "photogrid" process. This is a photographic method of producing a network of fine lines on metallic surfaces, which becomes distorted when the test specimen is deformed as a whole. Findings to date indicate marked inhomogeneities in deformation within the crystals and also certain interesting effects in the neighbourhood of the boundaries.

A third approach has involved the thermal etching of silver, in which a differential evaporation effect occurs at the boundaries.

(iv) *Powder Metallurgy.*—The studies of the fundamentals of powder metallurgy have been directed towards the influence of particle size distribution and surface area of powders on the physical and mechanical properties of sintered compacts. An apparatus to produce spherical powders has been built and the separation into various size fractions performed by air elutriation. Experiments with electrolytic copper powder have shown that during the pressing operation, neither the rate of pressing nor the time of "dwell" are significant within considerable limits.

(v) *Corrosion.*—The investigations on corrosion in aircraft cooling systems and on corrosion in power station condenser tubes have both been completed. The prime cause of corrosion in these tubes was found to be differential aeration of the cooling water, the cathodic deposition of copper being a subsidiary effect. The nature of the so-called "impingement corrosion" was found to be basically different from that proposed by previous investigators. "Biological corrosion", formerly believed to be due to sludge deposits, does not exist as such. Sludges merely tend to accelerate corrosion by other causes, notably differential aeration.

Work on stress corrosion has commenced with experiments on the corrosion of aluminium in tap water while under stress. Aeration and de-aeration of the water caused marked changes in the potential values obtained. An investigation is in progress on the fundamentals of electrolytic polishing of metals.

4. Aerodynamics.

(i) *High-speed Flow.*—During the year the small team available has continued the work of completing the auxiliaries necessary for the proper operation of the variable pressure tunnel.

After completion of the fan drive system, cooling system, and the screens used for reducing the turbulence in the tunnel, tests were carried out to determine the maximum Mach number (the ratio of the wind speed in the working section to the speed of sound) which could be attained with the circular working section then fitted. Though the fan had been designed to enable the speed of sound to be reached at low tunnel pressures, on test it was found that the maximum Mach number which could be attained was 0.82, the total loss coefficient of the tunnel being 75 per cent. higher than was estimated. A lengthy series of experiments showed that there was no serious flow breakaway in any part of the tunnel, most of the increase in the loss coefficient occurring in the diffuser immediately following the working section. The underestimation of the losses must be attributed to the fact that little is known of the behaviour of boundary layers in adverse pressure gradients under compressible flow conditions. This was one of the investigations for which the tunnel was built. A new fan has been designed and ultimately the power of the tunnel must be increased to obtain the performance originally specified.

As will be reported subsequently, a considerable amount of research has been carried out during the year on a 31.5 per cent. thick GLAS II. suction airfoil. With very thick sections of this type compressibility effects are met at quite low speeds, the estimated critical Mach number for this particular section being 0.43, i.e. well within the capacity of the tunnel in its present form. To determine these effects a temporary rectangular working section has been installed in the tunnel. The side walls of the section are rigid and the adjustable top and bottom walls of thin plywood stiffened by closely spaced wooden ribs. Perspex windows in the side walls of the working section will enable Schlieren equipment to be used for observing and photographing the shock waves produced when the sonic velocity has been exceeded on the model surface.

A technique has been developed for the production of the hollow metal airfoil sections required, by casting in a dental plaster mould. The models produced by this method are so smooth that only a very small amount of cleaning up and polishing is required after casting.

In the field of supersonics the first item of equipment which it is intended to make, and of which the drawings are now complete, is a "shock tube" for experimental investigations on shock waves. A mathematical analysis had been made of the formation and behaviour of shock waves in a long uniform tube in which a piston accelerates from rest to the speed of sound. The shock tube will be used to verify the mathematical analysis and to determine the behaviour in the high Mach number region where the mathematical analysis breaks down.

As part of a policy to foster research in the Universities in fields related to those being actively pursued in these laboratories, the Division has borne some of the cost of providing a mathematical assistant to the Professor of Mathematics at Melbourne University. Under the latter's direction, a solution has been obtained of the problem of the flow of a compressible fluid past an elliptic cylinder based on the hodograph method. In addition to this work, a comprehensive thesis on compressible flow, involving a very extensive review of the literature, is now well under way.

(ii) *The Use of Suction to Increase Efficiency at Moderate Speeds.*—Work has been progressing on various aspects of flow around the thick suction aerofoil chosen for flight tests.

An 8-ft. chord model of the wing section was extensively tested in the wind tunnel, and a great deal of knowledge gained which will be of value in the design and operation of those aerofoils. During the tests it was found necessary to modify the theoretical shape of the wing in the region of the slots in order to make the flow stick to the surface with a reasonable power expended in suction. An extension of the aerofoil design theory to take account of the air sucked away was carried out by two students from Melbourne University and confirmed quantitatively the modification found by experiment.

During the course of the work it was established that the boundary layer could be controlled more efficiently by two or more slots than by one. A theoretical analysis based on simple assumptions was made at the University of Sydney to confirm this theory.

Since a considerable part of the loss in the suction system is encountered at the slots, care must be taken in the design of the entry, throat, and diffuser of the slots. This design is further complicated when two or more slots open to a common suction duct, in which case the flow through the different slots has to be matched. During the tests on the 8-ft. chord model a theory for the design of such slots was evolved and used for the arrangement finally adopted.

For the original single slot arrangement the suction quantity can be readily calculated by a simple theory. When more than one slot exists, as on the modified aerofoil, this theory no longer applies with any degree of accuracy and it becomes necessary to study in some detail the effect of suction slots on a turbulent boundary layer if economy in suction is to be achieved. A study of available literature showed the problem to be a fundamental one about which very little experimental data had been collected; hence the problem is being approached both experimentally and theoretically.

The success of the suction type aerofoil depends in a large measure on retaining the laminar flow if possible up to the first slot. This retention depends on a number of variables, one of which is surface waviness. The present limit on waviness is a very stringent one; however, it is known that with large favorable pressure gradients this limitation may be relaxed. It is to be expected therefore that the permissible waviness for the GLAS II. may be greater than that laid down as the result of experimental work on much smaller favorable gradients. To extend the work a series of experiments will be made on a glass plate on which waves of known severity are superimposed and along which the desired pressure gradients have been simulated.

Stability and control and general aerodynamic behaviour have been studied on a $\frac{1}{8}$ scale complete model of the glider fitted with a suction wing. Tests show that the glider characteristics should be satisfactory both with and without suction.

(iii) *Turbulence.*—Completion of the low turbulence tunnel has been delayed because of difficulties experienced in the production of blades for the axial flow fan. Initially the fan will be operated with three stages which are now being assembled.

In the interim, a restricted research programme has been carried out using the small model tunnel. The theory of diffusion by continuous movements of particles from a fixed source in a turbulent stream has been developed in terms of the correlation between the velocity of a particle at any instant and the velocity of the same particle after a certain interval of time. When the correlation coefficient is near unity the rate of diffusion is proportional merely to the intensity of turbulence, whilst for zero correlation the ordinary equation of molecular diffusion holds. For intermediate values the diffusion depends on the correlation coefficient. Basic to the theory is the assumption that the probability distribution of the turbulent velocities is Gaussian at all times. This assumption has been verified by means of experiments on the diffusion of heat from a line source in the turbulent field of square mesh grids. Graphical analysis of the results has also provided an indication of the form of the Lagrangian correlation coefficient.

On the theoretical side, the basic problem of isotropic turbulence is to explain or deduce the energy decay law. The decay process seems to involve two distinct mechanisms, firstly the transfer within the fluctuations, of low frequency energy to high, and secondly viscous dissipation of the high frequency energy. This matter of the progressive change in the spectrum function is being investigated at the moment.

(iv) *Development of Radio-controlled Flying Models.*—The development of radio-controlled flying models was undertaken by the Division in order to open new possibilities for aerodynamic and structural research; at the same time, such models should satisfy the need of the Division of Radiophysics for small robot aircraft to carry out meteorological research.

The project was initiated by the Division of Radiophysics with the construction of an 8-ft. span delta wing glider as a temporary measure. Soon after, the Division of Aeronautics started development of a 12-ft. span tailless model with better aerodynamic characteristics. When the former was nearing completion, a United States target model of 12-ft. span was acquired. This and the delta wing glider were launched by a catapult constructed for the purpose. Both models though under radio control crashed after short flights owing to inexperience in handling.

In order to overcome this deficiency it was decided to develop two simple aircraft types and perfect the launching and flying techniques before completing the construction of the 12-ft. span tailless aircraft. The more elementary type is the "Shark", a conventional 8-ft. span model, which was developed by the Division of Radiophysics in conjunction with the Sydney University Group. The other type is the "Stork", a conventional 10-ft. span model. Both types were successfully flown under radio control both as gliders and as powered aircraft. The type of power plant used was an American resonant jet engine. In these flights the models were launched from a runway by towing behind a truck to several hundred feet altitude before release. Altogether 24 flights were made, the duration of any one being limited by the fuel supply to fifteen minutes. The models were flown to over 1,000-ft. altitude within a radius of a mile. Control was not difficult in flight but landing required considerable skill.

The tests with the "Shark" model, and with the "Stork" in its present form, have been discontinued because the objectives were achieved; namely to acquire a safe launching and handling technique and to prove in flight the design method used for predicting stability and control characteristics. At present the "Stork" is being modified to a twin jet installation in order to develop ramp launching, to investigate control at higher speeds, and to allow tests with telemetering equipment. Work has recommenced on the 12-ft. span tailless aircraft.

5. Aircraft Propulsion.

The work is now principally on problems related to gas turbine engines, and only a small diminishing group is concerned with reciprocating engines. Some of the new items of equipment for turbine research are installed and working but the larger items of plant cannot be acquired rapidly; for instance, a large air compressor for combustion research and other purposes which has recently been ordered will not be delivered for two and a half years.

(i) *Combustion in Turbine Engines.*—An essential requirement of an aircraft gas turbine combustion chamber is a high rate of heat release per unit volume, together with high thermal efficiency and low pressure drop. It is known that turbulence in the air and air-fuel mixture is necessary if a high heat release is to be achieved, but there is no precise knowledge of the fundamental effects of turbulence on the combustion process or of the type and degree of turbulence which is desirable in the various zones of the combustion chamber.

A long-term investigation of this problem has been commenced. For the present the work is being done at low pressures, with the combustion chambers supplied with air by fans; it will be extended into the high-pressure region when a compressor becomes available.

Experiments are being performed to determine the effect on flame speed of adding to the fuel certain compounds of a type formed as intermediate products in the combustion process (e.g. aldehydes). It is known that the formation of such products, which is determined by the heating to which the air-fuel mixture is subjected before it reaches the flame front, has an important effect on flame speed and the subsequent course of the reaction, but the matter is imperfectly understood and no quantitative data are available. The experimental work is complicated by the fact that most of the intermediate products are unstable, and compounds of similar type which can be chemically prepared and kept for a time must be used as additives in their place.

As an adjunct to the combustion investigations, means of measuring temperature in flames of the order of 2000 °C. are being investigated. Two lines of attack are being followed. First, an attempt is being made to produce certain types of high temperature thermocouple which are also required for metallurgical work; a tungsten-molybdenum couple shows promise. Second, a two-colour radiation pyrometer with photoelectric cells as the measuring elements is being developed.

(ii) *Turbine Engine Performance and Thermodynamics.*—An officer who had been seconded to the National Gas Turbine Establishment, England, to gain experience of the theoretical analysis of the efficiency, control, and stability of the many thermodynamic cycles which may be used in gas turbine engines, has recently returned, and is in charge of a small group working on problems of this kind. Two projects have been commenced: first an examination of the effect of atmospheric temperature on engine performance—a matter of special importance in some parts of Australia, where high atmospheric temperature may reduce the power output of gas turbines; second, a comparison of the various means of arranging a turbine engine to provide suction for boundary layer control as well as propulsion.

The large engine test plant is being modified to take jet engines, but it has been decided that dynamometers to test propeller turbine engines will not be provided at present. That plant is, however, being arranged so that dynamometers can be installed later.

(iii) *Compressor and Turbine Blading.*—(*a*) *Aerodynamic Design.*—In designing compressor or turbine blading, the usual procedure is to select a blade shape and calculate the velocity distribution around it. Several attempts may have to be made before an acceptable velocity distribution is achieved.

An attempt is being made to put blade design on a more rational basis by applying a method which permits blades to be designed for a specified velocity distribution, a reversal of the usual procedure. The mathematical work is complicated and tedious, but three blade cascades have been designed for test in a low-speed cascade wind tunnel and are now being constructed. The cascade tunnel for this work has been built; it is driven by a 40 horse-power motor and has a maximum air speed of 120 f.p.s.

The mathematical design method referred to, results in a blade with an infinitely small included angle at the trailing edge. This is unpractical from a constructional point of view and the effect on the velocity

distribution of modifying the blade so that the trailing edge angle is finite is being examined, using the relaxation method.

(*b*) *Turbine Blade Vibration.*—A survey of methods of calculating the natural vibration frequencies of compressor and turbine blades has been completed, and a report critically examining the various methods has been issued. Work is now proceeding on an analysis of the effect of the air flow on the vibration of a cascade of blades; at certain air velocities an effect analogous to the "flutter" of aircraft wings is encountered.

(iv) *Piston Ring Lubrication.*—This investigation, reported last year, has been carried a stage further by the completion of a series of tests of the effect of lubricant composition and properties on the conductivity of the oil film between piston ring and cylinder. The experimental technique has been greatly improved, enabling the work to proceed faster and with more certainty.

Extremely interesting results have been obtained with various additives in the oil. Many additives, including those regarded as "oiliness" agents, showed no significant improvement in the trace, but additives of the "anti-wear" type gave a substantial improvement, and the further addition of an "oiliness" agent then gave still better results. An hypothesis has been evolved to explain these results, which are believed to have an important bearing on the problem of cylinder wear, and a report describing the work is now being prepared for publication. A further series of experiments to determine the effect of the shape of the piston rings on the oil film is being commenced.

(v) *Rotary Valve Engines.*—Work on the single cylinder experimental rotary valve engine has been delayed by mechanical failure, not associated with the valve, but these difficulties have been overcome, and it has been shown that, with a rotary valve, the optimum valve timing is substantially different from that which is appropriate for a poppet valve engine. The cylinder head and valve are now being modified to permit a more detailed study of valve timing especially at high speeds.

A two-cylinder rotary valve engine, intended as an auxiliary power plant for large aircraft, has been designed and built for the Royal Australian Air Force by the Aircraft Production Division of the Department of Supply and Shipping, with the advice and assistance of this Division. The prototype was completed recently, and is being run-in preparatory to type tests.

(vi) *Engines for Flying Models.*—A series of tests has been carried out on small engines of the resonant jet type which are used in the radio-controlled model aircraft mentioned earlier. The thrust and fuel consumption have been measured over a range of mixture strengths both statically and in an air stream up to 150 feet per second. When initial operational and installation difficulties had been overcome the engines proved successful for short flights when the high fuel consumption was not a limitation on their use.

A small two-cylinder vee two-stroke engine has been designed and built as a power plant for the 12-ft. span radio-controlled aircraft under construction. The engine weighs approximately 7 lb. and has developed 4 h.p. under test. To ensure stability of the aircraft, it has been found necessary to fit contra-rotating propellers and a gearbox for this purpose is being constructed.

A subsequent aircraft which is intended for high altitude operation will be larger and will require a more powerful supercharged engine, which has been designed. It is somewhat unorthodox with a single cylinder, opposed pistons, and a propeller on each crankshaft, and works on the two-stroke cycle, supercharged by a Roots blower. The design power is 24 h.p. at 18,000 feet, and it is hoped that the aircraft will reach 40,000 feet.

(vii) *Dust Investigations.*—The investigation of engine wear due to dust, and of means of excluding dust from engine intakes, which has been going on for several years, is now in its final stages. The work on the effect of filter geometry on the pressure drop through vee-type air cleaners has been completed, and a report has been issued. In order to determine the effects of dust concentration and particle size on engine wear, a series of experiments is being conducted with a single-cylinder aircraft engine to which dust of measured quantity and size is fed and the rate of cylinder and piston ring wear measured. These tests will provide information of value in the design of air cleaners, since they will show what quantities and sizes of dust may safely be allowed to pass.

(viii) *Other Investigations.*—The suction plant for the suction wing glider, mentioned in the last report, has been tested both on the ground and in flight in a Dakota aircraft. Following a change in the airflow requirements a second fan was designed, and it and the engine are now being installed in the glider.

No further tractor tests according to the Nebraska Code have been conducted during the year, but it is expected that several tractors, some locally-made and some imported from England, will be submitted for test shortly. A local firm which has availed itself of the tractor testing facilities has provided the Division with a heavy truck as a loading vehicle. This is being fitted with a drawbar dynamometer and means for power absorption.

6. Electronics and Instruments.

The development of the special instruments without which many of the foregoing investigations would have been difficult, if not impossible, to pursue continues to be an important activity. Some of these instruments have already been described; others are mentioned here.

Work has commenced on the development of automatic instrumental control for use in the radio-controlled flying models described earlier in this report. It is intended to develop a simple form of automatic pilot which is considerably smaller and lighter than any existing equipment. This is possible as the accuracy of direction can be reduced in this case to that sufficient to enable the course of the models to be plotted and corrected by radio methods. Effort has been concentrated so far on procuring or developing suitable components for use in the equipment; for example, integrating servo systems of various kinds.

The construction of a high-speed recording electrometer for the measurement of potentials in corrosion investigations has been completed, but work is continuing on an improvement in stability of instruments of this type. Another aspect of the metallurgical work calls for the rapid recording of the expansions of small samples of special alloys when they are heated to an elevated temperature, and methods of doing this have been investigated. The apparatus, a model of which has been assembled, incorporates many novel features and aims at an accuracy of the order of 10^{-5} cm.

There is often a demand in much of the work for a stable direct voltage amplifier. Often a thermionic valve with grid control cannot be used, because the input and output circuits cannot be at a potential chosen to suit the application and which is independent of the amplifier itself. This is a distinct limitation. An amplifier in which the input and output circuits are isolated by a photoelectric link has been constructed and exhaustively tested in the laboratory. A good deal of effort continues to be devoted to facilitating the use of electric resistance strain gauges in exploring strains in structures and machines under operating conditions.

Two additional types of strain-measuring equipment have been developed, employing the Wheatstone bridge type of circuit with active and temperature-compensating gauges in adjacent arms. The first, which is the simplest and the cheapest but which nevertheless has adequate accuracy and sensitivity for laboratory work, operates on a partly null and partly deflection principle; 24-channel instruments of this type are now available from a Melbourne manufacturer.

The other instrument utilizes the remarkable linearity and stability of the Tinsley D.C. amplifier to amplify the small out-of-balance voltage from the strain gauges and use it to deflect an accurate mirror scale current meter. Low strains of the order of one-millionth of an inch can be accurately read.

At the request of the Royal Australian Air Force a laboratory model of a generator to give constant frequency independent of wide speed variations was devised and thoroughly tested. This gave results which would be sufficiently encouraging to warrant the construction of prototypes for flight trials.

7. Applied Work.

A constant flow of inquiries for information and assistance is received. Much of this is diverted to other establishments, but in certain cases the experience of the Division is clearly applicable. The more interesting are described.

(i) *Speed Sprayer for Orchards.*—For adequate pest control in orchards, it is necessary to spray a whole orchard within a very short period. The orthodox method of spraying liquid from pressure-fed jets is slow and consumes considerable man-power and a better method is to blow at the tree a jet of air into which the liquid is sprayed. This speeds up the spraying enormously and brings the operation under the control of one man driving a tractor and towing a power sprayer. A full size prototype needing about 25 horsepower is being designed and will be built; various tests are now being carried out to provide the essential data for design.

(ii) *Prosthetic Frames for Infantile Paralysis.*—Prosthetic frames for the treatment of poliomyelitis have been developed, using aircraft structural materials and principles. The purpose of these frames is to relax the patient in the attitude of maximum rest during the period of treatment. The frames being developed are light and adjustable in ten dimensions to cover a wide range of patient size. This latter feature allows them to be constructed in quantity before an epidemic and stored. The present type of frame can only be "tailor-made" after the patient has contracted the disease, and the consequent delay may have a very serious permanent effect on the patient. Two sizes of frame, adult and child, have been designed and constructed and are being tested in hospital service.

(iii) *Frost Fans.*—The experiment made to find whether fans rotating horizontally in order to draw warm air down and spread it over the ground will be effective in preventing frost damage in orchards and vineyards have been continued. Tests with fans of 12, 20, and 30 feet diameter on towers up to 30 feet high were instituted at the Council's Irrigation Research Stations at Merbein and Griffith. The Division of Radiophysics is also co-operating in this work. The trials were made during the winter of 1946 and 1947 and will be continued in 1948.

Owing to the small number of frosts and the experimental difficulties the trials will have to extend over several seasons to be conclusive. The tentative conclusions are that each fan will give protection to an area of about 3 acres for a power expenditure of 5 horsepower per acre. Capital costs are not prohibitive and the fans can be brought into action automatically when the temperature falls to danger point.

XV. INDUSTRIAL CHEMISTRY.

1. General.

In an earlier report reference was made to the policy of decentralizing the activities of the Division of Industrial Chemistry. Further effect has been given to this policy by the establishment of a ceramics laboratory in Adelaide, in conjunction with the South Australian School of Mines, and the undertaking of chemical engineering investigations in collaboration with the Department of Chemical Engineering of the University of Sydney. The latter investigations will be considerably expanded in the near future when an officer of the Division, at present receiving specialized training overseas, returns to set up a laboratory for the investigation of high pressure processes in the same Department.

Shortage of accommodation remains a pressing problem, and temporary laboratories have been provided to permit development of the cement, ceramics, and refractories investigations. The erection of a permanent building to house the Organic Chemistry and Biochemistry Sections and provide additional laboratory space for the Physical Chemistry and Cement Sections, has been commenced. Much thought has been devoted to the design of this building so that the laboratory space may be readily adapted to the requirements of future changes in research programmes. The design developed is of general application and numerous requests for sets of detailed drawings have been received from those responsible for designing new laboratory buildings.

A number of novel processes developed in the Division have now reached the stage at which industrial application can be recommended. During the year, information released regarding a process for the production of chromium chemicals from chromite ore, and a method of enzyme digestion for the recovery of wool from sheepskin pieces, caused widespread interest and resulted in many requests for details of the plant operations. Firms interested in applying the processes industrially have been given technical assistance by officers of the Division.

Despite shortage of accommodation, efforts have been made to provide laboratory space for guest workers from outside research laboratories who have desired to take advantage of specialized equipment or facilities, or to collaborate with research groups in the Division in investigations having a bearing on their own research. Accommodation has been provided for eleven such guest workers in four different sections of the Division, the majority in the Chemical Physics Section. In addition, in numerous instances members of the staffs of industrial firms have visited the Chemical Engineering Section for periods of a few days to make use of units of pilot plant equipment.

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. Minerals Utilization Section.

The utilization of minerals for industrial or other purposes may be considered under two headings. Firstly, the purified mineral may be used as such by virtue of some intrinsic property of its composition or structure which fulfils an existing or potential requirement. Secondly, the mineral may be considered as a raw material which by chemical means may be converted into one or more entirely different products having new properties and uses.

Both forms of utilization offer scope for research work of the type undertaken in this Section, but attention has hitherto been confined chiefly to such aspects as involve transformation of the mineral into

other products. During the past year, both fundamental and applied research has been undertaken on a series of minerals of Australian origin with the dual object of improving methods of chemical treatment and of devising new uses for derived products.

Emphasis has been placed on the derivatives obtainable from components of the heavy mineral sands which are such a notable feature of the eastern Australian littorals. To this extent investigations of compounds of titanium, zirconium, rare earths, and related materials have been prominent. The industrial chemistry of other rare elements has also received attention. On the other hand, studies on chrome iron ores, manganese oxides, and graphite have been carried on concurrently.

In most instances the work described is a continuation of projects referred to in the previous report.

(i) *Chromite.*—Pilot plant tests of a new process initiated in this Section for the production of chromic anhydride from chrome iron ore by an acid digestion method have now been completed by the Chemical Engineering Section. Industrial interest in the potentialities of this process has been well maintained both in Australia and abroad. Recent laboratory work within the Section has been confined to certain fundamental aspects of the solubilities of the sulphates of iron, aluminium, and magnesium which accompany the chromium compounds both before and after the electrolytic oxidation of the solutions. This work has an important bearing on the efficiency of the selective crystallization of the chromic anhydride and also determines the extent to which cyclic operation of the process is possible.

(ii) *Monazite.*—Comprehensive investigations covering the chemistry of the many components of monazite have been continued with the object of compiling alternative quantitative flow sheets for the acid-processing of this mineral. In addition to the separation of the several rare earths present, attention has been directed towards improved recovery of thorium and the removal of phosphate from these several products. This work has involved a study of the fundamental chemistry of the various elements present. In another connexion a detailed examination of the properties of the double alkali fluorides of thorium has been made. The reaction between thorium metal, carbon, and thorium carbide has also been investigated.

(iii) *Rutile.*—Work on various derivatives of titanium tetrachloride, which is obtained by the anhydrous chlorination of rutile, has been continued. The results obtained from butyl titanite heat-resistant paint films, developed by this Section in conjunction with the Munitions Supply Laboratories, have continued to evoke industrial interest both here and overseas. Investigations on the formation and bonding of hard compacts of titanium nitride have been continued with encouraging results.

(iv) *Zircon.*—Fundamental studies on the reduced halides of zirconium have been continued. This work has a bearing on methods of separating the hafnium which accompanies the zirconium in the mineral zircon, which is a major component of beach sand concentrates from eastern Australia. Preparation of large amounts of crude zirconium tetrachloride by anhydrous chlorination of zircon has been a feature of the preliminary work. This material is a useful intermediate for the preparation of other zirconium derivatives.

(v) *Uranium Ores.*—Leaching of low grade phosphatic uranium ores and selective recovery of uranium concentrate has been continued. The work has been designed to assess the relative merits of various methods for the ores concerned. The processing of certain more complex uranium ores has also received attention, and in this case the recovery of associated elements, such as titanium, has been studied concurrently.

(vi) *Manganese Dioxide.*—A large number of natural and synthetic manganese oxides have been examined, both chemically and by X-ray diffraction methods, in co-operation with the Chemical Physics Section. The object of the work has been to obtain fundamental data on the structure of the various oxides and to correlate this with the performance of the materials as depolarizers in dry cells. The causes of certain types of premature corrosion of the zinc containers of dry cells have been traced to certain impurities in the manganese oxide; means for avoiding this trouble have been studied.

(vii) *Graphite.*—Various methods of chemical purification of Australian graphite concentrates have been developed, and samples of exceptional purity have been prepared. Problems associated with the grinding and colloidal dispersion of high-purity graphite have been examined. Fundamental studies were made on the properties of graphite derivatives such as graphite oxide and interlamellar compounds such as graphite-ferrichloride. The latter material may have important novel applications. The behaviour of various types of graphite in electrical dry cells has been examined in conjunction with that of artificial manganese dioxides.

Throughout the year industrial contacts were maintained and extended, and a large number of inquiries on miscellaneous problems of minerals utilization were answered.

3. Cement and Ceramics Section.

(i) *Cement Investigations.*—The investigation of the deterioration of concrete as the result of reactions between its cement and aggregate components has been continued. Factors which affect mortar expansion, such as the amount of reactive material in the aggregate and the amounts of alkalis and available water, have been investigated. The material produced by reaction between alkalis and reactive siliceous material has been studied, and its volume has been shown to depend largely on its water content. Additional evidence showing that reacting aggregate causes deterioration by producing fine cracks in the concrete has been obtained. As a result of further information gained from the behaviour of Australian aggregate materials, it has been possible to advise public bodies on the choice of aggregates for large concrete projects. Much attention has been given to the rapid determination of sodium and potassium in cement, and a flame photometric method and a rapid gravimetric method have yielded satisfactory results. A study of the mechanism of air-entrainment in cement and mortar pastes and the behaviour of Australian materials in this connexion has recently been commenced in collaboration with the Council's Building Research Section.

The cement investigations have been assisted by the co-operation and financial support of the Cement and Concrete Association of Australia.

(ii) *Refractories Investigations.*—The study of materials for cement kiln linings has been continued. This has included investigations of the chemical and physical factors which limit the life of the bricks at present in industrial use, and attempts have been made to develop special refractory compositions.

The investigations of bricks for coal gas retorts has been considerably extended. The examination of a number of commercial samples has, in some instances, given indications as to how a more satisfactory brick can be produced. The distribution and fluctuation of temperature in retorts is also receiving attention. The National Gas Association continues to contribute both active co-operation and financial support to the work on gas retort refractories.

(iii) *Ceramics Investigations.*—The preliminary survey of Australian ceramic materials is still proceeding, and considerable progress has been made in the survey of the clays of South Australia. Certain of

(vi) *Technique of Fluidization.*—Work has been undertaken on the development of both laboratory and pilot plant equipment for the application of the technique of fluidization to both catalytic and non-catalytic reactions. Primarily, this work has been directed to developing suitable experimental equipment and methods for the application of this modern technique to reactions between gases and solids and for the laboratory determination of reaction rates in flow systems.

(vii) *Production of Chromic Anhydride.*—Developmental work on the pilot plant production of chromic anhydride from chromite ore by an acid process has been completed and has resulted in a process capable of competing economically with conventional methods, with the additional advantage that lower grade ores may be processed. This work which has attracted considerable interest from various industrial companies is fully described in a paper now in the course of preparation.

(viii) *Fuel Research.*—Because many of the technological problems of fuel utilization are of a chemical engineering nature initial steps have been taken to develop a fuel research programme. An officer of this Section has commenced a survey of certain fuel research developments in England and the United States.

Pilot-scale work has also been commenced on the production of gas suitable for use in the Fischer-Tropsch synthetic liquid fuel process. At the present time results of work on the gasification of brown coal appear promising.

(ix) *Spray Drying.*—An experimental stainless steel spray-drying chamber with auxiliary equipment has been installed for the purpose of studying the application of spray drying in industry as an alternative to vacuum evaporation. Owing to the possibility of a good heat economy, spray drying appears to be an economic competitor for the concentration on a large scale of even the cheapest products, as well as being a desirable method for concentrating and drying solutions of heat sensitive materials.

XVI. RADIOPHYSICS.

1. Introduction.

The past year has seen continued progress along the general lines laid down in last year's report, namely, in radio researches of a fundamental character, on problems in the radio meteorological field, and in the practical application of radar techniques to civilian uses. The more important accomplishments of the past year have been—

(i) Advancement of our knowledge of the characteristics of radio-frequency emissions from the sun.

(ii) The discovery and location of seven discrete sources of cosmic noise, some of which appear to show features similar to those of solar noise.

(iii) The use of radio reflections from the moon as a means of studying the ionosphere.

(iv) Further development in radar navigational devices for use in civil aviation.

(v) Fundamental studies of the air traffic control problem.

(vi) The use of radar for the measurement of long baselines in geodetic survey.

2. Extra-terrestrial Noise.

Until a few years ago our knowledge of the universe was based almost entirely on visual observation of the sun and stars. It has long been known that these hot bodies would emit radiation in the radio spectrum, but attempts to observe it were unsuccessful because of the lack of sufficiently sensitive receiving equipment. Sensitive receivers are now available over the microwave spectrum and radio waves can be received from the sun, the moon, and the stars. The study of "radio noise", as it is called, has become an important method of conducting astrophysical investigations and is likely to lead to new knowledge of the physical conditions in and around stellar bodies.

(i) *Solar Noise.*—A large part of the Laboratory's research effort has been devoted to studies of noise from the sun. This has involved the collection and analysis of experimental data, the development of new techniques for the study of specific events in the sun, and theoretical investigations of processes occurring in the solar atmosphere. The different lines of work being undertaken are as follows:—

(*a*) *Thermal radiation.*—Measurement of the intensity of solar noise at different wavelengths provides a means of determining the temperature and electron density existing at different levels in the corona right down through the chromosphere to the surface of the sun. The radio measurements indicate that the temperature of the corona is a million degrees, decreasing progressively to the expected value of six thousand degrees at the surface of the visual disc.

(*b*) *Enhanced radiation.*—It was shown last year that, in addition to radiation of thermal origin from the sun, large irregular increases in intensity sometimes occur. These may last for periods of several days at a time. It has been called enhanced radiation and it is clear from the variations which occur that it cannot be of thermal origin. It originates in the immediate vicinity of sunspot groups and is circularly polarized. Although several theories have been advanced to account for this radiation, its origin is at present obscure. More recent results show that sunspots are not always accompanied by enhanced radiation, while there is evidence to suggest that "incipient" sunspots may sometimes be detected by radio means before there is any visual evidence of their existence.

(*c*) *Bursts and outbursts.*—If noise from the sun is observed continuously, short periods of activity lasting from 1 to 60 seconds and of intensity comparable with that from sunspot noise are sometimes noticed. These are referred to as "bursts". Very much larger ones are sometimes observed and these are referred to as "outbursts". They differ from bursts only in magnitude and duration. Their intensity may be greater by several hundredfold and they generally persist for several minutes at a time.

The origin of bursts and outbursts is also at present unknown. They have been found to be randomly polarized and they therefore differ in an important way from enhanced radiation. No correlation has yet been detected between bursts and other solar phenomena, though there is evidence that outbursts are associated with solar eruptions. A further observation has been that these disturbances are usually seen over a range of wavelengths, those on shorter wavelengths usually arriving first by a matter of some seconds. This time delay suggests that the initiating cause may be matter moving outwards in the sun's atmosphere.

(ii) *Cosmic Noise.*—A detailed investigation of the discrete source of cosmic radio frequency radiation in the constellation Cygnus has led to an accurate determination of its position and shown that it possesses characteristics similar to solar noise.

In addition, six other sources have been found in other parts of the sky. This result is particularly interesting since it throws doubt on the generally accepted theory of the origin of radiation from the galaxy. Until recently it was believed that it originated in interstellar matter. These new results show that at least some of the radiation has its origin in the stars. Improved equipment has been built in

an attempt to establish the precise celestial co-ordinates of these sources of stellar noise. It is obviously important to determine whether these coincide with the positions of any known stars; if they do not, it might be that a new type of star, termed a "radio star", has been discovered.

The technique employed in examining these galactic sources is to observe the interference between the direct radiation and that reflected from a smooth surface such as the sea. For the highest accuracy in establishing the positions of the sources, observations are needed at rising and setting from a site well above sea level. As these conditions are not available on the east coast of Australia, an expedition has been sent to New Zealand to make measurements at a specially selected site in the North Island.

Simultaneous observations are being made near Sydney and, as a result of this work, it is hoped to fix the co-ordinates of the various sources sufficiently well to say whether or not they have their origin in known stellar bodies and whether the observed variations in intensity arise within the earth's atmosphere or are characteristic of the source.

3. Radio Reflections from the Moon.

Radio reflections from the moon were first obtained by overseas workers early in 1946. Both in these experiments and in the study of radio "noise" received at the earth's surface from outer space, there is evidence that some of the variations occurring may have arisen in the outer region of the earth's atmosphere known as the ionosphere. Although for many years it has been possible to study the under-side of the ionosphere, little is known about its upper regions because radio waves which are capable of reaching there are not returned to the earth. For a study of the outermost regions of the earth's atmosphere, a signal is needed which comes through the ionosphere from outer space; echoes from the moon might be used for this purpose.

This possibility has been tested using special transmissions from the powerful short wave transmitter, Radio Australia (located at Shepparton, Victoria), in conjunction with receiving equipment built and installed at the Division's field station at Hornsby, New South Wales. The Postmaster-General's Department and the Department of Information co-operated in making the transmitter available at times when it was not being used for overseas broadcasts, and in providing a landline connexion between Hornsby and Shepparton for transmission of the signals which were used to "key" the transmitter.

It so happens that the moon passes twice each month through the aerial beam used for transmissions to Canada and the United States of America. Tests are only possible at these periods, and provided the transmitter is not required for other purposes at that time. The occasions on which both these conditions are satisfied simultaneously have necessarily been infrequent but radio echoes from the moon have been obtained on thirteen out of the fifteen tests so far made.

A preliminary analysis of the results shows that the experiments are likely to yield new results of scientific importance and the work is being continued.

4. Temperature of the Moon.

The average temperature of the moon has been known from measurements at optical wavelengths to be of the order of 350° K. at full moon, and to show a regular cyclic variation throughout the lunar cycle.

Sensitive receiving equipment on a wavelength of 1.25 centimetres which has been developed as part of the solar noise investigations has been found to be capable of measuring the temperature of the moon at this wavelength. Results have been obtained throughout three complete lunar cycles and show very interesting features. A much smaller temperature variation from full moon to new moon is indicated and this is interpreted as revealing that the radio waves are being received not from the surface of the moon but from a depth below the surface. This work is proceeding and is likely to lead to knowledge of the thermal and electrical characteristics of the surface material of which the moon is composed.

5. Radio Meteorology.

It was indicated in last year's report that success had been achieved in stimulating clouds to produce rain by artificial means. It was emphasized that progress in this subject was dependent on a thorough understanding of the physical processes involved, and work has been concentrated in this direction. It has included: (*a*) studies of the effect of seeding clouds with dry ice; (*b*) a study of clouds and cloud structure; (*c*) the development of instruments for measurement of the physical conditions in and around clouds.

The work is being undertaken at a site provided by the R.A.A.F. at Richmond, New South Wales. This change of venue and changes in the flying arrangements during the year restricted the amount of flying which was undertaken during the summer months, but the situation has been improved with the arrival of a detachment of the R.A.A.F. Aircraft Research and Development Unit at Richmond aerodrome and the allocation of a high flying Dakota aircraft for rainmaking flights. The following investigations are now being undertaken.

(i) *Experimental Seeding of Clouds.*—It is possible that quite a number of seeding agents would be effective in stimulating clouds to rain but attention is being concentrated on the most promising of these, namely, dry ice. It is found that the probability of successfully producing rain with dry ice depends on whether the cloud temperature is above or below a critical value when the dry ice is dropped. Alternatively, it is possible that the height of the cloud above freezing level is the main determining factor. Information is being collected to substantiate this point.

An investigation is being made of the time which elapses between the dropping of dry ice and the first appearance of rain from the base of the cloud. On the few occasions it has been possible to observe this satisfactorily, the time has been of the order of twenty minutes. This is in close agreement with a calculation made by Bergeron in 1933 of the time taken for an ice nucleus to grow to raindrop size.

(ii) *Cloud Physics.*—A complete understanding of artificial rain formation will require much more detailed knowledge than exists at present on the physical conditions in and around natural clouds. A study of cloud physics is therefore being made in parallel with the rainmaking programme. The three methods of investigation being used are: (*a*) visual and photographic observations of clouds from the ground; (*b*) horizontal traverses through clouds by means of specially equipped aircraft; (*c*) radar observations of the constituent drops and particles. Owing to difficulties of observation, it may be a considerable time before this work produces tangible results.

6. Mathematical Physics.

As in previous years this Section has been concerned with theoretical work arising out of or incidental to other phases of the Division's research programme. Now that the pattern to this work has become clearly defined, consideration has been given to the use of mechanical aids to computation and as a result it has

(iv) *Heterogeneous Catalysis.*—The earlier kinetic studies of the catalytic dehydration of 2,3-butandiol over thoria to butadiene have now been followed by a more detailed study of certain steps in the reaction. Measurements have been made of the adsorption equilibria on thorium dioxide of the butandiol, butadiene, and the other reaction products—water, methyl vinyl carbinol, and methyl ethyl ketone. As a result useful information has been obtained of the nature of the substances which poison the catalyst and concerning conditions favorable for the overall reaction. Additional helpful information to this end has resulted from measurements of the surface area of the catalyst, from X-ray examination and from conductance measurements on thorium oxalate during its thermal decomposition.

Latterly, emphasis has been withdrawn from this particular reaction and attention given to less specific but more fundamental work on the nature of catalysis, especially to the development of new physical methods for the examination of individual steps in adsorption processes. Equipment for the measurement of rapid adsorption rates is being used to study the kinetics of adsorption at elevated temperatures.

(v) *Plastic Investigations.*—(*a*) *Adhesives of Tannin-Formaldehyde.*—The reactions between formaldehyde and a number of tannin extracts from native Australian trees have been studied, and it has been shown that certain of these tannins, phenolic in nature, may be used to prepare highly satisfactory adhesives. Some of the tannins in this class have not yet been exploited and they could become useful by-products of the timber industry. These adhesives, which are very reactive and set at moderate temperatures, can be used for the production of plywoods which pass the A x 100 grade for water resistance (B.S.S. 1203-1945). A relatively small amount of formaldehyde is needed to produce these adhesives, and preliminary reaction between tannin and formaldehyde is not necessary.

Tannin extracts from the barks of *Acacia mollissima, Callitris calcarata, Callitris glauca,* and *Eucalyptus crebra,* and also from the wood of *Eucalyptus consideniana* and *Eucalyptus redunca* var. *elata* have been examined. Resins obtained with tannins from the last two eucalypt species were not sufficiently reactive to be satisfactory adhesives. All other extracts gave adhesives which produced water-resistant and high-strength bonds when pressed at 90° C. under 200 lb. pressure for ten minutes. Resins from *C. calcarata* and *A. mollissima* gave moderately strong and water-resistant bonds at 25° C. Unfortunately, these cold-setting adhesives, unlike those which must be pressed hot, remain liquid only for a short time after mixing and are therefore not easy to handle.

(*b*) *Kinetics of the Phenol-Formaldehyde Reaction.*—Some earlier studies of the chemistry of resins used to manufacture improved woods showed the need for an investigation of the kinetics of the reaction between phenol and formaldehyde. This reaction, though fundamental to the phenolic resin industry, still awaits a thorough study, no doubt largely because of its complexity, and work of this kind has recently been commenced.

(vi) *Micro-analysis.*—Facilities for elementary micro-analysis are essential for research work in organic chemistry and especially in dealing with natural products, and steady progress has been made in building up these facilities within the section. An apparatus for the micro-determination of carbon and hydrogen has been made automatic, and an automatic Unterzaucher apparatus for the direct micro-estimation of oxygen has been constructed.

Research investigations in this field are justifiable as a stimulus to active interest in micro-analysis; but they have also proved necessary in order to have satisfactory methods of analysis. During the year the micro-determination of acetyl groups has been critically examined and modifications made. At present the determination of methylimide groups is under examination and modifications have been made to the apparatus used, for this determination and for methoxyl groups.

8. Biochemistry Section.

Research of direct practical interest to the fellmongering industry has been continued during the year, and liaison with the industry has been maintained through visits to fellmongeries and by the six-monthly distribution of circulars. It has become increasingly evident, however, that, although further improvements could be made in some fellmongeries by the application of existing scientific knowledge and specific recommendations from this Section, significant advances in the industry are unlikely without more basic knowledge of wool and skin and the action of various chemical and biological agents on them. Such knowledge would be of considerable importance to research workers concerned with other aspects of the sheep and wool industry and would, in fact, be a valuable contribution to the Council's wool research programme. In view of its general importance, more effort will henceforth be devoted to fundamental research on wool in the Biochemistry Section, with particular reference to its mode of formation, the chemical structure of its constituents, their relationship to other proteins, and the action of enzymes on wool keratin and on the prekeratinous material in the wool root.

