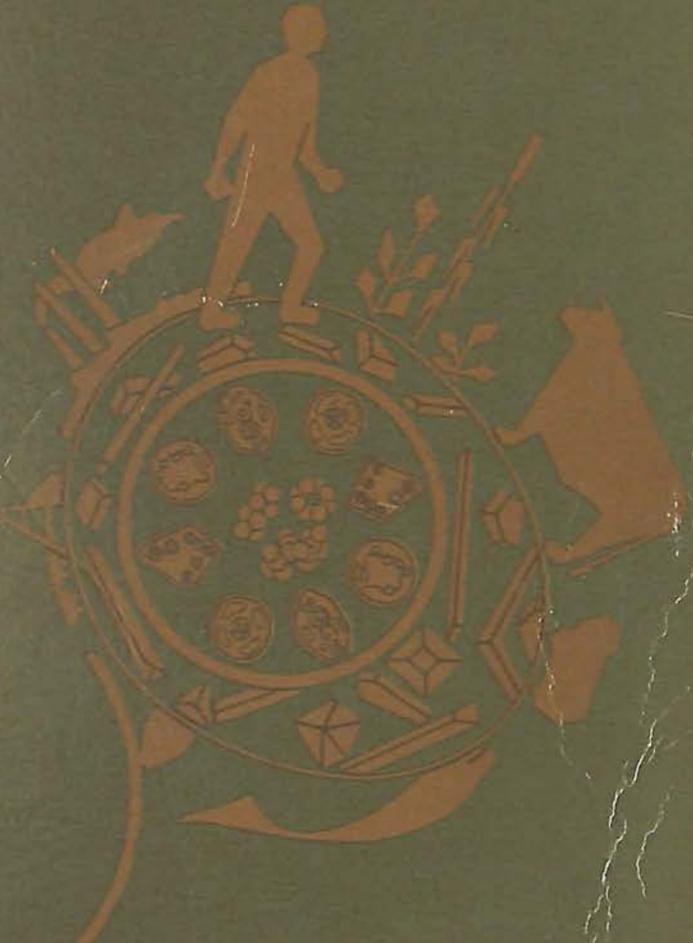
MR. J J RUSSELL

CSIRO



ANNUAL REPORT

1964-65

Commonwealth Scientific and Industrial Research Organization, Australia

CSIRO

Seventeenth Annual Report

1964-65

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

AUSTRALIA

THIS REPORT on the work of the Commonwealth Scientific and Industrial Research Organization for the year ending June 30, 1965, has been prepared for presentation to Parliament as required by Section 30 of the Science and Industry Research Act 1949–1959.

The Executive gratefully acknowledges the valuable assistance that CSIRO has received from Commonwealth and State government departments and instrumentalities, the Australian universities, members of primary and secondary industries, and private individuals. Considerable help has also been received from many overseas institutions.

The Executive also wishes to thank those who have made their knowledge and experience freely available to the Organization by serving on CSIRO committees or by personal advice.

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General Review

THE PURPOSE of this Annual Report is to explain how the resources available to CSIRO have been used in the year under review. It summarizes some of the more important investigations in progress and provides short accounts of some of the advances that have been made. As far as possible it is written in non-technical language. More detailed technical accounts of the Organization's work are provided in the annual reports of individual Divisions and Sections (see page 25). These are widely circulated and are readily available to those who are interested.

The powers and functions of CSIRO are set out in the Science and Industry Research Act 1949–1959. Within the broad scope of its primary duty, which is the promotion of Australian development by scientific research, the Organization is always faced with more problems to investigate than the available resources will permit. How best to employ these resources to the maximum advantage is a question that is constantly before the Executive, Chiefs of Divisions, and the individual research scientists.

Most of the research work of CSIRO is "committed" or "applied" in that it is directed towards finding practical answers to national problems and fostering national development. In the study of a problem, however, the scientist is often aware that the basic knowledge required for effective work is not available and in such cases any results obtained by direct investigation will be limited in application and not of lasting value. It has always been held, therefore, both by CSIRO and by its predecessor, CSIR, that any problem accepted for investigation should be tackled on as fundamental a basis as is necessary for an effective solution to be found. Although a more limited approach is often urged upon it, the Organization is convinced that this policy is sound and must be retained.