(i) *Fellmongering Investigations.*—(*a*) *Recovery of Wool from Whole Skins.*—The beneficial effect of cooling the soak water from 23° C. to approximately 10° C. on the quality of the pickled pelts obtained by the painting process was shown in a large-scale fellmongery experiment. Another illustration of the important influence of temperature was the demonstration of severe tendering of pickled pelts observed during storage for five days between 50° and 57° C.

(*b*) *Recovery of wool from skin pieces.*—Modifications in the design of the incubator cabinet used for the production of mould on bran and improvements in the mode of handling, which were effected jointly by officers of the Biochemistry and Chemical Engineering Sections, have made it possible to produce mould bran of consistently high proteolytic activity for use in the recovery of wool from skin pieces by the enzyme digestion process. Experience gained with this method has been made available to the industry, and mould bran of requisite activity is now in commercial production. Changes have also been adopted in the digestion process on a pilot plant scale, leading to more rapid digestion and improved colour of the wool recovered from skin pieces. Arrangements are being made with some fellmongers for the process to be tested on an industrial scale.

(ii) *Biochemical Studies on Wool and Wool Roots.*—A new method of preparing wool roots in quantity has been devised to permit the study of the constituents of roots and comparative studies of the root above and below the zone of keratinization in the follicle. This should lead to an understanding of the mechanism of protein synthesis in the wool follicle and the more efficient use of depilatories. The roots are collected by shearing the wool close to the skin surface, applying a mixture of beeswax and rosin to the epidermal side and, when set, peeling it away from the skin and clipping off the exposed roots which project from the wax surface. Already, by appropriate examination of this material, it has been possible to demonstrate the presence of several amino acids, carboxylic acids, soluble protein, and several enzyme systems. Some of these constituents are also extractable from wool, and the separation of some of them has been facilitated by preliminary disintegration of the roots in an ultrazonic apparatus.

(iii) *Mould Enzyme Investigations.*—A liquid protein-free culture medium has been developed on which the strain of *Aspergillus oryzae,* used for the production of the skin-digesting enzyme on bran, grows vigorously and yields appreciable quantities of enzyme. The filtrate from these cultures is rich in the skin-digesting and wool-loosening enzymes and therefore serves as an excellent source of enzymes for purification and characterization studies. A circulating vacuum evaporator has been constructed for the low temperature concentration of the filtrate, and some progress has been made in the fractionation of the proteolytic and other enzymes in this concentrate.

(iv) *Enzyme Systems in Some Fermentation Bacteria.*—Further evidence has been obtained for the composite nature of the "hydrogenlyase" of *Aerobacillus polymyxa* and *Escherichia coli.* Although this is generally regarded as an adaptive enzyme, an alternative explanation of the experimental data obtained with hydrogenlyase has been evolved.

(v) *Preparation of Enzyme Substrates.*—In order to know precisely which linkages in protein molecules are split by purified enzymes, it has become necessary to synthesize a variety of peptides from amino-acids for use as enzyme substrates. When the structural requirements for enzyme activity have been established, the enzymes will be used to hydrolyze protein derivatives, such as those from wool, thereby providing valuable information about the structure of the protein molecule.

(vi) *Collection of Micro-organisms.*—The Section's collection of bacteria, yeasts, and moulds has been enlarged to include additional micro-organisms of industrial importance and other species used in the estimation of amino-acids. In some instances these estimations involve the production of lactic acid and in others the use of bacteria as a source of decarboxylases for specific amino-acids. One officer of the Section has acted as secretary of a Committee which is planning the establishment of an Australian National Collection of Cultures of Micro-organisms. Through the Australian Chemical Institute, a preliminary survey has been made of cultures already available in this country.

9. Chemical Engineering Section.

During the year the process development work remaining from the war period was completed and the general research programme of the Section re-organized to fulfil the two principal functions of the Section, namely, to undertake research directed to the development of fundamental chemical engineering knowledge and to undertake the pilot-scale development of new chemical processes originated in other Sections of the Division. Considerable care has been taken in developing a group of fundamental research projects, each of which alone may yield an important contribution to chemical engineering knowledge and which as a group has the long-term aim of relating the physical properties of pure components and of their mixtures to process behaviour and molecular structure. This type of work is essential for the further development of methods of chemical engineering design and for the development of new methods of processing.

In the applied field work has continued on the installation and instrumentation of a wide variety of pilot-scale processing equipment. Equipment now installed has been extensively used during the year for pilot plant studies both by officers of the Division and by technologists from private industry. The staff of the Section has continued to provide advisory services to chemical industry and to other Sections of the Division, and to design and construct research equipment, and provide facilities as required by the Division.

(i) *Distillation Research.* — An investigation designed to determine the equilibrium conditions for the liquid and vapour phases of selected binary mixtures has been commenced in an attempt to assign a physical significance to the constants of existing empirical equations used to express the deviations from Raoult's law and upon which present methods of design of industrial fractional distillation equipment are based. The ultimate aim of this project is to obtain sufficient information to permit the prediction of liquid vapour equilibria for binary and ternary mixtures from a knowledge of the molecular structure of the pure components. At the present time, equipment is available for the preparation of pure compounds and for the precise determination of liquid and vapour equilibrium concentrations for binary mixtures over a wide range of temperatures and pressures.

A mathematical investigation of the most general expression for interpreting liquid-vapour equilibria data has also been undertaken.

(ii) *Solvent Extraction Research.*—Work has commenced on the development of methods of design of industrial continuous solvent extraction equipment based on the physical properties and molecular structure of the solute and solvents. Initially this study is being directed to the determination of rates of solute diffusion across a liquid interface using a specially developed interferometric method. Recently the officer engaged on this project was transferred to the University of Sydney where he will continue this work under the direction of Professor T. G. Hunter.

(iii) *Determination of the Physical Properties of Gases and Liquids at High Pressures.*—During the year initial steps were taken to establish a laboratory for the determination of the physical properties and behaviour of pure compounds and of binary and ternary mixtures at pressures up to 10,000 lb./sq. in. This work will be a necessary supplement to the experimental work in both the distillation and solvent extraction investigations. The high-pressure laboratory will be established in the Chemical Engineering Department, University of Sydney, and although primarily devoted to fundamental studies of physical properties its equipment will be available for the study of chemical reactions at elevated pressures. At the present time one of the Section's officers is studying recent research developments in this field overseas.

(iv) *Development of Adsorption Processes.*—Work is in progress on the development of a new method of separation based on selective adsorption. Adsorption equilibria and adsorption rates are being studied with a view to developing a continuous industrial process for the separation of physically similar materials hitherto not readily separated by current industrial methods. It is expected that the new technique will have particular application in the purification of antibiotics and other biological materials.

(v) *The Study of Fine Particles.*—The behaviour of fine solid particles suspended in gas or liquid media is being investigated with a view to correlating such diverse industrial operations as dust and fume removal, sedimentation, filtration, thickening, and pneumatic conveying. This work has involved the development of methods of preparation, classification, and measurement of uniformly sized and shaped spherical particles in the size range from 0.5 to 25.0 microns. Studies are being made of the dynamics of flow of gases and liquids through porous beds produced from these accurately sized and shaped spheres and of the fluid dynamics of systems composed of both dilute and dense suspensions of these spheres. This latter phase of the work has direct application in developing the new industrial technique of solid fluidization.

these clays have been characterized mineralogically, and data of immediate ceramic interest have been obtained. The Geology School of the University of Melbourne is co-operating in the mineralogical work while the South Australian Department of Mines has assisted in the survey of South Australian ceramic materials. A laboratory has been established in Adelaide in conjunction with the South Australian School of Mines and Industries and an experienced officer is now available to assist in the solution of the problems of local manufacturers. Additions to the staff in Melbourne have rendered possible the initiation of physical and chemical studies of problems which are of fundamental ceramic interest, and are likely to have a direct bearing on the Australian industry.

4. Foundry Sands Investigations.

The Section is concerned chiefly with the investigation of sands, clay and core-binding materials used by the foundry industry. Surveys of moulding sands in the several States of Australia are being conducted in collaboration with the respective Mines Departments. The surveys in New South Wales and Western Australia have been completed and reports are in press. The testing of Queensland moulding sands has reached an advanced stage. In Victoria work has been continued on alternative sources of supply of grades of sands in danger of depletion. Firms establishing foundries in country districts have been assisted in selecting moulding sands from local sources.

The acute shortage of linseed oil, which is extensively used as a core-binder, has led to an investigation of a number of possible substitutes of Australian origin. Materials now being investigated include waste-liquor from paper manufacture, safflower oil, yacca gum, and candlenut oil.

Close contact has been maintained with the foundry industry to which an advisory service on moulding sand problems is available. A number of tests has been undertaken to characterize sands and clays required for specific purposes, and information has been supplied in response to a large number of inquiries concerning the choice of moulding sands, the dielectric baking of cores, a new process for coating moulding sands, the effect of red sand additions on synthetic resin binders, Australian alternatives for American sand mixture, and other matters.

5. Physical Chemistry Section.

Work has been continued on a number of aspects of surface chemistry with particular reference to the principles underlying the flotation process for minerals separation and the use of detergents in wool scouring.

(i) *Flotation Investigations.*—The mechanism whereby mineral particles become attached to air bubbles in the flotation cell has been studied and a paper has been published which supports the hypothesis of direct collision between the bubble and mineral particle. A factor of fundamental importance in froth formation is the rate at which the surface tension at a new interface is reduced by the adsorption of surface-active compounds present in the solution. This is being investigated by the vibrating jet method.

A fundamental study of the use of long-chain carbon compounds as collectors in the differential flotation process has been undertaken. This subject is of wide general importance in mineral beneficiation. The experimental programme has been concerned primarily with the flotation of the tungsten mineral scheelite, which is a particularly suitable mineral for use in the general investigation. At the same time, beneficiation of scheelite ore is of national importance in view of the extensive deposit of ore of this type on King Island.

A satisfactory method has been developed for separating scheelite by flotation from all other minerals in the King Island deposit with the exception of calcite. Work on the separation of calcite from the scheelite concentrate is continuing.

(ii) *Detergency.*—Work has been continued both on the fundamental aspects of detergency and the development of an improved method for the scouring of wool. By the use of a small amount of solvent which is added to the scouring bath in the form of an emulsion, the wool grease may be effectively removed without heating the scouring solutions. A difficulty which presented itself in this work was the formation of a troublesome scum, but it has been found that this can be avoided by incorporating a small amount of soap fatty acid in the solvent.

(iii) *Surface Area of Solids.*—A knowledge of the surface area of finely divided solids is important in a wide variety of reactions. The method employed depends upon the direct relationship between the surface area of the powder and the amount of nitrogen which it can absorb at the temperature of liquid air. Many determinations have been made in connexion with the flotation of mineral particles and problems being studied in other Sections. Materials submitted by other Sections included cements which had been used as standard samples for determination of surface areas by the permeability technique, and samples of bentonite from which it is hoped to determine a relationship between the surface areas of clays and their properties for use in the ceramic industry.

6. Chemical Physics Section.

During the year, some of the modern physical techniques which have been established in this Section have been made available to research workers from other institutions; consequently, this report covers a variety of scientific work not normally within the scope of this Section's activities.

(i) *Protein Structure Studies.*—Fibrous wool keratin, together with other fibrous animal proteins, obtained from nerve, muscle and tendon, have been intensively investigated by electron microscopical methods. Preliminary X-ray crystallographic studies have also been made, and it is proposed to extend this work with the aid of a high power X-ray generator at present under construction. Information has been obtained concerning the organization of the fibrous structures on the macromolecular level, which confirms the contention that the protofibrils of such proteins are linear aggregates of corpuscular protein molecules. A new technique, which provides data on the distribution of inorganic matter in these systems, has been developed; it is of particular value in establishing the localization of calcium and potassium in the myofibrils of striated muscle.

(ii) *Luminescent Materials.*—Further research on the mechanism of the luminescent process has involved theoretical study of various models and spectroscopic, X-ray, and electron diffraction studies on exceedingly pure vacuum-sublimed zinc sulphide. In the course of this work, a novel method for establishing the temperature of the $\alpha \rightarrow \beta$ transformation of zinc sulphide has been devised and used.

(iii) *Structural Problems in Organic Molecules.*—Infra-red spectroscopic methods have been applied to problems associated with the molecular structure of compounds important in agriculture and secondary industry. Among the compounds studied are hypericin, the pigment of St. John's wort; oximino-propionic acid and derivatives; the sydnones; and a series of amide waxes.

(iv) *Interferometric Methods applied to Physical Measurement.*—Multiple-beam interference methods have been applied to many problems involving the accurate measurement of displacements smaller than

the wavelength of light. Precise calibration of the magnification of the electron microscope, essential in studies of periodic structure in fibrous proteins and in establishing the dimensions of protein molecules and virus particles, has been rendered possible by the use of such a technique. The method has also been applied to the design of sensitive infra-red detectors and high-vacuum gauges.

(v) *Electron Microscopy of Animal Viruses.*—The viruses of chicken pox and herpes zoster have been studied in collaboration with the Commonwealth Serum Laboratories, and the haemagglutination of influenza virus in collaboration with the Walter and Eliza Hall Research Institute. The first two viruses have been shown to be identical and their dimensions have been established.

(vi) *Use of the Mass Spectrometer in Structural Analysis.*—Certain problems of molecular structure of industrially important compounds may be solved by the use of mass spectrometry. The potentialities of this method are being investigated thoroughly by a fundamental study of appearance potential curves of ion fragments—in particular, those which result from abnormal molecular rearrangement.

(vii) *Mechanism of Arc and Spark Discharges.*—Spectrographic analysis has now become of major importance in process control in many industries; yet little is known of the mechanism of excitation of the spectra. Further development of this powerful tool requires a basic knowledge of the processes by which these spectra are produced in the arc and spark discharges in air. Experimental data are being collected, and theoretical studies are being made in an effort to understand this mechanism.

(viii) *Studies on the Surfaces of Solids.*—The flotation of minerals depends for its successful operation on the nature of the mineral surfaces. Electron microscopical and diffraction investigations of natural and modified mineral surfaces are being made in an effort to establish their nature and properties.

(ix) *Miscellaneous Investigations.*—Numerous minor investigations, carried out at the request of industry and technical institutions include—

(*a*) *Electron Microscopy.*—Study of the cockroach cuticle in relation to the mode of entry of insecticides; studies on ground-wood paper pulps; particle size distribution and crystalline habits of numerous pigments; characterization of clay minerals and soil colloids; and various metallographic problems.

(*b*) *Spectroscopy.*—Spectrochemical analyses of numerous materials by both ultra-violet and infra-red techniques.

(*c*) *X-ray Spectroscopy and Diffraction.*—Phase identification in a series of high temperature alloys; analysis of numerous mineral samples; development and use of X-ray spectroscopic methods for the analysis of rare earth and zirconium-hafnium mixtures.

(*d*) *Mass Spectroscopy.*—Analyses relative to estimation of fractionating column efficiency; analysis of products of respiration of apples, a problem associated with fruit storage.

(x) *Instrumentation.*—A large variety of glass, mechanical, and electrical equipment and instruments has been designed and constructed for the use of this and other Sections of the Division.

7. Organic Chemistry Section.

The programmes of work described in the previous report have been continued and extended.

(i) *Waxes.*—(*a*) *Wool Wax.*—It is highly probable that wool wax varies widely with the type of fleece and the method of extraction. It is important for exact work that a relatively large uniform sample of known origin and treatment be available; such a sample has been prepared by the solvent extraction of a bale of Merino wool using the mildest possible treatment to refine it. Methods of analysis are now being worked out using a commercial sample of wax.

When saponified, wool wax yields a non-acidic portion composed chiefly of higher alcohols. Commercial methods for resolving this mixture of alcohols have been designed mainly to yield cholesterol. These commercial methods as well as others reported in the literature have now been examined in a preliminary way and appear to be far from quantitative and much in need of improvement. Cholesterol is of considerable value, whereas the remaining alcohols, consisting chiefly of triterpenes and amounting to over 60 per cent. of the whole, have been regarded as relatively unwanted by-products. Since relatively little is known concerning the structure of these compounds, an officer who returned during the year from abroad, after gaining experience in the chemistry of triterpenes, has commenced a detailed examination of those present in wool wax.

(*b*) *Sugar-cane Wax.*—Sugar-cane wax, when obtained by the solvent extraction of filter muds, contains varying amounts of undesirable ash-yielding substances (soaps, phosphatidates) and colouring matters. Work in progress on this wax is aimed to discover suitable means of removing these unwanted components. Little is known of the colouring matters present, and although a systematic study of chemical bleaching agents may reveal a suitable method for their removal, it may be necessary to examine the nature of the colouring matter before a suitable decolourization process can be found.

(ii) *The Reaction between Acetone and Ammonia.*—The modification of this reaction to give quickly a 90 per cent. yield of a pentamethyl-pyrimidine and its conversion to a hexane diamine was described in the previous report and has since been published. In methods used to make the diamine, the reagents employed were suited essentially to laboratory conditions and fine chemical manufacture. Attempts have therefore been made to produce the diamine by methods suited to large scale manufacture. The results have been disappointing, other reaction courses being followed, but it is planned to examine the products so obtained in greater detail. Other products obtained from the pentamethyl-pyrimidine are being studied, for this compound is an attractive intermediate.

(iii) *Australian Alkaloids.*—Work on alkaloids from native Australian plants has continued along two main lines; firstly, the preliminary examination of numbers of likely plants, and secondly, the detailed structural investigation of certain of the alkaloids isolated in the preliminary examination. Since the second is much the slower phase, structural investigations of some of these alkaloids are being conducted in collaboration with the chemistry departments of the Universities of Melbourne and Sydney.

The many alkaloids of known structure include derivatives of most of the simpler heterocyclic nitrogen systems. A notable feature has been the non-occurrence of alkaloids based on acridine, but this gap has now been filled, since alkaloids from the Queensland rain-forest tree *Melicope fareana* prove to be N-methylacridones. These alkaloids are of interest since, in addition to being members of a new group, their degradation has involved some novel reactions which may encourage further work in the somewhat neglected field of pyridone and quinolone chemistry. A full investigation of alkaloids from *Medicosma cunninghamii* and other rutaceous species has been commenced.

A report has been made to the Department of Supply and Shipping upon the extraction of morphine from Australian-grown opium poppies.

been decided to install punched-card equipment of the Hollerith type. Practical and theoretical work on the design and development of modern high-speed electronic computing devices has also been initiated.

During the year the following projects have received attention:

(i) *Superrefraction.*—A theoretical discussion of the anomalous propagation in the neighbourhood of a focus has been completed. Preparations have also been made for carrying out a practical survey of field strengths under coastal front conditions to check some of the findings of this work.

(ii) *Traffic Studies.*—A theoretical study of some of the problems involved in the control of traffic at an airport has been completed. This has led to a better understanding of the basic factors involved and given a clear lead on the direction along which further study might be made.

(iii) *Artificial Precipitation.*—Numerical studies have been made of the factors governing the close approach and coalescence of raindrops.

(iv) *Propagation.*—Pending the completion of a differential analyser under construction in the Division of Electrotechnology, preparatory work has been done on problems involving non-uniform propagation.

Hollerith Equipment.—The adoption of punched-card techniques for scientific computation possesses possibilities which have been little studied even in Great Britain or America. Through the courtesy of the Commonwealth Statistician facilities have been made available for testing punched-card methods on several problems and as a result of this a range of equipment has been ordered from the British Tabulating Machine Company. It is expected that this will be ready for use early in 1949.

In anticipation of this equipment becoming available next year, exploratory work on tables of functions is proceeding and other work is in hand in furtherance of longer range problems for the use of the equipment when it arrives.

7. Electronic Computation.

High-speed electronic and relay type computers are playing an increasingly important part in modern methods of computation. The activities of the mathematical group have, therefore, been extended to embrace this field and the following work is in hand.

(i) *Relay-multiplier.*—This multiplier is intended to compute the 16 decimal product of two 8 decimal numbers with a round-off adjustable on the lowest 12 figures of the product. It is intended for attachment to and incorporation in the general scheme of punched-card equipment.

The theoretical design, the sequence of operations, and the organization of the circuits involved have all been fixed and tests of some of the circuits have been completed. It is planned that this equipment should be completed by the time the Hollerith machine becomes available.

(ii) *High-Speed Computers.*—Progress has been made on both practical and theoretical aspects of the design of high-speed computers. A survey of various aspects of the design of such devices has been made and arising out of this the main design principles for such a computer have been fixed and a specification has been prepared for a preliminary model electronic computer.

The first objective is to construct a simple computer capable of all the essential functions needed in automatic computation. It will operate on the binary scale and receive its instructions, i.e. the problem will be fed in, via punched cards. The output will be recorded on cine film and converted separately to cards in decimal form. Each operation of reading, interpreting, and acting upon an instruction will occupy two milliseconds.

Practical work has included the design and construction of several acoustic delay lines which form the basis of the computer's "memory". The basic pulsing equipment has also been constructed, and gate and counter systems are being studied. A large amount of developmental work is involved in this programme and it is not expected that the preliminary model will be in full scale operation before the end of 1949.

8. Vacuum Physics.

Pending the return from overseas of officers who are at present studying abroad the Division's experimental work in the field of vacuum physics has been confined to finishing several projects which have already reached an advanced stage of completion.

The Valve Laboratory has been fully staffed with technical personnel throughout the year and its facilities placed at the disposal of other Divisions of the Council and the Electrical Engineering and Physics Department of Sydney University. A number of researches and investigations in which these departments are particularly interested have been carried out.

Million Volt X-ray Machine.—Development of a piece of equipment which is capable of producing a million volt X-ray beam has been completed. This makes use of a single cavity excited at a frequency of 1200 Mc/s. and provides a compact source of high voltage X-rays. These have a particularly useful application in industrial radiography. The machine has been transferred to the Munitions Supply Laboratory, Department of Supply and Shipping, and assistance has been given in installing it at Maribyrnong, Melbourne.

9. Measurements and Standards.

Since the end of the war this Division has co-operated with the Division of Electrotechnology in the development of techniques and instruments for standard measurements in the new ultra-high frequency region which was so successfully exploited during the war years. A programme of development of noise generators as an absolute source of power at microwave frequencies and on the techniques for measuring power, impedance, and frequency at these wavelengths has now been substantially completed. The Standards and Measurements Section which has been mainly concerned with this work has accordingly now been transferred permanently to the Division of Electrotechnology.

The test room, which is responsible for the maintenance and calibration of the considerable amount of electronic test equipment in constant use in this Division, has been active throughout the year. This section is also responsible for the development of new pieces of test equipment required from time to time within the Division. During the year the following projects have been carried out:—

(*a*) Development of a power measuring thermistor bridge for the accurate measurement of radio frequency power at low levels. Two of these bridges are under construction. (*b*) Extension of the range of the crystal controlled frequency measuring equipment down to a frequency of 50 cycles per second. This now provides a series of low frequency standards of high precision. (*c*) Construction of three concentric slotted-line impedance measuring bars, each covering a frequency range 60 to 300 Mc/s. (*d*) Construction of a special low noise receiver for testing diode noise generators used as an absolute source of noise power. (*e*) Construction of various electronic voltage regulators and high frequency peak diode voltmeters required for general use through the laboratory.

10. Civil Aviation.

The development of radar aids for civil aviation has continued throughout the year in close co-operation with the Department of Civil Aviation. In this work the Division has had the benefit of discussion on various phases of the programme through the medium of the Aviation Radio Research Committee which continues to act as an advisory body to the Council on its aviation radio research programme. This committee consists of representatives of the Department of Civil Aviation, the Royal Australian Air Force, Postmaster-General's Department, the major airline companies, the Pilots Association, and the Council for Scientific and Industrial Research. The extensive experimental flying work carried out during the year has been made possible by the provision by the Royal Australian Air Force of a special flight for the purpose at Richmond, New South Wales. A new programme of work on the fundamental problems of Air Traffic Control has recently been started and is already producing useful results. This is described in detail below.

(i) *Distance Measuring Equipment.*—The Distance Measuring Equipment is a light-weight radar developed by the Division to give to the pilot a direct reading on a meter of his distance in miles to various beacons along the route. The development is complete and the Division's principal commitment is to give assistance to the Department of Civil Aviation and manufacturers in placing it into large-scale use. Several new applications of the equipment have also arisen, one of which is the creation of a glide path along which an aircraft can descend to break through low cloud safely. The glide path is created by combining altimeter height with radar distance in a constant ratio. This information is presented to the pilot on a meter and with this guidance an aircraft is enabled to descend to an airport at a constant angle until it has broken through a cloud layer.

(ii) *Multiple Track Range.*—The Multiple Track Range is an instrument providing 60 or more tracks into or out of an airport along which a pilot can fly. He is provided with a meter display which tells him his departure from the selected track. The system is representative of a type of aid which the International Civil Aviation Organization recommended should continue active development. The system was used recently in the United Kingdom by the Royal Air Force Transport Command as a major component in their rapid landing trials. Transport Command have since published reports on the trials and specifically on the Australian Multiple Track Range in which it was highly commended for its accuracy, reliability, and easy operational use.

The system has been refined so that it is able to give aircraft guidance to the airport area and is sufficiently accurate to aline the aircraft with the runway so that instrument landing procedures may be used in the final stage of descent.

(iii) *Approach Control Radar.*—The Approach Control Radar is an equipment for giving the control officer the position of all aircraft within about 20 miles of the airport. The experimental installation which the Division installed at Kingsford-Smith Airport, Mascot, New South Wales, has been running in the hands of the Department of Civil Aviation for some time. The Department has found this equipment of sufficient value to justify proceeding with similar installations at other major airports in Australia.

(iv) *Airways Control Radar.*—Airways Control Radar is one intended to give the control officer the position of aircraft within about 100 miles of the airport. The system consists of a radar station, a radio relay link to reproduce the display in the control building, and a plotter to present the information in a suitable form to the controller. An experimental set made by this Division has been working on combined trials with the Department of Civil Aviation for about six months. Extensive trials and analysis will be required to determine the operational effectiveness of such a system.

(v) *Traffic Control Studies.*—As the density of air traffic increases, the most important factor limiting the capacity of an airport under conditions of bad visibility is the ability to control traffic in its immediate vicinity. The problem is one of transforming the random arrivals of aircraft in the airport area into safe and orderly landings on the runway.

A number of lines of investigations are being followed which together are expected to lead to better methods of traffic control and a clear understanding of the instrumental aids required both in the air and on the ground.

(*a*) *Theoretical Studies.*—Mathematical studies of what happens when a random flow of aircraft is reduced to an orderly flow have produced important results on the correct interpretation of the capacity of an airport, the delays to aircraft wishing to land and the amount of crowding about the airport under various traffic densities. The results are important not only because they serve as a guide to all further theoretical and experimental work on traffic control but because they have direct bearing on such major works as airport construction.

(*b*) *Operational Analysis.*—In order to provide an understanding of the characteristics of airline operations and traffic controls as they are at present, a statistical analysis has been made of some of the relevant factors. The analysis showed the kind of paths aircraft follow in the immediate vicinity of the airport as recorded by a radar set. A study of times of arrival gave data on the probable error in a pilot's estimation of his time of arrival at various points along the route and at his destination. Data have also been obtained on the average time taken to land from a specified distance from the airport, the average time spent on the runway, and the average time taken to taxi.

(*c*) *Flight Tests of an Approach Procedure.*—By making use of air navigation aids already developed by the Division a large amount of experimental flying has been done in order to determine how accurately an aircraft flying on instruments could conform to a procedure decided upon as desirable for traffic control purposes.

The procedure studied is known as orbiting and is one which aims not only at keeping aircraft at a safe separation but also places them in the correct position in preparation for landing at the right instant. The orbiting procedure separates aircraft by assigning to them orbits of different radius at which to circle the airport (instead of heights which are used as a means of separation in the present "stacking" procedure). The tests have all been done in a Royal Australian Air Force C47 aircraft but the Department of Civil Aviation and airline companies have generously supplied a roster of pilots in order to provide a cross section of the performance of a representative number of airline pilots using the procedure. The tests have also provided an excellent opportunity for airline pilots to study some of the aids which the Department of Civil Aviation intends placing in service.

(*d*) *Traffic Studies by Simulation.*—The flight tests provide data on the probable performance of an individual aircraft but the performance of a complete system could only be determined by trials at an actual airport with large numbers of aircraft. Such trials are scarcely practicable, but useful results can be obtained by methods of simulation. Equipment has been constructed to simulate the whole process of traffic control about an airport, and from it is coming some indication of the best methods of traffic control and the maximum arrival rate which might be handled.

11. Radar Aids to Ground and Aerial Survey.

The American radar equipment known as "Shoran" which was acquired last year has been modified to make it suitable for the measurement of long base lines, and fitted in a Royal Australian Air Force Dakota. The equipment consists of a transmitter which is installed in the survey aircraft and two radar beacons which are placed at either end of the base line to be measured. The transmitter "interrogates" the two beacons, and precise timing equipment carried in the aircraft measures the sum of the times of travel of the radio waves to and from the transmitter in the aircraft and the beacons at either end of the base line. In practice the survey aircraft flies at right angles to the base line being measured and determines the minimum sum of these time intervals. From this and the known speed of travel of radio waves, the height of the aircraft and the heights of the terminal points of the base line, the distance between the two points can be computed.

A series of about 50 measurements has been made of the distance between the Laboratory and a point at Mount Stromlo near Canberra. A careful investigation has been made of the errors which may enter under different conditions of operation and as a result of this it is known that the mean value of a series of such measurements has a probable error of 30 feet, i.e. the accuracy of distance determinations by "Shoran" is about 3 parts in 100,000.

Further tests are being made over other accurately surveyed base lines. A series of measurements of the distance between Sydney and Tamworth has been completed and this is being followed by a determination by radar of the distance between Sydney and Condobolin.

A further use to which radar methods may be put is in the accurate determination of the position of an aircraft engaged on a photographic survey. Additional equipment to allow "Shoran" to be used for this purpose is under construction in the Laboratory.

12. Radio Control of Model Aircraft.

As an aid to aeronautical and meteorological research the Division has developed radio equipment for the remote control of model aircraft. The work is part of a joint programme being undertaken in collaboration with the Council's Division of Aeronautics. The Division of Aeronautics is anxious to use the technique as an aid in free flight research. When the technique is sufficiently established it will be applied to a number of meteorological measurements of interest in the radio-meteorological work of this Laboratory. A number of successful flights have so far been made with the model in sight of the ground controller.

XVII. TRIBOPHYSICS.

1. Introduction.

The work of the Division has developed rather unevenly during the year. This has been caused partly by the absence overseas of several members of the staff, and partly by the greatly increased activity of the group studying the effect of deformation on the structure and properties of metals.

Work on the mechanism of explosion has been temporarily suspended pending the return from England of two officers studying reaction kinetics and supersonics at Oxford.

An extension of the work on the properties of monolayers has been made possible by the co-operation of the Chemical Physics Section of the Division of Industrial Chemistry which has allowed very free use of its electron diffraction camera.

The limits of much of the work are at present dictated by rather cramped quarters but Professor Hartung is still generously allowing the Division to occupy a considerable part of the Chemistry building of the University of Melbourne. Approval has been given for the erection within the University Grounds of a new building to house the Division, and it is expected that its construction will be started within the next few months. Meanwhile the Division continues to receive the most active co-operation and help from the Science and Engineering faculties of the University of Melbourne, to which it is greatly indebted for the use of many facilities.

For convenience the account of the year's work has been divided under several headings but no such separation exists within the Division itself.

2. Friction and Lubrication.

(i) *Friction.*—Work in this field is developing on two main lines: on the nature of the forces restraining the movement of clean metal surfaces over each other, and on the physical and chemical properties of the films of molecular dimensions used as boundary lubricants.

(*a*) *Metallic Friction.*—When clean metals slide over each other the coefficient of friction is high and deformation of the metal occurs for a considerable distance below the surface. This effect occurs even when the apparent surface damage is small. When a lubricant is present the amount of deformation is very much reduced. The deformation can be conveniently studied by observing the re-crystallization of the deformed metal after suitable heat treatment. The nature of the adhesion between the sliding surfaces is being investigated by studying the type of sub-surface deformation produced under different sliding conditions.

There is considerable evidence to show that metallic friction is in part due to the force required to shear the small welded junctions between the surfaces. But since metallic surfaces are never perfectly flat it is obvious that an additional force is required to "plough" the surface irregularities of one metal through the other. If the shape and size of these irregularities are known then the frictional force due to them can be calculated. Surfaces with artificial "irregularities" of known geometrical shape, which can be varied, are being constructed and it is hoped that by measurement of their frictional properties it will be possible to separate some of the various factors responsible for frictional resistance.

(*b*) *The Mechanics of Metal Cutting.*—The effect of crystal orientation on the shear angle of the chip and the formation of built-up edge on the tool is being examined microscopically using a heavy microtome blade as a cutting tool.

(*c*) *Radioactive Tracers for the Detection of Wear.*—Radioactive cobalt and iron have been found to be satisfactory tracer elements for the detection of metallic transfer during unlubricated sliding of iron and steel surfaces, but sufficient quantities of the isotopes were not available to allow quantitative measurements to be made with lubricated sliding. This work is now in abeyance owing to staff difficulties.

(ii) *Lubrication.*—(*a*) *Lubrication by Thin Films.*—It has long been known that monomolecular films of certain polar molecules will greatly reduce the friction between metal surfaces. But the reason why a given type of molecule will lubricate one metal and not another, is not clear.

It has now been shown that the first essential is that the monomolecular film shall be solid, i.e., below its melting point, and that for satisfactory lubrication there must be a chemical force binding the molecule to the metal surface. This means that, for example, a long chain fatty acid will not lubricate a metal with which it does not react, but will be a good lubricant for those metals with which it forms metallic soaps, and it will continue to lubricate up to the melting point of the soap.

This has been shown by direct frictional measurement on a wide variety of reactive and non-reactive metals on which lubrication breaks down at temperatures corresponding to the melting points of the soaps and acids respectively. It has also been shown that there are variations in the frictional force corresponding to known structural changes in the crystal structure of the films below their melting point.

Molecular films of various thicknesses on a series of metals are being examined in an electron diffraction camera which has been put at the disposal of the Division by the Chemical Physics Section of the Division of Industrial Chemistry. The results have confirmed those obtained by frictional measurements and have shown that below their melting point the molecules of a fatty acid film deposited on metal by the Langmuir trough method appear to be oriented parallel to each other but with no lateral regularity. At the melting point, diffraction patterns corresponding to two-dimensional soap crystals are obtained. The work is being continued with non-reactive metals and with films adsorbed from solution of organic solvents.

(*b*) *Electrical Properties of Thin Films.*—The long chain molecules normally used as boundary lubricants are electric dipoles. A regularly oriented monomolecular film deposited on a metal surface will therefore alter its surface potential. Changes in the composition and structure of the film will produce corresponding changes in the surface potential which is thus a convenient method of following the behaviour of the film under varying conditions. A sensitive electronic apparatus, based on a method reported by American workers, has been constructed to determine the electrical properties of the films being examined in the electron diffraction camera. Preliminary experiments in air have shown promising and reproducible results and a start has been made on the construction of a high-vacuum apparatus.

(*c*) *Silicone Lubricants.*—The work on amyl and ethyl silanes described in last year's report has been published. One of the officers concerned is now studying structural silicon chemistry with Professor Emeleus at Cambridge.

Work is being continued in an attempt to prepare silanes with longer alkyl groups. Cetyl silane has been identified and various methods of preparation have been investigated in an attempt to increase the exceedingly small yield to useful proportions. Cetyl silane produces strongly water-repellent films of silicone on glass and metal surfaces, and the lubricating properties of these films are now being examined.

(*d*) *Lubrication of Piston Rings and Bearings.*—(1) *Piston Ring Lubrication.*—Difficulties associated with making electrical connexion to the piston ring in the single cylinder test engine at speeds representative of normal engine practice have now been overcome. Work has been considerably delayed by staff shortages and by the necessity of remounting the engine on vibration absorbers to prevent interference with delicate apparatus in the University Chemistry Department.

(2) *Bearing Testing.*—An account of earlier work, using an electrical resistance method of estimating the running performance of sleeve bearings has now been submitted for publication.

The construction of the friction balance in the more comprehensive bearing testing apparatus has now been completed and the balance calibrated. Preliminary running tests have been satisfactory and a start has now been made on the determination of the factors affecting the running-in of bearings.

3. Metal Physics.

Work in the field of metal physics is still concerned with the plastic properties and strength of metals and with the mechanism of phase transformations.

(i) *Plastic Deformation and Strength.*—It is hoped that an increase in our knowledge of the way deformation takes place and the effects of grain boundaries will allow the optimum conditions of a material for any required purpose to be stated.

(*a*) *Effect of Surface Conditions on Plasticity and Strength.*—Cracks and flaws, known to be present both in the interior and at the surfaces of crystals, act as stress concentrators and influence the observed plastic properties. Russian workers have shown that by absorption of surface-active substances the strength of a crystal is markedly reduced. The work is being checked at present with single crystals of known orientations. A special tensile machine has been constructed for this purpose and preliminary experiments have been made but the results so far are inconclusive.

(*b*) *Measurement of Energy Stored in a Material during Plastic Deformation.*—Whereas the main part of the work done in deforming a metal is immediately released as heat, a small part is stored as energy of deformation. This stored energy produces a change in the specific heat. In conjunction with the Division of Aeronauties, a calorimeter has been constructed in order to carry out an accurate determination of the specific heat of a deformed metal as a function of temperature. It is hoped that a correlation of this effect with the change in X-ray diffraction patterns produced by deformation will allow us to explain why metals become harder on working.

(*c*) *Interaction between the Crystals at the Grain Boundaries.*—The aim of these investigations is to find the basis for the calculation of the properties of a polycrystalline aggregate from the properties of the crystals. The interaction between the crystals is obviously of great importance.

(1) *Anisotropy of Plastic Properties.*—The investigation described in the previous report on the inhomogeneity of plastic deformation of crystals in an aggregate has been completed and published. It was shown that the deformation is continuous across the grain boundary. This continuity of deformation has to be the basic assumption for any calculation of the stress-strain curve of polycrystalline materials from the tensile curves of the crystals comprising the aggregate. An obvious disadvantage of this method is that the small indentations used as gauge marks themselves deform the surface. The work is therefore being continued in conjunction with the Division of Aeronautics, using as gauge marks fine grids produced photographically.

(2) *Presence of Two Phases in an Alloy.*—The work on the deformation and recrystallization of 60–40 brass has now been published. Because of difficulties in interpretation of the results, due to the order-disorder transformation, work on similar lines is being carried out with silver-rich silver-magnesium and copper-rich copper-iron alloys.

In a slowly cooled silver-magnesium alloy after small deformations the β phase starts to recrystallize before the α phase and after large deformations the α phase recrystallizes first. The α crystals nucleate at twins and grain boundaries with other α crystals, and the β crystals start to recrystallize at the α–β boundaries. This means that the deformation of the α crystals is inhibited at their boundary with the harder β crystals and that the deformation of the β crystals is enhanced near the soft α crystals.

(*d*) *Non-uniformity of Deformation in Drawing and Rolling.*—The work described in last year's report has been completed and published.

(ii) *Phase Changes in Metals.*—(*a*) *Diffusion.*—The mechanism by which diffusion takes place is being investigated using radioactive isotopes. A satisfactory technique has now been worked out and some rates of diffusion of cobalt into iron have been measured. The

effect of crystal structure on the heat of activation for diffusion will be calculated from measurements at various temperatures.

A similar technique has been worked out for determining the rate of self-diffusion in tin. It is hoped to determine the effect of small amounts of impurities on the rate of self-diffusion and to correlate this with the known effect on the rate of transformation from white to grey tin (tin pest).

(*b*) *Order-Disorder Transformation.*—The work on $\alpha - \beta$ brass has been completed and a preliminary account published. It was found that the electrical resistivity of the β phase increased as expected if the long-range order is destroyed by cold working. However, the resistivity of the α phase, in which no long-range order exists, also increased markedly. This is in contradiction to the literature. It is suggested that there is short-range order in the α phase before deformation.

In order to test the possibility of short-range order affecting the electrical resistivity, experiments are now being carried out with an alloy in which the existence of short-range order has been established by means of X-rays.

4. Explosives.

Earlier work had shown that the detonation of nitroglycerine in thin films is a discontinuous process, with a velocity at the point of initiation of about 400 metres a second which rises abruptly after a short distance to about 1,800 metres a second. Similar effects have now been observed with a wide variety of liquid explosives and thus appear to be characteristic of such substances. A short account of this work has been published.

Two officers of the Division are studying reaction kinetics and supersonics in Professor Hinshelwood's laboratory at Oxford and during their absence work is proceeding on the construction of a high-speed rotating camera with which it is hoped to make a detailed study of the mechanism of propagation. The lens system has been completed and an experimental mirror has been cast.

5. General.

(i) *Electronics.*—The electronics group has been very active. A replica of the Division's 60 kV X-ray diffraction unit has been completed for Professor Sir Kerr Grant and installed at Adelaide University. Electronic equipment has been constructed for the measurement of surface potential, and for determining the yield point of clay suspensions. An apparatus for measuring the friction between rapidly vibrating surfaces has been designed and completed but experimental work has been held up owing to lack of staff. A great deal of assistance and advice has been given to the other research workers in the Division.

It was never envisaged, however, that the electronics group should act merely as an instrument section. Since the measurement of X-ray intensities by photographic methods is unsatisfactory and since the accurate measurement of such intensities is of major importance in crystal structure work in general and for our work on deformation in particular, a method using Geiger counters for this purpose is being developed. There are many experimental difficulties but the general usefulness of such an apparatus will justify the considerable effort involved. Measurement of intensities and the interpretation of results will thus be the major activity of the group.

(*b*) *Electrolytic polishing.*—There has been a very wide demand for the mimeographed report prepared on this subject last year. In view of the increasing interest in electrolytic polishing the report is being rewritten and brought up to date and it is hoped to publish it in a more permanent form. A large number of requests for advice and assistance have been received from industrial firms and individual research workers.

(*c*) *Australian Bentonites as a Base for Oil Well Drilling Fluids.*—The properties of various Australian and Papuan bentonites and bentonitic clays have been examined in an attempt to find a satisfactory base for oil well drilling fluids. The rheological properties of most of them can be improved by leaching, but though one sample may have satisfactory gel forming properties and another form filter cakes with low permeability, no one Australian bentonite has been found to be a satisfactory substitute in all respects for Wyoming bentonite.

In the course of the work two sensitive instruments have been developed for determining the absolute value of the yield values of a non-Newtonian liquid based on the measurement of the force required to move a flat plate through the liquid in its own plane. Somewhat surprisingly this force is found to vary with the composition of the plate. This phenomenon is now being investigated in detail.

(*d*) *Miscellaneous.*—In addition to its normal research programme the Division has investigated a number of *ad hoc* industrial problems mainly concerned with lubrication, bearing design, electronics, and electrolytic polishing. Assistance and advice has been given to many government departments and industrial firms.

The metallurgical colloquia initiated last year in conjunction with the various metallurgical laboratories in Melbourne have proved most successful and are being continued.

XVIII. BUILDING MATERIALS RESEARCH.

1. General.

Satisfactory progress has been made during the year under review, despite experimental work having been hampered by building alterations. The senior staff, most of whom on appointment had little knowledge of building materials research, have gained experience and confidence, and with the acquisition of a considerable quantity of equipment a stage has been reached where really effective work is possible. Although the staffing position has been eased somewhat by the appointment of a further six research officers, it is still acute and much important work has had to be deferred because of inability to obtain staff of the desired calibre.

The close liaison already established with the various branches of the building industry has been maintained. In this regard, a development has been the appointment of a "Project Committee" consisting of representatives of paint manufacturers, fibrous-plaster manufacturers, the Victorian Housing Commission, the Munitions Supply Laboratories, and of the Section. This Committee was set up to plan and guide an investigation into certain problems associated with the decoration of fibrous plaster, and it has been of great assistance. As opportunity offers, it is proposed to appoint further such Committees.

The Section has taken an active part in the work of the various committees of the Standards Association of Australia which are engaged in the preparation of standard specifications for building materials.

The Officer-in-Charge returned in November, 1947, after a nine months' visit to North America, Great Britain, and several countries in Western Europe, during which a study of the organization, programmes, and accomplishments of building research organizations was made. Much useful information on new developments in the industry was obtained. One of the most important results of the visit was the making of personal contacts which have already been of very great value in obtaining information not otherwise available.

It is considered essential that the senior officers should obtain overseas experience as soon as possible, and the officer in charge of masonry investigations left Australia in April, 1948, to visit laboratories and works in Europe and America.

An event of great importance in the development of building research in Australia was the visit of Sir Reginald Stradling, Chief Scientific Adviser to the United Kingdom Ministry of Works and formerly Director of the D.S.I.R. Building Research Station in England. Sir Reginald made a detailed examination of the building industry and the organization of building research in this country, and, as a result, made certain recommendations which are now being considered by the Council and the Department of Works and Housing. As one result of these recommendations it has been decided that as from 1st July, 1948, the word "Materials" will be dropped from the title of the Section, which will then be known as the Building Research Section.

2. Information and Library.

(i) *Library.*—There has been a steady increase in the quantity of reference material filed in the library. The number of books has risen to 700 and periodicals to about 180. In addition, 2,600 pamphlets (including reprints and standards), 900 trade catalogues, and 160 patent specifications were received.

During the latter part of the year a revision of the key to the Universal Decimal Classification was commenced.

The Library Bulletin, which lists the publications currently added to the library, has been issued periodically but, because of the shortage of paper supplies, it is distributed now only to libraries and such other organizations to which it is of most immediate value.

(ii) *Information Section.*—It has not been possible to develop the information work along all the lines previously planned because attention has had to be given to other phases of the work, notably photography and assistance to the library staff in classification. These activities, together with general inquiry work and the preparation of the abstract bulletins, have taken up most of the time of the information officers.

For some time it has been felt that a number of the abstracts being included in the abstract bulletin were of rather too specialized a nature to be really suitable for the general distribution being given to the bulletin. Articles relating to fields such as those of chemistry, physics (particularly electronics), and materials testing, although of value to the research worker, often have little direct relationship to building, and therefore appear out of place in a general abstract bulletin. To overcome this, abstracts of articles of this type are now included in an internal abstract bulletin, which has been designed primarily for internal circulation, but which is available also to organizations which are interested in this type of information. During the year approximately 180 inquiries covering a wide variety of subjects were dealt with by the Information Section, 50 were from official organizations, 40 from commercial firms, and the rest from private individuals.

(iii) *Frost Fans.—The experiments made to find* graphic work of the laboratories has been carried out by the officer in charge of the Information Section, but this has meant that only a limited service could be given. Arrangements have therefore been made to obtain a photographer. The bulk of the photographic equipment required has now been assembled, and work is well under way with the establishment of a photographic unit consisting of a studio, darkroom, and theatrette.

3. Physical and Mechanical Testing Laboratory.

(i) *General.*—Progress has been made in the study of the weather resistance of building materials in general and of the special problem of developing a more durable and colour-fast surface for concrete roofing tiles. Because of high costs and the dollar shortage it has not so far been possible to obtain the desired mechanical testing equipment and conditioning rooms. This has greatly restricted the experimental work of the Section.

(ii) *Weathering Studies.*—One of the main projects on which the laboratory was engaged was the development of techniques for the rapid assessment of the durability of building materials. At present, accelerated testing must be treated cautiously as there is seldom sufficient information available from which to design test procedures or on which to base the interpretation of results. To obtain further information, investigations have been started on the intensity, duration, and distribution of solar energy. Standard meteorological equipment has been installed at the laboratory for correlation of climatic conditions with local exposure tests.

Meanwhile, some attention has been given to the development of an accelerated aging device, designed especially for testing the durability of coloured surface finishes on concrete roofing tiles. This equipment is still under development, but preliminary experiments have shown that, for the usual types of surface finish, break-down, equivalent to that obtained in twenty years of service in Melbourne, might be expected in less than one year of exposure to the artificial conditions of radiation and rain in the equipment.

(iii) *Concrete Roofing Tiles.*—Investigations on concrete roofing tiles have been concentrated on the development of a more durable surface finish by improving the resistance to erosion and preventing fading. Incorporation of water-repellent admixtures has been tried but is not wholly effective. From a consideration of the relative thermal and moisture coefficients of expansion of the tile body and the applied finish as well as from a study of the behaviour of the tiles in exposure tests it has been concluded that disintegration of cement-pigment surfaces cannot be prevented without the addition of an aggregate. A method has been developed whereby sand or other siliceous material may be incorporated in the usual spray mix of cement and pigment and the material may be applied in greater thickness and with a relatively low water/cement ratio. The process requires further investigation but exposure tests indicate that the surfaces so produced will be more durable and reasonably free from crazing.

A roof of English tiles, somewhat similar in design to the usual Australian Marseilles-pattern tile but lacking a weathering check, has been laid in order to determine the suitability of this particular design under local conditions of weather and building practice. It is a type easily mass-produced and therefore of considerable importance to the industry in this country. Some of these tiles were found to be unsatisfactory in respect of permeability, but, as this is largely a matter of production control, such a failure should not detract from the use of the design in question in this country if it is otherwise suitable.

Chemical analyses of a number of pigments being sold for tile-colouring have been made. The pigments examined ranged in oxide content from 20 to 100 per cent., which contrasts with the consistently high quality called for in overseas practice.

(iv) *Studies on Discontinuously Graded Mortars.*—Preliminary experiments have been made to compare the mechanical and physical properties of discontinuously graded mortars with those graded according to the Bolomey formula. This work was undertaken in an attempt to develop a method of grading which, on theoretical grounds and on the basis of some evidence, should yield a superior mortar. Increased strengths have in fact been recorded in a number of cases, but there was no evidence of improvements in respect of the dimensional change associated with changes in temperature and moisture content. The work has since been discontinued until better mechanical testing facilities are available.

(v) *Mechanical Testing Equipment.*—Progress in the establishment of mechanical testing facilities required by many of the Section's activities has been disappointing. The installation of a 1,000,000 lb. capacity universal testing machine was planned originally, and the weighing mechanism and blue-prints for this machine arrived during 1946-47. It has, however, been temporarily abandoned, owing to lack of accommodation and the probable high cost of completion. The possibility of constructing, in Australia, a 250,000 lb. machine, using the weighing mechanism already received, is being explored.

Lack of the necessary dollar exchange has prevented the intended purchase of a 60,000 lb. machine from the United States, but attempts are being made to make other arrangements.

A machine of 5,000 lb. capacity, constructed by the Section, is now being calibrated but is limited in its usefulness. The Division of Aeronautics has undertaken the construction of a 30,000 lb. machine which should be ready by the end of the calendar year.

4. Concrete Investigations.

(i) *General.*—Experimental work has suffered greatly from the shortage of staff, but a limited amount of work has been done on the preparation and properties of foamed concrete. In addition, a study of air-entrainment has been begun in co-operation with the Division of Industrial Chemistry. Much time has been spent in answering technical inquiries, approximately 300 requests for information having been received during the year.

(ii) *Foamed Concrete.*—Vesiculation of cement paste and mortars has been effected by the following methods:—

(*a*) Prefoaming surface-active agents by means of an air jet or rotating whisk, followed by incorporation of the cement and aggregate, and by thorough agitation of the whole.

(*b*) Addition to the wet mix of 100-mesh flake aluminium powder in the proportion of 0.2–0.3 per cent. by weight of the cement, the amount of aluminium being dependent on the type of fine aggregate used and the proportions of the mix.

(*c*) A combination of methods (*a*) and (*b*).

When method (*b*) was used, the addition of a wetting agent to the mix tended to reduce the size of the bubbles and to improve their evenness and distribution. The use of excess aluminium did not necessarily increase the final expansion but, on the contrary, tended to cause rupture and slumping of the expanded mass. With all methods, best results were obtained when the temperature of the mixing water was 25° to 30° C. The amount of water needed was greater than for ordinary concrete, the water-cement ratio ranging from 0.66 for cement paste to 1.00 for 1:3 cement mortars.

A combination of methods (*a*) and (*b*) was used for producing very light-weight insulating concrete, having a bulk density as low as 10 lb. per cubic foot.

As aggregates for this concrete it was found possible to use successfully waste materials, such as very fine sand, stone dust, granulated boiler ash, fly ash, neutralized sawdust, and pulverized residual mica. Other aggregates which have been used for special purposes are crushed firebrick grog for refractory products, paper pulp and corkdust for improved nailability and resilience, exfoliated vermiculite for increased insulation, and teased fibrous materials, such as coconut fibre, cow-hair, asbestos, and anthopyllite, as light reinforcement.

The permeability of the foamed concrete can be appreciably decreased by the use of integral water repellents such as metallic stearates or bitumen.

The rate of hardening did not appear to be much affected by the use of calcium chloride, but the addition of 0.25–0.5 per cent. (of the weight of the cement) of triethanolamine reduced the setting time very considerably.

Steam curing at 150 lb./sq. in. produced a marked improvement in the strength and dimensional stability of foamed concrete only when fine silica, in one form or another, was present in the mix.

The average ultimate crushing strength in lb./sq. in. of brick-size specimens having bulk densities from 30 to 90 lb./cu. ft. was found to be from 7 to 10 times their bulk density in lb./cu. ft., the actual figures being dependent on the type of aggregates used, the proportions of the mix and the method of curing.

Slabs of foamed concrete are still in good condition after twelve months' exposure to the weather.

(iii) *Air-entrainment Studies.*—Air-entrainment, which was originally introduced in United States of America to improve the resistance of concrete to freezing and thawing, has aroused considerable interest in recent years. Although the original purpose of air-entrainment is of no great importance in Australia, its other advantages, for example improved plasticity, are of sufficient interest to justify a long-term investigation. So far, work has been confined to a study of the literature, the preparation of a tentative research programme, the design, construction, and testing of a small Klein air meter, and preliminary experiments with a number of air-entraining agents.

5. Masonry Investigations.

(i) *General.*—The past year has been devoted chiefly to the organization and equipping of the Section. The alterations being made to the building have made it possible, so far, to install the chemical and physical laboratories, some equipment for which has been obtained. Apparatus for petrological microscopy is almost ready for use in the research work on clays, lime, and their products.

Good progress has been made in installing the pilot plant for heavy clay-work and, at present, a jaw-crusher, an edge-runner mill, an extruder, a humidity dryer, and an experimental kiln are in use, a pug mill and a ball mill have been obtained and will be working in the near future; a mechanical screen and a de-airing extruder are on order and should be available soon. The plant will be completed by the addition of a set of grinding rollers and a clay-washer. The equipment has already been used for two investigations of technological problems.

Because of the detrimental effect of lime and its products on clay the same equipment cannot be used for investigations on both these materials; a somewhat similar small scale plant is therefore to be set up for the lime investigations.

(ii) *Clay Investigations.*—(*a*) *Field Work*—A general survey of the clay deposits and the production methods of brick and tile plants in Australia was commenced. Visits to Western Australia and South Australia led to good contacts with manufacturers, who freely disclosed their main problems and difficulties. In these States the wire-cut and the stiff-plastic processes for brick manufacture are of equal importance. Semi-dry pressing, employed in only two plants in South Australia, is used parallel with the stiff-plastic process. In one of the plants, where correct grinding is carried out on medium hard shales, the appearance of the dry-pressed bricks is no worse than that of the stiff-plastic bricks, but in the other the dry-pressed bricks were definitely inferior in quality. It appears that the full efficiency of the dry-press process is not reached in either plant. This is mainly due to the use of a mixture of ground shales with the plastic surface clays necessary for the stiff-plastic machines in the dry-pressing operation.

The main problem in wire-cut brick plants is that of drying. Natural drying is adopted in most cases but artificial drying in chamber dryers was found in one instance where the owner expressed his full satisfaction with the results.

The roofing tile industry is, because of the common use of interlocking tiles, quite uniformly organized. Plastic clay mixes, mostly with a content of pipe-clay and frequently shortened with ground shale, are extruded in slabs which are later moulded in rotating presses. Ridge tiles are usually produced in hand-worked screw-presses. One de-airing extruder was seen in operation. Artificial drying, using the waste heat from kilns, is used in some instances. For burning the tiles, rectangular kilns are generally used. salt-glazing being applied.

(*b*) *Laboratory Work.*—Pilot-scale laboratory investigations were carried out on plastic clays from two deposits, Fairfield and Blacktown, near Sydney, and on shales from quarries near Canberra.

(iii) *Lime Investigations.*—With the grave shortage of portland cement in several States, there is considerable interest in the use of lime as a binder, and a comprehensive study of this material has been started. Particular attention is being paid to a study of (*a*) "carbide lime", resulting from the reaction of calcium carbide and water in the production of acetylene, and (*b*) hydraulic lime. Carbide lime has been used for mortar in New South Wales but it is claimed to be inferior to quicklime or hydrated lime for this purpose. However, European experience with this type of lime has been satisfactory and it is proposed to study the properties of the locally produced carbide lime to determine whether the Australian objections have a sound basis. Hydraulic limes have been little used in Australia but, since their production requires less coal than does portland cement, their use as an alternative to that material for certain special purposes such as construction in contact with sulphates or sea-water is worth considering.

(iv) *Masonry Construction.*—Investigations on the deterioration of brickwork were commenced. An instance of heavy damage caused by "salt-lamp" in parts of brickwork both above and below the damp-course was examined. Work on efflorescence will be carried out in the near future.

6. Surfacing Materials Investigation.

(i) *General.*—Work has continued on three major projects, namely, floor surfaces with special regard to those based on concrete, surfacing materials for kitchen and bathroom walls, and the study of gypsum plasters. In addition, a study of the external rendering of building boards and the surfacing of bituminous roofing materials has been begun in co-operation with other sections.

(ii) *Floor Surfaces.*—(*a*) *Comfort*—After considerable difficulty, a gauge has been developed capable of measuring the transient pressures on the foot during walking. The best technique for the use of the gauge is now being determined; the pressure-time curves for a number of individuals using different types of shoes have been obtained and the results are being analysed. The instrument will be used for determining the effect upon foot pressures of different surfaces and sub-floors to determine the relationship, if any, between the results obtained and the subjective assessment of relative comfort, as determined by a panel of twelve observers. The gaits of these observers have been checked for normality by the staff of the Physiology Department of the University of Melbourne.

Laboratory testing of floor surfacing materials for foot comfort has been retarded by the unsatisfactory behaviour both of the British standard indentation tester and the falling ball tests widely used overseas. Careful examination has shown that these latter tests give results at variance with experience because they fail to measure that property of a floor which our feet record as comfort. The British indentation tester has proved unsatisfactory because of poor mechanical design, and it is hoped that a new instrument, the design of which has been based on an American pattern, will prove more satisfactory. It is expected that this instrument will enable measurements of rate of indentation with time to be made and that these will yield data which can be correlated both with mechanical comfort and with resistance to marking by furniture.

To measure the "warmth factor" of flooring materials a calorimeter has been constructed after the manner of those used by Reim and co-workers at the University of Natal. Preliminary studies indicate that the technique requires further refinement.

(*b*) *Durability.*—A Taber Abraser has been obtained, and drawings prepared for the construction of another abrasion tester based on that developed by Cizek, Kallas, and Nestlen (A.S.T.M. Bull. Dec. 1946) for floor surfacing materials. The Taber Abraser has been used to examine the wear resistance of cork tiles, linoleum, asphalt tile, and similar materials, chiefly in connexion with inquiries from the Department of Works and Housing.

Further experiments with the British Standard rumbler-type abrasion tester have shown that: (1) The accumulation of dust in the rumbler tends to protect the surface of the concrete slabs so that the rate of wear is greatly influenced by the frequency of cleaning. (2) None of the proprietary floor hardeners tested had a sufficiently great effect on the abrasion resistance of the concrete slabs to outweigh the usual variation between slabs.

(*c*) *Service Tests.*—As, in common with other building materials, the final test of a floor surfacing material is its behaviour on an actual floor, service tests are being arranged as opportunity offers. The cold-laid, bituminous, mastic toppings which were laid on concrete in various parts of the laboratory are providing improved comfort and most of them are wearing satisfactorily. Further floors with bituminous toppings are being installed in experimental structures in the laboratory grounds but it is considered that traffic conditions in such buildings will not approach very closely to those in a normal house. In consequence, arrangements have been made with the Victorian Housing Commission for the erection of an experimental house on an estate near the laboratory. It is being built by the usual V.H.C. precast concrete wall system except that a suspended reinforced concrete floor cast *in situ* by the Rose system will replace the usual timber floor. This concrete sub-floor will be covered with a different type of topping in each room and photocell counters will be installed in the doorways in order to relate wear with traffic. It is hoped to correlate this wear with that of test samples set in busy corridors in the laboratory, and eventually with the wear produced by laboratory abrasion machines. The house will be occupied by the officer responsible for investigations into floor surfacing materials so that a trained observer will be available to study the behaviour of the floors in use, particularly with respect to the more subjective aspects. It is realized that the data obtainable from this one house will not be very extensive both as regards type of floor and impressions of comfort, ease of maintenance, &c., and it is hoped to extend the experiment to other houses as opportunity offers. Arrangements are being made for the use of the concrete floor of another house (to be occupied by another trained observer) for similar experiments.

Although the primary experimental purpose of the house at present under construction was to investigate promising floor surfacing materials, opportunity will

be taken to make full-scale trials of wall surfacing materials for the kitchen and bathroom, paperhanging techniques for concrete walls, manufacture, erection and decoration of fibrous plaster ceilings under controlled conditions in connexion with the current investigation into staining of fibrous plaster, thermal and moisture movements of concrete wall slabs and the behaviour of mastic joint-filling compounds.

(iii) *Bathroom and Kitchen Wall Surfaces.*—Work on this project has been impeded because of the non-availability of the cyclic testing cabinet, due partly to the difficulty of obtaining components and partly to building alterations. The cabinet is now complete except for a pump, and it is hoped that it will shortly be in service.

Small-scale static tests have been continued, in the meantime, on local and imported wall boards and plastic tiles. The only materials so far examined which show first-class soap resistance are boards coated with nitrocellulose lacquers and polystyrene tiles. Both these, however, have mechanical defects; the lacquer coatings are brittle and the polystyrene is soft and easily scratched.

(iv) *Solid Plastering.*—In conjunction with the Building Boards Section a co-operative project on the rendering of building boards has been started. A method developed for measuring the adhesion of plastering mixes to various types of material is being used in connexion with this investigation. A survey of the properties of plastering sands available around Melbourne has been commenced, and it is hoped to extend this investigation to other areas.

(v) *Gypsum Plaster.*—The survey made of the gypsum plaster industry has shown that not only are the raw materials used in Australia very different (at least physically) from the dense rock gypsum normally used overseas, but that they vary widely from State to State and even from mill to mill. With the exception of one deposit of not very high grade rock, the gypsum deposits being worked are surface deposits of recent origin (in some cases still in the process of formation) varying from loosely packed crystals an inch or so across to fine dust much of which will pass a 200-mesh sieve. Despite this wide range of raw material types, very little effort has been made in most mills to design plant suited to the gypsum available, but rather it is the practice to copy that used either overseas or in mills already established in Australia. For example, two mills operating on the fine dust have copied the equipment of a mill operating on the rock deposit even to the extent of passing all raw material through a hammer mill before calcination. It is difficult to say at this stage to what extent the alleged variations in quality between the plasters produced by the various mills are due to this following of established practice without proper consideration of the characteristics of the raw material. The claim of the industry is that some gypsum deposits will make good plaster but that others will not.

A study of the properties of Australian plaster has been commenced but progress has been hindered by the unsatisfactory nature of many of the usual testing methods; in consequence, a considerable amount of time has been spent on an examination of testing methods with a view to their improvement.

The determination of particle size and particle size distribution—for which sieves have proved particularly unsatisfactory because of the large amount of material in the sub-sieve range, the blocking of the fine sieves, and the progressive grinding which occurred with the usual sieve-shaking machines—has received the major attention in this particular field. Because of the importance of such work in other related fields (portland cement, clays, pigments, &c.) a co-operative project under the guidance of a committee of interested workers from this laboratory and the Division of Industrial Chemistry has been instituted to study the whole programme of particle size work and the fractionation of fine powders. An apparatus for determination of particle size distribution by air elutriation has been designed and built. Preliminary investigations with this apparatus have shown that while the design and method are very promising the technique requires further refinement.

Investigations into the methods for determining setting time, consistency, and mechanical strength of plasters, as well as into improved methods of their chemical analysis, are also continuing.

For the study of the dehydration of gypsum a small-scale plaster kettle has been obtained and a specially designed laboratory oven is under construction.

The studies of the equilibrium moisture content of set plasters, which have been commenced to provide data both for the Standards Association of Australia and for the co-operative project on decoration troubles with fibrous plaster sheets, have been handicapped by the unsuitability of the apparatus available. Preliminary results show that small amounts of hygroscopic materials have a marked influence on the moisture content of the plaster but, for accurate data, it will be necessary to wait until suitable humidity cabinets are available.

Investigations have been commenced, in co-operation with the Physical and Mechanical Testing Laboratory, into the strength, permeability and durability of the reinforced gypsum plaster slab house walls being used in South Australia and north-western Victoria.

It has been shown that the addition of small amounts of lime to gypsum plaster will greatly reduce the corrosion of iron embedded in the plaster without seriously reducing the strength of the material. This could be of use in preventing the not uncommon staining of fibrous plaster sheets from the accidental inclusion of small fragments of iron in the plaster and may also be of value in protecting the reinforcement in gypsum slab walls.

Gypsum deposits have been examined both in the laboratory and in the field and advice on their utilization given to prospective lessees.

7. Building Boards and Insulating Materials Investigations.

(i) *Building Boards.*—Lack of staff has prevented the development of a comprehensive research programme aimed at evaluating the properties required of building boards. Some preliminary work has, however, been undertaken to determine the dimensional stability of building boards under conditions of changing moisture content (the "moisture expansion"). This disclosed a gradation in materials similar to that shown by experience; it is obvious, therefore, that this test will be of great value in assessing new types of boards and, more particularly, in determining possible joint treatments.

Some progress has also been made in the investigation of the properties of boards intended for use as bases for external rendered finishes. A timber frame has been sheathed with various types of board in panels approximately 10 feet by 9 feet which have been exposed to conditions as nearly identical as possible. It is intended to study the behaviour of these panels in conjunction with laboratory tests. This will enable methods of evaluating the properties of new boards to be determined.

(ii) *Thermal Investigations.*—Construction of the 12-in. by 12-in. and the 48-in. by 48-in. thermal conductivity apparatus to the design of the National Standards Laboratory has proceeded. Considerable time has been spent at the National Standards Laboratory in the setting up and testing of the 12-in. apparatus constructed there. It has been found that a new heating plate is necessary to overcome difficulties which

have arisen during preliminary testing. The design and construction of this plate is in hand. The 48-in. apparatus has also been assembled, but is awaiting a suitable location.

Some work has been carried out upon methods for simultaneously determining the thermal conductivity and the specific heat of a material. Two promising methods have been explored, both of which enable tests to be completed in a time which will not cause serious discrepancies due to the movement of the moisture in the sample. They are based upon guard ring heaters supplied with energy at a constant rate in contact with one side of the specimen, the other side being either completely insulated (arranged by a symmetrical layout of two heaters and samples) or else in contact with a cold plate at a constant temperature. One method gives a good measure of the specific heat with the conductivity determined to a lower order of accuracy, whilst in the other, which approximates the normal guarded hot-plate arrangement, the measure of the conductivity is the more accurate. All such "dynamic" methods necessitate the prior conditioning of samples and means of doing this at temperatures of 32°, 77° and 122° F. (0°, 25° and 50° C.) are being arranged.

Investigations on the effect of radiation upon heat transfer in buildings have commenced with attempts to measure the absorption and emission co-efficients of surfaces in the near and far infra-red bands. These indicate a gradation from almost zero to 100 per cent., but more accurate measurement is necessary to enable better calculations of the effect of radiation to be made. Observations taken over a 24-hour period in April with a "Sol-Air" thermometer (which measures the temperature of a black surface having a backing of low conductivity and heat capacity when exposed in turn to north, east, south, west, and vertically upwards) indicate that the effect of radiation is equivalent to an increase of temperature during the day of 30° to 40° F. and a decrease during the night of up to 10° F.

(iii) *Electronics.*—A number of items of electronic equipment have been produced for use by various sections of the laboratory. Of particular interest is a meter, based upon an R.F. comparison circuit, for measuring the moisture content of fibrous plaster. This enables the moisture content of a sheet to be measured *in situ* by pressing a plate onto the surface; its reading has been shown to be independent of the salt content of the plaster which, heretofore, has influenced measurements based upon electrical phenomena.

8. Organic Materials Investigations.

(i) *General.*—Studies of the properties of caulking materials have been continued, and new projects undertaken include investigations into the properties of bituminous roofing materials and a co-operative investigation into the causes of failure of paint films on fibrous plaster.

Work has also been carried out on two *ad hoc* problems, namely, the specification of satisfactory steel sash putties and the properties of jointing compounds for flat-roof pavements.

(ii) *Caulking Compounds.*—Work on this problem has been directed simultaneously along the lines of exposure testing and of laboratory methods of evaluation. Proprietary caulking compounds have been utilized as the working materials for this investigation, and data on the characteristics of the various types of material represented, have been gradually collected. The principal methods of testing employed at present are those evolved by the United States National Bureau of Standards and incorporated in United States Federal Specification TT-C-598. Generally speaking, the evaluation of a mastic on the basis of this code has been found to agree with that made on the basis of outdoor weathering testing in grooved blocks at Highett. This is particularly true for materials rated as satisfactory after exposure testing under the conditions mentioned.

A considerable proportion of the available Australian mastics are of bituminous types, chiefly of the fibrated cut-back variety. These, as a class, have failed to give satisfactory results after some eighteen months' weathering, the greatest single cause of failure being excessive shrinkage. However, concurrent artificial weathering tests under high humidity conditions have indicated that these materials may be more durable than oil-based mastics in damp situations, and it is clear that weathering tests under graded conditions are necessary for proper evaluation. A series of exposure tests designed to evaluate the effects of various priming compositions on the performances of mastic joint seals were undertaken during the year. At the time of writing these specimens are only five months old and have not aged sufficiently for comparative evaluation.

In order to investigate the performance of materials under the dynamic conditions such as prevail in the constructional joints in buildings, an expanding joint apparatus was constructed and has proved satisfactory for routine testing. The device imparts a continuous cyclical displacement to joints of a given width made between slabs of a standard masonry material; an automatic record is made of the number of cycles impressed upon the specimen. Performances so far obtained (on the basis of the present cycle and displacement) range from 2 to 250 cycles before failure (usually by loss of adhesion). At present the choice of displacement is somewhat arbitrary, but, for purposes of comparison, steps have been taken to measure the actual movement in joints of a standard "V.H.C." type prefabricated concrete house shortly to be made available by the Victorian Housing Commission for a variety of experiments.

In an effort to correlate performance with composition, analyses have been made of a number of the materials under test, but because of inherent difficulties in separating and characterizing the ingredients, this phase of the work has not been very promising. However, a broad classification of the compounds may be made, and it will be possible to use this as a basis for the synthesis of experimental mixtures.

Lack of suitable staff has precluded any serious investigation of the rheological properties of caulking compounds. Progress was made in studying the movement of thin plates embedded in mastics, but although some results of interest were obtained using putties, the technique could not be applied satisfactorily to caulking materials.

In co-operation with the Council for Scientific and Industrial Research Information Service work has been commenced on the filming of a documentary account of the uses, properties, and testing of caulking compounds. It is intended that the film should also illustrate the operation of the B.M.R. pneumatic caulking gun which is now in use as standard equipment on concrete house projects of the Victorian Housing Commission.

(iii) *Bituminous Roofing Fabrics.*—It became possible during the year to commence investigations, which had been planned for a considerable time, into the properties of bituminous roofing materials. In view of the vast amount of work that has been undertaken in other parts of the world on bituminous materials, it was considered desirable at the outset to make a careful survey of the literature, with particular reference to the chemistry of weathering of bitumens and to the properties and utilization of bituminous fabrics for waterproofing and roof construction. This survey is still progressing, but sufficient progress has been made

to indicate the lines along which the present work might be usefully directed. These include examination of the causes of "blistering" in built-up roofs and other matters associated with constructional technique, the preservation of bituminous surfaces exposed to the weather, the relation of fabric base characteristics to the performance of bituminized felts, the relative merits of asphaltic residues, both natural and artificial, and of coal tar pitches, &c., under various conditions. So far, experimental work has been of a preliminary nature only, but, as a basis for initial investigations, supplies of a range of proprietary roofing felts have been obtained, working plans for the testing of these in the laboratory have been drawn up, and routine testing of properties has been begun. In addition, a programme of exposure testing both on small specimens and on a larger scale is under way. The larger scale tests actually comprise the construction of experimental roofs; two such roofs have now been built and constitute portion of the experimental features in the two timber-framed test huts that have been erected at Highett. In these roofs, variations in pitch, grade of roofing fabric, constructional technique and surface treatment have been incorporated, and the effects of these variables are under observation. Other factors are to be studied in later experiments as roofing space becomes available. Insufficient time has elapsed to permit any definite conclusions, other than some rather elementary facts concerning practicable surfacing treatments, to be drawn.

(iv) *Miscellaneous.*—(*a*) *Steel Sash Putties.*—This investigation, referred to in the previous annual report, was completed. A report, with recommendations, has been forwarded to the Victorian Housing Commission, the body originally requesting that the investigation be undertaken.

(*b*) *Jointing Compounds for Flat-Roof Pavements.*—A request was received from the Commonwealth Department of Works and Housing for assistance in the selection of materials suitable for application to joints between the flat-roof paving slabs of the projected administrative buildings, Canberra. In view of the close connexion between materials of this type and caulking compounds, and of the importance of, and general interest in, concrete expansion joint materials, an undertaking was given to investigate this matter. It was decided to compare possible materials under practical conditions by means of a test pavement constructed according to the actual roof specification. This pavement, comprising a concrete base slab 14 ft. 6 in. square covered with building paper and followed by a 1-inch thickness of insulating board, a three-layer three-ply built-up bituminous membrane and finally concrete paving slabs 2 ft. square by 1.5 in., has now been constructed at Highett. Provision has been made to test electrically, by means of suitably placed electrodes beneath the slab joints, the water resistance and general integrity of the various jointing materials placed between adjacent slabs. Discussions were held with various manufacturers, as a result of which some 20 jointing materials, representative of the following types, have been selected for incorporation in the experiment: bitumens (natural and residual), bitumen rubber caulkings, cold set-up (solventless) bituminous mastics, bituminous cements and bitumen rubber cements (cut-backs), bitumen emulsion mixtures, rubber latex-cement systems, vulcanized latex-road oil fillers, oil mastics.

(*c*) *Adhesives for Papering Concrete Surfaces.*—Observations on the experiments started in 1947 were continued and have now yielded positive results. Arrangements have been made for full-scale service tests by papering various rooms in the experimental concrete house referred to above.

9. The Decoration of Fibrous Plaster.

As mentioned above, an investigation into problems relating to the decoration of fibrous plaster is being made under the guidance of a "Project Committee" representing outside interests as well as the laboratory staff. Most of the detailed work is being carried out by members of the Organic Materials, Building Boards, and Surfacing Materials sub-sections of the laboratory.

At the inaugural meeting of the Project Committee it was agreed that the following troubles were widespread and required investigation:

(i) Adventitious surface stains associated with the presence of impurities (such as iron particles in the plaster and contaminants, e.g. grease, rot-proofing agents, in fibre reinforcement).

(ii) Dark-coloured stains principally associated with flush joints but also occurring elsewhere in the surface; their possible relation to the moisture content of the plaster and to presence of mould growths.

(iii) Loss of adhesion of paint films (flaking and peeling) notably over flush jointed areas.

Progress in regard to these matters is dealt with under the following headings:—

(*a*) *Surveys and Defects.*—As a preliminary arrangements were made through the architects of the Victorian Housing Commission, responsible for provincial housing, for the circulation of a questionnaire to the various country housing estates. Replies indicated widespread troubles and made it evident that adequate surveys of all centres would be a lengthy process. Accordingly the Victorian Housing Commission Estates at East Geelong were selected for close examination since these estates (four in all) comprised a large number of houses with defects typical of those apparently prevalent elsewhere. They provide some evidence concerning the nature of several of the defects encountered and suggest avenues for further laboratory investigations.

Less detailed investigations that have been made of conditions in Victorian Housing Commission Estates at North Geelong, Heidelberg, Moe, and Mildura, led to conclusions similar to those drawn from the East Geelong survey.

(*b*) *Treatment of Adventitious Sheet Stains resulting from Impure Materials.*—On the basis of preliminary laboratory tests, experiments were undertaken to study the effects of incorporating lime in plaster on the development of rust marks. This treatment has been found to inhibit the appearance of these stains in plasters containing particles of iron without causing material loss of strength. Full-scale tests of this treatment have not yet been made, nor has the effect of the lime content on decorative coatings been evaluated.

Laboratory trials on the sealing of fibre-stained sheets before distempering have been carried out, and an aluminium pigmented, light-bodied varnish has been found successful in suppressing the development of such stains in the decorative coatings. Subsequently, this technique was tested with satisfactory results in a Victorian Housing Commission unit at Heidelberg in which the undecorated sheets were exceptionally severely stained. Although perhaps unsatisfactory on economic grounds for new construction, the technique is considered feasible as a remedy for grossly stained walls and ceilings in existing dwellings.

(*c*) *Investigation into the Nature of Dark Coloured Joint and Sheet Stains.*—Stains of this nature have been investigated closely in four houses (two of which were situated in the East Geelong Estate and were typical of many others.) Laboratory tests indicated that stains were readily dispersed by treatment with hydrogen peroxide, and full-scale operations, in which a dilute solution of this material was sprayed over affected walls and ceilings in the houses referred to, effected decolouration with complete success. Unfortunately,

this treatment cannot be regarded as a cure, since in certain instances the stains have been found to recur. There are several reasons that might account for this and laboratory investigations of the chemical nature of the stains and the mechanism by which they are produced are still in progress. Present indications are that the stains consist of ferrous sulphide, but the mechanism by which this compound is formed has not yet been finally determined.

It may be stated that mould growths have not been encountered extensively and fungi are certainly not responsible for the more common defects in fibrous plaster in Victoria. Nevertheless some instances of mould growth have been encountered, and experiments designed to determine the precise conditions under which these organisms may grow on fibrous plaster are in hand.

(*d*) *The Causes and Remedies of Adhesion Failures of Distempers on Fibrous Plaster.*—No investigations have yet been made concerning the mechanism of adhesion failures. However, it has been observed that such defects are commoner in humid atmospheres, and it has been determined, as a result of analysis of failures of this type at the V.H.C. East Geelong Estates, that certain sealers markedly reduce the tendency of distempers to peel from flush joints.

(*e*) *General.*—Experiments aimed at inducing defects of the types referred to above under controlled, full-scale conditions, have been planned and are in course of execution. These comprise the introduction into buildings of variables relating to plaster sheet materials and manufacture, its fixing technique, paint materials and decorating technique. The first building, a private home, has been completed and sundry defects have already been noted. The lining of two experiment huts at Highett is in progress, and arrangements have been made for the inclusion of similar tests in the experimental prefabricated concrete house referred to previously.

XIX. FLAX RESEARCH.

1. General.

During the latter part of 1947 alterations to that portion of the Highett building being used for the main flax laboratory were completed to a stage where it could be occupied and the whole of the flax staff moved to Highett. The improved accommodation and the centralization of the work has been of great assistance in facilitating the work of the laboratory.

A building to house the experimental spinning plant has since been erected and the plant itself has recently arrived from overseas. The acquisition of this machinery for flax preparing and spinning experiments marks a very important milestone in the Section's development. The equipment consists of seven separate units, all essentially of the most modern commercial design but single-headed instead of multi-headed as in commercial installations. The spinning of a wide range of yarns is made possible by the provision of interchangeable parts on the spinning frame. The building in which the spinning equipment is housed is to be air-conditioned and when this is completed it is anticipated that much valuable information will be obtained as regards both the comparison of the spinning quality of different fibres and also in connexion with spinning techniques.

A feature of the work of the Section during the period under review has been the extension of laboratory investigations to large scale trials at flax mills; as a result, a number of recommendations have been made which should materially increase the efficiency of commercial operations. In connexion with the fundamental research programme of the Section, arrangements have been made for one of the senior officers to proceed to the Shirley Institute at Manchester to work on advanced methods of analyses in cellulose chemistry.

2. Agricultural.

(i) *Survey of Factors Influencing Fibre Quality.*—Much of Australian flax is low grade and unsuitable for fine yarns and one of the main objectives of the laboratory's investigations is to devise means of improving quality. One possible method of doing this is to determine the agricultural features associated with the best fibre produced so that production can be concentrated along these lines. From both the 1946 and 1947 flax crops some 60 were selected and all details regarding the history of the field and its preparation and the growing, harvesting and processing of the crop have been carefully recorded. The figures are being statistically examined but processing returns from the mills are incomplete and it will be some time before the work can be concluded. One important feature of the investigation is the chemical analyses of green leaf samples from each crop to determine the levels of the major and minor nutrient elements.

(ii) *Processing and Fibre Evaluation of Field Trials.*—Close contact is maintained with the Departments of Agriculture of Victoria, South Australia, Western Australia and Tasmania, the Waite Research Institute, and the Flax Production Committee, all of which organizations include flax field trials in their programme of work. Samples of straw from these trials are forwarded to the Flax Research Laboratory for processing and the determination of fibre yield and quality; in future it will be possible to carry out actual spinning tests as well.

The more important trials are concerned with the testing of new varieties and selections, the rate and method of sowing, the time of harvesting, and the use of various fertilizers. Some of these have now been carried on for a number of years and have reached the stage where definite recommendations can be made.

3. Processing.

(i) *Purchase of Crops.*—The purchasing of flax crops on the basis of the value of the fibre they contain rather than simply according to the weight of straw has obvious advantages. However, to enable the growers to be paid promptly for their flax by the former method it would be necessary to sample each crop as it was delivered to the mill. In order to compare the fibre and grades obtained from such samples with those from the whole crop, the Flax Production Committee requested the Flax Research Laboratory to carry out trial tests on the 1946 and 1947 crops. This work has been completed as far as the laboratory work is concerned and although all the mill results are not yet available, sufficient information has been obtained to provide a basis for the purchase of the 1948 crops.

(ii) *Water Retting.*—As indicated in previous reports, Australian flax is particularly difficult to ret, the retting action appearing to cease prematurely. This is probably due to the high acidity which quickly develops in the liquor, and means of controlling the pH have been examined. The use of a chemical neutralizing agent is perhaps the most obvious method, and both laboratory and mill scale experiments have been made, in which chemicals such as sodium carbonate, magnesium carbonate and calcium carbonate have been added to the retting liquor. The results have been encouraging but further work is necessary to determine the optimum quantities of chemicals required.

Probably a more satisfactory solution to the problem of pH control during retting lies in the continuous aeration of the liquor. Using this method, retting times have, in some cases, been reduced from 90 to about 60 hours without detriment to the fibre yield or grade. In addition to the possibility of improved retting times, the aeration technique, if adopted, will result in less water consumption and also assist appreciably in overcoming any effluent disposal problems.

A third method which gives partial control of the pH consists of completely replacing the retting liquor after about 48 hours; the results of such a technique have not, however, shown very great promise as the retting action appears to be slowed up by the addition of the fresh water and although the straw eventually rets well, the total retting time is increased.

The possibility of increasing the output from the retting tanks by increasing the amount of straw in each ret has also been investigated. In co-operation with the Flax Production Committee rets have been made with baled straw and with straw packed horizontally rather than vertically as is the usual practice. With baled straw the tank capacity was increased by 58 per cent., but the cost of baling was prohibitive and the retting was somewhat uneven; with horizontal packing the increase was 30 per cent. and retting proceeded normally. The general adoption of the latter technique seems likely.

In a comparison of the efficiency of Australian and Belgian flax retting practices using matched straw and fibre obtained from Belgium, it has been shown that the methods employed in this country are capable of producing results as good as those obtained overseas.

The study being made of retting bacteria has progressed steadily. Some hundreds of cultures of sporing anaerobic bacteria, isolated from retting flax, have been purified and a detailed study of their characteristics is being made. Included in these cultures are 27 isolated from samples of Belgian straw, the comparison of which with those of local origin should prove of considerable interest.

(iii) *The Rolling of Retted Flax Straw.*—The practice of passing wet retted straw through squeezing rollers is fairly common overseas where it is claimed that not only does the treatment facilitate the drying but that it improves the fibre quality. A series of tests has recently been concluded at one of the flax mills. Although there was a fairly consistent improvement in the colour and "nature" of the fibre as a result of the rolling, the improvement was not sufficient to increase the value by one grade. Tensile strength, fineness and spinning performance of the fibre have yet to be determined.

(iv) *Flax Machinery Investigations.*—The main project undertaken during the last twelve months was the development of a knotter-elevator. This machine is intended for use behind a tractor from which it will be driven. Sheaves of retted straw after drying are fed to a mechanical knotter and, after being tied, are elevated to a trailer. Preliminary mill trials of the equipment are now being made.

4. Chemical Properties of Flax.

(i) *Cellulose.*—The major constituent of flax fibre is cellulose, and a careful study has been made of some of the more important properties of this constituent and the correlation of these properties with fibre quality. The alkali solubility and its dependence on both the degree of polymerization, and the extent of the crystalline structure have been examined.

(ii) *Flax Wax.*—It has been shown that flax wax consists of a lipoid (wax and oil) and a resinous component and that the proportion of these is closely related to fibre quality. For example, double retted fibre of appreciably higher grade than single retted fibre from the same straw, differs chemically from the latter mainly in regard to its resin content. Methods by which a single ret could be modified to give similar results have been considered.