Basic studies on topics for which there may be no clearly foreseeable practical application are also undertaken to a limited extent, when the work has an unusually high degree of originality. It is research of this type that leads to the discovery of important new knowledge which may become the basis of new industries. It is by this means that the greatest advances in new processes and new techniques are made.

In dealing with local problems, the primary producer has available the advice and help of the State authorities; in secondary industry many companies maintain their own laboratories, and other bodies, such as research associations, are also available. CSIRO feels justified in entering this field only when the necessary knowledge and facilities for the work are not available elsewhere.

It is not enough to discover the solution to a scientific problem. The new knowledge must be passed to the man who can use it, and sometimes the man who can use it needs to be persuaded to use it. CSIRO needs the collaboration of industry for the development of its research results to the point where they can be put to practical use. Development is an activity that is essentially different from the research that precedes it. It requires staff of different capabilities and usually resources of a different magnitude. In addition, any new process must be adapted specifically to fit into the manufacturing situation of the company concerned. There are thus definite limits beyond which it is impracticable for CSIRO to take development on its own. Similarly, it is dependent upon the research and extension services of the State governments for the application of the results of its research in agriculture. Some of the ways in which the Organization is achieving these ends are also outlined in this Report.

Buildings and Accommodation

The provision of laboratory accommodation continues to be one of the most pressing problems facing the Executive, and is proving to be the most difficult to resolve. An increase in the level of annual expenditure several years ago made possible the erection of some substantial laboratory buildings and relieved some of the worst conditions. Without this increase the Organization's work would have been hampered very seriously, and even at the present rate of progress, accommodation will remain acutely restrictive for at least another ten years. The amount of Treasury funds expended by the Department of Works on buildings for CSIRO in 1964/65 was £1,203,368 compared with £1,031,131 in 1963/64. A further £101,666 (£74,957 in 1963/64) was spent by the Department from funds contributed to the Organization from other sources.

Expansion of CSIR during World War II was very rapid, particularly in the groups which had then only recently been formed to assist secondary industry. There was a rapid expansion of the research staff to meet the emergency and temporary and often quite inadequate accommodation was all that could be provided under wartime conditions. More recently the Organization has gone through a period of consolidation with steady but not spectacular growth. Some new areas of work have been opened up, many projects have been discontinued, but the greater changes have come from development and modifications of existing programmes. These modifications have affected not only the programme, but also the staff and facilities required. Mention is made in a later section of this Report of the changing pattern of staff needs. The computer network is an example of the many forms of new facilities for scientific research that must be made available if the Organization is to continue to function effectively.

The result has been a serious deficiency in laboratory accommodation, and despite the continued existence of substandard accommodation the Executive has reluctantly had to give priority at times to capital expenditure on new developments.

During the year under review, the second of three stages of re-housing the Division of Animal Genetics at North Ryde, N.S.W., has been completed. This has made it possible for all the headquarters staff of the Division to be accommodated in the one centre, but under conditions of considerable overcrowding which on present indications will not be relieved for many years. The new laboratory completed for the Division of Chemical Physics at Clayton, adjacent to Monash University in Melbourne, will enable it to vacate the worst of the makeshift accommodation at Fishermen's Bend and also provide some relief for other units of the Chemical Research Laboratories at present remaining at the site. Other major projects completed this year provided accommodation for new developments, including the main laboratory for the extension of the activities of the Division of Tropical Pastures into the Townsville region of Queensland.

MAJOR PROJECTS COMPLETED DURING 1964/65

New South Wales	
North Ryde, Division of Animal Genetics—Poultry Research Unit	£130,000
Culgoora, Divisions of Radiophysics and Physics—Radio heliograph, spectrograph and optical telescope projects	£97,000
Victoria	
Parkville, Division of Protein Chemistry—Main block, floor for leather research	£10,000
Parkville, Division of Animal Health—Small animals building	£44,000
South Melbourne, Division of Forest Products—Laboratory extensions	£40,000
Clayton, Division of Chemical Physics—New laboratory	£446,000
Maribyrnong, Division of Animal Health—Access and internal roads	£10,800
Maribyrnong, Division of Animal Health—Surgery and amenities building	£21,000
Queensland	
Indooroopilly, Division of Animal Health—Calf-rearing pens	£54,000
Lansdown, Division of Tropical Pastures—Field laboratory, administration block and quarters	£46,000
Townsville, Division of Tropical Pastures—Main laboratory	£171,000
Australian Capital Territory	
Black Mountain, Division of Plant Industry—Workshop building	£63,000

New works admitted to the programme for 1964/65 totalled £995,300, compared with £1,024,500 for 1963/64. Of the new major projects only one, the new laboratory for the Western Australian Regional Laboratory, exceeds £50,000 in value.