(iii) *Comparison of Belgian, English, Irish, and Australian Fibre.*—The results of a comparison of the chemical properties of a representative range of fibre samples from each of the above countries have shown that resin and components of the fibre soluble in N/50 sodium hydroxide are important in relation to quality. Better quality is associated with low resin content, but both the amount and composition of the sodium hydroxide solubles appear to be of importance.

Australian flax differs from overseas samples as regards the composition of the hemicellulose, the proportion of uronic acids in this component being lower and the water solubles and pentosans correspondingly higher than in overseas fibres.

It seems possible that the ash content of the fibre might bear some relation to its quality, as there is a tendency for this constituent to increase with increase in fibre grade. The ash percentages of Australian fibre are low by comparison with overseas samples.

5. Physical Properties of Flax.

Observations have been made microscopically of the development of fibre in the stem of flax straw from germination to maturity, and the effect of growth conditions on this development. A comparison has also been made of the dimensional characteristics of Australian and overseas fibre and the effect of these on spinning quality.

The dependence of the tensile strength of flax on the ultimate fibres is evidenced by the fact that the breaking of a fibre strand results from the breaking of ultimate fibres comprising the strand rather than the pulling apart of the ultimate fibres. It has also been shown that they seldom break at the "dislocation marks" which occur at intervals along their length.

XX. DAIRY PRODUCTS RESEARCH.

1. General.

The dairy industry in Australia is becoming increasingly aware of the need to use for human food all the constituents of milk. In an ill-fed world the present inefficient practice of feeding much of the high quality protein, lactose, mineral salts, and vitamins of skim milk to stock leaves much to be desired. It is the intention of this Section to direct a large part of its efforts to assisting, and increasing, the efficiency of, those forms of dairy manufacture which make fullest use of the milk constituents, and to develop and initiate means of using skim milk solids as human food. During the past year it has been possible to carry out some work along these lines, but problems which are of outstanding economic importance in butter manufacture have again claimed the larger part of our efforts.

Laboratory accommodation at Fishermen's Bend has become even more limited and the number of research officers remains at five. Plans have been prepared for new laboratories and pilot-plant building which are to be erected at Highett.

During the year the Australian Dairy Produce Board requested the assistance of the Section in the testing of several new continuous butter-making processes. Much valuable work in these tests is being undertaken by the Departments of Agriculture in the States concerned. Organization of the trials has nevertheless demanded considerable attention.

2. The Utilization of Skim Milk Solids.

(i) *In Bread Manufacture.*—Of the several ways in which a consistent and large-scale demand for milk solids-not-fat for use in human food might be established, the inclusion of dried skim-milk in Australian bread remains the most important. It was reported last year that although the major obstacle to such addition had been overcome by the simultaneous incorporation of a small proportion of a plastic fat, minor difficulties remained—the longer fermentation time, the alterations necessary to normal baking practice, and the response of various flours. Arrangements have been made for the continuation of this work in Sydney as soon as a suitable officer can be obtained.

(ii) *Egg Substitutes.*—Another promising avenue for the better use of milk solids-not-fat is the German "Milei" egg-substitutes developed during the war. In the preparation of these, an alkaline or "swelling" salt is added to the concentrated skim milk before drying, with the further addition, in the case of whole-egg substitutes, of a mucilaginous carbohydrate such as carob-bean meal. The products are designed to reproduce some of the more important physical properties of whole-egg and egg-albumin so that they may be used as substitutes for certain purposes, notably baking. The milk products do not reproduce the nutritive properties of eggs, but they do supply, much more cheaply, very valuable food constituents. The Ministry of Food in Great Britain is interested in these products. With the co-operation of milk-drying firms, experimental lots have been prepared here using various manufacturing methods. The Division of Food Preservation and Transport is testing the suitability of the products for various uses, and shipments have been made to the Ministry of Food.

(iii) *Sweet Skim-Milk Spreads.*—During the year a sweet spread for bread with skim-milk solids as the main constituent was developed. This is an attractive product and although household use would be restricted by its limited keeping quality there should be scope for its commercial use as cake filling and for similar purposes. The method of preparation from dried skim milk presents no difficulties.

3. The Manufacture of Butter Without Washing.

Butter for export to Great Britain and for sale in most Australian States must contain a legal minimum of 80 per cent. of butterfat. Because the moisture content is limited by law to 16.0 per cent., the salt is limited by trade requirements to about 1.5 per cent., and the normal method of manufacture will give a curd content of only about 1.0 per cent., most butter contains considerably more than the minimum requirement of butterfat. Experiments last year showed that when the usual step in butter manufacture of washing the butter granules is omitted, the curd content is increased by about 0.4 per cent. This means that a given quantity of cream yielding 100 lb. of commercial butter made in the orthodox way would yield 100.4 lb. if washing is omitted. If applied generally to Australian manufacture the increase in production would be approximately 600 tons of butter per annum with a value of £140,000.

Study of whether the practice of omitting the washing of butter has any adverse effect on butter quality, and if so the nature and degree of the effect, was continued during the year. This matter is also of importance in relation to some of the more promising of the new butter-making methods in which fat concentration is brought about by centrifuging so that no washing takes place.

Several butter factories co-operated in the production under commercial conditions of unwashed and washed butters from the same bulk of cream. The butters were graded, their keeping quality determined at room temperature and in cold storage, and their bacteriological and chemical characteristics were studied. The general conclusion is that some factories can produce unwashed butter equal in quality to washed butter, but that from other factories the unwashed butter is a little lower in grade, the average difference in one factory amounting to one-fifth of a grade point. The considerable economic gains associated with omission of washing can only be obtained reliably where bacterial and heavy metal contamination are maintained at low levels, and where the general quality of the cream is such that inclusion of the additional cream serum will not adversely affect the flavour of the butter.

In butter factories in some of the warmer dairying districts the application of chilled butter-wash water is relied upon for reducing the temperature of, and so firming, the butter granules. If necessary, the arrangement of other means of obtaining the same effect should present no great difficulty.

The results of this investigation have been presented to the industry at a meeting of the Institute of Dairy Factory Managers and Secretaries, and have also been prepared for publication.

4. Weed Taint in Butter.

The main areas in which butter may be affected by weed taint are the summer rainfall districts of Northern New South Wales and Southern Queensland, extending from Sydney in the south to Port Curtis in the north. The taints occur chiefly in the winter and early spring when maintenance of good pasture is often difficult and when weeds thrive in the absence of competition from other species. Paddocks which are bare following summer cropping are also a common source of weeds. Absence of alternative feed forces the stock to eat the weeds, the cream becomes tainted, and the usual methods of factory cream treatment intensify rather than lessen the flavour. The resultant tainting of the butter is a source of lower grades and economic loss.

This problem has been studied, during the weed season, at the Queensland Agricultural College, at Lawes. To obtain a clear picture of the nature and extent of the problem, extensive contact has been made with dairy industry personnel in the districts affected. Information on suspected weeds, together with samples, have been supplied by dairy officers of the State Departments of Agriculture.

Suspected weeds have been fed to milking cows under controlled conditions and the effect noted. The main objective of this part of the work during the 1947 season was to define the degree to which weeds other than the lesser swine cress, *Coronopus didymus,* are serious sources of weed taint. Growth of weeds was much more abundant than in the previous year and considerable progress was made. The possibility that bacterial action may play some part in the development of these taints, even if weed-derived substances are primarily responsible, greatly complicates the investigations.

While the long-term solution to the weed-taint problem may well lie in the modification of agricultural practice, any immediate remedy must be in the nature of a cream treatment which will eliminate the flavour. Much effort has been devoted to the development of such a treatment and progress has been made in spite of considerable difficulties. To provide a sound basis for this work the chemical nature of the substance or substances responsible for the taint is being investigated.

5. Testing of Continuous Butter Processes.

The Australian Dairy Produce Board is purchasing several of the new butter-making machines which have been developed in various countries, including Australia. The new processes claim to give cheaper manufacture by continuous methods and to give increased yields. They also provide opportunity to eliminate the bacterial contamination often associated with wooden churns. The Board has asked the assistance of this Section in testing the suitability of these machines for butter manufacture under Australian conditions.

Procedure for the trials has been outlined, and with the co-operation of the State Departments of Agriculture and of the Department of Commerce and Agriculture the necessary organization has been established. Testing of the Swedish "Alfa" machine at Lismore in New South Wales is already well under way.

6. Use of Rennet Casein for Glue.

Rennet casein for use in the production of plastics must be of the highest quality. Inferior casein showing discoloration or other serious quality defects is not wanted by the plastics industry, and for any such batches of defective rennet casein which may be produced the casein manufacturer must find an alternative outlet. This is made difficult by the unsuitability of rennet casein for use in glues. The relatively high ash content or, more specifically, the high content of soluble calcium prevents solution of the rennet casein on application of lime in the preparation of the glue.

To enable slightly defective rennet casein to be usefully disposed, a limited investigation was made of treatments which might allow preparation from rennet casein of a satisfactory glue. A satisfactory method using treatment with dilute sulphuric acid was developed. A paper reporting this work has been prepared for publication.

7. Miscellaneous.

(i) *Oxidized Flavour in Whole Milk.*—Work in the United States has indicated that the development of oxidized flavour in whole milk may be closely associated with the oxidation of the ascorbic acid. Oxidized or oily flavours sometimes appear in butter, particularly sweet cream butter, under conditions which do not give appreciable oxidation of the fat. Nothing is known of the ascorbic acid content of cream as received at the butter factory, and the whole subject needs investigation. An investigation begun last year has been recommenced.

(ii) *Thickening in Unsweetened Condensed Milk.*—The problem of thickening in unsweetened condensed milk was given further attention. It became clear that while much could be done by the part of the industry concerned through more complete scientific control in manufacture, seasonal variation in the susceptibility of milk to this defect called for further investigation. There also appeared to be scope for developmental work on the use of ion-exchange processes to correct salt unbalance in the milk serum. These projects are, however, beyond the capacity of the Section with its present limited staff.

(iii) *Australian Butter Survey.*—The report on the Australian butter survey, which collected information on manufacturing methods, conditions and production, and variations in composition and in fat constants in Australian butter, was completed and submitted for publication.

(iv) *Filter Cloths.*—The practical value of the new method devised for treatment of filter cloths used in lactose manufacture has been confirmed in commercial use. A saving of about 75 per cent. in use of filter cloth has been effected.

(v) *Babcock Test.*—Assistance was given in the compilation of the report " On the Babcock Test for Fat in Dairy Products " by a sub-committee of the Victorian Division of the Society of Dairy Technology.

XXI. MATHEMATICAL STATISTICS.

1. General.

An expansion in the scope of activities of the Section has been made possible this year, as the result of an increase in staff now sufficiently trained to assume some responsibility for the planning of experiments and treatment of results.

In its main function of advising in the many projects of the Council, the Section has continued to provide assistance with long-range experiments, and has undertaken additional work, including several large-scale trials involving considerable preparation and routine analysis. In this capacity also, experiments have been designed, and subsequent results analysed, for many external organizations, including University research teams, Commonweatlh and State departments, and commercial enterprise.

A good deal of time has necessarily been spent in lecturing, both to junior sectional staff as part of their course of preliminary training, and to graduate and undergraduate classes in the Universities with which the Section is closely associated.

The Section's own research programme, which it is hoped to extend as fresh staff is obtained, has made steady progress. The primary analysis for determining the expectation of monthly rainfall in South Australia is complete, and the results are now being illustrated graphically on a series of maps. The work is being extended to establish the relationship between variability of rainfall within zones of equal mean rainfall, and plant ecology, and to assess the probabilities of drought of varying intensity and duration.

Investigation of the trend in yield throughout the wheat belt of South Australia during the period 1913-37 has been completed, and a detailed report prepared. Areas of declining, stationary, and increasing yields have been accurately delineated, and also the trends related to soil type, seasonal rainfall, and the full cropping history of each region. More detailed examination of these data has revealed that the major part of the area showing increasing yields is not improving at rates consistent with the developments in agriculture during the past 50 years, and it has been established that this is due mainly to the continued use of the exploitative short-term rotation of wheat-fallow since its development in the early years of the industry.

To investigate yield trends, allowance had to be made for variations in the seasons, and consequently, as a by-product of the analysis a considerable amount of information was obtained on the relationship between yield and rainfall. The quantitative effects on yield, of autumn, winter, and spring rains have been assessed, and related to soil type and general cropping practices in each district. These findings have been checked for a number of representative centres in the wheat belt, by analysis of yields obtained from government experimental or from private farms, where the exact conditions of cropping are known.

2. Assistance to Divisions.

Close association with the research programmes of the separate departments of the Council's activities has been maintained, and the nature of this is indicated below.

(i) *Division of Animal Health and Production.*—As a background to the work to be conducted at the Regional Pasture Laboratory, Armidale, the Section has this year undertaken an extensive analysis of data for rainfall and temperature with a view to preparing detailed maps of their reliability. Mean lambing percentages and wool cuts per head for the last 25 years have also been obtained for the New England Region, and the influence on these of rainfall and temperature at different times of the year is being studied.

In addition to work on problems of experimental design and sampling techniques for the Division generally, assistance has been given to specialist sections on matters such as the development and checking of methods for assessing the degree of helminth infestation by means of ova counts in the faeces of sheep and cattle, and for measuring association between antibody titre and helminth ova counts in sheep. A study of contour of wool fibre cross-sections was made for the Wool Biology Section.

A good deal of consideration has been given to the development of techniques in preparation for large-scale experiments in the Division's future programme.

For one of these concerned with the measurements of sheep, methods for measuring body dimensions have been tested extensively and problems relating to the sampling of fleece of the living animal for different purposes have been investigated.

Another of these large-scale projects, known at present as the "strain trial", concerns the comparison of various strains of Merino sheep under different environments. A number of ewes of varying strains will be run and bred at Gilruth Plains, Armidale, and Deniliquin, and in the pre-schedule of observations to be made, and sampling techniques to be used in measurements of body and fleece, the Section will take an active part. A rate-of-stocking and rotational grazing trial is similarly planned for Armidale, and trials to compare breeding systems are in progress at Gilruth Plains.

(ii) *Division of Biochemistry and General Nutrition.*—The effects of trace element deficiencies on sheep in particular areas of South Australia have been further studied for this Division.

(iii) *Commonwealth Research Station, Merbein.*—Responsibility for handling the results of manurial, pruning, and irrigation trials for the Station has recently been undertaken. To date, an experiment to determine the nitrate content of soil on tomato plots under different watering rates, has been completed.

(iv) *Division of Economic Entomology.*—In the preparation of techniques for varying routine trials, the Section provides constant assistance to the Division in laboratory and field. The testing of various insecticidal sprays and dusts in the control of insect pests has been continued, and the immediate and residual effects of D.D.T. on the red-legged earth mite, lucerne flea, and Bdellid mite have been investigated.

An examination was made to indicate the density of grass grub in relation to soil, moisture, and pasture. Data on the distribution of grasshoppers in relation to neighbouring trees were also analysed. Other results included those on the intestinal secretion of insects in relation to their intake of food.

(v) *Division of Fisheries.*—Assistance has included questions of the measurement of fish populations, examination of the characteristics of these for latitude effect, and the effect of year, time of year, river of habitation, and sex on the length of an individual species. Marine bacteriological problems have also been under consideration.

(vi) *Flax Research.*—Results of field experiments concerned with retting, grade, and yield have been analysed, regressions of yield and quality of straw on various environmental and cultural factors studied, and chemical constituents of fibre calculated with a view to learning the constituents which determine grade.

(vii) *Division of Food Preservation and Transport.*—A large-scale factorial trial on the influence of sulphiting, blanching, drying to different degrees, and conditions of storage on the storage qualities of dehydrated potatoes, silver beet, carrots, beetroot, and cabbages has been analysed.

Considerable attention has centred on the design of tasting tests, and a comprehensive scheme of taste testing for the Division is under discussion.

Sampling of orchards for storage tests on fruit, and of cornfields for canning of sweet-corn cobs, has been studied; in a survey of yields and ascorbic acid content of potatoes from different localities, both variety and farm differences have been established.

(viii) *Division of Forest Products.*—The help of the Section is being increasingly sought at the initial stage of the Division's experiments, that is, in their design, and particularly in examining at first-hand, field techniques and difficulties, problems of surveying, and instrument calibrations. The following gives briefly some of the problems that have been dealt with during the year:

(*a*) *Wood Chemistry.*—Practically all work this year has been concerned with pulp and paper investigations: in design and subsequent analysis of experiments to determine the effect on properties of numerous factors, such as addition of resin, and of salts at various concentrations, ageing time, varying basis weight, multiple ply papers, weight of pulp per sheet, and beating time.

(*b*) *Wood Structure.*—Further assistance has been given in experiments on dimensions, shrinkage, delignification, and twisting of normal wood and tension wood fibres, and new work dealing with pore formation in alpine ash undertaken. The effect on basic density of staying was considered, and growth curves obtained for data on mountain ash.

(*c*) *Timber Physics.*—A factorial experiment was designed to study variables in gluing wood, another experiment to determine the effect of temperature on modulus of rupture for different species was analysed, and correlations between cleavage and tensile strength were calculated.

(*d*) *Timber Mechanics.*—Correlations between mechanical properties of various Empire and American species have been calculated and compared. Design and analysis were made of an experiment to determine the effect of type of floor, spacing of joists, and density of timber on properties of flooring strength. In addition, the precision of calibration of a torsion strain gauge was investigated, as were similar tests on an extensometer, and examination was made of effect of size of the loading head in static bending tests, and of a new hardness machine for consistency with the standard type. Experiments to determine the effect of shape and size of test specimens on the estimates of mechanical properties were also carried out.

(*e*) *Seasoning.*—A factorial experiment on the kiln seasoning of veneer was designed to determine the effect of position in tree, kiln conditions, chemical seasoning, and reconditioning; and a prediction formula has been investigated with a view to estimating from temperature and humidity readings the actual moisture content of certain timber specimens.

(*f*) *Preservation.*—Data on the minimum to concentration of boric acid in the preservation various species have been analysed to determine satisfactory treatment schedules; as have results of tests on fence posts; telephone line cross-arms, and railway sleepers for calculation of frequency of splitting.

(*g*) *Veneer and Gluing.*—Analysis has been made of data from a survey of gluing characteristics of Australian timbers, using various methods. The calibration constants for a Störmer viscometer were determined, and a study made of methods by which viscosity of resins and their setting properties could be determined.

(*h*) *Utilization.*—Assistance is being given with the mill-scale study project, and a survey of scantling and flooring timber quality, to estimate the effect of alterations of the grading rules, has been adapted to enable punched cards and mechanical tabulation to be used.

(ix) *Division of Industrial Chemistry.*—The errors in estimation of a theoretical curve to fit the chemical properties of a binary liquid system were investigated.

(x) *Division of Plant Industry.*—The Section is in close contact with this Divisional programme, and is able to follow the conduct of experiments through all stages. Among analyses carried out have been those, for Agrostology, of the data from several long-term grazing trials. In addition, many fertilizer tests on pastures were designed and analysed; as also were various experiments testing hormone weed-killers, and attempting to control *Paspalum* in irrigation channels by oil sprays.

Numerous fertilizer, cultural and varietal trials at irrigation centres and for Plant Introduction were similarly treated, a particular instance being a citrus culture experiment at Griffith, for which a method of analysis has been developed and applied to results so far obtained.

The schedule for Plant Pathology has included the study of transmission of virus and pre-emergence blight in peas, the response of pine plantations to fertilizers, and incidence of gummosis in apricots. For the Regional Pastoral Laboratory at Deniliquin, consideration has been given to the subject of expectation of rainfall in the area.

(xi) *Miscellaneous.*—In addition to the foregoing, assistance with design or calculation has been provided to the Division of Soils, and to the Sections of Building Materials Research, Dairy Research, Foundry Sands and Meteorological Physics.

3. Assistance to Outside Organizations.

Among analyses conducted for extra-Council organizations, the following have been included:—

(i) *Bacteriology School, University of Melbourne.*—Experiments on the efficacy of different vaccines, and the planning of others to determine satisfactory techniques for folic acid assays.

(ii) *Commonwealth Serum Laboratories.*—Fitting of gene frequencies to data on Rhesis reactions for samples of the aboriginal populations of Australia and New Caledonia; and the preparation of methods of analysis for experiments on the testing of antitoxins against toxins.

(iii) *South Australian Department of Agriculture.*—A comparison has been made of the incidence of frosts at centres in the river Murray districts, as a means of determining their suitability for settlement.

(iv) *Western Australian Department of Agriculture.*—A spraying trial against the apple leaf jassid was planned, and the results treated.

(v) *Miscellaneous.*—Assistance, either of an advisory or practical nature, has been given to numerous other organizations in the different States.

XXII. OTHER INVESTIGATIONS.

1. Radio Research Board.

The aim of the Radio Research Board since its inception in 1928 has been to carry out fundamental research in radio propagation and, in particular, to assist and encourage such research in the Universities.

This policy was well maintained before the war by the establishment of research groups within the Universities, in particular in Sydney and Melbourne. These groups consist of a few experienced full-time C.S.I.R. officers assisted by post-graduate students of the Universities, or of members of the University staff who spend part of their time on the researches of the Board. They operate under the general direction of the Radio Research Board as to the broad lines of work but the details of the research work are supervised by the professor in whose department the groups work.

In this way there is a convenient pooling of facilities and the combined staffs form very satisfactory research teams. The pre-war work of the Radio Research Board had a very high international reputation in its fields of investigation. Moreover, the knowledge gained and the students trained in radio work later played a very important part in the war effort.

During the war the full-time staff of the Board was largely diverted to form the basis of the Radiophysics Division on its establishment, and the remainder later became fully occupied in developing an Ionosphere Prediction Service, which was a very important factor in maintaining the best possible radio communications over long distances. Since this work has passed from the field of fundamental research to that of applied research supplying a regular public service, it has been thought appropriate to transfer it to the Department of the Interior. As from 1st July, 1947, therefore, the Radio Research Board has returned to its original field of pure research under two of its senior officers returned from other war-time activities.

The central group of the Board is still located in the Electrical Engineering Department of the University of Sydney under the direct supervision of Sir John Madsen. This group, using improved equipment and new techniques developed during the war, has recently made important new discoveries regarding the movement of disturbances in the ionosphere.

A second group, which operates at Canberra in close co-operation with the Commonwealth Observatory, has made important contributions on tidal effects in the upper atmosphere and to the study of electrical noise radiated from the sun.

A further group at the University of Queensland, under the supervision of Professor Parnell, is carrying out investigations based mainly on the regular operation of a variable frequency ionosphere recorder, and the Board is assisting the University of Tasmania to carry out similar work in Hobart. A new group is now being formed to work under Professor Ross at the University of Western Australia.

The Board also co-operated with the Australian National Antarctic Research Expedition in training an officer and supplying equipment for radio investigation on Macquarie Island.

2. Mineragraphic Investigations.

Twenty-three investigations have been carried out on the mineral associations of rocks, ores and mill products submitted by mining organizations and institutions. Each investigation was directed to some specific problem relating to the occurrence or recovery of the valuable mineral and several were related to the intensive search for new ore bodies, now being conducted by some of the larger mining corporations.

Previous studies of South Australian talc deposits were extended by a petrological examination of the high-grade deposits near Mt. Fitton, Northern Flinders Range, South Australia. These deposits are highly cleaved lenses in sheared schistose marble in a zone of contact metamorphism adjoining an outcrop of non-schistose granite. The introduction of the siliceous solutions required to form talc from dolomite has also led to siliceous replacements of the dolomite, some of which have the fine-grained character of jasperoids.

A microscopic study of the blast furnace slags from the Broken Hill Associated Smelters has shown that the bulk of the lead losses in the slag are due to globules of metallic lead and that only a very minor proportion is due to the formation of lead silicates. Many of the globules of metallic lead are coated by thin films of magnetite which protect the lead from chemical reagents unless the slag is very finely ground.

An investigation of mill products from the Lake George Mines, Captain's Flat, has been carried out for comparison with similar, previous examinations. Owing to the fine grained nature of the ore, finer grinding had been introduced in the mill and the examination was able to give a comparative picture of the results.

The occurrence of chromium in ilmenite residues from beach sands from Nories Head, New South Wales, has been found to be due to two types of chromite. The more abundant type is uniform in composition and

relatively non-magnetic. The second type is non-uniform and relatively magnetic and consists of marginal rims and veins of a more ferriferous chromite, surrounding and intersecting the normal non-magnetic chromite.

A study has been made of the mineral occurrences at Vatukoula goldfield, Fiji. The outstanding feature of the lodes at Vatukoula is the important amount of gold in combination with tellurium as sylvanite, associated with relatively abundant native tellurium and small amounts of the silver telluride, hessite. The hessite is the isotropic variety which crystallized below 149° C. The mercury telluride, coloradoite, and the nickel telluride, melonite, are only present in very minute amounts. Gold has been deposited over a wide range of temperature. Some is associated with the early formed pyrite and some is associated with the later tellurides. Gold deposited with the early pyrite contains little silver and has a fineness up to 940. Gold deposited with the tellurides is relatively high in silver.

These investigations have been facilitated by contributions from a number of mining companies through the Australian Institute of Mining and Metallurgy. The University of Melbourne has also assisted by granting laboratory accommodation in the Geology School. Extensions to the Geology School building have been in progress during the year and, when completed, will provide increased accommodation for the Mineragraphic Section.

3. Ore-dressing Investigations.

At Kalgoorlie, where investigations are being carried out with the co-operation of the Kalgoorlie School of Mines, some 42 samples were received during the year. Of these, 29 were either ores, tailings, or mill products associated with gold mining. The information generally desired was for a method of treatment, and the work done principally concerned amalgamation, cyanidation, and flotation tests. One copper ore was submitted to determine a method of treatment. Some preliminary work on asbestos tailings was completed, and further work is in progress. A sample of slag containing lead was submitted to see if the lead could be recovered; work on it is still in progress.

At Adelaide, the work was almost solely devoted to the beneficiation of industrial minerals. Towards the end of the period under review, the investigator resigned and the investigations ceased. It is probable that future work on ore-dressing at Adelaide will concern the treatment of industrial minerals and be closely related to the programme of the Division of Industrial Chemistry.

At Melbourne, where work is being carried out in co-operation with the Metallurgy School of the University, 22 reports were issued; half related to gold ores and the remainder to base metal ores and non-metallics. Problems associated with the retreatment of gold tailing dumps at Yea, Stawell, and Ballarat (Victoria) and Tennant Creek (Northern Territory) were studied. Another investigation indicated that the gold contained in a gravity concentrate from Charters Towers (Queensland) could be recovered by cyanidation, but that such treatment, after roasting, was ineffective because of the lead minerals in the concentrate. Mill products from various mines in Victoria were studied with a view to improving plant performances.

Base metal ores investigated included those of lead, zinc, tin, antimony, and tungsten. In an unusual investigation the possible application of ore-dressing methods of the beneficiation of a natural resin (yacca gum) was demonstrated; by a combination of sink-float and electrostatic concentration, a product containing less than 0.5 per cent. woody matter and 0.05 per cent. non-volatile matter was obtained. Work on the treatment of heavy mineral and beach sands was also continued and during the year a physicist was appointed to investigate the principles of electrostatic separation of these materials.

4. Physical Metallurgy.

In its second year of existence the Section has been strengthened by new additions to staff and equipment. Work has continued on the constitution and properties of alloys using titanium as the basis metal, and on determining the mechanism of deformation by X-ray diffraction technique.

(i) *Titanium Programme.*—New techniques have been developed for producing specimens for microscopic examination. The first technique is by sintering the alloys made by mixing the alloying metals in the form of fine powders. The mixed powders are then pressed using a demountable die and a locally constructed 200-ton press. The bar or pellet so obtained is heated in a silica tube in high vacuum at 1000° C. for some hours to allow the metallic particles to mix by diffusion in the solid state and for volatile impurities to be removed. It is not possible to take to a higher temperature because silica then becomes relatively porous to atmospheric gases. To obtain higher temperatures, approaching the melting point of the alloys, small samples are heated inside an evacuated glass tube by means of a high frequency oscillating current. The sample is surrounded by a water-cooled copper work coil, so that the outer glass cover does not get very hot, whilst the specimen is raised to such a temperature that it just begins to melt. In this way diffusion is assisted and the temperature at which melting commences is determined. A device for introducing cold hydrogen in the form of a jet impinging on the specimen has also been constructed. This permits rapid cooling or quenching of the specimen from high temperature, thus enabling examination of the microstructure in a non-equilibrium condition.

The second technique for preparing alloys consists in actually melting them after they have received the preliminary sintering treatment. The melting is done on a water-cooled copper electrode in the form of a saucer, by means of an arc struck from a tungsten electrode. The operations are conducted under a water-cooled bell in an atmosphere of argon, this being inert to the titanium. In this furnace ingots of 100 grams can be melted.

Most progress has been made in determining the constitution of the alloys of chromium with titanium. It has been shown that the high melting point of titanium which appeared to be a valuable asset from the point of view of its use at high temperatures is rapidly lowered by the addition of chromium and with 20 per cent. of the latter has fallen from 1780° to 1130° C. The present survey is only concerned with the primary solid solutions of titanium and these are complicated by the existence of an allotropic transformation at 860° C. This complexity is, however, a useful feature in that it makes possible a variation of properties by heat treatment. A means of exploring the constitution rapidly has been developed in the laboratory recently and looks as though it will prove to be a very useful technique. It consists simply of measuring the pressure of hydrogen in a closed system containing the alloy. Each phase develops an equilibrium pressure at a given temperature and the curve showing the relationship between pressure and

temperature has deviations corresponding with phase boundaries. Microscopic exploration is being carried out to establish the correctness of the constitution so determined.

Progress has also been made with the constitution of the alloys of titanium with iron and the relationships appear to be similar to those found with chromium alloys. Again the melting point of titanium is considerably lowered— to 1050° C. by addition of 15–20 per cent. iron.

In both the above cases it has been shown that the alloys are machineable but harder and therefore stronger than titanium itself.

Owing to the great reactivity of titanium with the atmospheric gases the influence of oxygen has been examined. Previous work has been confirmed showing that oxygen is in solid solution up to about 12 per cent. The presence of oxygen makes the alloys very brittle, but they might still be useful for high temperature work. X-ray diffraction technique is being developed to help in determining the constitution of these alloys, and a camera for use at temperatures up to 1,000° C., capable of evacuation to 10^{-4} mm. of mercury is being designed. At ordinary temperatures structures conforming with the two allotropes of titanium and a third structure associated with a so far unidentified phase have been obtained from titanium chromium alloys.

(ii) *Mechanism of Deformation of Metals under Stress.*—This is a joint programme undertaken between members of the staff of the Baillieu Laboratory in the University of Melbourne and the Council's Division of Aeronautics at Fishermen's Bend. The X-ray equipment mentioned in the last report has been completed and is in operation. This is being used to determine the mechanism of failure of metals by fatigue, in particular to determine the structural condition associated with failure of metals under cyclic stresses.

Another investigation has been the determination of the nature and magnitude of the internal stresses remaining in metals after they have been deformed plastically. After longitudinal extension the remaining internal stresses between crystals are surprisingly high. On removing the stress after stretching, the stresses remaining are compressional, with transverse and longitudinal components which may reach an order of magnitude comparable with the yield strength of the metal. The necking of the test specimen prior to fracture coincides with the relieving of the stresses. Publication of these results is in progress.

5. Meteorological Physics.

(i) *General.*—Attention of the Section is to be directed to problems of a fundamental nature, to complement the work of the Meteorological Bureau. Although meteorology must be studied locally its more fundamental problems are world-wide. In Australia, where the primary industries are so dependent on meteorological processes, both the local and the global aspects must receive consideration. Certain lines of work have been selected in which an advance in knowledge should in the long run prove of especial benefit to Australia, while contributing at the same time to the wider field.

(ii) *Dynamic Meteorology.*—A theoretical study of the circulation of air in depressions and anticyclones, and of the laws which govern the air motion, will lead to a better understanding of these weather-determining pressure systems. Progress has been made with the past year towards a fundamental explanation of the observed size of depressions and anticyclones, their persistence from day to day, and some of the factors which determine their movement, intensification and decline.

(iii) *General Circulation and Heat Balance.*—An important aim is the quantitative description of the internal and external heat balance of the atmosphere and the maintenance of its general circulation. A real understanding of the processes determining the average state must precede a similar understanding of the departures from that state. It is these departures which constitute the broad weather trends and the variations in season between one year and another. During the past year a tool has been developed by which these problems can be attacked. International interest in the method has been shown by acceptance of a paper, describing the method and some preliminary results, for presentation to the Assembly of the U.G.G.I. (International Union of Geodesy and Geophysics) in Oslo this year. Its use in Australia depends on the establishment in the Southern Hemisphere of an adequate network of upper air sounding stations measuring daily wind, temperature, pressure, and humidity. Without such a network the problems are likely to remain unsolved on other than an empiric basis.

The Officer-in-Charge of this Section has served on advisory committees for the Australian Antarctic Research Expedition. Meteorological problems are prominent in the work of the Expedition. Apart from the day-to-day use in synoptic meteorology, there exists a unique opportunity to make observations of world-wide interest and importance.

(iv) *Micro-meteorology.*—Many applications of meteorology, particularly those in agriculture and soil and moisture conservation, depend on a study of the microstructure of the eddying motion in the surface layers. The interactions and transfers of heat and moisture between the air and the ground or sea are also vital in the purely meteorological problems outlined above.

The concept of air masses plays a central part in modern meteorology. Air masses derive their characteristics from prolonged interactions with the bounding surface. As the major continental air mass source region of the Southern Hemisphere, Australia constitutes an admirable laboratory for research into the processes of air mass modification.

It is planned to carry out experimental and theoretical work in this field. This work will be started when temporary laboratory and workshop facilities are available at Highett. The first phase will be the development of instruments and techniques for measuring and recording, on a sufficiently fine scale, the physical characteristics of atmospheric eddies and the distribution of physical properties in the surface layers.

6. Atomic Physics.

The research work carried out in the Atomic Physics Section may be classified in the following groups: nuclear physics, cosmic ray studies, precision atomic measurements.

(i) *Nuclear Physics.*—(1) *Million Volt Electrostatic Generator.* During 1947 the Van de Graaff generator itself, the accelerating tube for the production of high energy ions by application of the generator potential, and the 90° magnetic spectrometer for the analysis of the ion beam, were completed. Ion beams of one to two microamperes at a million volts were produced and the proton component resolved in November 1947. Leakage currents down the insulating columns supporting the high potential terminal of the generator have been materially reduced by the installation of an air conditioning unit which maintains the room at a relative humidity of approximately 45 per cent. at 60° F.

The rotating voltmeter has been calibrated in terms of the gamma ray resonance potentials of lithium and fluorine under bombardment with protons. Experiments

on the angular distribution of alpha particles produced by the disintegration of lithium and fluorine by protons are proceeding at present.

(2) *Neutron Scattering Experiments.*—(*a*) The 200-kilovolt neutron generator has been rebuilt to bring the target to earth potential and to make it possible to work safely closer to the source of neutrons. The generator uses the reaction of deuterons accelerated to an energy of 200-kilovolts on the deuterons contained in a target of heavy paraffin wax to produce neutrons of energy 2.5 million volts.

(*b*) The angular distribution of neutrons from the deuteron-deuteron reaction has been studied using silver cathode Geiger counters, and the measurements are being extended now using nuclear emulsion plates.

(*c*) A study of the scattering of 2.5 M.e.v. neutrons by deuterons has been made using an expansion chamber filled with heavy methane. This experiment showed an angular distribution of deuteron recoils which was consistent with the assumption of ordinary rather than exchange forces in a close encounter between a neutron and the bound neutron-proton pair which form the nucleus of deuterium. The result is unexpected and the experiments are being extended with greater refinement of measurement.

(3) *Electron Experiments.*—(*a*) The 2.5 M.e.v. Betatron constructed in the laboratory operated satisfactorily. The X-rays produced by impact of the high energy electrons on a tungsten target were shown to be equivalent in ionization intensity to the radiation produced by 1 gram of radium. The energy spectrum was studied with the aid of recoil electrons photographed in a magnetic expansion chamber and it was shown that the distribution was typical neither of thick nor thin target radiation. The maximum of the intensity error is at 1 M.e.v. and tails off rapidly towards the 2.8 M.e.v. limit. This distribution appears to be typical of all electromagnetic electron accelerators. The Betatron is at present under reconstruction for use as a Synchrotron which is expected to produce electrons with energy of 15 M.e.v.

(*b*) About 1,000 electron and a like number of positron tracks of energies ranging between 0.4 and 1.2 M.e.v. have been photographed using a magnetic expansion chamber, and artificial radio elements as sources of electrons and positrons. The particles are scattered as they pass through a thin gold foil, the distribution being significantly different for the negatively and positively charged particles. These experiments show for the first time the effect of spin interaction in the scattering process.

(ii) *Cosmic Ray Research.*—(*a*) A 3-ton magnet which provides a field of 15,000 gauss has been erected. It is provided with trays of Geiger counters above and below the magnet gap which makes possible the resolution of the spectrum of the incoming high energy cosmic ray particles. It is possible to resolve particles with energies approaching 10^{10} electron volts.

(*b*) The mean life of the meson is being measured by measuring the time interval between the arrival in a counter system of a meson and the appearance of the decay electron. Equipment has been constructed for measuring time intervals as small as 10^{-8} sec. Significant differences in the behaviour of positive and negative mesons will be looked for by resolving the oppositely charged particles in an intense magnetic field.

(*c*) Scientific expeditions to Heard Island and Macquarie Island and the *Wyatt Earp* survey voyage have been provided with cosmic ray equipment for recording total intensity of cosmic rays, meson content, and in the cases of the island expeditions, with equipment for recording 1-metre showers and 200-metre showers. Ionization chambers were also sent with the island parties.

The results of the *Wyatt Earp* voyage show a strong correlation between pressure and narrow angle total radiation, the meson content, and the total wide angle record. It was shown that it is necessary to separate the daily and long term temperature correlation coefficients in regions where continental climates exist. It was found that no measurable latitude effect remains after pressure and temperature corrections have been made. The ratios of the total to meson content and the narrow angle intensity to wide angle intensity are independent of latitude south of Melbourne.

(iii) *Precision Atomic Measurements.*—Investigations of the charge on the electron by the oil drop method have been continued. Work during the year includes an investigation of the effect of walls on the motion of falling droplets. The Lorentz correction for this effect has been verified. Effects due to oxidation of the oil, impurity of the air, and the oil layer formed on the bottom plate of the condenser in which the drops are studied have been measured. These experiments have thrown new light on differences in value of e obtained by different workers using this method. A value of e is obtained which agrees with the X-ray value with an accuracy limited only by that of the viscosity of air.

7. Tracer Elements.

(i) *General.*—Early in 1947 the Council and the Commonwealth Department of Health jointly decided to appoint a physicist for work in this rapidly growing field. Dr. T. H. Oddie was appointed in May, 1947, to work in the Commonwealth Department of Health's X-ray and Radium Laboratory at the University of Melbourne.

The work being undertaken includes the following: (i) The procurement, subdivision, and issue of Australian requirements for radioactive tracer elements. (ii) The issue of information and advice on the assay and applications of these materials, both for medical research and therapy and for other research in various scientific fields. (iii) Advice, with the Health Department's officers, on matters of protection and handling of radioactive materials. (iv) Where possible, help with chemical processing or assay measurements of tracer materials.

(ii) *Procurement of Isotopes.*—It is hoped to obtain supplies of radio-isotopes from England as soon as production from the atomic pile there has increased, but at present the only source of supply of isotopes is the United States of America. Artificial radio-elements are obtained from the United States Atomic Energy Commission, whilst some stable isotopes are obtained from the Commission and others from private companies.

(iii) *Investigations.*—The following investigational work is in progress or has been completed: (*a*) Design of minimum weight lead-protected shipping box for gamma ray emitting isotopes. (*b*) Investigation of method of measurement of radio-iodine *in situ* in the human thyroid gland, and analysis of the uptake-time relationship. This work is being done with Dr. R. Kaye Scott and the Royal Melbourne Hospital. (*c*) Design of standard form of probe unit for Geiger counter tubes, to provide well-defined directional properties. Further sensitivity measurements remain to be done for several different radioactive sources. (*d*) Investigations of the suitability of the fluorescent screen method of measuring beta ray emitting isotopes.

8. Electrical Research Board.

The Electrical Research Board was established in 1945 to advise the Council on matters connected with research on electricity and magnetism. It is representative of the Council for Scientific and Industrial Research, the Universities, and the Electricity Supply Association of Australia, and its functions are analogous to those of the Radio Research Board. The Electricity Supply Association of Australia is actively interested in the work of the Board, and its members have agreed to contribute funds totalling £5,000 per annum to enable electrical research to be fostered in the Universities.

Since its inception the Board has been able to give financial assistance to the Electrical Engineering Departments of the Universities of Melbourne, Adelaide, Sydney, Tasmania and Queensland, in connexion with research on the detection of slight out-of-balance conditions in balanced transformer circuits, an electronic switch applied to six-phase problems, the study of the production of radio interference by electric arcs, a high frequency amplifier with positive and negative feedback, and the incidence of lighting on transmission lines.

During the past year work has been initiated at the University of Melbourne on power system stability studies, in order to check the validity of the usual assumptions made in stability studies and to obtain design data for inter-connected systems. At the University of Sydney work has been started on wave telemetering and supervisory control systems.

An investigation concerned with the application of recurrent surges to reactive simulating networks using a recurrent surge oscillograph has been started at the University of Adelaide. Support has been given to work on transient phenomena being carried out at the University of Tasmania.

9. Rubber (Guayule) Investigations.

The work on the study of the growth and rubber content of the guayule plant under Australian conditions has been continued, as designed, along the lines indicated in the earlier reports. Progress has been satisfactory and comparative results for plant samples obtained from the various areas at five years from seed sowing should be available at the end of the current year. As yet, there has been no indication that the rubber content has reached a maximum in any of the localities in which the guayule plots have been established. It is proposed that this work should be continued until the end of June in the coming year, to enable certain aspects of the effects of the different irrigation treatments, in contradistinction to the observed behaviour of plants grown under natural conditions of rainfall and in divergent areas, to be studied more effectively.

The most recent results show that the plants are increasing both in dry weight and rubber content in all the areas being studied. Where rapid growth occurs percentage rubber usually falls although there may still be a substantial increase in total rubber in the plant. As the growth rate decreases both percentage rubber and the total rubber are expected to increase.

Certain effects ascribed to accumulation of salt and water-logging in the soil at Loveday, South Australia, under irrigation, have been observed, but in the same area where no waterlogging has occurred high yields of rubber (123 g. per plant) have been obtained. The irrigated plot at Loxton, South Australia, also maintains its high values (111 g. per plant) and this is from somewhat younger material than that from Loveday. The plot at Morphett Vale, which is near Adelaide, and growing under entirely natural conditions, is giving extremely interesting and relatively high results (80 g. per plant), especially when compared with a plot at Loveday which has not been irrigated since September, 1945, and is yielding only 49 g. per plant.

Analytical work is still continuing on samples collected from guayule plots maintained by the Division of Plant Industry at Canberra, A.C.T., and Lawes, Queensland.

10. Oenological Research.

During the year, the investigation of the factors which influence the growth and metabolism of the film-forming sherry yeasts has been continued. Further information concerning the effects of oxygen supply, sugars, and organic acids on the metabolism of the yeast, has been obtained by using suspensions of non-proliferating cells as well as growing cultures. Four additional strains of the sherry yeasts have been obtained from the University of California collection. These are being compared with strains already in our collection, but up till the present the new strains appear to be inferior to the best of those previously studied. Strains which have been selected as suitable for the production of sherry, on the basis of laboratory trials, have been supplied to a number of winemakers in response to requests for such cultures.

XXIII. INFORMATION SERVICE AND LIBRARY.

A. Information Service.

1. *General.*

The Information Service has continued to occupy temporary accommodation at 425 St. Kilda-road, where it has now been in operation for over two and a half years. It was transferred to the Council's Head Office at the end of the present year.

During the latter part of the year the Officer-in-Charge resigned to take up the position of Chief Scientific Liaison Officer in charge of the Australian Scientific Research Liaison Office, London.

A member of the staff has been appointed Liaison Officer for the Commonwealth Agricultural Bureaux in Australia.

Royal Society Conference on Scientific Information.—Arising from the 1946 Conference in London, a British Commonwealth Conference on the collection, indexing, and distribution of scientific information was held in London in June, 1948. The Officer-in-Charge acted as convener of one of the sub-committees set up to collate the views of those interested in Australia.

2. *Information Section.*

(i) *General.*—The main trend in the work of the Information Section has been towards a greater emphasis on the solution of technological problems, as opposed to bibliographic research such as is undertaken by the modern well-equipped special library. Use of the technical literature, of course, is, and will remain, an essential part of the technique of the Section.

(ii) *Inquiries.*—During the past year about 3,250 inquiries have been handled, representing an increase of 11 per cent. over 1946-47. Approximately 1,350 of these were dealt with summarily by telephone or at personal interview, these being classified for statistical purposes as "minor" inquiries. "Major" and "minor" inquiries, however, are distinguished on the basis of extent of action undertaken by the Information Service and bear no relation to the relative importance of inquiries. A statistical record has been kept of certain details of all major inquiries, the following excerpts from which may be of interest. Industry (industrial processes) was responsible for 47 per cent. of major inquiries, education (private or scientific research, broadcast talks, &c.) for 9, the press (confirmation of news items, &c.) for 1, Government departments for 12, Council for Scientific and Industrial

Research Divisions and Sections for 4, and others (rural, domestic, and miscellaneous) for 27 per cent. Of the total inquiries 70 per cent. were received in the first instance by the Melbourne office and 30 per cent. by the Sydney office. Of the latter total, inquiries amounting to about 2 per cent. of the whole, but including 16 per cent. of major inquiries, were referred to the Melbourne office for attention.

There has been a decrease in the relative number of inquiries received from New South Wales, with slight rises in the numbers received from other, including overseas, sources. Percentages are as follows:—Federal Territories 2, New South Wales 26, Queensland 7, South Australia 5, Tasmania 3, Victoria 51, Western Australia 3, and overseas 3.

Major inquiries have concerned agriculture and biology 23½ per cent., food and food products 9, forestry and forest products 4, building materials and construction 4, chemistry and chemical industries 30, mining, mineralogy, and metallurgy 9, physics and engineering 14½, and miscellaneous 6 per cent.

Staff difficulties, which hampered the Section in the earlier part of the period, have been to some extent mitigated by the addition of first one, and later, a second junior information officer. These appointments have been very successful, and it has been found that a junior, working under close supervision of a trained information officer, is able to make a large contribution to the total output by handling the simple, but time-consuming, routine work.

(iii) *Technical Reports.*—Because of the saturation of the Section's resources by straight-out inquiry work, little has been done to further other projects. One major report has been completed and released, T.6 "Silicones".

The report on liquid liquid extraction referred to in the previous report has been brought to the stage of a final draft, in this case by officers of the Chemical Engineering Section of the Division of Industrial Chemistry, who have been collaborating in this project, and it is likely to be published later in 1948. Some progress has also been made in the preparation of a brochure intended to be a practical guide to those having occasion to use scientific and technical literature.

(iv) *Bibliographies and Summaries of Information.*—Ninety-six bibliographies and summaries of information were prepared during the year. Selected lists of these productions have been published at intervals in appropriate technical and trade journals.

(v) *Photostats.*—Increased use of photostat copies of literature references continues. No difficulty has been experienced in securing the return of this material, which is then of use for subsequent inquiries on the same subject.

(vi) *Australian Chemical Abstracts.*—During the year Information Service officers have prepared about 360 abstracts covering material of chemical interest appearing in Australian periodicals. These abstracts are published monthly by the Australian Chemical Institute as a supplement to its Journal and Proceedings.

(vii) *Phytochemical Register of Australian Plants.*—Research workers have frequently expressed a desire for a comprehensive reference collation of information on chemicals which have been identified as occurring in Australian plants. As a first step a trial compilation covering the family Rutaceae has been undertaken. This will serve as a basis for a rough assessment of the work involved in the proposed comprehensive survey, and will at the same time, supply information requested by a worker in this field.

(viii) *Sydney Office.*—The work of the Sydney office shows an increase as compared with the previous year. The number of inquiries received has increased by 7 per cent., and the distribution of the Council's publications by 40 per cent. As in previous years most of the inquiries have come from secondary industry and were mainly chemical. Inquiries concerning building materials were also frequent. In all, approximately 1,000 inquiries were dealt with.

3. *Translation Section.*

In addition to the translation of technical and scientific material for officers of the Council, this Section has continued the systematic preparation and circulation of contents sheets and summaries of certain Russian scientific journals.

The languages handled by the five translators of the Section have been Russian, German, Swedish, Dutch, French, Italian, Portuguese, Spanish and Norwegian, in about that order of importance. Apart from the large volume of oral translation, the Section has completed well over 1,000 pages of full, formal translation in the period under review. A survey of the requirements of the various Divisions and Sections over a twelve-month period revealed that approximately a quarter of all translation work was required by officers stationed in New South Wales and the Australian Capital Territory, and that their requests were almost entirely for translation from Russian. This suggested the location of a translator, fluent in Russian, at the Sydney office, since oral translation with the officer concerned has proved very efficient. Approval for this arrangement has recently been obtained.

There is a steady demand for translation from Dutch and Scandinavian languages on the part of the Division of Forest Products and the Sections of Building Research and Flax Research. Fortunately these laboratories are all located in Melbourne, and it has been possible for a translator to specialize within a small group of languages and subjects. Such specialization can only be exceptional with a small staff, but, where it is possible, it makes for greater efficiency.

The Section holds, on microfilm, numerous wartime issues of journals from enemy and enemy-occupied countries. Series are incomplete in most instances, and have not been added to, since, in many cases, the originals can now be obtained. However, requests for photostats of some of this material are still being received.

4. *Cine-photographic Section.*

The role of this Section is the production of 16 mm. scientific and technical films on subjects nominated by the Divisions and Sections, which will collaborate closely to ensure that the films are scientifically correct, both in action and commentary. The Department of Information, through its Producer-in-Chief, has kindly offered to assist with certain technical aspects of production. In particular, the Department of Information will undertake to do sound recording and printing for the Section.

During the year the following films were released:—

(*a*) "Northern Australia Reconnaissance Surveys: Part 1—Darwin Katherine Section" (black and white, sound on film, 15 minutes running time). This very briefly records the initial activities of the survey party and gives a good idea of the type of country in this region. The actual photography, in this case, was the work of the leader of the party, a member of the Division of Plant Industry.

(*b*) "Irrigation Research N.S.W." (colour, sound on film, 20 minutes running time). This outlines the research work of the Irrigation Research Station at Griffith in the Murrumbidgee Irrigation Area, New South Wales. It was requested by the Officer-in-Charge of the Station primarily for screening during his visit to similar research stations in the United States of America.

Films which are at present in the course of production are—

(*a*) "Suction Stabilized Wing—The Glas II. Type Aerofoil", for Division of Aeronautics.

(*b*) "Northern Australia Reconnaissance Surveys: Part 2—Barkly Tableland Area", for Division of Plant Industry.

(*c*) "C.S.I.R.—1948" Parts 1 and 2 (a re-edited version of the C.S.I.R. Research Facilities Film made in 1946, which is now being shortened and brought up to date), for the Executive Committee.

(*d*) "Caulking Compounds—Their Use in Modern Building Construction", for Building Research Section.

(*e*) A series of short films on current overseas building construction, methods, and materials (the film shots for this were made by the Officer-in-Charge, Building Research Section, during his recent visit abroad), for Building Research Section.

(*f*) Two short films on current research on improved materials and methods of building construction, for Building Research Section.

Three projects involving the application of cinephotography to research are at present under consideration. The cine record is now recognized as being of particular value in research, as it permits subsequent closer examination of details, with a consequent improvement in analysis and understanding of results.

5. *Central Information Service Activities.*

(i) *Dissemination of Information from Overseas.*—Arrangements have been made for ensuring that the widest use is made of information passed back to Australia by the overseas liaison offices. Unpublished material is carefully appraised and passed to an appropriate library for holding, and those likely to be interested informed of its availability by means of a series of accession lists. These include brief informative abstracts and show the holding points, so that loans may be arranged.

Publication of selected abstracts of reports of wartime research taken from the United States Department of Commerce Bibliography of Scientific and Industrial Reports in Australian scientific and technical journals has continued throughout the period. Over 10,000 such abstracts have now been forwarded to various journals for publication, and requests have been received for procurement of nearly 3,000 reports. Of these, over 2,000 have been ordered from the United States of America and the balance has been made available from local sources, including 284 supplied by the Division of Industrial Development. Current numbers of the Bibliography mentioned above are largely devoted to German material, much of which has not been published before in any form. In appropriate cases the Information Service procures a complete group of documents on microfilm, thus enabling prints of particular frames to be made to meet local demands at a cost far below that asked in the United States of America. This, of course, reduces delays and conserves dollars.

(ii) *Declassification of Reports of Australian Wartime Research.*—Information Service has undertaken to arrange for the declassification of reports of Australian war-time research in appropriate cases. Abstracts of several hundred declassified reports have so far been prepared and these are now appearing in the United States Department of Commerce Bibliography of Scientific and Industrial Reports.

6. *Commonwealth Agricultural Bureaux.*

As Australian Liaison Officer of the Commonwealth Agricultural Bureaux, the Officer-in-Charge of Information Service, in October, 1947, called a conference of all the Official Correspondents in Australia. The work of the 1946 Imperial (now Commonwealth) Agricultural Bureaux Conference in London was discussed and the list of existing Official Correspondents overhauled and several new appointments made. Steps have also been taken to improve the position regarding distribution and sale of C.A.B. publications in Australia.

7. *Dairy Production Abstracts.*

A Sub-Committee of the Australian Committee on Animal Production has now arranged to issue, at quarterly intervals, a collection of selected Dairy Production Abstracts, intended primarily for distribution by State Departments of Agriculture. The Information Service has accepted the responsibility for production of these quarterly issues from references selected by the Sub-Committee. Three issues, each of 500 copies, have been made to date. So far Dairy Production Abstracts have been limited to selections from Commonwealth Agricultural Bureaux publications and from the United States Department of Agriculture Experiment Station Record, but it is proposed, when the staff position permits, to include abstracts of accounts of Australian work.

B. Library.

The library, as maintained by the Council, is of interest in that it is a library system rather than a library unit. Each of the Divisions, Centres, and Research Stations has its individual collection of books, periodicals, and other library material and, in fact, carries out all activities connected with the working of a research library. The work of these individual libraries is, however, co-ordinated in the Head Office library where the main connecting link, the Union Catalogue, is maintained. In this catalogue a record is kept of the holdings of all the other libraries, no matter how large or how small. The maintenance of this catalogue is becoming an ever increasing problem as each new Section or library is established.

The Head Office library receives a continual stream of inquiries by letter, by telephone, or by personal request for book and periodical references. By means of the Union Catalogue the whole resources of the libraries of the Council are available for answering these inquiries. If the publication under request is in one of the other Divisions the inquirer can either be referred direct there or the publication is borrowed by Head Office and made available. By this means, the resources of a relatively large scientific reference library, covering all branches of scientific and technical literature, is available not only to all officers of the Council but to scientific research workers throughout the Commonwealth. The maintenance of this Union Catalogue lessens the danger of unnecessary duplication of books and periodicals in the various Divisional libraries.

The revised edition of the Catalogue of Scientific and Technical Periodicals has reached the stage at which reproduction by the Varitype process has been commenced. It is not anticipated, however, that it will be available for distribution for some time yet.

XXIV. FINANCIAL MATTERS, STAFF, PUBLICATIONS AND COMMITTEES.

1. Finance.

The statement of expenditure from 1st July, 1947, to 30th June, 1948, is as follows:—

	£	£	£
1. Salaries and contingencies			111,621*
2. Remuneration of Chairman and Members of Council			3,835†
3. Investigations—		£	
(i) Animal Health and Production Problems		183,463	
Less contributions from—	£		
Wool Research Fund	69,357		
Wool Industry Fund	9,652		
Commonwealth Bank	2,700		
Queensland Government	1,000		
Australian Cattle Research Association	3,750		
Australian Meat Board	320		
Ian McMaster Estate	523		
Alex Fraser Memorial Fund	300		
George Aitken Pastoral Research Trust	275		
Australian Wool Board	71		
Revenue Funds—			
Vaccine	3,708		
Pleuro-pneumonia	1,985		
Mastitis	865		
F. D. McMaster Field Station	371		
Poultry	730		
"Gilruth Plains" Field Station	5,164		
Parkville	246		
Tooradin Field Station	434		
Oestrus Investigations	272		
Bacteriology	177		
Parasitology	122		
Toxaemic Jaundice—Parkville	43		
Barooga Field Station	12		
		102,077	
			81,386
(ii) Biochemistry and General Nutrition Problems		57,186	
Less contributions from—			
Commonwealth Bank	900		
Wool Research Fund	21,155		
Wool Industry Fund	7,469		
George Aitken Pastoral Research Trust	225		
		29,749	
			27,437
(iii) Plant Problems—Division of Plant Industry		183,344	
Less contributions from—			
Wool Research Fund	34,109		
Wool Industry Fund	23,600		
Tobacco Fund	4,106		
Department of Post-war Reconstruction	6,981		
Western Australian Golf Association	3		
		68,799	
			114,545
(iv) Entomology Problems—Division of Economic Entomology		58,536	
Less contributions from—			
Wool Research Fund	556		
		556	
			57,980
(v) Horticultural Problems of the Irrigation Settlements—			
(*a*) Citricultural—Research Station, Griffith	38,111		
Less contributions	8,728		
		29,383	
New South Wales Water Conservation and Irrigation Commission	2,697		
New South Wales Department of Agriculture	1,225		
Rural Bank of New South Wales	1,368		
Yenda Producers' Co-operative Society Limited	137		
Griffith Producers' Co-operative Company	410		
Leeton Fruit Growers' Co-operative Company	137		
Leeton Co-operative Canneries Limited	821		
Rice Equalization Association Limited	250		
Rice Marketing Board	250		
Griffith Revenue Fund	1,433		
(*b*) Viticultural—Research Station, Merbein	16,576		
Less contributions	2,575		
		14,001	
			43,384
Dried Fruits Control Board	1,052		
Irymple Packing Proprietary Limited	183		
Mildura Co-operative Fruit Company	183		
Red Cliffs Co-operative Fruit Company	183		
Aurora Packing Proprietary Limited	183		
Nyah-Woorinen Dried Fruits Enquiry Committee	55		
Merbein Research Station Revenue Fund	736		
(vi) Soil Problems		41,657	
Less contribution from—			
Commonwealth Bank	2,000		
		2,000	
			39,657

* 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.

	£	£	£
(vii) Food Preservation and Transport Problems		59,761	
Less contributions from—			
Commonwealth Bank	2,400		
New South Wales Department of Agriculture	1,000		
Queensland Meat Industry Board	850		
Australian Meat Board	375		
Metropolitan Meat Industry Commission	500		
Egg Producers' Council	30		
Department of Commerce and Agriculture	810		
William Angliss Grant	328		
Food Preservation Revenue Fund	75		
		6,368	
			53,393
(viii) Forest Products Problems		106,387	
Less contributions from—			
Australian Paper Manufacturers Limited	500		
Associated Pulp and Paper Mills Limited	500		
Australian Newsprint Mills Limited	500		
Commonwealth Bank	2,000		
Beetle Plastics Proprietary Limited	47		
Miscellaneous contributions	62		
Forest Products Revenue Fund	245		
		3,854	
			102,533
(ix) Mining and Metallurgy		9,647	
Less contributions from—			
Australasian Institute of Mining and Metallurgy	500		
		500	
			9,147
(x) Radio Research		18,196	
Less contributions from—			
Postmaster-General's Department	4,500		
Departments of Army, Navy and Air	9,000		
		13,500	
			4,696
(xi) Information Service, including Library			25,317
(xii) Industrial Chemistry		153,114	
Less contributions from—			
Wool Research Fund	5,328		
Australian Cement Manufacturers Association	750		
National Gas Association	300		
		6,378	
			146,736
(xiii) Fisheries Investigations		62,591	
Less contributions from—			
New South Wales Government	250		
Oyster Revenue Fund	150		
		400	
			62,191
(xiv) Aeronautical Research			165,687
(xv) National Standards Laboratory		170,219	
Less contributions from—			
Wool Research Fund	1,537		
		1,537	
			168,682
(xvi) Building Research			61,734
(xvii) Flax Research			21,140
(xviii) Radiophysics Laboratory			135,015
(xix) Tribophysics			30,712
(xx) Miscellaneous—			
(*a*) Mathematical Research		14,741	
(*b*) Dairy Research		7,620	
(*c*) Oenological Research		1,028	
(*d*) Various		12,814	
		36,203	
Less contributions—			
Australian Wine Board		485	
			35,718
(xxi) Nuclear Energy Research			23,345
(xxii) Metallurgical Research			7,195
(xxiii) Meteorological Research			5,787
(xxiv) Overseas Studentships		15,161	
Less contributions—			
Wool Research Fund		394	
			14,767
(xxv) Fuel Research including Coal Dust Investigations			2,124
(xxvi) Unforeseen			420
(xxvii) Wool Textile Research		10,295	
Less contributions from—			
Wool Research Fund	9,583		
Wool Industry Fund	712		
		10,295	
Total of Item 3—Investigations			1,440,728
4. Grants to Research Associations—			
Leather Research			1,935

2. Contributions and Donations.

The following statement shows the receipts and disbursements during the year 1947-48 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled "The Specific Purposes Trust Account":—

	Receipts 1947-48 and balances brought forward from 1946-47. £	Expenditure 1947-48. £
Wool Industry Fund Account ..	53,803 ..	41,432*
Commonwealth Bank (Animal Health and Production, Horticultural, Food Preservation and Transport, and Forest Products Investigations)	10,091 ..	10,000
Australian Wool Board (Animal Health and Production Investigations—Sheep Research) ..	2,579 ..	71
Australian Cattle Research Association (Mastitis Investigations)	3,750 ..	3,750
George Aitken Pastoral Research Trust (Animal Health and Production Investigations) ..	1,000 ..	500
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)	1,000 ..	320
Australian Meat Board (Caseous Lymphadenitis Investigations—Animal Health and Production)	212 ..	..
Alexander Fraser Memorial Fund	300 ..	300
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) ..	523 ..	523
Victorian Central Citrus Association—Citrus Problems (Plant Industry Investigations) ..	100 ..	..
West Australian Golf Association (Plant Industry Investigations)	200 ..	3
Tobacco Trust Fund—Prime Minister's Department and Department of Commerce—Tobacco Problems (Plant Industry Investigations)	8,057 ..	4,135A
Department of Post-war Reconstruction—Northern Australia Regional Survey (Division of Plant Industry)	6,981 ..	6,981
United Graziers Association of Queensland—Buffalo Fly and Cattle Tick Investigations (Economic Entomology)	172 ..	..
Beetle Plastics Ltd.—Eucalypt Pulp (Division of Forest Products)	47 ..	47
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 (M.I.A. Irrigation Research Extension Service) ..	1,358 ..	1,226
New South Wales Water Conservation and Irrigation Commission (M.I.A. Irrigation Research Extension Service)	788 ..	697
Griffith Producers' Co-op. Co. Ltd. (M.I.A. Irrigation Research Extension Service)	463 ..	410
Rural Bank of New South Wales (M.I.A. Irrigation Research Extension Service)	1,546 ..	1,368
Yenda Producers' Co-op. Society Ltd. (M.I.A. Irrigation Research Extension Service)	154 ..	137
Carried forward ..	96,254 ...	74,900

* Expended as follows:—Extensions and erections, Armidale—£3,339. Advance purchase cost Sheep Biology Laboratory land, Prospect—£6,000. Acquisition fees "Saumarez" property—£3. Purchase Army hut, Cobram—£310. Purchase property and buildings, Konjonup—£23,100. Advance erection house, Trangie—£500. Erection store and garage, O'Halloran Hill—£3,842. Erection Nutrition Laboratory, Adelaide—£3,626. Purchase and erection Army huts, Geelong, £712.

A. Includes £29 on account of 1946-47 expenditure.

	Receipts 1947-48 and balances brought forward from 1946-47. £	Expenditure 1947-48. £
Brought forward ..	96,254 ..	74,900
Leeton Fruit Growers' Co-op. Society Ltd. (M.I.A. Irrigation Research Extension Service) ..	200 ..	137
Leeton Co-op. Canneries Ltd. (M.I.A. Irrigation Research Extension Service)	927 ..	821
Rice Marketing Board, Leeton (M.I.A. Irrigation Research Extension Service)	250 ..	250
Rice Equalization Association (M.I.A. Irrigation Research Extension Service)	250 ..	250
Mildura Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	193 ..	193A
Irymple Packing Co. (Dried Vine Fruits Investigations, Merbein)	193 ..	193A
Red Cliffs Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	193 ..	193A
Aurora Packing Co. (Dried Vine Fruits Investigations, Merbein)	193 ..	193A
Dried Fruits Control Board (Dried Fruits Investigations) ..	1,600 ..	1,052
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	288 ..	57
Australian Meat Board (Meat Investigations)	500 ..	500B
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)	1,200 ..	1,200C
A. Lawrence and Co. (Division of Food Preservation and Transport)	74 ..	..
W. Angliss Ltd. (Division of Food Preservation and Transport) ..	502 ..	328
L. Berger and Sons (Division of Food Preservation and Transport)	25 ..	..
Batlow Packing House Co-op. Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations)	400 ..	..
Ungars Peanuts Pty. Ltd. (Division of Food Preservation and Transport—Canning Investigations)	10 ..	..
Various Contributors (Division of Food Preservation and Transport —Fruit Juice Investigations) ..	40 ..	..
Egg Producers' Council (Division of Food Preservation and Transport—Egg Investigations) ..	32 ..	32D
Department of Commerce and Agriculture (Division of Food Preservation and Transport—Dehydration Investigations) ..	810 ..	810
New South Wales Department of Agriculture—Quick Freezing of Fruit and Vegetables (Division of Food Preservation and Transport)	234 ..	32E
Australian Paper Manufacturers Ltd. (Paper Pulp Investigations)	500 ..	500
Associated Pulp and Paper Mills Ltd. (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 ..	62
Sundry Contributions (Forest Products Investigations)	2,404 ..	245
Australasian Dairy Council (Wood Taint in Butter Investigations)	11 ..	..
Carried forward ..	109,708 ..	84,298

A. Includes £10 on account of 1946-47 expenditure.
B. Includes £125 on account of 1946-47 expenditure.
C. Includes £200 on account of 1946-47 expenditure.
D. Includes £2 on account of 1946-47 expenditure.
E. Includes £32 on account of 1946-47 expenditure.

	Receipts 1947-48 and balances brought forward from 1946-47.	Expenditure 1947-48.
	£	£
Brought forward ..	109,708	84,298
Miscellaneous Contributors (Division of Forest Products—Veneer and Gluing Work)	8	..
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	500	500
Postmaster-General's Department (Radio Research)	4,500	4,500
Departments of Army, Navy and Air (Radio Research)	9,000	9,000
Sundry Contributions (Foreign Journal Service)	9	..
New South Wales Government (Fisheries Investigations) ..	250	250
Drug Houses of Australia (Division of Fisheries—Agar Production)	25	..
Commonwealth Fertilizers and Chemicals (Industrial Chemistry)	200	..
National Gas Association (Gas Investigations—Industrial Chemistry)	1,333	300
Australian Cement Manufacturers (Cement Investigations—Industrial Chemistry, Soils) ..	750	750
Australian Cement Manufacturers —Calibrating Cement Testing Equipment (National Standards Laboratory)	150	..
Department of Commerce and Agriculture (Apple and Pear Investigations)	55	..
Department of Navy	1,270	..
Sundry Contributors (Council for Scientific and Industrial Research—Publications) ..	24	..
Various Contributors (Division of Industrial Chemistry) ..	637	..
Wool Scourers, Carbonizers and Fellmongers Federation of Australia (Division of Industrial Chemistry)	3,000	..
Alfred Lawrence and Co. Ltd. (Division of Industrial Chemistry) ..	105	..
British Industrial Plastics (Plastics Research—Division of Industrial Chemistry)	50	..
Various Contributors (Foundry Sands Investigations—Division of Industrial Chemistry) ..	28	..
Commonwealth Aircraft Corporation (Division of Metrology, N.S.L.)	1,167	..
Australian Wine Board—Oenological Research	485	485
Revenue Fund—Fleece Analysis Laboratory (Animal Health and Production Investigations) ..	56	..
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Production Investigations)	1,408	42
Revenue Fund—Contagious Pleuro-pneumonia Investigations (Animal Health and Production Investigations)	2,198	1,985
Revenue Fund—Helenslee Field Station (Animal Health and Production Investigations) ..	451	..
Revenue Fund—Oestrus Experiment (Animal Health and Production Investigations) ..	907	272
Revenue Fund—Sale of Contagious Pleuro-pneumonia Vaccine (Animal Health and Production Investigations) ..	3,708	3,708
Revenue Fund—Sale of Strain 19 Vaccine (Animal Health and Production Investigations) ..	581	..
Revenue Fund—Anaplasmosis Investigations (Animal Health and Production Investigations)	96	..
Revenue Fund—Parkville Laboratory (Animal Health and Production Investigations) ..	291	246
Revenue Fund—Tooradin Field Station (Animal Health and Production Investigations) ..	1,015	434
Carried forward ..	143,965	106,770

	Receipts 1947-48 and balances brought forward from 1946-47.	Expenditure 1947-48.
	£	£
Brought forward ..	143,965	106,770
Revenue Fund—Poultry Breeding Investigations, Werribee (Animal Health and Production Investigations)	919	730
Revenue Fund—Werribee Farm Mastitis Investigations (Animal Health and Production Investigations)	3,968	865
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)	5,164	5,164
Reserve Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Production Investigations)	469	..
Revenue Fund—Bacteriological Investigations (Animal Health and Production Investigations)	177	177
Revenue Fund—Parasitological Investigations (Animal Health and Production Investigations)	1,561	122
Revenue Fund—McMaster Laboratory Regional Pasture Research Station (Animal Health and Production Investigations) ..	1,422	..
General Donations—Building Research Section	26	..
Revenue Fund—Infertility, F. D. McMaster Field Station (Animal Health and Production Investigations)	3,197	370
Dairy Revenue Fund—F. D. McMaster Field Station (Animal Health and Production Investigations)	104	..
Revenue Fund—Toxaemic Jaundice Investigations, Barooga, New South Wales (Animal Health and Production Investigations)	473	12
Revenue Fund—Nutrition Laboratory (Biochemistry and General Nutrition Investigations) ..	2,148	..
Revenue Fund—Plant Industry Investigations	5,245	..
Revenue Fund—Medicinal Plants (Plant Industry Investigations)	4	..
Revenue Fund—Entomological Investigations	985	..
Revenue Fund—Griffith Research Station (Citricultural Investigations)	1,792	1,433
Revenue Fund—Merbein Research Station (Viticultural Investigations)	9,674	736
Revenue Fund—Division of Food Preservation and Transport ..	148	75
Revenue Fund—Egg Investigations, Egg Producers' Council (Division of Food Preservation and Transport)	224	..
Revenue Fund—Mining and Metallurgy	14	..
Revenue Fund—Ore-dressing Investigations	962	..
Revenue Fund—Fisheries Investigations	111	..
Revenue Fund—Oyster Investigations	250	150
Revenue Fund—Division of Aeronautics	180	..
Revenue Fund—Physics ..	653	..
Revenue Fund—National Standards Laboratory	33	..
Revenue Fund—Metrology ..	1,475	..
Revenue Fund—Dairy Investigations	10	..
Revenue Fund—Electrotechnology	172	..
Revenue Fund — Industrial Chemistry	490	..
Revenue Fund—Radiophysics ..	28	..
Carried forward ..	186,106	116,604

	Receipts 1947-48 and balances brought forward from 1946-47. £	Expenditure 1947-48. £
Brought forward ..	186,106	116,604
Revenue Fund—Merbein Research Station—Production of Pyrethrum	185	..
Revenue Fund—Information Service	76	..
Revenue Fund—Fellmongery Research	27	..
	186,394	116,604

3. Wool Research Trust Account.

A credit balance of £183,368 was brought forward from 1946-47 in the Wool Research Trust Account. A further £546,799 was received during 1947-48 from the Department of Commerce and Agriculture. Expenditure during 1947-48 was as follows:—

	£	£	£
Division of Animal Health and Production—			
Parkville Laboratory—Chemical Pathology including—			
Toxaemic Jaundice Investigations	2,338		
Sheep Physiology Investigations	3,046		
Field Investigations at Barooga and selected properties—Toxaemic Jaundice Investigations ..	1,444		
McMaster Laboratory—			
Parasitology Investigations ..	2,204		
Parasite Physiology and Toxicology	1,579		
Dipping and External Parasites	961		
Biochemical Investigations ..	1,159		
Physiology of Reproduction ..	1,527		
Fellowship in Genetics and Animal Breeding	19		
Wool Biology Laboratory, Sydney—Investigations	7,707		
Armidale Laboratory—Parasitology Field Investigations	28,317		
Villawood—Fleece Analysis Laboratory	10,427		
Prospect—Sheep Biology Laboratory	64		
McMaster Field Station	3,652		
"Gilruth Plains"—			
Capital	1,037		
Annual	1,500		
Agrostology	403		
Animal Breeding Investigations	1,973		
		69,357	
Division of Plant Industry—Agrostology Investigations ..	34,235		
		34,235	
Division of Economic Entomology—Cockchafer Grub Investigations ..	557		
		557	
Division of Industrial Chemistry ..	5,328		
		5,328	
Division of Physics—Wool Research	1,537		
		1,537	
Division of Biochemistry and General Nutrition—Biochemical and Nutritional Investigations	21,155		
		21,155	
Miscellaneous—			
Overseas Studentships	394		
Wool Textile Research	9,583		
		9,977	
			142,146
Grants from Wool Research Trust Account to Institutions undertaking wool research—			
University of Melbourne—Survey of Wool Industry in Western District	3,250		
University of Western Australia—Investigations at Institute of Agriculture, Western Australia	1,800		
Department of Agriculture, Western Australia—Sheep Infertility Investigations	2,408		
Roseworthy Agricultural College—Investigations	100		
Carried forward ..	7,558	..	142,146

	£	£	£
Brought forward ..	7,558	..	142,146
Sydney Technical College—Extramural Co-operative Investigations	1,500		
Department of Agriculture, Brisbane—Extramural Co-operative Investigations	193		
Gordon Institute of Technology, Geelong—Extramural Co-operative Investigations	1,500		
Wool Industries Research Association, Leeds, U.K.—Extramural Co-operative Investigations ..	2,508		
		13,259	
Grants from Wool Research Trust Account to Institutions undertaking research in agricultural economics—			
University of Western Australia—Rural Economics	887		
University of Adelaide—Debt Structure and Interest Costs in Wool-growing	550		
University of Tasmania—Investigations	225		
Department of Commerce and Agriculture—Reimbursement of Expenditure	8,634		
Department of Post-War Reconstruction—Reimbursement of Expenditure	356		
		10,652	
Wool Consultative Council—Members' fees and sitting expenses ..	*Cr.* 12	*Cr.* 12	
			23,899
			166,045

4. Staff.

The following is a list of the staff of the Council as at 30th June, 1948. 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. White, M.Sc., Ph.D.
Executive Officer—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.
Assistant Secretary—G. B. Gresford, B.Sc.
Assistant Secretary (Finance and Supplies)—M. G. Grace, A.I.C.A.
Miss J. Dunstone, B.Sc., Dip.Ed.
Architect—W. R. Ferguson, B.E.
Electrical and Mechanical Engineer—R. N. Morse, B.Sc., B.E.
Mechanical Engineer—F. G. Hogg, B.Eng.
Clerical Assistant to Chairman—Miss A. Slattery, B.A.
Editorial—
Editor—N. S. Noble, D.Sc.Agr., M.S., D.I.C.
Miss L. F. Plunkett, B.Sc.
Library—
Chief Librarian—Miss E. Archer, M.Sc.
Librarian—Miss A. L. Kent.
Librarian—Miss F. V. Murray, M.Sc.
Assistant Librarian—Miss J. A. Conochie, B.Sc.
Assistant Librarian—Miss E. E. Scurrah.
Assistant Librarian—Miss J. M. Flaherty, B.A.
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. Knuckey.

Liaison Overseas—
London—
J. E. Cummins, B.Sc., M.S.
D. T. C. Gillespie, M.Sc.
Washington—
N. A. Whiffen, F.S.T.C.
Information Service—
Administration—
Acting Officer-in-Charge—C. M. Gray, O.B.E., M.Sc.
Technical Secretary—F. A. Priest, A.S.A.S.M.
Technical Records—Mrs. J. M. E. Travers, B.Sc.
Information Section—
Senior Research Officer—C. M. Gray, O.B.E., M.Sc.
Senior Research Officer—A. B. Cashmore, M.Sc. (C.A.B. Liaison Officer).
Senior Research Officer—D. T. C. Gillespie, M.Sc. (seconded).
Research Officer—G. J. Wylie, B.A., B.Sc.
Research Officer—Miss J. McL. Baldwin, B.Sc. (on leave).
Research Officer—Miss S. M. Andrews, B.Sc.
Research Officer—H. E. Booth, A.S.T.C.
Research Officer—D. R. Meadley, B.Ag.Sc.
Overseas Liaison—Miss I. H. Robertson, M.Sc., D.A.C.
Translation Section—
Senior Translator—A. L. Gunn.
Translator—E. Feigl, Ph.D.
Translator—E. W. Selman Towt.
Translator—Mrs. M. Slade.
Cine-photographic Section—
Research Officer—S. T. Evans, B.Sc.
Sydney Office—
Research Officer—A. M. Andrews, B.Sc.

2. *Secretaries of State Committees.*

New South Wales—
A. M. Andrews, B.Sc., Phillip House, 199 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.), Department of Agriculture, Perth, W.A.
Tasmania—
F. J. Carter, c/o Premier's Office, Hobart.

3. *Division of Plant Industry.*

(Head-quarters: Canberra, A.C.T.)

At Canberra—
Administration—
Chief—B. T. Dickson, B.A., Ph.D.
Technical Secretary—W. Ives, M.Ec., A.I.C.A.
Technical Officer (photographer)—J. B. Pomeroy.
Librarian (half time)—Miss J. Humphreys, B.A., Dip.Ed.
Senior Clerical Officer (half time)—K. J. Prowse.
Accountant (half time)—D. W. Banyard.
Plant Pathology—
Principal Research Officer—H. R. Angell, O.B.E., Ph.D.
Senior Research Officer—W. V. Ludbrook, M.S., B.Ag.Sc., Ph.D.
Research Officer—D. O. Norris, D.Sc.(Agric.)
Research Officer—J. H. E. Mackay, B.Sc.Agr.
Research Officer—Miss M. Mills, B.Sc.
Research Officer—Miss K. Helms, B.Sc.
Plant Introduction—
Senior Research Officer—W. Hartley, B.A., Dip.Agr.
Research Officer—C. A. Neal-Smith, B.Ag.Sc., R.D.A.
Horticultural Investigations—
Principal Research Officer—C. Barnard, D.Sc.
Medicinal and Drug Plant Investigations—
Senior Research Officer—K. L. Hills, M.Agr.Sc.
Research Officer—Miss C. Rodwell, B.Sc.
Technical Officer—Miss S. I. Eldridge.
Plant Physiology—
Senior Research Officer—R. F. Williams (seconded).
Research Officer—J. Calvert, D.Sc.
Herbarium—
Research Officer—Miss N. T. Burbidge, M.Sc.
Agrostology—
Senior Principal Research Officer—J. G. Davies, B.Sc., Ph.D.
Principal Research Officer—C. S. Christian, M.Sc.
Senior Research Officer—C. M. Donald, M.Ag.Sc.
Research Officer—W. M. Willoughby, B.Sc.Agr.
Research Officer—K. D. McLachlan, B.Sc.Agr.
Research Officer—E. F. Biddiscombe, B.Sc. (Agric.).
Research Officer—R. A. Perry, B.Sc.
Technical Officer—R. E. Herrington, Q.D.H.
Technical Officer—G. R. Thomas, Q.D.A.H.
Junior Technical Officer—R. G. Fawcett, R.D.A.
Technical Assistant—A. Axelsen, Q.D.A.H.
Agrostology, Pasture Ecology—
Research Officer—C. W. E. Moore, B.Agr.Sc.
Agrostology, Weeds Investigations—
Senior Research Officer—R. M. Moore, B.Sc.Agr.
Technical Officer—R. T. Milligan, Dip.Agr.D.
Technical Officer—C. S. McKay, Dip.Agr.D.
Technical Officer—J. A. Robertson, Q.D.D.M.
Agrostology, Mineral Deficiency Studies—
Research Officer—A. J. Anderson, B.Sc.(Agric.).
Research Officer—D. Spencer, B.Sc.
Technical Officer—D. Moye, H.D.A.
Agrostology, Weeds Physiology—
Senior Research Officer—C. G. Greenham, M.Sc.
Research Officer—P. Goldacre, B.Sc.
Agrostology, Pasture Chemistry—
Technical Officer—F. K. Mayer, Q.D.A.
Tobacco Investigations—
Senior Research Officer—A. V. Hill, M.Agr.Sc.
Research Officer—R. Johanson, B.Sc.
Research Officer—T. G. Haney, B.Sc.Agr.
Research Officer—W. J. Lovett, B.Agr.Sc.
Technical Officer—G. P. Kelenyi, Dip.Agr.D.
Technical Officer—R. Wells, Q.D.A.
Vegetable Investigations—
Senior Research Officer—E. M. Hutton, M.Sc., B.Ag.Sc.
Research Officer—D. C. Wark, M.Agr.Sc.
Research Officer—R. D. Brock, B.Agr.Sc.
Technical Officer—A. R. Peak, H.D.A.
Technical Officer—C. D. Matthews, R.D.A.
Dickson Experiment Station, Canberra, A.C.T.—
Manager—L. Sharp, Dip.Agr.D.
At Queensland University, Brisbane, Queensland—
Senior Research Officer (agrostology)—T. B. Paltridge, B.Sc.
Senior Research Officer (plant introduction)—J. F. Miles, B. Agr.Sc.
Research Officer (pasture chemistry)—E. H. Kipps, B.Sc.
Technical Officer (agrostology)—G. H. Allen, G.D.A.
Technical Officer (native plants investigations)—L. J. Webb, B.Sc.
Clerical Officer—K. J. Fogarty.

At Cooper Laboratory, Queensland Agricultural High School and College, Lawes—
Research Officer (agrostology)—N. H. Shaw, B.Agr.Sc.
Research Office (plant introduction)—S. G. Gray, B.Sc.Agr.
Research Officer (agrostology)—W. J. Bisset, B.Agr.Sc.
Research Officer (agrostology)—Miss H. Barford, B.Sc.
Research Officer (agrostology)—F. H. Kleinschmidt, B.Agr.Sc.
Technical Officer (plant introduction)—K. B. Andersen, Q.D.A.
Technical Officer (plant introduction)—W. G. Robertson, Q.D.A. (on study leave).
Technical Officer (agrostology)—W. J. Wyndham, Q.D.D.H.
Technical Officer (agrostology)—R. Milford, Q.D.A. (on study leave).
Technical Officer (agrostology)—G. J. Downing, Q.D.A.H.
Technical Officer (agrostology)—T. W. Elich, Dip.Col.Ag.
Technical Officer (agrostology)—R. H. Macarthur, Q.D.A.H.
Technical Officer (agrostology)— W. H. J. Pieters, Dip.Col.Ag.

At Gilruth Plains, Queensland—
Technical Officer (agrostology)—A. J. Callander, H.D.A.
Technical Officer (agrostology)—K. C. Baker, Q.D.H.

At Stanthorpe, Queensland—
Senior Research Officer (horticultural investigations)—L. A. Thomas, M.Sc.
Research Officer (horticultural investigations)—R. C. Colbran, B.Agr.Sc.

At Regional Pastoral Laboratory, Deniliquin, New South Wales—
Senior Research Officer (agrostology)—R. W. Prunster, B.Sc.(Agric).
Senior Research Officer (agrostology)—A. L. Tisdall, M.Agr.Sc.
Research Officer (agrostology)—O. B. Williams, B.Agr.Sc.
Technical Officer (agrostology)—K. R. Brown, Dip.Agr.D.
Technical Officer (agrostology)—F. Arndt, Q.D.A.
Clerical Officer—S. J. Cossar.

At Falkiner Memorial Field Station, Deniliquin, New South Wales—
Station Manager—G. A. Vasey.

At the University of Western Australia, Perth, Western Australia—
Research Officer (agrostology)—R. C. Rossiter, B.Sc.(Agric.).
Research Officer (plant introduction)—E. T. Bailey, B.Sc.
Research Officer (agrostology)—H. L. Pennington, B.Sc.(Agric.).
Technical Officer (plant introduction)—N. B. Gayfer, Dip.Agr.D.
Technical Officer (agrostology)—R. J. Pack, Q.D.A.
Technical Officer (agrostology)—J. Beresford, Dip.Agr.D.

At Regional Pastoral Laboratory, Armidale, New South Wales—
Senior Research Officer (agrostology)—R. Roe, B.Sc.(Agric.).
Research Officer (agrostology)—E. J. Hilder, B.Sc.(Agric.).
Technical Officer (agrostology)—R. G. Wilson, Q.D.D.M.
Technical Officer (agrostology)—M. J. Hibberd, Q.D.A.H.
Junior Technical Officer (agrostology)—E. G. Harrison, Dip.Agr.D.

At Huonville, Tasmania—
Senior Research Officer (horticultural investigations)—D. Martin, B.Sc. (seconded).

At Kimberley Research Station, Western Australia—
Technical Officer (agrostology)—E. C. B. Langfield.