MAJOR PROJECTS COMMENCED DURING 1964/65

New South Wales	
Griffith, Irrigation Research Laboratory—Emergency generator	£10,000
Ryde, Division of Textile Physics—Extension of mill building	£32,000
Victoria	
Highett, Division of Building Research—Acoustic chambers	£39,300
Port Melbourne, Division of Mineral Chemistry—Laboratory alterations	£50,000
Maribyrnong, Division of Animal Health—Virology units	£20,000

Queensland

Indooroopilly, Division of Animal Health—Cattle tick fever pens	£26,500
St. Lucia, Division of Tropical Pastures—Glasshouse workshop	£13,000

Western Australia

Floreat Park, Western Australian Regional Laboratory—Laboratory building, including air-conditioning, and site services	£536,000

Australian Capital Territory

Black Mountain, Division of Entomology—Installation of fire sprinklers	£16,500

The programme to which the Executive is currently working can cover only the most urgent projects. Details of forward plans are as follows:

Division of Radiophysics. The proposal for a new laboratory at Epping, N.S.W., has been approved by the Parliamentary Standing Committee on Public Works. The project will now be included in the 1965/66 programme.

Divisions of Animal Health and Entomology. The laboratories available to these Divisions for their work in Queensland are quite inadequate for their current needs. A request has been made that proposals for new laboratories be referred to the Parliamentary Public Works Committee to have this project included in the 1966/67 programme.

Division of Land Research and Regional Survey. The activities of this Division are still hampered by its occupancy of scattered and unsuitable accommodation. It had been hoped to include the second stage of the re-housing of this Division in the 1965/66 programme, but this has not proved possible.

Division of Chemical Engineering. The transfer of this Division to Clayton is planned as the next stage of the progressive re-housing of the Chemical Research Laboratories.

Division of Coal Research. This Division still occupies much temporary accommodation and the Executive has approved, in outline, proposals for a major new laboratory building. This project will be submitted to Cabinet after the Chemical Engineering project, with a view to commencement in 1967/68.

National Standards Laboratory. This Laboratory at present occupies one substantial building in the grounds of the University of Sydney, together with a number of temporary structures and adjacent poor-quality rented accommodation that has been adapted for laboratory purposes. Plans are being made for the re-housing of part of the Laboratory at a site at Bradfield Park, a suburb of Sydney. It does not at present appear that a start can be made within the next five years.

Division of Food Preservation. New developments financed from contributory funds make a substantial and welcome addition to the programme. The new Meat Research Laboratory at Cannon Hill, Qld., for the Division of Food Preservation will be financed almost entirely from the Australian Cattle and Beef Research Trust Account, and is expected to go to tender in July 1965.

Head Office. The plans for the transfer of the Organization's Head Office to Canberra are mentioned on page 13 of this Report.

Finance

Over the last five years, CSIRO's expenditure has risen by about 90%. Approximately one-quarter of the increase has been absorbed by rises in cost, particularly of salaries. Many of the Organization's laboratories still need larger numbers of supporting staff (see also page 9), a situation that the Executive is currently seeking to alleviate. Apart from this, the finance available at present is adequate to provide the facilities needed for the existing level of the Organization's activities. There are, however, many serious national problems that are not yet being tackled. The Executive hopes to introduce some of these into the programme in the coming financial year.

A feature of recent years has been the increase in support from industry research funds. The rate of increase of these now slightly exceeds the rate of increase of income from Treasury sources. The support for a wide variety of research projects now received from these funds is very welcome, but their growing influence is giving some cause for concern in that a significant proportion of the research programme of CSIRO must also be submitted to and approved by committees, whereas approval of the programme financed by the Government is the responsibility of the Executive alone. This development has had a number of results, one of which is the large amount of work involved in preparing reports of progress and papers supporting requests for further grants. This has led to rising costs in some areas of administration. There is also a danger that the research workers may be left with less time for productive research.