At Katherine Experiment Station, Northern Territory—
Research Officer—W. Arndt, B.Agr.Sc.
Technical Officer—L. J. Phillips, Q.D.D.M.
Farm Manager—F. Kent, H.D.A.
Clerical Officer—A. T. C. Watson.

At State Experiment Farm, Trangie, New South Wales—
Technical Officer (agrostology)—R. J. Hutchings, Dip.Agr.D.

At Waite Agricultural Research Institute, Adelaide, South Australia—
Research Officer (gummosis investigations)—Miss J. Grace, B.Sc.Agr.

Northern Australia Regional Survey—
Supply and Transport Officer—H. J. Mason.

4. *Division of Economic Entomology.*
(Head-quarters: Canberra, A.C.T.)

At Canberra—
Administration—
Chief—A. J. Nicholson, D.Sc.
Technical Secretary—I. F. B. Common, M.A., B.Agr.Sc.
Principal Research Officer—F. N. Ratcliffe, B.A.
Librarian (half-time)—Miss J. Humphreys, B.A., Dip.Ed.
Senior Clerical Officer (half-time)—K. J. Prowse.
Accountant (half-time)—D. W. Banyard.
Biological Control and Museum—
Senior Research Officer—F. Wilson.
Research Officer—T. G. Campbell.
Research Officer—S. J. Paramonov, D.Sc.
Research Officer—E. F. Riek, M.Sc.
Technical Officer—A. T. Mills.
St. John's Wort—
Research Officer—L. R. Clark,M.Sc.
Research Officer—Mrs. N. Clark, B.Sc.Agr.
Physiology and Toxicology—
Senior Research Officer—D. F. Waterhouse, M.Sc.
Research Officer—M. F. Day, B.Sc., Ph.D.
Research Officer—D. Gilmour, M.Sc.
Research Officer—R. H. Hackman, M.Sc. (abroad).
Research Officer—R. W. Kerr, B.Sc.
Research Officer—R. F. Powning, A.S.T.C.
Technical Officer—J. H. Calaby.
Locust and Pasture Pests—
Senior Research Officer—K. H. L. Key, D.Sc.
Research Officer—P. B. Carne, B.Agr.Sc.
Vegetable Pests and Virus Vector Investigations—
Research Officer—G. A. H. Helson, M.Sc.
Research Officer—T. Greaves.
Technical Officer—N. E. Grylls, Dip.Agr.D.
Termite Investigations—
Research Officer—F. J. Gay, B.Sc., D.I.C.

At Yeerongpilly, Queensland—
Veterinary Entomology—
Senior Research Officer—L. F. Hitchcock, M.Sc.
Senior Research Officer—K. R. Norris, M.Sc.
Research Officer—W. J. Roulston, B.Sc.

Research Officer—G. J. Snowball, B.Sc.
Technical Officer—R. A. J. Meyers, Q.D.A.H., Q.D.D.
Technical Officer—J. T. Wilson, Dip.Ag.

In Western Australia—
Earthmite Investigations—
Research Officer—M. M. H. Wallace, B.Sc.
Technical Officer—J. A. Mahon, Dip.D.Sci.

At Trangie, New South Wales—
Locust Investigations—
Technical Officer—L. J. Chinnick, Dip.Agr.

At Bright, Victoria—
St. John's Wort Investigations—
Technical Officer—E. R. Pearce, Dip.Agr.

5. *Division of Animal Health and Production.*

(Head-quarters: Cr. Flemington-road and Park-street, Parkville, Melbourne.)

At Animal Health Research Laboratory, Melbourne—
Officer-in-Charge—A. W. Turner, O.B.E., D.Sc.,
Divisional Secretary—A. J. Vasey, B.Agr.Sc.
Clerk—J. J. Foley.

At Animal Health Research Laboratory, Melbourne—
Officer-in-Charge—A. W. Turner, O.B.E., D.Sc., D.V.Sc.
Principal Research Officer (bacteriology)—T. S. Gregory, B.V.Sc., Dip.Bact.
Principal 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.
Senior Research Officer (immuno-chemistry)—A. T. Dann, M.Sc.
Senior Research Officer (chemical pathology and bacteriology)—A. T. Dick, M.Sc.
Research Officer (bacteriology, dairy cattle)—E. Munch-Petersen, M.Sc., Ph.B.
Research Officer (poultry breeding investigations)—F. Skaller, B.Agr.Sc.
Research Officer (bacteriology, anaerobic infections)—A. W. Rodwell, M.Sc. (abroad).
Research Officer (chemical pathology and analytical chemistry)—J. B. Bingley, D.A.C.
Research Officer—Miss C. E. Eales, B.Sc.
Research Officer—Miss M. J. Monsbrough, B.Sc.
Research Officer—H. G. Turner, B.Agr.Sc. (abroad).
Research Officer—G. Alexander, B.Agr.Sc.
Research Officer—G. W. Grigg, B.Sc. (part-time).
Technical Officer—Miss V. E. Hodgetts, B.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, New South Wales—
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 (parasitology)—W. P. Rogers, M.Sc., Ph.D.
Senior Research Officer (bacteriology)—D. F. Stewart, B.V.Sc., Dip.Bact.
Research Officer (biochemistry)—C. R. Austin, M.Sc., B.V.Sc. (abroad).
Research Officer (physiology)—W. K. Whitten, B.V.Sc.
Research Officer (biochemistry)—R. L. Reid, B.Sc.Agr. (abroad).
Research Officer (ectoparasites)—Miss T. M. Scott, B.Sc.
Research Officer (parasitology)—Miss P. M. Sambell, B.A.
Research Officer (parasitology)—Miss M. Lazarus, B.Sc.
Research Officer (parasitology)—A. C. Jennings, B.Sc.
Technical Officer—E. A. Parrish.
Technical Officer—H. A. Offord.
Technical Officer—F. J. Hamilton.
Technical Officer—H. V. Whitlock.
Clerk—H. H. Wilson.
Librarian—Miss A. G. Culey, M.Sc.

At Wool Biology Laboratory, Sydney, New South Wales—
Officer-in-Charge (wool biology)—H. B. Carter, B.V.Sc.
Research Officer (wool biology)—Miss M. Hardy, M.Sc. (abroad).
Research Officer (wool biology)—K. Ferguson, B.V.Sc.
Research Officer (wool biology)—Miss P. Davidson, B.Sc.

At Fleece Analysis Laboratory, Villawood, New South Wales—
Officer-in-Charge (wool metrology)—N. F. Roberts, M.Sc.
Research Officer (wool metrology)—L. T. Wilson, B.Sc.
Technical Officer—Miss L. Folley.

At Regional Pastoral Laboratory, Armidale, New South Wales—
Officer-in-Charge (parasitology, field studies)—I. L. Johnstone, B.V.Sc.
Research Officer (animal husbandry)—J. F. Barrett, B.V.Sc.
Research Officer (parasitology)—W. H. Southcott, B.V.Sc.
Technical Officer (overseer)—V. D. Prentice, O.B.E.
Technical Officer—R. S. Norton.

At F. D. McMaster Field Station, Badgery's Creek, New South Wales—
Officer-in-Charge (animal genetics)—R. B. Kelley, D.V.Sc.
Senior Research Officer (beef cattle production)—W. A. Beattie, B.A., LL.B.
Senior Research Officer (wool production)—J. H. Riches, B.Sc.(Agric.), Ph.D.
Research Officer (sheep breeding)—R. H. Hayman, B.Agr.Sc.
Research Officer (sheep breeding)—R. A. Bettenay, B.Sc.(Agric.).
Technical Officer—J. R. Holloway.
Technical Officer—P. B. Sutton.

At Veterinary Parasitology Laboratory, Yeerongpilly, Queensland—
Officer-in-Charge (parasitology)—F. H. S. Roberts, D.Sc.

At Food Preservation Research Laboratory, Cannon Hill, Queensland—
Research Officer (carcass appraisal)—N. T. M. Yeates, B.Sc.Agr., Ph.D.

At National Field Station, "Gilruth Plains", Cunnamulla, Queensland—
Officer-in-Charge (sheep breeding)—J. F. Kennedy, M.Agr.Sc.
Technical Officer (overseer)—I. D. B. Yuille.

At Western Australian Department of Agriculture, Animal Health and Nutrition Laboratory, Nedlands, 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.
Principal Research Officer—A. W. Peirce, D.Sc.
Senior Research Officer—E. W. Lines, B.Sc.
Senior Research Officer—H. J. Lee, B.Sc.
Senior Research Officer—D. S. Riceman, M.Sc., B.Agr.Sc.
Research Officer—F. V. Gray, M.Sc.
Research Officer—G. B. Jones, M.Sc.
Research Officer—I. G. Jarrett, M.Sc.
Research Officer—T. A. Quinlan-Watson, M.Sc.
Research Officer—Miss S. H. Allen, B.Sc.
Research Officer—Miss P. Macbeth, B.Sc.
Research Officer—A. F. Pilgrim, B.Sc.
Research Officer—B. J. Potter, B.Sc.
Research Officer—J. K. Powrie, B.Sc.(Agric.).
Research Officer—R. M. Smith, B.Sc.
Research Officer—R. A. Weller, B.Sc.
Technical Officer—D. W. Dewey.
Technical Officer—G. W. Bussell.
Technical Officer—J. O Wilson.
Technical Officer—C. E. Sleigh.
Technical Officer—R. F. Trowbridge.
Technical Officer—D. F. Graham.
Technical Officer—V. A. Stephen.
Technical Officer—T. M. Rilstone, A.S.A.S.M.
Farm Manager—R. H. Jones, R.D.A.
Librarian—Miss I. Sanders, B.A.

7. *Division of Soils.*
(Head-quarters: at Waite Agricultural Research Institute, Adelaide.)

Administration—
Chief—J. K. Taylor, B. A., M.Sc., B.Sc.Agr.

Soil Survey Section—
Senior Research Officer—C. G. Stephens, M.Sc.
Research Officer—R. Brewer, B.Sc.
Research Officer—E. J. Johnson, B.Sc.Agr.
Research Officer—T. Langford Smith, M.Sc. (seconded).
Research Officer—K. H. Northcote, B.Agr.Sc.
Research Officer—G. A. Stewart, B.Agr.Sc.
Research Officer—G. Blackburn, B.Agr.Sc.
Research Officer—G. W. Cochrane, M.Sc.
Research Officer—E. W. Boehm, B.Sc.(Agric.).
Research Officer—R. Hare, B.Sc. (Agric.).
Research Officer—J. R. Sleeman, B.Agr.Sc.
Draughtsman—P. D. Hooper.
Technical Officer—L. W. Pym, R.D.A. (on leave).
Technical Officer—C. H. Thompson, G.D.A.

Soil Physics Section—
Senior Research Officer—T. J. Marshall, M.Ag.Sc., Ph.D.
Research Officer—G. D. Aitchison, B.E.
Research Officer—G. B. Stirk, B.Sc.
Research Officer—K. Norrish, M.Sc.
Research Officer—J. P. Quirk, B.Sc.Agr.
Technical Officer—C. G. Gurr, B.Sc.
Technical Officer—A. W. Palm.

Soil Chemistry Section—
Senior Research Officer—C. S. Piper, D.Sc. (part-time).
Research Officer (spectrography)—A. C. Oertel, M.Sc.
Research Officer—H. C. T. Stace, B.Sc.
Research Officer—B. M. Tucker, B.Sc.
Research Officer—R. S. Beckwith, B.Sc.
Research Officer—J. T. Hutton, B.Sc.
Technical Officer—Miss B. R. Begg, B.Sc.
Technical Officer—Miss S. E. Correll.

Soil Microbiology Section—
Research Officer—Miss M. P. Thomas, B.Sc. (on leave).
Research Officer—J. R. Harris, B.Sc.

At Hobart—
Research Officer (soil surveys)—K. D. Nichols, B.Sc., B.Agr.Sc.

At Perth—
Research Officer (soil surveys)—R. Smith, B.Sc. (Agric.).

At Canberra—
Research Officer (soil surveys)—R. G. Downes, M.Agr.Sc.

At Brisbane—
Senior Research Officer—G. D. Hubble, B.Agr.Sc.

At Deniliquin—
Research Officer (soil surveys)—B. E. Butler, B.Sc. (Agric.).

Rubber Investigations—
Research Officer—R. E. Shapter.

8. *Irrigation Settlement Problems.*

At Irrigation Research Station, Griffith—
Officer-in-Charge—E. S. West, B.Sc., M.S.
Senior Research Officer (chemist)—N. G. Cassidy, M.Sc.
Senior Research Officer (plant physiology)—R. F. Williams, M.Sc.
Research Officer (irrigation)—O. Perkman, B.Sc.Agr.
Research Officer (drainage)—V. J. Wagner, B.Agr.Sc.
Research Officer (vegetable agronomy)—K. Spencer, B.Sc.Agr.
Research Officer (weeds)—L. F. Myers, B.Agr.Sc.
Research Officer (horticulture)—H. J. Frith, B.Sc.Agr.
Research Officer (plant physiology)—C. T. Gates, B.Sc.Agr.
Research Officer—E. L. Greacen, B. Sc.Agr. (absent on studentship).
Senior Technical Officer (orchard superintendent)—B. H. Martin, H.D.A.
Technical Officer (photography)—Miss Z. Lasscock.
Librarian—Miss M. Russell.

Seconded to New South Wales Department of Agriculture—
Senior Research Officer—R. R. Pennefather, B.Agr.Sc.
Senior Research Officer—D. V. Walters, M.Agr.Sc.
Research Officer—A. F. Gurnett Smith, B.Agr.Sc., Q.D.D.
Research Officer—Mrs. Joan Tully, B.Sc., Ph.D.

At Commonwealth Research Station, Merbein—
Officer-in-Charge—A. V. Lyon, M.Agr.Sc.
Principal Research Officer—E. C. Orton, B.Sc.
Research Officer—J. G. Baldwin, B.Agr.Sc., B.Sc.
Research Officer—G. V. F. Clewett, B.E.
Research Officer—W. J. Webster, B.Sc.
Research Officer—A. J. Antcliff, B.Sc.
Research Officer—M. R. Sauer, B.Agr.Sc.
Research Officer—S. F. Bridley, B.Agr.Sc.
Research Officer—R. C. Woodham, B.Agr.Sc.
Technical Officer—J. E. Giles.
District Officer (Nyah-Woorinen)—R. C. Polkinghorne (part-time).
District Officer (Wakool)—H. Jackson (part-time).
District Officer (Renmark)—J. V. Seekamp (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.
Clerk—J. Bourne.
Clerk—A. D. Rampling.
Records Clerk—G. K. Johnson.
Senior Technical Officer—L. Santer, Dip.Eng.

Wood Structure Section—
Senior Principal Research Officer-in-Charge—H. E. Dadswell, D.Sc.
Research Officer—H. D. Ingle, B.For.Sc.
Research Officer—Miss M. M. Chattaway, B.A., B.Sc., D.Phil.
Research Officer—G. L. Amos, M.Sc.
Research Officer—I. J. W. Bissett, B.Sc.
Research Officer—A. B. Wardrop, M.Sc. (abroad).
Technical Officer—C. S. Lee, B.Agr.Sc.
Technical Officer—Miss F. V. Griffin.

Photography—
Technical Officer—E. S. Smith.
Technical Officer—Miss A. M. Lightfoot.
Technical Officer—W. G. Hastie.

Wood Chemistry Section—
Senior Principal Research Officer-in-Charge—W. E. Cohen, D.Sc.
Senior Research Officer—D. E. Bland, M.Sc.
Research Officer—D. H. Foster, M.Sc.
Research Officer—C. M. Stewart, B.Sc.
Research Officer—A. J. Watson, A.M.T.C.
Research Officer—Miss C. M. Emery, B. Sc.
Technical Officer—A. G. Charles.
Technical Officer—W. E. Hillis, B.Sc., A.G.Inst.Tech.
Technical Officer—G. Ho, B.Agr.Sc.
Technical Officer—Miss J. Meade.
Technical Officer—Miss G. Schwerin, B.S.

Timber Physics Section—
Senior Research Officer-in-Charge—R. S. T. Kingston, B.Sc., B.E.
Research Officer—L. N. Clarke, B.Eng.Sc.
Research Officer—G. A. Forster, B.Sc.
Technical Officer—I. G. Scott, F.M.T.C.
Technical Officer—A. Ack Hing, A.S.M.B.
Technical Officer—N. C. Edwards.
Technical Officer—L. D. Armstrong.

Timber Mechanics Section—
Senior Research Officer-in-Charge—K. L. Cooper, M.A., B.Sc. (abroad).
Research Officer (acting-in-charge)—N. H. Kloot, B.Sc.
Research Officer—J. D. Boyd, B.C.E.
Research Officer—C. E. Dixon, M.Sc.
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.
Research Officer—C. V. Lansell, B.Eng.Sc.
Research Officer—E. L. Ellwood, B.Sc. (For.).
Technical Officer—H. D. Roberts.
Technical Officer—L. J. Brennan.
Technical Officer—G. S. Campbell.

Timber Preservation Section—
Senior Research Officer-in-Charge—N. Tamblyn, M.Sc.(Agric.).
Research Officer—R. W. Bond, B.Sc.
Research Officer—E. W. B. Da Costa, M.Agr.Sc.
Research Officer—G. W. Tack, B.Agr.Sc.
Research Officer—G. N. Christensen, B.Sc.
Technical Officer—J. Beesley, B.Sc.(For.), Dip. For.
Technical Officer—A. Rosel.
Technical Officer—N. Robinson.
Technical Officer—T. A. McLelland, Dip.App.Chem. (on leave).

Veneer and Gluing Section—
Senior Research Officer-in-Charge—A. Gordon, B.Sc. (seconded).
Research Officer (Acting-in-Charge)—H. G. Higgins, B.Sc.
Research Officer—A. W. Rudkin, B.Sc.
Research Officer—K. F. Plomley, B.Sc.Agr.
Technical Officer—C. Koch, B.S.(For.).
Technical Officer—J. F. Hayes, B.Sc.

Utilization Section—
Principal Research Officer-in-Charge—R. F. Turnbull, B.E.
Research Officer—A. E. Head, B.Sc.
Research Officer—C. H. Hebblethwaite, Dip.For.
Technical Officer—R. G. Skewes, Dip.E.E., Dip. Mech.Eng.

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.)

Administration 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—M. C. Taylor, M.Sc.
Research Officer—G. M. Rostos, Dipl. Ing.
Technical Officer—M. B. Smith, A.S.A.S.M.
Technical Officer—J. Mellor (on leave).

Microbiology Section—
Senior Research Officer—W. J. Scott, B.Agr.Sc.
Research Officer—M. R. J. Salton, B.Sc.Agr.
Research Officer—W. G. Murrell, B.Sc.Agr.
Technical Officer—P. R. Maguire.
Technical Officer—D. F. Ohye, Dip.Ind.Chem.

General Chemistry Group—
Senior Research Officer—F. E. Huelin, B.Sc., Ph.D.
Research Officer—H. A. McKenzie, M.Sc. (on leave).
Research Officer—Mrs. A. R. Thompson, B.Sc.
Technical Officer—R. A. Gallop, A.S.T.C.
Technical Officer—F. S. Shenstone, A.S.T.C.

Fruit Storage Section—
Principal Research Officer—R. N. Robertson, B.Sc., Ph.D.
Research Officer—E. G. Hall, B.Sc.Agr.
Research Officer—J. F. Turner, M.Sc.
Research Officer—Miss M. Wilkins, 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.
Research Officer—R. S. Mitchell, M.Sc.Agr.
Research Officer—V. M. Lewis, B.Sc.Agr. (on leave).
Research Officer—B. V. Chandler, B.Sc.
Technical Officer—P.C.O. Thompson, A.S.T.C.
Technical Officer—G. F. Greethead, A.S.T.C.
Technical Officer—R. Allan.

Dried Foods Section—
Senior Research Officer—Miss T. M. Reynolds, M.Sc., D.Phil.
Senior Research Officer—A. Howard, M.Sc.
Research Officer—H. S. McKee, B.A., D.Phil.
Research Officer—A. R. Prater, B.Sc.Agr.
Research Officer—D. McG. McBean, B.Sc.
Research Officer—J. Shipman, B.Sc.Agr.

Meat Investigations (at Brisbane Abattoir)—
Senior Research Officer—A. R. Riddle, A.B., M.S.
Technical Officer—H. J. E. Prebble, Dip.Ind.Chem.
Technical Officer—H. A. MacDonald, Dip.Ind.Chem.

At Australia House, London—
Senior Research Officer—N. E. Holmes, B.E.E., M.Mech.E. (seconded).

11. *Division of Fisheries.*

(Head-quarters: Cronulla, New South Wales.)

At Head-quarters—
Chief—H. Thompson, M.A., D.Sc.
Technical Secretary—Mrs. L. M. Willings, B.A.
Senior Research Officer (bacteriologist)—E. J. Ferguson Wood, B.A., M.Sc.
Senior Research Officer (biologist)—A. G. Nicholls, B.Sc., Ph.D.
Research Officer (chemist and hydrologist)—D. J. Rochford, B.Sc.
Research Officer (biologist)—J. A. Tubb, M.Sc. (seconded).
Research Officer (biologist)—I. S. R. Munro, M.Sc.
Research Officer (biologist)—W. S. Fairbridge, M.Sc.
Research Officer (ichthyologist)—A. A. Rapson, M.Sc.
Research Officer (biologist)—J. S. Hynd, B.Sc.
Research Officer (algologist)—Mrs. V. Jones, M.Sc.
Research Officer (planktologist)—Miss P. Kott, B.Sc.
Technical Officer (laboratory)—A. Proctor.
Gear Officer—A. Temple.
Clerk—T. A. Lewis.

At Melbourne—
Principal Research Officer—S. Fowler.
Research Officer (biologist)—M. Blackburn, M.Sc.

At Perth—
Senior Principal Research Officer (officer-in-charge)—G. W. Rayner, M.Sc.
Senior Research Officer (biologist)—D. L. Serventy, B.Sc., Ph.D.
Research Officer (biologist)—J. M. Thomson, M.Sc.
Research Officer (chemist and hydrologist)—R. S. Spencer, B.Sc.
Technical Officer—K. Sheard.
Technical Officer (sea-going)—B. Shipway.
Clerk—W. B. Gibson.

At Hobart—
Research Officer (biologist)—A. M. Olsen, M.Sc.

12. *Australian National Standards Laboratory.**

Clerical—
Chief Clerk—R. F. Williams.
Accountant—W. J. Gillespie, A.F.I.A., A.C.I.S.

Drawing Office—
Chief Draughtsman—C. Williamson.

Library—
Librarian—Miss M. Barnard, B.A.
Librarian—Miss B. V. Mortlock, B.A.
Librarian—Miss M. McKechnie, B.A.
Assistant Librarian—Miss E. Andrews, B.A.
Assistant Librarian—Miss J. M. Cook.

Workshops—
Works Supervisor—J. Hanna.

* The services shown hereunder are common to the Divisions of Metrology, Electrotechnology and Physics, housed in the Laboratory.

13. *Division of Metrology.*

(Head-quarters: National Standards Laboratory at University of Sydney.)

Chief—N. A. Esserman, B.Sc.
Technical Secretary—N. H. Winters, B.E.
Senior Research Officer—P. M. Gilet, B.Sc., B.E.
Senior Research Officer—G. A. Bell, B.Sc.
Research Officer—C. F. Bruce, M.Sc.
Research Officer—H. J. Ritter, Dr.rer.nat.-math.
Research Officer—J. A. Macinante, B.E.
Research Officer—R. H. Furniss, A.S.T.C.
Research Officer—E. E. Adderley, B.Sc.
Research Officer—W. A. F. Cunninghame, B.E.
Research Officer—Miss M. C. Dive, B.Sc.
Research Officer—Miss M. G. I. Pearce, M.Sc.
Research Officer—Mrs. P. M. Aitchison, B.Sc.
Research Officer—Miss P. M. Yelland.
Research Officer—R. J. Ellis, B.E.
Research Officer—J. Waldersee, B.Sc.
Research Officer—Miss M. M. Douglas, B.Sc.
Research Officer—Mrs. C. M. Knight, B.Sc.
Technical Officer—A. J. Carmichael.
Technical Officer—D. H. Fox.
Technical Officer—W. Dollar, A.S.T.C.
Technical Officer—O. Pain.
Technical Officer—E. L. Thomas, A.S.T.C.

14. *Division of Electrotechnology.*

(Head-quarters: National Standards Laboratory at University of Sydney.)

Chief—D. M. Myers, B.Sc., D.Sc.Eng. (abroad).
Acting Chief—F. J. Lehany, M.Sc.
Technical Secretary—L. G. Dobbie, M.E. (abroad).
Technical Secretary (acting)—R. C. Richardson, B.E.
Senior Research Officer—W. K. Clothier, B.Sc., M.E.
Senior Research Officer—W. R. Blunden, B.Sc., B.E.
Senior Research Officer—A. M. Thompson, B.Sc.
Senior Research Officer—R. J. Meakins, B.Sc., Ph.D., D.I.C. (seconded from Division of Industrial Chemistry).
Research Officer—B. V. Hamon, B.Sc., B.E.
Research Officer—D. J. Cole, B.E.E.
Research Officer—D. L. Hollway, B.E.E., M.Eng.Sc.
Research Officer—L. Medina, Dipl.Ing.
Research Officer—R. K. Oliver, B.E.
Research Officer—J. S. Dryden, M.Sc. (abroad).
Research Officer—G. J. A. Cassidy, B.E.E.
Research Officer—H. W. Stokes, B.Ec.
Technical Officer—R. W. Archer.
Technical Officer—F. C. Brown, A.S.T.C. (abroad).
Technical Officer—R. J. Keith, A.S.T.C.
Technical Officer—H. Bairnsfather.
Technical Officer—E. Cowcher, A.S.T.C.
Technical Officer—J. S. O'Rourke, A.S.T.C.
Technical Officer—Miss J. Mulley, A.S.T.C.
Technical Officer—H. A. Smith.
Technical Officer—R. L. Gregory.

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.
Research Officer—W. R. G. Kemp, B.Sc.
Research Officer—R. G. Wylie, M.Sc.
Research Officer—W. A. Caw, B.Sc.
Research Officer—Miss R. Scott, B.Sc.
Technical Officer—J. H. Bestford, B.Sc.
Technical Officer—J. K. Braithwaite, A.M.T.C.

Light—
Senior Research Officer—R. G. Giovanelli, M.Sc.
Research Officer—W. H. Steel, B.A., B.Sc.
Research Officer—J. W. Pearce, B.Sc.
Research Officer—K. A. B. Wright, B.Sc.
Research Officer—G. H. Godfrey, M.A., B.Sc. (part-time).
Research Officer—H. F. Pollard, M.Sc. (part-time).
Technical Officer—V. R. Schaefer.

Solar Physics—
Senior Research Officer—R. G. Giovanelli, M.Sc.

Wool Research—
Research Officer—Mrs. K. R. Makinson, B.A.

Electrical Standards—
Research Officer—Miss R. Scott, B.Sc.

Technical Services—
Technical Officer—J. E. Thompson.

Officers Abroad—
Research Officer—E. H. Mercer, B.Sc.
Research Officer—W. I. B. Smith, B.Sc.
Research Officer—J. K. Mackenzie, B.A., B.Sc.

16. *Division of Aeronautics.*

(Head-quarters: Lorimer-street, Fishermen's Bend, Melbourne; Postal Address: Box 4331, G.P.O., Melbourne.)

Administration—
Chief—L. P. Coombes, D.F.C., B.Sc.(Eng.).
Divisional Secretary—F. M. McDonough, B.C.E.
Clerk—V. H. Leonard.

Structures and Materials Section—
Senior Principal Research Officer—H. A. Wills, B.E.
Senior Research Officer—F. S. Shaw, B.E. (abroad).
Research Officer—W. W. Johnstone, M.E.
Research Officer—J. Solvey, B.Sc., B.Ae.E.
Research Officer—F. H. Hooke, B.Sc., B.E.
Research Officer—R. C. T. Smith, M.A., D.Phil., B.Sc.
Research Officer—F. W. Hooton, B.Sc., B.E.
Research Officer—J. P. O. Silberstein, B.A. (abroad).
Research Officer—Miss E. H. Mann, B.A. (abroad).
Research Officer—A. O. Payne, B.E.Sc.
Research Officer—R. W. Traill-Nash, B.E. (abroad).
Research Officer—N. B. Joyce, B.E.
Research Officer—Miss D. A. Lemaire, B.Mech.E.
Research Officer—M. S. Paterson, B.Sc.E. (abroad).
Research Officer—L. H. Mitchell, B.Sc.E.
Research Officer—W. Freiberger, B.A.
Research Officer—J. R. M. Radok, B.A.
Technical Officer—N. E. Richards.
Technical Officer—J. H. Straw.
Technical Officer—C. M. Bailey.
Technical Officer—G. W. Wycherley.
Technical Officer—C. A. Patching.
Technical Officer—J. Y. Mann.
Technical Officer—B. B. Capon, B.Sc.(Eng.).

Metallurgy Section—
Senior Research Officer—J. B. Dance, B.Met.E. (abroad).
Senior Research Officer—P. F. Thompson.
Research Officer—A. R. Edwards, B.Met.E.
Research Officer—H. L. Wain, B.Met.E.
Research Officer—H. T. Greenaway, B.Met.E.
Research Officer—C. J. Osborn, B.Met.E.
Research Officer—J. E. T. Lumley.
Research Officer—N. A. McKinnon, M.Sc.
Research Officer—F. G. Lewis, B.Sc.
Research Officer—N. F. Dewsnap, B.Met.E.
Research Officer—Mrs. M. K. McQuillan, M.A.
Technical Officer—K. R. Hanna.
Technical Officer—L. M. Bland.
Technical Officer—S. T. M. Johnstone.
Technical Officer—F. D. Rowe.

Aerodynamics Section—
Senior Research Officer—J. R. Green, D.Phil., B.E.
Senior Research Officer—F. W. David, Dipl.Ing.
Research Officer—R. W. Cumming, B.E.
Research Officer—J. F. M. Scholes, B.Eng.Sc., B.E.
Research Officer—J. B. Willis, M.Sc.
Research Officer—A. F. Pillow, B.A. (abroad).
Research Officer—J. M. Evans, B.E.
Research Officer—E. R. Johnson, M.Sc.
Research Officer—R. A. Wallis.
Research Officer—J. K. Strachan, B.A., B.Sc.
Research Officer—J. R. Baxter, B.E., B.Sc.
Research Officer—J. A. Barker, B.A., B.Sc.
Research Officer—H. C. Levey, B.Sc. (part-time).
Technical Officer—L. T. Watson.
Technical Officer—V. J. Smith.
Technical Officer—A. F. W. Langford.
Technical Officer—J. D. Belot.

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.
Senior Research Officer — W. B. Kennedy, B.Mech.E.
Research Officer—F. G. Blight, B.Sc., B.E.
Research Officer—J. C. Wisdom, B.Mech.E.
Research Officer — R. E. Pavia, M.Eng.Sc., B.Mech.E.
Research Officer—R. A. Wright, B.Mech.E.
Research Officer—R. V. Pavia, B.Mech.E.
Research Officer—D. B. Leason, Ph.D., B.Sc.
Research Officer—R. L. Brooks, B.Sc.Eng.
Research Officer—A. L. Deans, B.Mech.E.
Research Officer—A. E. Billington, B.Sc.
Research Officer—W. Howard, B.E.(Aero.).
Research Officer—D. G. Stewart, B.Mech.E.
Technical Officer—D. Pescod.
Technical Officer—S. Heath.
Technical Officer—H. J. F. Gerrand.
Technical Officer—L. J. Berry.
Technical Officer—M. L. Atkin.

Instruments Section—
Senior Research Officer—A. A. Townsend, M.Sc. (abroad).
Research Officer—H. M. Nelson, B.Sc.
Research Officer—B. E. Swire, B.E., B.Sc.
Research Officer—R. C. H. Bravington, B.Sc.
Senior Technical Officer—Z. Merfield.
Technical Officer—A. N. A. Clowes.

Applied Research Section—
Senior Research Officer—B. McA. Foster, B.C.E., D.I.C.

Workshops—
Workshops Supervisor—D. W. Eaton.

Drawing Officer—
Sectional Draughtsman—J. M. Morgan.

Photography—
Technical Officer—Miss E. F. Lightfoot.

Library—
Librarian (half-time)—Miss B. M. Brown, B.Sc.

17. *Division of Industrial Chemistry.*

(Head-quarters: Lorimer-street, Fishermen's Bend, Melbourne; Postal Address: Box 4331, G.P.O., Melbourne.)

Administration—
Chief—I. W. Wark, Ph.D., D.Sc. (abroad).
Divisional Secretary—L. Lewis, B.Met.E. (acting Chief).
Assistant Secretary—A. E. Scott, M.Sc. (acting Secretary).
Clerk—R. C. McVilley, A.C.I.S., A.F.I.A.

Minerals Utilization Section—
Senior Principal Research Officer—R. G. Thomas, B.Sc.
Senior Research Officer—A. Walkley, B.A., B.Sc., Ph.D.
Senior Research Officer—A. W. Wylie, B.Sc., Ph.D.
Research Officer—P. Dixon, M.Sc.
Research Officer—T. R. Scott, M.Sc., B.Ed.
Research Officer—F. R. Hartley, M.Sc.
Research Officer—F. K. McTaggart, M.Sc. (abroad).
Research Officer—R. C. Croft, B.Sc.
Research Officer—A. D. Wadsley, M.Sc.
Research Officer—I. Kraitzer.
Research Officer—E. S. Pilkington, A.S.T.C.
Research Officer—T. A. O'Donnell, M.Sc.
Research Officer—I. E. Newnham, M.Sc.
Technical Officer—H. R. Skewes.

Cement and Ceramics Section—
Principal Research Officer—A. R. Alderman, Ph.D., D.Sc. (abroad).
Senior Research Officer—W. O. Williamson, B.Sc., Ph.D.
Research Officer—H. E. Vivian, B.Agr.Sc.
Research Officer—S. M. Brisbane, B.A., B.Sc.
Research Officer—R. H. Jones, B.Sc.
Research Officer—E. R. Segnit, M.Sc. (abroad).
Research Officer—H. R. Samson, M.Sc.
Research Officer—A. J. Gaskin, M.Sc. (part-time).
Research Officer—C. E. S. Davis, B.Sc. (Hons.).
Technical Officer—Miss B. E. Terrell, B.Sc.
Technical Officer—J. H. Weymouth, B.Sc.
Technical Officer—J. Coutts, A.M.T.C.

Foundry Sands Section—
Research Officer—H. A. Stephens, B.Sc.(Hons.).
Technical Officer—G. V. Cullen, Dipl.Met., Dipl.-Chem. Eng.

Physical Chemistry Section—
Research Officer—W. E. Ewers, M.Sc.
Research Officer—K. F. Lorking, M.Sc.
Research Officer—W. W. Mansfield, B.Sc.(Hons.).
Technical Officer—L. F. Evans, A.S.M.B.
Technical Officer—J. A. Corbett.
Technical Officer—H. F. A. Hergt, A.M.T.C.

Chemcial Physics Section—
Principal Research Officer—A. L. G. Rees, M.Sc., Ph.D.
Research Officer—A. Walsh, M.Sc.
Research Officer—A. McL. Mathieson, B.Sc. Ph.D.
Research Officer—J. L. Farrant, M.Sc.
Research Officer—M. S. Walker, B.E.
Research Officer—J. M. Cowley, M.Sc. (abroad).
Research Officer—G. R. Hercus, M.Sc.
Research Officer—A. Hodge, B.Sc.(Hons.).
Research Officer—J. P. Shelton, M.Sc., A.B.S.M.
Research Officer—A. G. Pulford, B.Sc.
Senior Technical Officer—W. G. Jones.
Technical Officer—G. F. Box.
Technical Officer—F. B. Williams.
Draughtsman—C. R. Johnstone.

Organic Section—
Senior Principal Research Officer—H. H. Hatt, B.Sc., Ph.D.
Senior Research Officer—J. S. Fitzgerald, M.Sc., Ph.D.
Senior Research Officer—J. R. Price, M.Sc., D.Phil.
Research Officer—M. E. Winfield, M.Sc., Ph.D.
Research Officer—K. E. Murray, B.Sc.(Hons.).
Research Officer—N. C. Hancox, M.Sc.
Research Officer—R. G. Curtis, M.Sc., D.I.C.
Research Officer—R. J. L. Martin, M.Sc. (abroad).
Research Officer—D. J. Clark, M.Sc.
Research Officer—L. K. Dalton, D.S.T.C.
Research Officer—W. D. Crow, M.Sc.
Research Officer—R. B. Bradbury, B.Agr.Sc., D.B.S.M.
Research Officer—P. Strasser, M.Sc.
Technical Officer—W. J. Troyahn, B.Sc.

Biochemistry Section—
Principal Research Officer—F. G. Lennox, D.Sc.
Research Officer—W. J. Ellis, A.S.T.C.
Research Officer—H. Lindley, B.A., Ph.D.
Research Officer—W. G. Crewther, M.Sc.
Research Officer—J. M. Gillespie, M.Sc.
Research Officer—Miss M. E. Maxwell, M.Sc.
Research Officer—D. H. Simmonds, M.Sc.

Chemical Engineering Section—
Senior Research Officer—D. R. Zeidler, M.Sc.
Research Officer—I. Brown, B.Sc.(Hons.).
Research Officer—R. W. Urie, B.S.c. (abroad).
Research Officer—J. F. Pearse, B.Sc.(Hons.) (abroad).
Research Officer—B. W. Wilson, M.Sc.
Research Officer—D. E. Weiss, B.Sc.
Technical Officer—A. Ewald, B.Sc.
Technical Officer—J. L. Clay, A.M.T.C. (seconded).
Technical Officer—D. H. Trethewey, A.M.T.C.
Technical Officer—L. R. Bull, Dip.Mech.Eng.
Technical Officer—K. A. Ophel.
Draughtsman—C. Simpson.
Draughtsman—J. Hession.

At University of Western Australia—
Research Officer (Alunite investigations)—D. F. A. Koch, B.Sc.(Hons.).

At Canberra, Division of Economic Entomology—
Research Officer—R. H. Hackman, M.Sc. (seconded).

At Sydney, Division of Electrotechnology—
Senior Research Officer—R. J. Meakins, B.Sc., Ph.D. (seconded).

At School of Mines, Adelaide—
Research Officer (ceramic investigations)—H. Ellerton.
Research Officer (uranium investigations)—J. Hayton, B.Sc.

At University of Sydney, Department of Chemical Engineering—
Research Officer—M. L. Newman, B.Sc.

Library—
Librarian (half time)—Miss B. M. Brown, B.Sc.

Photography—
Technical Officer—F. D. Lugton.

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.

Research—
Principal Research Officer—J. L. Pawsey, M.Sc., Ph.D.

Solar Noise—
Principal Research Officer—J. H. Piddington, M.Sc., B.E., Ph.D.
Senior Research Officer—L. L. McCready, B.Sc., B.E.
Senior Research Officer—W. N. Christiansen, M.Sc.
Research Officer—H. C. Minnett, B.Sc., B.E.
Research Officer—Miss R. Payne-Scott, M.Sc.
Research Officer—S. F. Smerd, B.Sc.
Research Officer—D. E. Yabsley, B.Sc., B.E.
Research Officer—J. G. Bolton, B.A.
Research Officer—K. C. Westfold, M.A., B.Sc.
Research Officer—N. R. Labrum, B.Sc.
Research Officer—J. P. Wild, B.A.
Technical Officer—J. V. Hindman.
Technical Officer—K. R. McAlister, A.S.T.C.

Technical Officer—G. J. Stanley, A.S.T.C.
Technical Officer—J. D. Murray.
Technical Officer—A. G. Little.
Technical Officer—Miss M. C. Clarke, A.S.T.C.

Extra-Terrestrial Echoes—
Research Officer—F. J. Kerr, M.Sc.
Research Officer—C. A. Shain, B.Sc.
Research Officer—R. S. Styles, B.Sc., B.E.
Research Officer—A. B. Thomas, B.A.
Technical Officer—C. S. Higgins.

Ionosphere—
Technical Officer—O. C. Turner.

Artificial Rain Formation—
Senior Research Officer—E. B. Kraus, Ph.D.
Senior Research Officer—P. Squires, M.A.
Research Officer—E. J. Smith, M.B.E., B.Sc. (Eng.)
Research Officer—Miss B. Lippmann, B.Sc.
Technical Officer—K. J. Heffernan.
Technical Officer—S. A. Pett.

Radar Meteorology—
Research Officer—H. N. Edwardes, B.Sc., B.E.
Technical Officer—P. T. Hedges, A.S.T.C.

Mathematical Physics—
Senior Research Officer—T. Pearcey, B.Sc.
Research Officer—Miss M. A. Adamson, B.A., Dip.Ed.
Research Officer—Miss H. Taylor, B.A., Dip.Ed.

Electronic Computing—
Senior Research Officer—M. Beard, B.Sc., B.E.
Research Officer—M. D. Ryan, B.Sc., B.E.
Technical Officer—F. G. Tonking, A.S.T.C.

Test Room—
Research Officer—G. A. Day.
Technical Officer—B. Nestor.

Vacuum Physics—
Technical Officer—F. C. James.
Technical Officer—R. Lorimer.

Development—
Senior Research Officer—V. D. Burgmann, B.Sc., B.E.

Radar Survey—
Research Officer—J. Warner, B.Sc., B.E.
Technical Officer—D. C. Dunn.
Technical Officer—R. C. Baker.
Technical Officer—S. E. Healey.

Civil Aviation—
Research Officer—J. G. Downes, B.Sc.
Research Officer—E. B. Mulholland, B.Sc., B.E.
Technical Officer—G. A. Wells, A.S.T.C.
Technical Officer—F. W. Campbell.
Technical Officer—K. Sheridan.
Technical Officer—R. E. Oldfield, A.S.T.C.
Technical Officer—J. Algie.

Telemetering—
Research Officer—B. F. C. Cooper, B.Sc., B.E.
Research Officer—H. L. Humphries, B.Sc., B.E.
Technical Officer—L. F. Clague.
Technical Officer—N. S. Thorndike.

Radio Control—
Senior Technical Officer—G. T. Miles.
Technical Officer—C. F. Attwood.

Traffic Studies—
Research Officer—R. B. Coulson, B.Sc., B.E.
Technical Officer—T. D. Newnham.
Technical Officer—K. A. Davidson.

Engineering Services—
Assistant Technical Secretary—J. P. Eagles.
Chief Draughtsman—F. C. Carter.
Works Supervisor—H. Byers.

Publications—
Research Officer—Miss M. Walkom, B.A.

Officers Abroad—
Research Officer—Miss J. M. Freeman, M.Sc.
Research Officer—R. N. Bracewell, B.Sc., B.E.
Research Officer—J. S. Gooden, B.Sc.
Research Officer—T. R. Kaiser, M.Sc.
Research Officer—F. Gardner, B.Sc., B.E.

19. Division of Tribophysics.

(Head-quarters: at University of Melbourne.)

Chief—S. H. Bastow, D.S.O., B.Sc., Ph.D.
Principal Research Officer—W. Boas, D.Ing., M.Sc.
Research Officer—T. V. Krok, B.E.
Research Officer—M. F. R. Mulcahy, M.Sc., A.G.Inst. Tech. (abroad).
Research Officer—A. J. W. Moore, B.Sc., Ph.D.
Research Officer—E. B. Greenhill, M.Sc., Ph.D.
Research Officer—R. G. Vines, M.Sc. (abroad).
Research Officer—D. Michell, B.E.E.
Research Officer—M. E. Hargreaves, B.Met.E. (abroad).
Research Officer—E. R. Ballantyne, B.Sc.
Research Officer—L. M. Clarebrough, B.Met.E., M.Eng.Sc.
Research Officer—A. J. Davis, B.Eng.
Research Officer—Miss M. J. Newing, B.Sc. (abroad).
Research Officer—J. F. Nicholas, B.Sc.
Research Officer—G. J. Ogilvie, B.Met.E., M.Eng.Sc.
Research Officer—J. V. Sanders, B.Sc.(Hons.), (abroad).
Research Officer—J. A. Spink, B.Sc.
Research Officer—G. W. West, B.E.E.
Technical Officer—R. A. Coyle.
Technical Officer—H. F. Eggington, A.S.T.C.
Technical Officer—F. H. Hay.
Technical Officer—D. S. Kemsley, F.M.T.C.
Technical Officer—R. G. Sherwood, A.M.T.C.
Part-time Officer—Miss E. M. Bennett, B.Sc.
Part-time Officer—P. J. Fensham, B.Sc.
Part-time Officer—W. R. Flower, B.Sc.

20. *Building Materials Research.**

(Head-quarters: Graham-road, Highett, Victoria.)

Administration—
Officer-in-Charge—I. Langlands, B.E.E., M.Mech.E.
Technical Secretary—W. F. Evans, B.Sc.

Information and Library—
Senior Research Officer—J. R. Barned, B.Sc.
Research Officer—R. C. McTaggart, B.Sc.
Research Officer—Mrs. C. M. Petrie, M.A., Ph.D. (part-time).
Librarian—Miss S. A. Hammill.

Mechanical and Physical Testing Laboratory—
Research Officer—P. H. Sulzberger, B.Sc.
Research Officer—A. J. Wilkins, B. E.
Research Officer—R. E. Halley, B.Sc.(Hons.).
Technical Officer—I. McLachlan.

Concrete Investigations—
Principal Research Officer—A. R. Alderman, D.Sc., Ph.D. (part-time).
Research Officer—W. H. Taylor, M.C.E.
Research Officer—G. M. Bruere, M.Sc.

Masonry Investigations—
Senior Research Officer—J. S. Hosking, M.Sc., Ph.D.
Research Officer—H. V. Hueber, Dr.Phil.
Research Officer—D. J. David, B.Sc.(Hons.).

Surfacing Materials Investigations—
Senior Research Officer—E. H. Waters, M.Sc.
Research Officer—J. E. Bright, B.Sc.
Research Officer—J. M. Hutson, M.A., B.Sc.

* Building Research Section as from 1st July, 1948.

Building Boards and Insulating Materials—
Research Officer—R. W. Muncey, B.E.E.
Research Officer—P. E. Hands, B.Sc.(Hons.)
Research Officer—T. S. Holden, B.Sc.
Technical Officer—A. W. Wilson.
Technical Officer—J. J. Russell.

Organic Materials Investigations—
Research Officer—B. M. Holmes, M.Sc.
Research Officer—J. J. Greenlands, B.Sc.(App.) (Hons.).
Technical Officer—V. Chew, B.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.
Senior Research Officer—Miss J. F. Couchman, B.Sc.
Research Officer—G. W. Lanigan, M.Sc.
Research Officer—A. M. Munro, M.A.(Oxon.)
Research Officer—W. Shepherd, B.Sc., B.Agr.Sc.
Technical Officer—M. Tisdall.
Draughtsman—D. K. Haslam.
Librarian—Miss D. Norman.

22. *Dairy Research Section.*

(Head-quarters: Lorimer-street, Fishermen's Bend, Melbourne).

Office-in-Charge—G. Loftus Hills, B.Agr.Sc.
Senior Research Officer—E. G. Pont, M.Sc.Agr.
Research Officer—J. Conochie, B.Sc.(Agr.).
Research Officer—A. J. Lawrence, B.Sc.
Research Office—D. A. Forss, M.Sc.

23. *Section of Mathematical Statistics.*

(Head-quarters: at University of Adelaide).

At Sectional Head-quarters—
Officer-in-Charge—E. A. Cornish, M.Sc., B.Agr.Sc.
Research Officer—R. Birtwistle, B.Sc.
Research Officer—G. G. Coote, B.A., B.Sc.
Research Officer—L. Mohr, B.Sc., A.S.T.C.
Research Officer—R. D. Munro, B.Sc.
Research Officer—Miss P. M. Ohlsson, B.Sc.
Research Officer—N. S. Stenhouse, B.Sc.

At Division of Animal Health and Production, Sydney—
Research Officer—Miss H. A. Newton Turner, B.Arch.
Research Officer—G. E. Ferris, B.Sc.
Research Officer—Miss E. F. Foster, B.Sc.

At Division of Forest Products, Melbourne—
Research Officer—E. J. Williams, B.Com.
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. (abroad).
Research Officer—A. T. James, B.Sc.(Hons.).

24. *Radio Research.*

(Head-quarters: c/o Electrical Engineering Department, University of Sydney).

At Sydney—
Principal Research Officer—G. H. Munro, M.Sc.
Research Officer—J. A. Harvey, B.Sc.
Research Officer—L. Heisler, B.Sc.

At Mount Stromlo, Canberra—
Senior Principal Research Officer—D. F. Martyn, D.Sc., Ph.D.
Technical Officer—R. O. Errey.

25. *Section of Physical Metallurgy.*

(Head-quarters: at University of Melbourne).

Officer-in-Charge (honorary)—Professor J. N. Greenwood, D.Sc., M.Met.E.
Senior Research Officer—D. W. Davison, B.Sc., Ph.D.
Research Officer—H. W. Wormer, M.Sc.
Research Officer—A. D. McQuillan, B.Sc.
Research Office—R. C. Gifkins, B.Sc.

26. *Ore-dressing Investigations.*

At University of Melbourne—
Officer-in-Charge—H. H. Dunkin, B.Met.E. (part-time).
Senior Research Officer—K. S. Blaskett, B.E.
Research Officer—S. B. Hudson.
Technical Officer—F. D. Drews.

At School of Mines, Kalgoorlie, Western Australia—
Officer-in-Charge—R. A. Hobson, B.Sc. (part-time).

27. *Other Investigations.*

Mineragraphic Investigations—
Senior Principal Research Officer—F. L. Stillwell, D.Sc.
Senior Research Officer—A. B. Edwards, D.Sc., Ph.D.
Research Officer—G. Baker, M.Sc.

Meteorological Physics Research—
Officer-in-Charge—C. H. B. Priestley, M.A.
Senior Research Officer—W. C. Swinbank, B.Sc.
Senior Research Officer—E. L. Deacon, B.Sc.
Research Officer—R. W. James, M.Sc.
Technical Officer—I. S. Groodin, Dip. Mat.

Tracer Elements—
Senior Research Officer—T. H. Oddie, D.Sc.

Atomic Physics—
Research Officer—W. B. Lasich, M.Sc.
Research Officer—J. R. Prescott, B.Sc.(Hons.).

Textile Technology—
Principal Research Officer—E. J. Drake.
Senior Research Officer—M. R. Freney, B.Sc.
Senior Research Officer—A. R. M. Lipson, B.Sc.
Technical Officer—Miss M. F. Chambers.

Oenological Research—
Research Officer—J. C. M. Fornachon, M.Sc., B.Ag.Sc.

5. Publications.

The following papers have been published during the year:—

1. *Division of Plant Industry.*

Anderson, A. J. (1948).—Molybdenum and other fertilizers in pasture development on the Southern Tablelands of New South Wales. *J. Aust. Inst. Agric. Sci.* 14: 28-32.

Anderson, A. J., and Spencer, D. (1948).—Lime in relation to clover nodulation on the Southern Tablelands of New South Wales. Ibid. 14: 39-41.

Angell, H. R. (1947).—Influence of fertilizers on take-all of wheat. *J. Coun. Sci. Industr. Res. Aust.* 20: 372-8.

Bald, J. G. (1947).—Treatment of cut potato setts with zinc oxide. 1. Condition of setts, growth and yield. Ibid. 20: 87-104.

Bald, J. G. (1947).—The treatment of cut potato setts with zinc oxide. 2. Infection of stems and tubers with *Rhizoctonia* and scab. Ibid. 20: 190-206.

Bald, J. G., Norris, D. O., and Helson, G. A. H. (1946).—Transmission of potato virus diseases. 5. Aphid populations, resistance and tolerance of potato varieties to leaf roll. Coun. Sci. Industr. Res. Aust., Bull. No. 196.

Christian, C. S. (1947).—North Australia Regional Survey, 1946, Katherine-Darwin Area. (Roneo, Melbourne 1-150.)

Davies, J. G. (1946).—Grazing management: continuous and rotational grazing by Merino sheep. 3. Note on pasture management. Coun. Sci. Industr. Res. Aust., Bull. No. 201.

Dickson, B. T. (1947).—Two decades. *J. Aust. Inst. Agric. Sci.* 13: 1-8.

Dickson, B. T. (1947).—United Nations Food and Agriculture Organization. Ibid. 13: 19-27.

Donald, C. M. (1947).—"Pastures and Pasture Research", pp. 1-117. (University of Sydney.)

Greenham, C. G. (1946).—Studies on chemical weed-killers with special reference to skeleton weed (*Chondilla juncea* L.). 5. Preliminary trials with hormone-like weed-killers. *J. Coun. Sci. Industr. Res. Aust.* 19: 341-6.

Greenham, C. G. (1947).—Value of reference spray solutions in investigations with weed-killers. *J. Aust. Inst. Agric. Sci.* 13: 142-3.

Hutton, E. M. (1947).—Resistance in the potato to the spotted wilt virus. Ibid. 13: 190-2.

Hutton, E. M., and Wark, D. C. (1947).—Tomato big bud Ibid. 13: 188-90.

Hutton, E. M., Mills, M., and Giles, J. E. (1947).—Fusarium wilt of tomato in Australia. Pt. 2. Inheritance of field immunity to Fusarium wilt in the tomato (*Lycopersicon esculentum*). *J. Coun. Sci. Industr. Res. Aust.* 20: 468-74.

Kipps, E. H. (1947).—Calcium/manganese ratio in relation to the growth of lucerne at Canberra, A.C.T. Ibid. 20: 176-89.

McIntyre, G. A. (1946).—Grazing management: continuous and rotational grazing by Merino sheep. Appendix: The measurement of pasture yield under grazing. Coun. Sci. Industr. Res. Aust., Bull. No. 201.

Miles, J. F. (1947).—Pastoral and agricultural growing season in north-eastern Australia. *J. Aust. Inst. Agric. Sci.* 13: 41-9.

Moore, R. M. (1947).—Preliminary investigations with plant growth-regulating substances as herbicides. Coun. Sci. Industr. Res. Aust., Div. Plant Ind. Rep. No. 1.

Moore, R. M. (1947).—The possibilities of plant growth-regulating substances as herbicides in Australia. *J. Aust. Inst. Agric. Sci.* 13: 54-8.

Moore, R. M., Barrie, N., and Kipps, E. H. (1946).—Grazing management: continuous and rotational grazing by Merino sheep. 1. A study of the production of a sown pasture in the Australian Capital Territory under three systems of grazing management. Coun. Sci. Industr. Res. Aust., Bull. No. 201.

Norris, D. O. (1946).—Strain complex and symptom variability of tomato spotted wilt virus. Coun. Sci. Industr. Res. Aust., Bull. No. 202.

Prunster, R. W., and Butler, B. E. (1948).—Assessment of Wakool Irrigation District soils for irrigation. Regional Pastoral Laboratory, Deniliquin. Local Report No. 1.

Roe, R. (1947).—Preliminary survey of the natural pastures of the New England District of New South Wales and a general discussion of their problems. Coun. Sci. Industr. Res. Aust., Bull. No. 210.

Rossiter, R. C. (1947).—Studies on perennial veldt grass (*Ehrharta calycina* Sm.). Coun. Sci. Industr. Res. Aust., Bull. No. 227.

Rossiter, R. C. (1947).—Effect of potassium on the growth of subterranean clover and other pasture plants on Crawley sand. 2. Field plot experiments. *J. Coun. Sci. Industr. Res. Aust.* 20: 389-401.

Rossiter, R. C., and Kipps, E. H. (1947).—The effect of potassium on the growth of subterranean clover and other pasture plants on Crawley sand. 1. Pot culture experiments. Ibid. 20: 379-88.

Rossiter, R. C., Curnow, D. H., and Underwood, E. J. (1948).—The effect of cobalt sulphate on the cobalt content of subterranean clover at three stages of growth. *J. Aust. Inst. Agric. Sci.* 14. 9-14.

Wark, D. C. (1946).—A method of selection within a variety of cabbage. Ibid. 12: 150-2.

White, N. H. (1947).—The etiology of take-all disease of wheat. 4. The effect of agronomic practices on the incidence and severity of take-all. *J. Coun. Sci. Industr. Res. Aust.* 20: 82-6.

White, N. H. (1947).—Etiology of take-all disease of wheat. 3. Factors concerned with the development of take-all symptoms in wheat. Ibid. 20: 66-81.

2. Division of Economic Entomology.

Carne, P. B. (1948).—Experiments in the use of DDT against the pasture cockchafer, *Aphodius howitti* Hope. *J. Coun. Sci. Industr. Res. Aust.* 21: 1-6.

Clark, L. R. (1947).—An ecological study of the Australian Plague Locust (*Chortoicetes terminifera* Walk.) in the Bogan-Macquarie Outback Area, N.S.W. Coun. Sci. Industr. Res. Aust., Bull. No. 226, 71 pp.

Clark, L. R. (1947).—Ecological observations on the Small Plague Grasshopper, *Austroicetes cruciata* (Sauss), in the Trangie district, central western New South Wales. Coun. Sci. Industr. Res. Aust., Bull. No. 228, 26 pp.

Gay, F. J. (1947).—Studies on the control of wheat insects by dust. 2. Further tests of various mineral dusts for the control of grain pests. Coun. Sci. Industr. Res. Aust., Bull. No. 225, pp. 21-8.

Gay, F. J. (1947).—Studies on the control of wheat insects by dust. 3. The use of dust barriers for the control of grain insects. Ibid., pp. 29-32.

Gay, F. J. (1947).—Studies on the control of wheat insects by dust. 4. The use of DDT- and 666-impregnated dusts for the control of grain pests. Ibid., pp. 33-8.

Gay, F. J., Ratcliffe, F. N., and McCulloch, R. N. (1947).—Studies on the control of wheat insects by dust. 1. Field tests of various mineral dusts against grain weevils. Ibid., pp. 7-20.

Greaves, T. (1947).—The control of silverfish and the German cockroach. *J. Coun. Sci. Industr. Res. Aust.* 20: 425-33.

Helson, G. A. H. (1947).—The use of insecticidal aerosols on agricultural crops. *J. Aust. Inst. Agric. Sci.* 13: 38-40.

Kerr, R. W. (1948).—The effect of starvation on the susceptibility of houseflies to pyrethrum sprays. *Aust. J. Sci. Res.* B 1: 76-92.

McCulloch, R. N., and Waterhouse, D. F. (1947).—Laboratory and field tests of mosquito repellents. Coun. Sci. Industr. Res. Aust., Bull. No. 213, 28 pp.

Norris, K. R. (1948).—Seasonal severity of the attack of the red-legged earth mite (*Halotydeus destructor*) on subterranean clover. *J. Coun. Sci. Industr. Res. Aust.* 21: 7-15.

Powning, R. F. (1947).—The sub-surface atmosphere of wheat infested with *Rhizopertha dominica* F. Ibid. 20: 475-82.

Waterhouse, D. F. (1947).—An examination of the Peet-Grady method for the evaluation of household fly sprays. Coun. Sci. Industr. Res. Aust. Bull. 216, 24 pp.

Waterhouse, D. F. (1947).—The relative importance of live sheep and of carrion as breeding grounds for the Australian sheep blowfly, *Lucilia cuprina*. Coun. Sci. Industr. Res. Aust., Bull. No. 217, 31 pp.

Waterhouse, D. F. (1947).—Studies of the physiology and toxicology of blowflies. 12. The toxicity of DDT as a contact and stomach poison for larvae of *Lucilia cuprina*. Coun. Sci. Industr. Res. Aust., Bull. No. 218, pp. 7-18.

Waterhouse, D. F. (1947).—Studies of the physiology and toxicology of blowflies. 13. Insectary tests of repellents for the Australian sheep blowfly, *Lucilia cuprina*. Ibid. pp. 19-30.

Waterhouse, D. F. (1947).—Spray tests against adult mosquitoes. 1. Laboratory spray tests with culicine (*Culex fatigans*) adults. Coun. Sci. Industr. Res. Aust., Bull. No. 219, pp. 9-27.

Waterhouse, D. F. (1948).—The effect of colour on the numbers of houseflies resting on painted surfaces. *Aust. J. Sci. Res.* B 1: 65-75.

Waterhouse, D. F., and Atherton, D. O. (1947).—Spray tests against adult mosquitoes. 2. Spray tests with anopheline (*Anopheles punctulatus farauti*) adults. Coun. Sci. Industr. Res. Aust., Bull. No. 219, pp. 29-40.

Wilson, F. (1946).—Interaction of insect infestation, temperature, and moisture content in bulk-depot wheat. Coun. Sci. Industr. Res. Aust., Bull. No. 209, 31 pp.

Wilson, F., and Gay, F. J. (1946).—The fumigation of wheat in bag stacks. Coun. Sci. Industr. Res. Aust., Bull. No. 207, 24 pp.

Wilson, F., and Mills, A. T. (1946).—Surface fumigation of insect infestations in bulk wheat depots. Coun. Sci. Industr. Res. Aust., Bull. No. 208, 31 pp.

3. *Division of Animal Health and Production.*

Austin, C. R. (1947).—The metabolism of thiamin in the sheep. *Aust. J. Exp. Biol. Med. Sci.* 25: 147-55.

Austin, C. R., Whitten, W. K., Franklin, M. C., and Reid, R. L. (1947).—The effect of hexoestrol on the food intake of sheep. Ibid. 25: 343-6.

Dick, A. T., and Bingley, J. B. (1947).—The determination of molybdenum in plant and animal tissues. Ibid. 25: 193-202.

Gordon, H. McL. (1948).—The epidemiology of parasitic diseases, with special reference to studies with nematode parasites of sheep. *Aust. Vet. J.* 24: 17-44.

Graham, N. P. H. (1947).—Some recent improvements in sheep dips. Yearbook Inst. Insp. Stock, N.S.W. 1947, pp. 102-5.

Johnstone, I. L. (1948).—The growth and development of the penis in sheep: Their possible relationship to posthitis. *Aust. Vet. J.* 24: 86-8.

*McQuillen, M. T., *Trikojus, V. M., Campbell, A. D., and Turner, A. W. (1948).—The prolonged administration of thyroxine to cows, with particular reference to the effects on thyroid function and on pituitary thyrotrophic hormone. *Brit. J. Exp. Path.* 29: 93-106.

Munch-Petersen, E., and Christie, R. (1947).—On the effect of the interaction of staphyloccal B toxin and Group-B streptococcal substance on red blood corpuscles and its use as a test for the identification of *Streptococcus agalactiae*. *J. Path. Bact.* 59: 367-71.

Rodwell, A. W. (1947).—Observations on various factors influencing the viability of *Br. abortus* strain 19 vaccine. *Aust. Vet. J.* 24: 133-43.

* Biochemistry School, University of Melbourne.

Stewart, D. F. (1948).—A preliminary note on a complement-fixation test to detect circulating antibodies in sheep infested with *Haemonchus contortus* and *Trichostrongylus* spp. Ibid. 24: 112-3.

Whitten, W. K. (1947).—Antigonadotrophic action of human saliva *in vivo*. *Aust. J. Sci.* 10: 49-50.

Whitten, W. K. (1947).—Enzymic inactivation of mare-serum gonadotrophin. Ibid. 10: 83-4.

Whitten, W. K. (1948).—Inactivation of gonadotrophin. 1. Inactivation of serum gonadotrophin by influenza virus and a receptor-destroying enzyme of *Vibrio cholerae*. *Aust. J. Sci. Res.* B 1: 271-7.

4. *Division of Biochemistry and General Nutrition.*

Gray, F. V. (1947).—The absorption of volatile fatty acids from the rumen. *J. Exp. Biol.* 24: 1.

Gray, F. V. (1947).—The analysis of mixtures of volatile fatty acids. Ibid. 24: 11.

Gray, F. V. (1947).—The digestion of cellulose by sheep. The extent of cellulose digestion at successive levels of the alimentary tract. Ibid. 24: 15.

Lee, H. J., and Moule, G. R. (1947).—Copper deficiency affecting sheep in Queensland. *Aust. Vet. J.* 23: 303.

Lugg, J. W. H., and Weller, R. A. (1948).—Partial amino acid compositions of some plant-leaf protein preparations: the arginine, histidine, and lysine contents. *Biochem. J.* 42: 408.

Lugg, J. W. H., and Weller, R. A. (1948).—Protein in senescent leaves of *Trifolium subterraneum*: partial amino acid composition. Ibid. 42: 412.

Marston, H. R. (1948).—Energy transactions in the sheep. I. The basal heat production and heat increment. *Aust. J. Sci. Res.* B. 1: 93.

Marston, H. R., and Lee, H. J. (1948).—The effects of copper deficiency and of chronic overdosage with copper on Border-Leicester and Merino sheep. *J. Agric. Sci.* 38: 229.

Marston, H. R., Lee, H. J., and McDonald, I. W. (1948).—Cobalt and copper in the nutrition of sheep. I. Ibid. 38: 216.

Marston, H. R., Lee, H. J., and McDonald, I. W. (1948).—Cobalt and copper in the nutrition of sheep. II. Ibid. 38: 222.

Pilgrim, A. F. (1948).—Production of methane and hydrogen by the sheep. *Aust. J. Sci. Res.* B 1: 130.

Quinlan-Watson, T. A. F., and Dewey, D. W. (1948).—Estimation of cytochrome c oxidase in animal tissues. Ibid. 1: 139.

Riceman, D. S. (1948).—Mineral deficiency in plants on the soils of the Ninety-Mile Plain in South Australia. 2. Effect of zinc, copper, and phosphate on subterranean clover and lucerne grown on Laffer Sand near Keith. Coun. Sci. Industr. Res. Aust., Bull. No. 234.

5. *Division of Soils.*

Clarke, G. B. (1948).—Effect of mechanical composition and nitrogen content on water stable aggregation of several soils. *J. Coun. Sci. Industr. Res. Aust.* 21: 51.

Clarke, G. B., and Marshall, T. J. (1947).—The influence of cultivation on soil structure. Ibid. 20: 162.

Gurr, C. G. (1948).—An electrolyte resistance thermometer for measurement of soil temperature. Ibid. 20: 502.

Marshall, T. J. (1947).—Mechanical composition of soil in relation to field descriptions of texture. Coun. Sci. Industr. Res. Aust., Bull. No. 224.

Oertel, A. C. (1947).—A note on background correction in spectrochemical analysis. *J. Coun. Sci. Industr. Res. Aust.* 20: 157.

Oertel, A. C., and Stace, H. C. T. (1946).—Errors in spectrochemical (flame) analysis. *J. Soc. Chem. Ind.* 65: 350.

Smith, R. (1948).—A relationship between soils and topography in south-western Australia. *J. Aust. Inst. Agric. Sci.* 14: 15.

Stace, H. C. T. (1947).—Flame excitation methods for quantitative spectrochemical analysis. *Aust. Chem. Inst. J.* 14: 144.

Stephens, C. G. (1947).—Functional synthesis in pedogenesis. *Trans. Roy. Soc. S.Aust.* 71 (2): 168.

Taylor, J. K. (1947).—Review Eighth Report Rural Reconstruction Commission. *J. Aust. Inst. Agric. Sci.* 13:34.

6. *Division of Forest Products.*

Amos, G. L., and Stewart, C. M. (1948).—Note on the turgidity of differentiating wood elements in *Eucalyptus regnans* F. v. M. *Aust. J. Sci.* 10 (5): 146.

Bland, D. E., Hansen, E. A., Stewart, C. M., and Watson, A. J. (1947).—Extraction of lignin from *Eucalyptus regnans* F. v. M. *J. Coun. Sci. Industr. Res. Aust.* 20: 553-63

Boas, I. H. (1947).—"Commercial Timbers of Australia," pp.344, 20 pls. Bibl. Coun. Sci. Industr. Res. Aust. (Copies obtainable from Tait Book Co. Pty. Ltd., 349 Collins-street, Melbourne. Price 12s. 6d., postage 8d.)

Cohen, W. E. (1947).—Pulp and paper in Japan. *Aust. Pulp Paper Ind. Tech. Ass. Proc.* 1: 49-62.

Dadswell, H. E. (1947).—Some forest products notes from the 1947 Empire Forestry Conference. *Aust. Forestry* 11: 20-33.

Dadswell, H. E., Eckersley, A. M., Griffin, F. V., and Ingle, H. D. (1947).—Extension of the card sorting method to war-time problems in timber identification. *J. Coun. Sci. Industr. Res. Aust.* 20: 321-37.

Dixon, C. E. (1948).—Packaging economy results from laboratory tests. *Mfrg. Mgmt.* (Melb.) 2 (8): 261-2.

Higgins, H. G., and Griffin, F. V. (1947).—Nature of the plastic deformation in wood at elevated temperatures. *J. Coun. Sci. Industr. Res. Aust.* 20: 361-71.

Kingston, R. S. T. (1947).—Variation of tensile strength and modulus of elasticity of hoop pine veneer with the direction of the grain. Ibid. 20: 338-44.

Kingston, R. S. T. (1947).—Variation of maximum crushing strength, maximum tensile strength and modulus of elasticity of hoop pine (*Araucaria cunninghamii* Ait.) plywood with moisture content. Ibid. 20: 538-52.

Kloot, N. H. (1947).—Tests on small clear specimens of North Queensland kauri (*Agathis palmerstoni* F. v. M.) Ibid. 20: 345-60.

Rudkin, A. W. (1947).—Simple method of testing glue lines in tension. Ibid. 20: 527-36.

Rudkin, A. W. (1947).—Recent developments in adhesives. *Build. Constr.* 23 (1150): 5.

Santer, L. (1948).—Comparator gauge for internal measurement. *Commonw. Engr.* 35 (11): 435.

Tamblyn, N. (1948).—Deterioration of timber. Causes and remedies. *Qld. Build. Yearb.* 2: 145, 147.

Wardrop, A. B., and Dadswell, H. E. (1947).—Contributions to the study of the cell wall. 4. Nature of intercellular adhesion in delignified tissue. 5. Occurrence, structure, and properties of certain cell wall deformations. Coun. Sci. Industr. Res. Aust., Bull. No. 221.

Wardrop, A. B., and Dadswell, H. E. (1948).—Nature of reaction wood. 1. Structure and properties of tension wood fibres. *Aust. J. Sci. Res.* B 1 (1): 1-15.

Wardrop, A. B., and Preston, R. D. (1947).—Organization of the cell walls of tracheids and wood fibres. *Nature* 160: 911-6.

Wright, G. W. (1947).—Sawmill studies in Victoria and Queensland. 1. *Aust. Timber J.* 13 (6): 369, 371, 373, 375, 377, 379. 2. Ibid. 13 (7): 441-2, 445, 447, 473, 478.

7. *Division of Food Preservation and Transport.*

Dwyer, F. P., and McKenzie, H. A. (1947).—The oxidation potentials of the tris 1,10-phenanthroline and tris 2,2'-dipyridyl ferrous ions. *J. Roy. Soc. N.S.W.* 81: 93.

Dwyer, F. P., and McKenzie, H. A. (1947).—A note on the instability constant of the tris 2,2'-dipyridyl ferrous ion. Ibid. 81: 97.

Hall, E. G. (1948).—The cool storage of pears. *Agric. Gaz. N.S.W.* 59: 77.

Huelin, F. E. (1947).—The determination of ascorbic acid. *Aust. Chem. Inst. J.* 14: 498.

Lewis, V. M., and McKenzie, H. A. (1947).—The amperometric determination of dissolved oxygen in orange juice. *Anal. Chem.* 19: 643.

McKenzie, H. A. (1947).—The determination of tin coating weights on tinplate. *J. Soc. Chem. Ind.* 66: 312.

McKenzie, H. A. (1948).—The colorimetric determination of iron in canned foods with 1,10-phenanthroline. *J. Roy. Soc. N.S.W.* 81: 147.

Robertson, R. N., and Wilkins, M. J. (1948).—Studies in the metabolism of plant cells. 7. The quantitative relation between salt accumulation and salt respiration. *Aust. J. Sci. Res.* B 1: 17.

Robertson, R. N., and Wilkins, M. J. (1948).—Quantitative relation between salt accumulation and salt respiration in plant cells. *Nature* 161: 101.

8. *Division of Fisheries.*

Blackburn, M., and Olsen, A. M. (1947).—Recent progress with pelagic fishing in Tasmanian waters. *J. Coun. Sci. Industr. Res. Aust.* 20: 434-44.

Cleland, K. W. (1947).—Studies on the economic biology of the sand whiting (*Sillago ciliata* C. & V.). *Proc. Linn. Soc. N.S.W.* 72: 215-28.

Cleland, K. W. (1947).—Some observations on the cytology of oogenesis in the Sydney rock oyster (*Ostrea commercialis* I. & R.). Ibid. 72: 159-82.

Humphrey, G. (1948).—The effect of narcotics on the endogenous respiration and succinate oxidation in oyster muscle. *J. Mar. Biol. Ass. U.K.* 27: 504-12.

May, V. (1948).—The algal genus *Gracilaria* in Australia. Coun. Sci. Industr. Res. Aust., Bull. No. 235.

Rochford, D. J. (1947).—The preparation and use of Harvey's reduced strychnine reagent in oceanographical chemistry. Coun. Sci. Industr. Res. Aust., Bull. No. 220.

Serventy, D. L. (1948).—*Allothunnus falai* a new genus and species of tuna from New Zealand. *Rec. Cant. Mus.* 5 (3): 131-5.

Sheard, K. (1947).—Plankton of the Australian-Antarctic quadrant. Pt. 1. Net-plankton volume determination. *B.A.N.Z. Antarctic Exped. Reps.* (Ser. B) Vol. 6, No. 1.

Thomson, J. M. (1947).—The Chaetognatha of south-eastern Australia. Coun. Sci. Industr. Res. Aust., Bull. No. 222.

9. *Division of Metrology.*

Greenham, C. G. (1947).—Some new types of slip gauges. *Engineering* 164: 436, 462-3.

10. *Division of Electrotechnology.*

Dryden, J. S., and Meakins, R. J. (1948).—Treatment of glass and steatite ceramic with quaternary ammonium compounds for the improvement of electrical insulation resistance. *Nature* 161: 23-4.

Love, A. W. (1948).—The behaviour of a diode noise generator at ultra high frequencies. *J. Inst. Engrs. Aust.* 20: 33-42.

11. *Division of Physics.*

Giovanelli, R. G. (1947).—A new method for the measurement of the mean diameter of fibres in a bundle. *J. Sci. Instrum.* 24: 314.

Giovanelli, R. G. (1948).—The emission of enhanced microwave solar radiation. *Nature* 161: 133.

Godfrey, G. H. (1948).—Diffraction of light from sources of finite dimensions. *Aust. J. Sci. Res.* A 1: 1.

Makinson, K. R. (1947).—The kinetic friction of wool. *J. Text. Inst.* 38: T-332.

12. *Division of Aeronautics.*

Dance, J. B., and Rowe, F. D. (1948).—Transmission of cracks from chromium plate to underlying metal. *Metal Progr.* 53: 537-8.

Dewsnap, N. F. (with Wood, W. A.) (1948).—Internal stresses in metals. *Nature* 161: 682.

Edwards, A. R., and Lewis, F. G. (1948).—Izod, tensile and hardenability tests on some aircraft steels of Australian manufacture. Aero. Res. Rep. ACA-38.

Evans, J. M. (1947).—Stability derivatives. Wind tunnel interference on the lateral derivatives l_p, l_r and l_v, with particular reference to l_p. Aust. Coun. Aero. Rep. ACA-33.

Evans, J. M., and Fink, P. T. (1947).—Stability derivatives. Determination of l_p by free oscillations. Aust. Coun. Aero. Rep. ACA-34.

Evans, J. M., and Fink, P. T. (1947).—Stability derivatives. Determination of l_p by free rolling. Aust. Coun. Aero. Rep. ACA-35.

Foster, B. McA. (1948).—Spraying the orchard by aerodynamic means. *Fruit World* 49: 539.

Greenaway, H. T. (1947).—The surface tension and density of lead-antimony and cadmium-antimony alloys. *J. Inst. Met.* 74: 133-48.

Keeble, T. S., and Wallis, R. A. (1947).—Automotive engine cooling systems. *J. Instn. Auto. Aero. Engrs.* 7 (6): 92.

Love, E. R., and Silberstein, J. P. O. (assisted by Radok, J. R. M.) (1947).—Vibration of stationary and rotating propellers. Aust. Coun. Aero. Rep. ACA-36.

McKinnon, N. A. (1948).—Symposium on recent advances in physical metallurgy. Part I. Dilatometry. *Aust. Eng.*, pp. 60-9 (March).

Radok, J. R. M., Silberstein, J. P. O., and Wills, H. A. (1948).—A new theory for the strength of wooden box beams. Aero. Res. Rep. ACA-40.

Townsend, A. A. (1947).—Measurements in the turbulent wake of a cylinder. *Proc. Roy. Soc.* A 190: 551-61.

Townsend, A. A. (1947).—The measurement of double and triple correlation derivatives in isotropic turbulence. *Proc. Camb. Phil. Soc.* 43: 560-70.

Wills, H. A. (1947).—The strength of wooden box beams. Paper presented at A.N.Z.A.A.S. Conference, 1947.

Wisdom, J. C., and Brooks, R. L. (1947).—Observations of the lubricating oil film between piston ring and cylinder of a running engine. Aust. Coun. Aero. Rep. ACA-37.

13. *Division of Industrial Chemistry.*

Alderman, A. R., Gaskin, A. J., Jones, R. H., and Vivian, H. E. (1947).—Studies in cement-aggregate reaction. Part 1. Australian aggregates and cements. Coun. Sc. Industr. Res. Aust., Bull. No. 229.

Bowman, R. P., Fitzgerald, J. S., and Jensen, Florence (1947).—The water absorption of phenol-formaldehyde resin mouldings. *J. Coun. Sci. Industr. Res. Aust.* 20: 503.

Bradbury, R. B., Hancox, N.C., and Hatt, H. H. (1947).—The reaction between acetone and ammonia: The formation of pyrimidine compounds analogous to the aldoxanes of Späth. *J. Chem. Soc.* 1947: 1394.

Brown, I., Symons, E. F., and Wilson, B. W. (1947).—Furfural: A pilot plant investigation of its production from Australian raw materials. *J. Coun. Sci. Industr. Res. Aust.* 20: 225.

Cowley, J. M. (1948).—Electron diffraction by fatty acid layers on metal surfaces. *Trans. Faraday Soc.* 44: 60.

Cowley, J. M., and Scott, T. R. (1947).—The nature of precipitated sodium fluoaluminates. *J. Amer. Chem. Soc.* 69: 2596.

Cowley, J. M., and Scott, T. R. (1948).—Basic fluorides of aluminium. Ibid. 70: 105.

Cowley, J. M., and Symonds, J. L. (1948).—Electron diffraction and rectification from silicon and pyrite surfaces. *Trans. Faraday Soc.* 44: 53.

Cowley, J. M., and Walkley, A. (1948).—Reaction between manganous ion and manganese dioxide. *Nature* 161: 173.

Curtis, R. G., Dobson, A. G., and Hatt, H. H. (1947).—The ketonization of higher fatty acids with some observations on the mechanism of the reaction. Studies of waxes. Part 1. *J. Soc. Chem. Ind.* 66: 402.

Dalton, L. K. (1947).—Lignocellulous residues as fillers for phenolic plastics. *J. Coun. Sci. Industr. Res. Aust.* 20: 272.

Dawson, I. M., Mathieson, A. McL., and Robertson, J. M. (1948).—The structure of certain polysulphides and sulphonyl sulphides. Part 1. A preliminary X-ray survey. *J. Chem. Soc.* 1948: 322.

Dixon, P., and Scott, T. R. (1947).—Preparation and properties of synthetic cryolite. Coun. Sci. Industr. Res. Aust., Bull. No. 214.

Ewers, W. E., and Bayliss, N. S. (1947).—Thermodynamics of some reactions involving alumina and anhydrous aluminium chloride. *Aust. Chem. Inst. J.* 14: 504.

Ewers, W. E., Bayliss, N. S., Cole, A. R. H., and Jones, N. K. (1947).—The system potassium sulphate, sodium sulphate, magnesium sulphate, water 35° C. *J. Amer. Chem. Soc.* 69: 2033.

Gaskin, A. J. (1947).—Studies in cement-aggregate reaction. VI. The effect of carbon dioxide. Coun. Sci. Industr. Res. Aust., Bull. No. 229.

Hackman, R. H. (1947).—Para-sulphonamide-benzamidoxine hydrochloride. *Aust. Chem. Inst. J.* 14: 150.

Hartley, F. H., and Wylie, A. W. (1948).—Preparation of rare-earth chlorides. *Nature* 161: 241.

Hatt, H. H., and Hillis, W. E. (1947).—The manna of *Myoporum platycarpum*, R. Br. as a possible commercial source of mannitol. *J. Coun. Sci. Industr. Res. Aust.* 20: 207.

Hill, C. G. A., Lovering, P. E., and Rees, A. L. G. (1947).—Electrophoretic deposition of powdered materials from non-aqueous suspensions. *Trans. Faraday Soc.* 43: 407.

Lord, M. P., Rees, A. L. G., and Wise, M. E. (1947).—The short period time variation of the luminescence of a zinc sulphide phosphor under ultra-violet excitation. *Proc. Phys. Soc.* 59: 473.

McTaggart, F. K. (1947).—Mineral chlorination studies. 3. Chlorination of Australian beryl. *J. Coun. Sci. Industr. Res. Aust.* 20: 564.

McTaggart, F. K. (1947).—Mineral chlorination studies. 4. The beneficiation of Australian graphite by treatment with chlorine at high temperatures. Ibid. 20: 1.

Pilkington, E. S. (1948).—Note on the recovery of potassium iodate in the iodate method for determination of thorium. *Aust. Chem. Inst. J.* 15: 101.

Pilkington, E. S., and Wylie, A. W. (1947).—Production of rare-earth and thorium compounds from monazite. Part. 1. *J. Soc. Chem. Ind.* 66: 387.

Plante, E. C. (1948).—Flotation of unoxidized and oxidized sulphide minerals—antimonite, arsenopyrite, covellite, lollingite, marcasite, orpiment, pyrrhotite, and tetrahedrite. A.I.M.M.E. Tech. Publ. No. 2298.

Rees, A. L. G. (1947).—The calculation of potential energy curves from band spectroscopic data. *Proc. Phys. Soc.* 59: 998.

Rees, A. L. G. (1947).—A note on the interpretation of the visible absorption spectrum of bromine. Ibid. 59: 1008.

Scott, T. R. (1947).—The preparation and properties of aluminium fluoride. Coun. Sci. Industr. Res. Aust., Bull. No. 230.

Ställberg-Stenhagen, S., Stenhagen, E., Sheppard, N., Sutherland, G. B. B. M., and Walsh, A. (1947).—Infra-red spectrum and molecular structure of phthiourane. *Nature* 160: 580.

Sutherland, K. L. (1947).—The determination of the surface energies of solids. *Aust. Chem. Inst. J.* 14: 268.

Sutherland, K. L. (1948).—The physical chemistry of flotation. XI. Kinetics of the flotation process. *J. Phys. Colloid Chem.* 52: 395.

Urie, R. W. (1947).—Pilot plant production of rare-earth oxides and thorium oxalate from monazite. *J. Soc. Chem. Ind.* 66: 437.

Urie, R. W., and Wylie, A. W. (1947).—Rare-earth oxides for glass polishing. Ibid. 66: 433.

Vivian, H. E. (1947).—Studies in cement-aggregate reaction. Part II. The effect of alkali movement in hardened mortar. Part III. The effect of void space on mortar expansion. Part IV. The effect of expansion on the tensile strength of mortar. Part V. The effect of void space on the tensile strength changes of mortar. Coun. Sci. Industr. Res. Aust., Bull. No. 229.

Vivian, H. E. (1947).—Studies in cement-aggregate reaction. Part VII. The effect of storage conditions on expansion and tensile strength changes of mortar. *J. Coun. Sci. Industr. Res. Aust.* 20: 585.

Walkley, Allan (1947).—A critical examination of a rapid method for determining organic carbon in soils. *Soil Sci.* 63: 251.

Walkley, Allan (1948).—A determination of the free energy of formation of the manganous ion from thermal data. *J. Electrochem. Soc.* 93: 6.

Walsh, A. (1947).—The spectrographic analysis of uranium. Gt. Brit., Minist. Supply, B.D.D.A. 98. (H.M. Stat. Off.)

Wilson, B. W. (1947).—The yield of furfural from pentosans. *J. Coun. Sci. Industr. Res. Aust.* 20: 258.

Wylie, A. W. (1947).—The determination of sulphate in sodium dichromate. *Analyst* 72: 250.

Wylie, A. W. (1948).—Note on constitution of monazite. *Nature* 161: 97.

14. *Division of Radiophysics.*

"A Textbook of Radar", a composite work written by the staff of the Division, was issued during the year. This was published by Angus and Robertson Ltd., of Sydney.

Allen, W. D., and Symonds, J. L. (1947).—Experiments in multiple gap linear acceleration of electrons. *Proc. Phys. Soc.* 59: 622.

Bolton, J. G., and Stanley, G. J. (1948).—Observations on the variable source of cosmic radio frequency radiation in Cygnus. *Aust. J. Sci. Res.* A 1: 58.

Bolton, J. G., and Stanley, G. J. (1948).—Variable source of radio frequency radiation in the constellation of Cygnus. *Nature* 161: 312.

Bowen, E. G., and Pearcey, T. (1948).—Delays in the flow of air traffic. *J. Roy. Aero. Soc.* 52: 251.

Bracewell, R. N. (1947).—Charts for resonant frequencies of cavities. *Proc. Inst. Radio Engrs.* 35: 830.

Briton, J. N. (1947).—Light weight air warning and GCI radar in Australia. *J. Instn. Engrs. Aust.* 19 (6): 121.

Downes, J. G. (1948).—Operational trials of the Australian distance measuring equipment and multiple track radar range. *J. Instn. Radio Engrs. Aust.* 9 (4): 10.

Hibbard, L. U. (1947).—A pulse peak kilovoltmeter. *J. Sci. Instrum.* 24: 181.

Lehany, F. J., and Yabsley, D. E. (1948).—A solar noise outburst at 600 and 1200 Mc/s. *Nature* 161: 645.

McCready, L. L., Pawsey, J. L., and Payne-Scott, Ruby (1947).—Solar radiation at radio frequencies and its relation to sunspots. *Proc. Roy. Soc.* A 190: 357.

Payne-Scott, Ruby (1948).—The visibility of small signals on radar PPI displays. *Proc. Inst. Radio Engrs.* 36: 180.

Payne-Scott, Ruby, Yabsley, D. E., and Bolton, J. G. (1947).—Relative times of arrival of bursts of solar noise on different radio frequencies. *Nature* 160: 256.

Pearcey, T. (1948).—Modern trends in machine computation. *Aust. J. Sci.* 10 (4): i-xx (Suppl.).

Warner, J. (1947).—The velocity of electromagnetic waves. Ibid. 10 (3): 73.

15. *Division of Tribophysics.*

Boas, W., and Hargreaves, M. E. (1948).—On the inhomogeneity of plastic deformation in crystals of an aggregate. *Proc. Roy. Soc.* A 193: 89.

Boas, W., and Honeycombe, R. W. K. (1947).—Recrystallization of duplex brass. *Nature* 159: 847.

Boas, W., and Honeycombe, R. W. K. (1948).—The disordering of beta brass by cold work. Ibid. 161: 612.

Boas, W., and Honeycombe, R. W. K. (1948).—The deformation and recrystallization of an alloy containing two phases. *Aust. J. Sci. Res.* A 1: 70.

Bowden, F. P. (1947).—The experiments of Boas and Honeycombe on internal stresses due to anisotropic thermal expansion of pure metals and alloys. Symposium on internal stresses in metals and alloys. London, October 1947.

Bowden, F. P., and Moore, A. J. W. (1947).—Internal stresses produced by the sliding of metals. Symposium on internal stresses in metals and alloys. London, October 1947.

Gregory, J. N., and Newing, Marjorie J. (1948).—Lubrication of metal surfaces of silicone films. *Aust. J. Sci. Res.* A 1: 85.

Honeycombe, R. W. K., and Collins, June (1948).—An investigation into the inhomogeneity of deformation in wire drawing and rolling. *J. Coun. Sci. Industr. Res. Aust.* 21: 59-65.

Michell, D., and West, G. W. (1947).—Electronics in industry. Aust. Inst. Met. Symposium on Recent Advances in Physical Metallurgy, September, 1947.

Mulcahy, M. F. R., and Vines, R. G. (1947).—The initial stages of explosion in nitroglycerine. *Proc. Roy. Soc.* A 191: 210.

Mulcahy, M. F. R., and Vines, R. G. (1947).—The propagation of detonation in thin layers of nitroglycerine. Ibid. 191: 226.

Muncey, R. W. R. (1948).—An electronic device for measuring mechanical phenomena. *J. Coun. Sci. Industr. Res. Aust.* 21: 141.

Tabor, D. (1948).—The frictional properties of lead-base and tin-base bearing alloys: The role of the matrix and the hard particles. Coun. Sci. Industr. Res. Aust., Bull. No. 212.

Vines, R. G. (1947).—Properties of liquid explosives. *Nature* 160: 400.

16. *Building Materials Research.*

Hueber, H. V. (1948).—An experimental kiln for ceramic ware. *J. Coun. Sci. Industr. Res. Aust.* 21: 160-4.

Hosking, J. S. (1948).—The cation exchange capacity of soils and soil colloids, 1. Variation with hydrogen ion concentration. Ibid. 21: 21-37.

Hosking, J. S. (1948).—The cation exchange capacity of soils and soil colloids. 2. The contribution from the sand, silt and clay fractions and organic matter. Ibid. 21: 38-50.

Langlands, I. (1948).—Overseas building materials. *Constr. Rev.* 20 (11): 23-38.

Muncey, R. W. (1947).—Note on the Hilsch centrifugal jet or "Maxwellian Demon". *J. Coun. Sci. Industr. Res. Aust.* 20: 402.

Muncey, R. W. (1948).—An electronic device for measuring mechanical phenomena. Ibid. 21: 141-7.

17. *Dairy Research Section.*

Hutchinson, R. C., West, H. E., and Jeffreys, J. T. (1947).—The addition of skim milk powder to Australian bread. *J. Coun. Sci. Industr. Res. Aust.* 20: 483-99.

Loftus Hills, G. (1947).—The effect of sodium chloride on the pH values of milk and of butter serum. *J. Dairy Res.* 15: 62-9.

Pont, E. G. (1947).—Some observations on the uses and properties of annatto. *Aust. J. Dairy Technol.* 2: 139-41.

Thiel, C. C., Loftus Hills, G., and Scharp, L. R. (1947).—Apparatus for routine estimation of oxygen in tins of milk powder. *J. Dairy Res.* 15: 121-6.

18. *Meteorological Physics.*

Priestley, C. H. B. (1948).—Dynamical control of atmospheric pressure. II. The size of pressure systems. *Quart. J. Roy. Met. Soc.* 74: 67-72.

Priestley, C. H. B. (1948).—Air circulation and the Antarctic. *Aust. J. Sci.* 10: 129-31.

Priestley, C. H. B. (1948).—Heat transport and zonal stress between latitudes (abstract). Prog. U.G.G.I., Assoc. de Meteorologie, Reunion d'Oslo 1948. (Pub. Los Angeles, U.S.A.)

Priestley, C. H. B. (1948).—Atmospheric pressure changes: The importance of deviations from the balanced (gradient) wind. *Aust. J. Sci. Res.* A 1: 41.

19. *Information Service.*

Wylie, G. J. (1948).—Literature research: its possibilities and technique. *Aust. J. Instrum. Technol.* 4 (3): 130-44.

XXV. ACKNOWLEDGMENTS.

In various sections of this Report reference has been made as in previous years 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
D. A. MOUNTJOY
} Executive Committee.

G. A. COOK, Secretary.

October, 1948.

APPENDIX.

PERSONNEL OF THE COUNCIL AND COMMITTEES ADVISING ON THE COUNCIL'S OWN WORK OR ON CO-OPERATIVE WORK IN WHICH THE COUNCIL IS ASSISTING.

COUNCIL (AS AT 30TH JUNE, 1948.)

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.
I. Clunies Ross, D.V.Sc.
D. A. Mountjoy.

CHAIRMEN OF STATE COMMITTEES.

A. J. Gibson, M.E. (New South Wales).
Professor E. J. Hartung, D.Sc. (Victoria).
Professor Sir Kerr Grant, M.Sc. (South Australia).
A. F. Bell, B.Sc., D.I.C. (Queensland).
P. H. Harper, B.A. (Western Australia).
F. H. Foster, B.C.E. (Tasmania).

CO-OPTED MEMBERS.

N. K. S. Brodribb, C.B.E., F.R.I.C.
Sir Harry Brown, C.M.G., M.B.E.
Professor F. M. Burnet, F.R.S., M.D., Ph.D.
Professor W. J. Dakin, D.Sc.
W. S. Kelly.
E. H. B. Lefroy.
G. Lightfoot, M.A.
Professor Sir John Madsen, B.E., D.Sc.
Professor S. M. Wadham, M.A., Dip.Agr.
C. E. Young, D.S.O.

STATE COMMITTEES (AS AT 30TH JUNE, 1948).

NEW SOUTH WALES.

A. J. Gibson, M.E. (*Chairman*).
Professor Sir Henry E. Barraclough, K.B.E., V.D., B.E., M.M.E.
J. N. Briton, B.Sc., B.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.
O. McL. Falkiner.
W. R. Hebblewhite, B.E.
Hon. Sir Norman W. Kater, M.L.C., M.B., Ch.M.
Sir Frederick McMaster.
Professor Sir John Madsen, B.E., D.Sc.
J. Merrett.
C. St. J. Mulholland, B.Sc.
R. J. Noble, B.Sc.Agr., M.Sc., Ph.D.
R. G. C. Parry Okeden.
J. G. Peake.
A. R. Penfold, F.R.I.C.
Professor J. D. Stewart, F.R.C.V.S., B.V.Sc.
E. H. F. Swain, Dip.For.
J. P. Tivey, B.A., B.Sc., B.E.
Professor W. L. Waterhouse, M.C., D.Sc.Agr., D.I.C.
Emeritus-Professor R. D. Watt, M.A., B.Sc.
C. M. Williams.

VICTORIA.

Professor E. J. Hartung, D.Sc. (*Chairman*).
R. S. Andrews, D.Sc.
W. Baragwanath.
N. K. S. Brodribb, C.B.E., F.R.I.C.
Professor F. M. Burnet, M.D., Ph.D., F.R.S.
Sir Herbert W. Gepp.
Professor J. N. Greenwood, D.Sc., M. Met.E.
Russell Grimwade, C.B.E., B.Sc.
H. Herman, D.Sc., M.M.E., B.C.E.
Professor E. S. Hills, D.Sc., Ph.D., D.I.C.
G. G. Jobbins.
Sir Dalziel Kelly, LL.B.
G. Lightfoot, M.A.
H. A. Mullett, B.Agr.Sc.
N. Taylor, B.Sc., F.R.I.C.
Professor J. S. Turner, M. A., Ph.D., M.Sc.
Professor S. M. Wadham, M.A., Dip.Agr.
W. E. Wainwright, A.S.A.S.M.
L. J. Weatherly, M.A.

SOUTH AUSTRALIA.

Professor Sir Kerr Grant, M.Sc. (*Chairman*).
A. J. Allen.
A. R. Callaghan, C.M.G., B.Sc., B.Sc.Agr., D.Phil.
S. B. Dickinson, M.Sc.
Sir James Gosse.
L. C. Haselgrove.
Professor T. H. Johnston, M.A., D.Sc.
W. S. Kelly.
H. R. Marston.
Sir Douglas Mawson, O.B.E., D.Sc., B.E., F.R.S.
Professor M. L. Mitchell, M.Sc.
F. W. Moorehouse, M.Sc.
F. T. Perry.
Professor J. A. Prescott, D.Sc.
S. D. Shield, A.S.A.S.M.
W. J. Spafford, R.D.A.
L. K. Ward, B.A., B.E., D.Sc.
Professor J. G. Wood, D.Sc., Ph.D.

QUEENSLAND.

A. F. Bell, M.Sc., D.I.C. (Chairman).
S. F. Cochran.
R. J. Donaldson, D.S.O., B.C.E.
V. Grenning.
J. B. Henderson, O.B.E., F.R.I.C.
Professor T. G. H. Jones, D.Sc.
Professor D. H. K. Lee, M.Sc., M.D.
J. McCann.
A. McCulloch, M.E.
W. M. McLean.
J. F. Meynink.
J. Michelmore.
P. B. Newcomen.
Professor T. Parnell, M.A.
C. R. Paterson, B. E.
Professor L. J. H. Teakle, M.S., B.Sc.(Agric.), Ph.D.
H. C. Urquhart, M.Sc.
R. Veitch, B.Sc.Agr., B.Sc.For.
J. L. Wilson.
C. E. Young, D.S.O.

WESTERN AUSTRALIA.

P. H. Harper, B. A. (*Chairman*).
G. K. Baron-Hay, M.C., B.Sc.(Agric.).
Professor N. S. Bayliss, B.A., B.Sc., Ph.D.
F. G. Brinsden.
W. G. Burges.
Professor E. de Courcy Clarke, M.A.
Professor G. A. Currie, D.Sc., B.Agric.Sc.
A. L. B. Lefroy.
E. H. B. Lefroy.
B. Meecham.
Professor G. E. Nicholls, D.Sc.
L. W. Phillips, M.Sc., M.Ed.
Professor A. D. Ross, M.A., D.Sc.
H. P. Rowledge, A.W.A.S.M.
T. N. Stoate, M.Sc., Dip.For.
G. L. Sutton, D.Sc.Agr.
Professor E. J. Underwood, B.Sc. (Agric.), Ph.D.
Professor H. Waring, D.Sc.
R. B. Williamson.

TASMANIA.

F. H. Foster, B.C.E. (*Chairman*).
L. R. S. Benjamin.
Professor A. Burn, M.Sc., B.E.
A. H. Crane.
F. W. Hicks.
S. L. Kessell, M.Sc., Dip.For.
A. W. Knight, B.Sc., M.E., B.Com.
Professor A. L. McAulay, M.A., B.Sc., Ph.D.
D. O. Meredith.
F. H. Peacock.
J. Pearson, D.Sc.
F. B. Richardson, M.A.
Hon. Sir Rupert Shoobridge, M.L.C.
H. B. Somerset, M.Sc.

COMMONWEALTH RESEARCH STATION, MERBEIN—CONSULTATIVE COMMITTEE.

B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R. (*Chairman*).
Professor J. A. Prescott, D.Sc., Waite Agricultural Research Institute, University of Adelaide.
J. K. Taylor, B.A., M.Sc., B.Sc.Agr., Division of Soils, C.S.I.R.
P. Malloch, Commonwealth Dried Fruits Control Board.
E. J. Casey, Commonwealth Dried Fruits Control Board.
A. E. Cameron, representing Advisory Committee.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Secretary*).

COMMONWEALTH RESEARCH STATION, MERBEIN—ADVISORY COMMITTEE.

A. E. Cameron, Red Cliffs Settlement (*Chairman*).
J. A. Aird, B.Sc., B.Agr.Sc., Dip.Com., State Rivers and Water Supply Commission, Victoria.
L. W. Andrew, Waikerie, South Australia.
P. T. Byrnes, Woorinen, Victoria.
E. J. Casey, representing Consultative Committee.
D. W. Cockcroft, Nyah-Woorinen Inquiry Committee.
C. E. Cole, B.Agr.Sc., Department of Agriculture, Victoria.
J. Gordon, Citrus Growers' Association, Merbein.
W. B. Hawson, First Mildura Irrigation Trust.
A. E. Hazel, Dried Fruits Association, Red Cliffs.
S. Heaysman, Coomealla, New South Wales.
W. Heaysman, Cardross Progress Association.
H. Jackson, Wakool Land-Use Committee.
J. A. Lochhead, Mildura Shire Council.
P. Malloch, representing Consultative Committee.
R. C. Polkinghorne, Nyah-Woorinen Inquiry Committee.
A. Rawlings, Merbein, Victoria.
C. G. Savage, Department of Agriculture, N.S.W.
J. L. Showell, Renmark Irrigation Trust.
R. Stevens, Nyah-Woorinen Inquiry Committee.
A. G. Strickland, M.Agr.Sc., Department of Agriculture, South Australia.
S. P. Taylor, Curlwaa, New South Wales.
O. Weste, Renmark, South Australia.
D. C. Winterbottom, Mildura Packers' Association.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (Secretary).

IRRIGATION RESEARCH STATION, GRIFFITH—CONSULTATIVE COMMITTEE.

B. T. Dickson, B. A., Ph.D., Division of Plant Industry, C.S.I.R. (*Chairman*).
Professor J. A. Prescott, D.Sc., Waite Agricultural Research Institute, University of Adelaide.
J. K. Taylor, B.A., M.Sc., B.Sc.Agr., Division of Soils, C.S.I.R.
H. N. England. B.Sc., Water Conservation and Irrigation Commission, N.S.W.
V. C. Williams, representing Irrigation Research and Extension Committee.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith (*Secretary*).

IRRIGATION RESEARCH AND EXTENSION COMMITTEE (MURRUMBIDGEE IRRIGATION AREAS).

V. C. Williams, Griffith Producers' Co-op. Co. Ltd. (*Chairman*).
R. R. Pennefather, M.I.A. Extension Organizer, Department of Agriculture, N.S.W.
H. J. Hynes, D.Sc.Agr., M.S., Department of Agriculture, N.S.W.
A. H. Skepper, H.D.A., Department of Agriculture, N.S.W.
C. G. Savage, H.D.A., Department of Agriculture, N.S.W.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
R. W. Prunster, B.Sc.(Agric.), Regional Pastoral Laboratory, Deniliquin.
E. R. Iredale, Rural Bank of New South Wales.
F. J. McKirdy, Rural Bank of New South Wales.
H. N. England. B.Sc., Water Conservation and Irrigation Commission, N.S.W.
H. Mallaby, H.D.A., Water Conservation and Irrigation Commission, N.S.W.
Professor J. R. A. McMillan, D.Sc.Agr., M.S., University of Sydney.

E. S. Clayton, H.D.A., Soil Conservation Service, N.S.W.
O. J. Longhurst, Yenda Producers' Co-op. Soc. Ltd.
H. J. Williams, Leeton Co-op. Cannery Ltd.
W. Jacka, Leeton Fruitgrowers' Co-op. Soc. Ltd.
A. D. McKellar, Rice Growers' Association, Leeton.
J. H. Reilly, Rice Growers' Association, Yenda.
T. Darchy, Rice Growers' Association, Murrami.
J. E. Morphett, Vegetable Growers' Association.
F. R. Polkinghorne, District Council of Extension Groups, Leeton.
J. Woodside, Large Area Extension Groups, Griffith.
R. St. C. Young, Large Area Extension Groups, Yanco.
B. O. French, Department of Agriculture (*Acting Secretary*).

CURLWAA AND COOMEALLA HORTICULTURAL ADVISORY COMMITTEE.

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Chairman*).
F. P. H. Barrett, Water Conservation and Irrigation Commission, N.S.W.
C. T. Lasscock, Rural Bank of New South Wales.
S. Heaysman, representing Coomealla Producers.
J. Bailey, representing Coomealla Producers.
S. P. Taylor, representing Curlwaa Producers.
W. Reeves, representing Curlwaa Producers.
F. S. Oldham, Department of Agriculture, N.S.W. (*Secretary*).

WAKOOL LAND-USE COMMITTEE.

A. Varcoe-Cocks, Wakool Shire Council (*Chairman*).
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
G. B. Gibbs, Water Conservation and Irrigation Commission, N.S.W.
K. Diamond, Rural Bank of New South Wales.
A. Crawford, Department of Agriculture, New South Wales.
C. G. Savage, Department of Agriculture, New South Wales.
G. Ellis, representing Wakool District Landowners' Executive.
L. Jeffers, representing Wakool District Landowners' Executive.
W. R. A. Smith, representing Wakool District Landowners' Executive.
F. J. Hollins, representing Wakool District Landowners' Executive.
K. Howe, representing Wakool District Landowners' Executive.
R. W. Prunster, B.Sc.(Agric.), Regional Pastoral Laboratory, Deniliquin, C.S.I.R.
H. Jackson, representing Wakool District Landowners' Executive (*Secretary*).

TYNTYNDER INVESTIGATION COMMITTEE, SWAN HILL.

J. D. Wallis, State Rivers and Water Supply Commission, Victoria (*Chairman*).
J. A. Aird, B.Sc., B.Agr.Sc., State Rivers and Water Supply Commission, Victoria.
F. Rogerson, State Rivers and Water Supply Commission, Victoria.
A. V. Lyon, M.Agr.Sc., Commonwealth Irrigation Station, Merbein.
F. Penman, M.Sc., Department of Agriculture, Victoria.
E. Pearce, Swan Hill Advisory Board.
L. M. Barrett, Tyntynder Progress Association.

NYAH-WOORINEN INQUIRY COMMITTEE.

Hon. P. T. Byrnes, M.L.C. (*Chairman*).
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
J. G. Baldwin, B.Sc., B.Agr.Sc., Commonwealth Research Station, Merbein.
J. A. Aird, B.Sc., B.Agr.Sc., State Rivers and Water Supply Commission, Victoria.
J. D. Wallis, State Rivers and Water Supply Commission, Victoria.
W. Bentley, State Rivers and Water Supply Commission, Victoria.
F. Penman, M.Sc., Department of Agriculture, Victoria.
F. M. Read, M.Agr.Sc., Department of Agriculture, Victoria.
D. D. Brown, Department of Agriculture, Victoria.
D. A. Cockcroft, Dried Fruits Board, Victoria.
A. McQueen, Department of Commerce.
A. S. P. Basey, Packers' Association.
A. Westcott, Woorinen Fruit Growers.
A. E. Jude, Woorinen Fruit Growers.
D. W. Cockcroft, Woorinen Fruit Growers.
H. Willoughby, Nyah Fruit Growers.
G. D. Willoughby, Nyah Fruit Growers.
R. Stevens, Nyah Fruit Growers.
L. M. Byrnes, Koraleigh Fruit Growers.
R. C. Polkinghorne (*Secretary*).

IRRIGATION ENGINEERING COMMITTEE.

A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein (*Chairman*).
J. A. Aird, B.Sc., B.Agr.Sc., State Rivers and Water Supply Commission, Victoria.
J. D. Lang, State Rivers and Water Supply Commission, Victoria.
F. P. H. Barrett, Water Conservation and Irrigation Commission, N.S.W.
F. B. Haigh, First Mildura Irrigation Trust.
J. G. Baldwin, B.Sc., B.Agr.Sc., Commonwealth Research Station, Merbein.
G. V. F. Clewett, B.E., Commonwealth Research Station Merbein (*Secretary.*)

IRRIGATION AND DRAINAGE COMMITTEE FOR SOUTH AUSTRALIA.

C. M. Fowles, Lands Department, South Australia (*Chairman*).
A. G. Strickland, M.Agr.Sc, Department of Agriculture, South Australia.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein, Victoria.
A. C. Gordon, Lands Department, South Australia.
H. G. Tolley, Engineering and Water Supply Department, South Australia.

VEGETABLE PROBLEMS COMMITTEE.

B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R. (*Chairman*).
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein, Victoria.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith, N.S.W.
K. Spencer, B.Sc.Agr., Irrigation Research Station, Griffith, N.S.W.
L. J. Lynch, B.Agr.Sc., Division of Food Preservation and Transport, C.S.I.R.
E. M. Hutton, B.Ag.Sc., M.Sc., Division of Plant Industry, C.S.I.R. (*Secretary*).

COMMITTEE OF REVIEW—AGRICULTURAL AND PASTORAL PROBLEMS.

L. B. Bull, D.V.Sc., Division of Animal Health and Production, C.S.I.R. (*Chairman*).
B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R.
H. R. Marston, Division of Biochemistry and General Nutrition, C.S.I.R.
J. K. Taylor, B.A., M.Sc., B.Sc.Agr., Division of Soils, C.S.I.R.
A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R.
I. Clunies Ross, D.V.Sc., C.S.I.R.
H. C. Forster, M.Agr.Sc., Ph.D., C.S.I.R. (*Secretary*).

REGIONAL PASTORAL CENTRE, DENILIQUIN—TECHNICAL COMMITTEE.

B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R.
J. K. Taylor, B.A., M.Sc., B.Sc.Agr., Division of Soils, C.S.I.R.
L. B. Bull, D.V.Sc., Division of Animal Health and Production, C.S.I.R.
H. R. Marston, Division of Biochemistry and General Nutrition, C.S.I.R.
J. G. Davies, B.Sc., Ph.D., Division of Plant Industry, C.S.I.R.
T. J. Marshall, M.Agr.Sc., Ph.D., Division of Soils, C.S.I.R.
A. J. Vasey, B.Agr.Sc., Division of Animal Health and Production, C.S.I.R.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
O. McL. Falkiner, Boonoke Station, Conargo.
J. N. Whittet, H.D.A., Department of Agriculture, New South Wales.
R. W. Prunster, B.Sc. (Agric), Division of Plant Industry, C.S.I.R. (*Secretary*).

REGIONAL PASTORAL CENTRE, ARMIDALE—CONSULTATIVE COMMITTEE.

D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Production, C.S.I.R. (*Chairman*).
R. B. Madgwick, M.Ec., D.Phil., New England University College.
A. H. Voisey, D.Sc., New England University College.
A. G. Brett, Graziers' Association of New South Wales.
J. A. Nivison, Graziers' Association of New South Wales.
H. F. White, Graziers' Association of New South Wales.
D. P. Macansh, Northern New South Wales Farmers' Union.
A. W. Weller, Northern New South Wales Farmers' Union.

Sir Hugh Croft, Council of Advice to the Pasture Protection Boards, N.S.W.
S. Payne, Council of Advice to the Pasture Protection Boards, N.S.W.
G. Edgar, B.V.Sc., Department of Agriculture, N.S.W.
J. N. Whittet, H.D.A., Department of Agriculture, N.S.W.
L. W. McLennan, B.Sc.Agr., New England Regional Development Committee.
J. G. Davies, B.Sc., Ph.D., Division of Plant Industry, C.S.I.R.
I. L. Johnstone, B.V.Sc., Division of Animal Health and Production, C.S.I.R. (*Secretary*).

REGIONAL PASTORAL CENTRE, ARMIDALE—TECHNICAL ADVISORY COMMITTEE.

L. B. Bull, D.V.Sc., Division of Animal Health and Production, C.S.I.R.
B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R.
J. G. Davies, B.Sc., Ph.D., Division of Plant Industry, C.S.I.R.
D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Production, C.S.I.R.
I. L. Johnstone, B.V.Sc., Division of Animal Health and Production, C.S.I.R.

"GILRUTH PLAINS" TECHNICAL COMMITTEE.

L. B. Bull, D.V.Sc., Division of Animal Health and Production, C.S.I.R.
B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R.
C. M. Donald, M.Ag.Sc., Division of Plant Industry, C.S.I.R.
R. B. Kelley, D.V.Sc., Division of Animal Health and Production, C.S.I.R.
J. F. Kennedy, M.Agr.Sc., Division of Animal Health and Production, C.S.I.R.

VETERINARY ENTOMOLOGICAL COMMITTEE.

(Formerly the Interdivisional Blowfly Committee; its function is to co-ordinate certain activities of the Divisions of Economic Entomology and of Animal Health and Production.)
L. B. Bull, D.V.Sc., Division of Animal Health and Production, C.S.I.R.
A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R.
A. W. Turner, O.B.E., D.Sc., D.V.Sc., Division of Animal Health and Production, C.S.I.R.
D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Production, C.S.I.R. (*Secretary*).

JOINT BLOWFLY CONTROL COMMITTEE

(Appointed as a means of co-ordinating the activities of the N.S.W. Department of Agriculture, the Queensland Department of Agriculture and Stock, and the Council.)
L. B. Bull, D.V.Sc., Division of Animal Health and Production, C.S.I.R. (*Chairman*).
A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R.
G. Edgar, B.V.Sc., Glenfield, Veterinary Research Station, Department of Agriculture, New South Wales.
H. G. Belschner, D.V.Sc., Department of Agriculture, New South Wales.
T. McCarthy, Department of Agriculture, New South Wales.
W. Webster, B.V.Sc., Department of Agriculture and Stock, Queensland.
F. H. S. Roberts, D.Sc., Division of Animal Health and Production, C.S.I.R.
D. A. Gill, M.R.C.V.S., D.V.S.M., Division of Animal Health and Production, C.S.I.R. (*Secretary*).

TECHNICAL COMMITTEE ON CATTLE TICK INVESTIGATIONS.

J. Legg, D.V.Sc., Department of Agriculture and Stock, Queensland (*Chairman*).
W. Webster, B.V.Sc., Department of Agriculture and Stock, Queensland.
M. White, M.Sc., Ph.D., Department of Agriculture and Stock, Queensland.
J. L. Wilson, Queensland United Graziers' Association.
A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R.
L. F. Hitchcock, M.Sc., Division of Economic Entomology, C.S.I.R.
F. H. S. Roberts, D.Sc., Division of Animal Health and Production, C.S.I.R.
Miss H. F. Todd, C.S.I.R. (*Secretary*).

QUEENSLAND PRODUCERS' ANIMAL INDUSTRY COMMITTEE.

P. B. Newcomen, Queensland United Graziers' Association (*Chairman*).
N. Bourke, Queensland United Graziers' Association.
F. M. Bell, Queensland United Graziers' Association.
P. A. Brown, Queensland United Graziers' Association.
P. A. Elliot, Queensland United Graziers' Association.
G. A. Fairbairn, Queensland United Graziers' Association.
J. F. Meynink, Queensland United Graziers' Association.
R. C. Philip, Queensland United Graziers' Association.
J. L. Wilson, Queensland United Graziers' Association.
L. J. Landsberg, Queensland United Graziers' Association.
Professor D. H. K. Lee, M.Sc., M.B., B.S., D.T.M., University of Queensland.
J. Legg, D.V.Sc., Department of Agriculture and Stock, Queensland.
G. R. Moule, B.V.Sc., Department of Agriculture and Stock, Queensland.
W. Webster, B.V.Sc., Department of Agriculture and Stock, Queensland.
M. White, M.Sc., Ph.D., Department of Agriculture and Stock, Queensland.
L. F. Hitchcock, M.Sc., Division of Economic Entomology, C.S.I.R.
F. H. S. Roberts, D.Sc., Division of Animal Health and Production, C.S.I.R.
I. M. Mackerras, B.Sc., M.B., Ch.M., Queensland Institute of Medical Research.
C. H. Jamieson, Queensland Dairymen's State Council.
T. B. Paltridge, B.Sc., Division of Plant Industry, C.S.I.R.
A. R. Riddle, A.B., M.S., Division of Food Preservation and Transport, C.S.I.R.
R. J. Donaldson, D.S.O., B.C.E., Brisbane.
Miss H. F. Todd, C.S.I.R. (*Secretary*).

NEW SOUTH WALES MEAT RESEARCH ADVISORY COMMITTEE.

L. J. Ashcroft, Liverpool, New South Wales.
E. J. Bowater, Messrs. Angliss and Co. Pty. Ltd., Sydney.
J. M. Davidson, Commonwealth Veterinary Officer, Sydney, representing the Department of Commerce.
J. Merrett, Metropolitan Meat Industry Commissioner, Sydney.
J. R. Vickery, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.

ADVISORY COMMITTEE ON FRUIT STORAGE INVESTIGATIONS IN NEW SOUTH WALES.

C. G. Savage, Department of Agriculture, New South Wales (*Chairman*).
H. Broadfoot, Department of Agriculture, New South Wales.
Professor N. A. Burges, M.Sc., Ph.D., Department of Botany, University of Sydney.
J. R. Vickery, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.
R. N. Robertson, B.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.
R. B. Withers, M.Sc., Dip. Ed., Division of Food Preservation and Transport, C.S.I.R. (*Secretary*).

COMMITTEE FOR CO-ORDINATION OF FRUIT AND VEGETABLE STORAGE RESEARCH.

W. M. Carne, Department of Commerce and Agriculture, Melbourne (*Chairman*).
S. M. Sykes, B.Sc.Agr., Department of Agriculture, New South Wales.
F. M. Read, M.Agr.Sc., Department of Agriculture, Victoria.
A. G. Strickland, M.Agr.Sc., Department of Agriculture, South Australia.
T. D. Raphael, M.A., Dip.Hort.(Cambridge), Department of Agriculture, Tasmania.
R. N. Robertson, B.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.
D. Martin, B.Sc., Division of Plant Industry, C.S.I.R.
S. A. Trout, M.Sc., Ph.D., Department of Agriculture and Stock, Queensland.
T. C. Miller, B.Sc., Department of Agriculture, Western Australia.
R. B. Withers, M.Sc., Dip.Ed., Division of Food Preservation and Transport, C.S.I.R. (*Secretary*).

DRIED FRUITS PROCESSING COMMITTEE.

C. G. Savage, Department of Agriculture, New South Wales (*Chairman*).
W. R. Jewell, M.Sc., B.Met., F.R.I.C., Department of Agriculture, Victoria.
W. M. Carne, Department of Commerce and Agriculture, Melbourne.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.

A. G. Strickland, M.Agr.Sc., Department of Agriculture, South Australia.
E. C. Orton, B.Sc., Commonwealth Research Station, Merbein.
J. R. Vickery, M.Sc., Ph.D., Division of Food Preservation and Transport, C.S.I.R.
D. G. Quinn, Department of Agriculture, Victoria.
R. B. Withers, M.Sc., Dip.Ed., Division of Food Preservation and Transport, C.S.I.R. (*Secretary*).

MILDURA DISTRICT DRIED VINE FRUITS PROCESSING COMMITTEE.

A. R. Hampton, representing Mildura Packers' Association (*Chairman*).
A. E. Hazel, Dried Fruits Association, Red Cliffs.
W. Heaysman, representing Merbein Advisory Committee.
W. R. Jewell, M.Sc., B.Met., F.R.I.C., Department of Agriculture, Victoria.
N. A. Johnson, Irymple, Victoria.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
K. H. C. McCallum, Red Cliffs, Victoria.
A. R. McDougall, Merbein, Victoria.
S. R. Mansell, Mildura, Victoria.
E. C. Orton, B.Sc., Commonwealth Research Station, Merbein (*Secretary*).

ADVISORY COMMITTEE ON ORIENTAL PEACH MOTH INVESTIGATIONS.

A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R. (*Chairman*).
G. A. H. Helson, M.Sc., Division of Economic Entomology, C.S.I.R.
F. M. Read. M.Agr.Sc., Department of Agriculture, Victoria.
H. J. Williams, Leeton Co-operative Cannery Ltd., New South Wales.
S. Fish, M.Agr.Sc., Department of Agriculture, Victoria (*Secretary*).

ADVISORY COMMITTEE ON RED-LEGGED EARTH MITE INVESTIGATIONS, WESTERN AUSTRALIA.

E. H. B. Lefroy (*Chairman*).
C. F. Jenkins, B.A., Department of Agriculture, Western Australia.
I. Thomas, Department of Agriculture, Western Australia.
Professor E. J. Underwood, B.Sc.(Agric.), Ph.D., University of Western Australia.
A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R.
M. M. H. Wallace, B.Sc., Division of Economic Entomology, C.S.I.R.
R. P. Roberts, M.Sc.(Agric.) (*Secretary*).

FLAX RESEARCH ADVISORY COMMITTEE.

J. A. Stevenson, Flax Production Committee (*Chairman*).
I. H. Boas, M.Sc., Melbourne.
R. B. Hogg, representing the Australian flax spinners.
A'b. Weigall, representing the growers.

COMMITTEE ON OENOLOGICAL RESEARCH.

Professor J. A. Prescott, D.Sc., representing C.S.I.R. (*Chairman*).
C. Haselgrove, representing the Federal Viticultural Council.
Professor J. B. Cleland, M.D., Ch.M., representing the University of Adelaide.
L. N. Salter, representing the Australian Wine Board.

FISHERIES ADVISORY COMMITTEE.

Professor W. J. Dakin, D.Sc., University of Sydney (*Chairman*).
T. C. Roughley, B.Sc., Chief Secretary's Department, New South Wales.
H. Thompson, M.A., D.Sc., Division of Fisheries, C.S.I.R.

FUEL RESEARCH ADVISORY COMMITTEE.

R. S. Andrews, D.Sc., Melbourne (*Chairman*).
Professor T. G. Hunter, B.Sc., Ph.D., University of Sydney.
S. B. Dickinson, M.Sc., Department of Mines, South Australia.
L. J. Rogers, M.Sc., B.E., Department of Supply and Development.
C. R. Kent, B.Sc., Ph.D., D.I.C., Joint Coal Board.
R. P. Donnelly, Government Chemical Laboratory, Western Australia.
H. R. Brown, B.Sc., Min.Eng., Coal Survey Section, C.S.I.R.
F. W. G. White, M.Sc., Ph.D., C.S.I.R.
G. B. Gresford, B.Sc., C.S.I.R. (*Secretary*).

MINING ADVISORY COMMITTEE.

Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S., C.S.I.R. (*Chairman*)
H. Herman, D.Sc., M.M.E., B.C.E., Electricity Commission of Victoria, Melbourne.
H. St.J. Somerset, Electrolytic Zinc Co. of Australasia Ltd., Melbourne.
W. E. Wainwright, A.S.A.S.M., Melbourne.
G. A. Cook, M.C., M.Sc., B.M.E., C.S.I.R. (*Secretary*).

MELBOURNE SUB-COMMITTEE.

H. Hey, Electrolytic Zinc Co. Ltd., Melbourne (*Chairman*).
W. Baragwanath, Director, Geological Survey, Department of Mines, Victoria.
G. B. O'Malley, B.Met.E., Melbourne.
W. J. Rose, B.M.E., Commonwealth Tariff Board.
H. H. Dunkin, B.Met.E., School of Metallurgy, University of Melbourne.
R. B. Mills. B.Sc., Electrolytic Zinc Co. Ltd., Melbourne.
M. A. E. Mawby, F.S.T.C., Zinc Corporation Ltd., Melbourne.

KALGOORLIE SUB-COMMITTEE.

J. S. Foxall, B.E., Department of Mines, Western Australia.
F. G. Brinsden, Australasian Institute of Mining and Metallurgy, Western Australia.
R. A. Hobson, B.Sc., School of Mines, Kalgoorlie, Western Australia.
J. R. Hylton, Great Boulder Pty. Gold Mines Ltd., Fimiston, Western Australia.

MINERAGRAPHIC COMMITTEE.

Emeritus-Professor E. W. Skeats, D.Sc., Melbourne.
W. E. Wainwright, A.S.A.S.M., Australasian Institute of Mining and Metallurgy.

TRACER ELEMENT RESEARCH COMMITTEE.

C. E. Eddy, D.Sc., Department of Health.
F. W. G. White, M.Sc., Ph.D., C.S.I.R.
F. G. Nicholls, M.Sc., C.S.I.R. (*Secretary*).

ATOMIC ENERGY RESEARCH ADVISORY COMMITTEE.

F. W. G. White, M.Sc., Ph.D., C.S.I.R. (*Chairman*).
Major-General L. E. Beavis, C.B.E., D.S.O., Department of Defence.
S. B. Dickinson, M.Sc., Department of Mines, South Australia.
Professor L. H. Martin, Ph.D., University of Melbourne.
H. G. Raggatt, D.Sc., Bureau of Mineral Resources, Geology, and Geophysics.
N. K. S. Brodribb, C.B.E., F.R.I.C., Department of Supply and Development.
G. H. Briggs, D.Sc., Ph.D., C.S.I.R
I. W. Wark, B.Sc., Ph.D., C.S.I.R.
G. B. Gresford, B.Sc., C.S.I.R. (*Secretary*).

ELECTRICAL RESEARCH BOARD.

Professor Sir John Madsen, B.E., D.Sc., University of Sydney (*Chairman*).
R. Liddelow, Electricity Supply Association of Australia.
V. J. F. Brain, Electricity Supply Association of Australia.
D. M. Myers, B.Sc., D.Sc.Eng., Division of Electrotechnology, C.S.I.R.
F. W. G. White, M.Sc., Ph.D., C.S.I.R
F. G. Nicholls, M.Sc., C.S.I.R. (*Conjoint Secretary*).
R. C. Richardson, B.E., Division of Electrotechnology, C.S.I.R. (*Conjoint Secretary*).

RADIO RESEARCH BOARD.

Professor Sir John Madsen, B.E., D.Sc., University of Sydney (*Chairman*).
Lt.-Cdr. A. Brook, R.N.
Lt.-Col. E. G. Foster, Director of Signal and Radar Equipment, A.M.F.
Wing-Cdr. J. W. Reddrop, Director of Telecommunications and Radar, R.A.A.F.
R. v.d. R. Woolley, M.A., M.Sc., Ph.D., Mt. Stromlo Observatory.
Professor T. Parnell, M.A., University of Queensland.
L. B. Fanning, Postmaster-General's Department.
E. G. Bowen, O.B.E., M.Sc., Ph.D., Division of Radiophysics, C.S.I.R.
F. W. G. White, M.Sc., Ph.D., C.S.I.R.
F. G. Nicholls, M.Sc., C.S.I.R. (*Secretary*).

METEOROLOGICAL RESEARCH CONSULTATIVE COMMITTEE.

R. v.d. R. Woolley, M.A., M.Sc., Ph.D., Mt. Stromlo Observatory (*Chairman*).
Professor Sir John Madsen, B.E., D.Sc., University of Sydney.
H. N. Warren, Commonwealth Meteorological Service.
F. Loewe, Ph.D., University of Melbourne.
E. G. Bowen, O.B.E., M.Sc., Ph.D., Division of Radiophysics, C.S.I.R.
C. H. B. Priestley, M.A., C.S.I.R.
G. B. Gresford, B.Sc., C.S.I.R. (*Secretary*).

AVIATION RADIO RESEARCH COMMITTEE.

E. G. Bowen, O.B.E., M.Sc., Ph.D., Division of Radiophysics C.S.I.R. (*Chairman*).
R. M. Badenach, Department of Civil Aviation.
C. S. Wiggins, Department of Civil Aviation.
Wing-Cdr. J. W. Reddrop, Director of Telecommunications and Radar, R.A.A.F.
M. H. Meyers, Qantas Empire Airways Ltd.
O. L. Wirsu, B.Sc., B.E., Australian National Airways Pty. Ltd.
J. H. Gerraud, Australian National Airlines Commission.
Captain E. H. O'Neill, Australian Air Pilots' Association.
F. G. Nicholls, M.Sc., C.S.I.R. (*Secretary*).

AERONAUTICAL RESEARCH CONSULTATIVE COMMITTEE.

Professor A. V. Stevens, M.A., University of Sydney (*Chairman*).
Professor T. M. Cherry, B.A., Ph.D., University of Melbourne.
W. A. S. Butement, O.B.E., Long-range Weapons Organization.
Air Vice-Marshal E. C. Wackett, O.B.E., R.A.A.F.
M. B. Woodfull, Division of Aircraft Production, Department of Supply and Development.
E. G. Bowen, O.B.E., M.Sc., Ph.D., Division of Radiophysics, C.S.I.R.
L. P. Coombes, D.F.C., B.Sc.(Eng.), Division of Aeronautics, C.S.I.R.
F. W. G. White, M.Sc., Ph.D., C.S.I.R.
G. B. Gresford, B.Sc., C.S.I.R. (*Secretary*).

BUILDING RESEARCH COMMITTEE.

I. Langlands, B.E.E., M.Mech.E., Building Research Section, C.S.I.R. (*Chairman*).
Professor J. A. L. Matheson, M.B.E., M.Sc., Ph.D., University of Melbourne.
T. J. Cavanagh, Sydney.
D. V. Isaacs, M.C.E., Department of Works and Housing.
O. A. Bayne, Department of Works and Housing.
R. E. Banks, Department of Works and Housing.
S. A. Clarke, B.E., Division of Forest Products, C.S.I.R.
W. F. Evans, B.Sc., Building Research Section, C.S.I.R. (*Secretary*).

CATALOGUE OF SCIENTIFIC AND TECHNICAL PERIODICALS—EDITORIAL COMMITTEE.

Leigh Scott, M.A., Librarian, University of Melbourne.
John Metcalfe, B.A., Principal Librarian, Public Library of New South Wales.
C. A. McCallum, B.A., Chief Librarian, Public Library, Melbourne.
Ellinor Archer, M.Sc., Chief Librarian, C.S.I.R.

Printed and Published for the GOVERNMENT of the COMMONWEALTH OF AUSTRALIA by
L. F. JOHNSTON, Commonwealth Government Printer, Canberra.