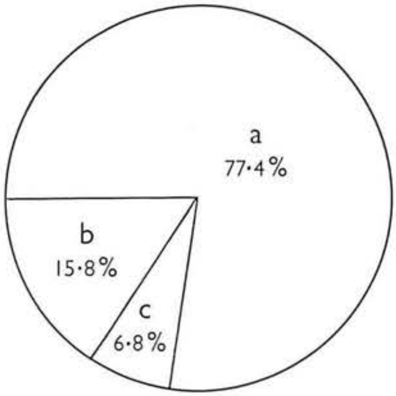
In the year under review, CSIRO expenditure was £18,246,109. Details are shown in Chapter 5. Of this sum, £15,414,791 was spent on actual research work and associated services (administration, library, etc.) and grants amounting to £449,030 were made for Studentships and to outside bodies such as the Commonwealth Agricultural Bureaux and the Standards Association of Australia. The sum of £2,382,288 was spent on capital works and services under the control of CSIRO. (It should be noted that in addition the Department of Works and Department of the Interior spent £1,328,478 on the construction of buildings, other works, and acquisition of properties for CSIRO.)

CSIRO derives its funds from the Commonwealth Treasury, from revenue from the sale of farm products, etc., from the Wool Research Trust Fund and similar industry funds, and from direct contributions from industry, foundations, and individuals (see Chapter 5). The table summarizes the sources of CSIRO funds and the categories of expenditure:

SOURCE OF FUNDS	*Investigations*	*Grants*	*Capital Works and Services*	*Total*
Treasury Appropriation	£11,753,381	£449,030	£1,962,484	£14,164,895
CSIRO Revenue	178,300	—	—	178,300
Total Treasury Funds	11,931,681	449,030	1,962,484	14,343,195
Wool Research Trust Fund	2,430,547	—	153,670	2,584,217
Contributions (other than Wool)	1,052,563	—	266,134	1,318,697
	£15,414,791	£449,030	£2,382,288	£18,246,109

Investigations

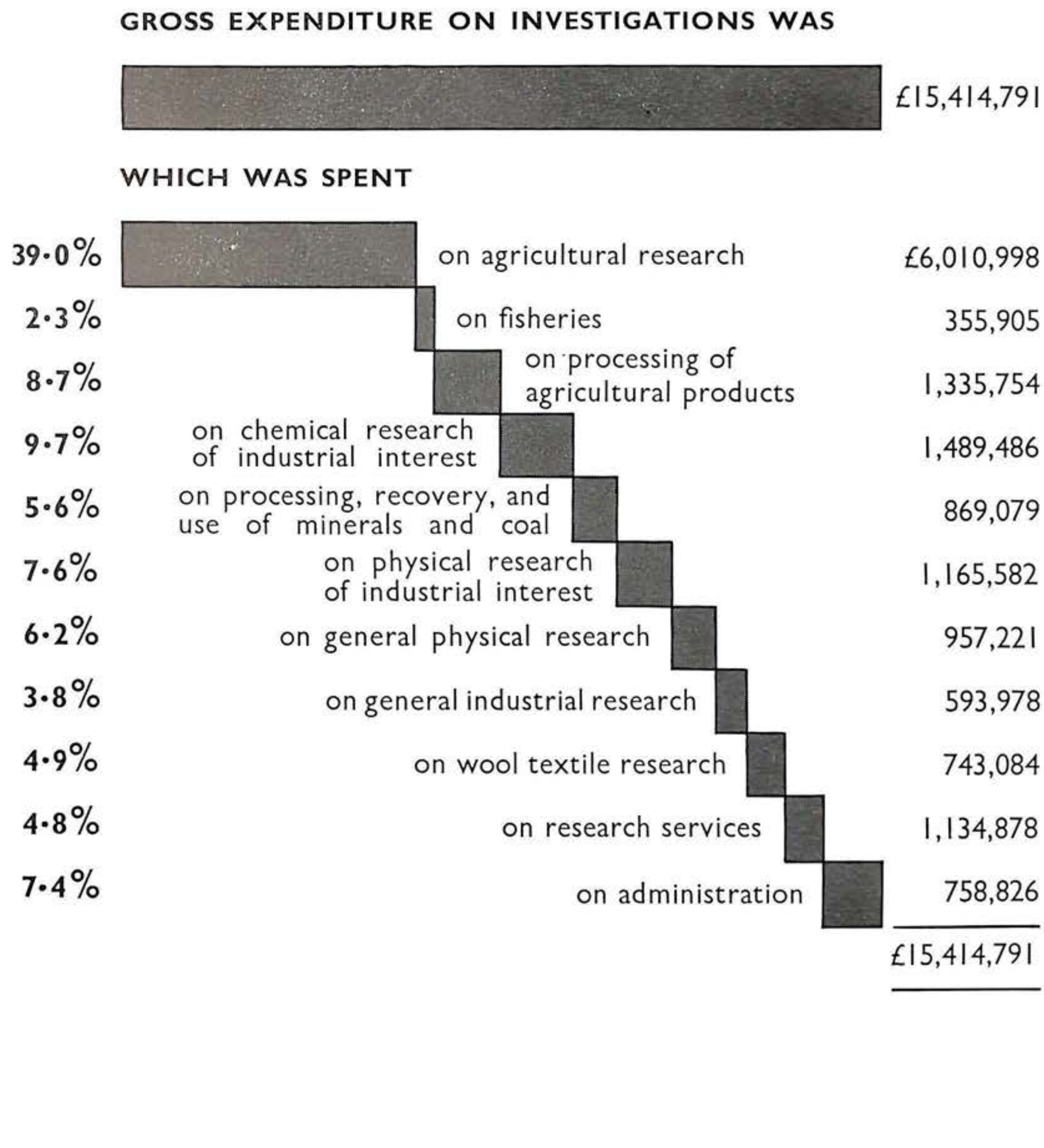
A more detailed analysis of the source of funds spent on investigations is as follows:



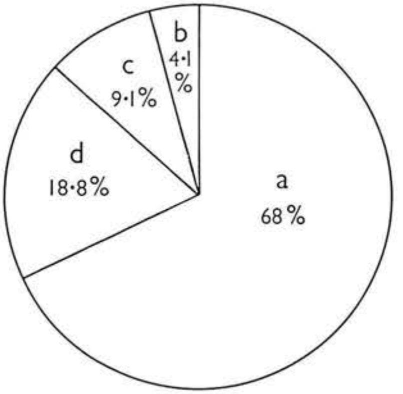
(a) Commonwealth Treasury		£11,931,681
(b) Wool Research Trust Fund		2,430,547
(c) Contributions—		
Cattle and beef investigations (Cattle and Beef Research Trust Account)	£170,094	
Dairy research (Dairy Produce Research Trust Account	92,191	
Wheat investigations (Wheat Research Trust Account)	74,378	
Tobacco investigations (Tobacco Industry Trust Account)	69,789	
New Guinea resources investigations (Department of Territories)	64,106	
Rice investigations (Department of Territories)	57,966	
Sirex wasp investigations (Department of Health)	44,398	
Radio Research Board activities (Postmaster-General's Department, Australian Broadcasting Control Board, and Overseas Telecommunications Commission	24,548	
Tasmanian tuna survey (Department of Primary Industry and Tasmanian Department of Agriculture)	22,783	
Radio astronomy investigations (U.S. National Aeronautics and Space Administration)	21,978	
Chemical and plant antifungal investigations (Fisons and J. R. Geigy Pest Control)	21,678	
Other contributions	388,654	
		1,052,563
		£15,414,791

Details of the contributions to each Division and Section are listed in Chapter 5.

The diagram below gives an indication of how the gross funds (£15,414,791) available to the Organization for investigations in 1964/65 were used. 'Chemical research of industrial interest' includes the Divisions of Chemical Engineering, Organic Chemistry, Physical Chemistry, Chemical Physics, and Protein Chemistry, while 'physical research of industrial interest' covers the Divisions of Physics, Applied Physics, and Tribophysics. The main fields in 'general physical research' are Radiophysics, Meteorological Physics, and Upper Atmosphere, and in 'general industrial research' such Divisions as Building Research and Mechanical Engineering and the Soil Mechanics Section. 'Wool textile research' covers the Divisions of Textile Industry and Textile Physics. 'Research services' covers such items as Library, Publishing, Film Unit, Mathematical Statistics, and the Computing Research Section.



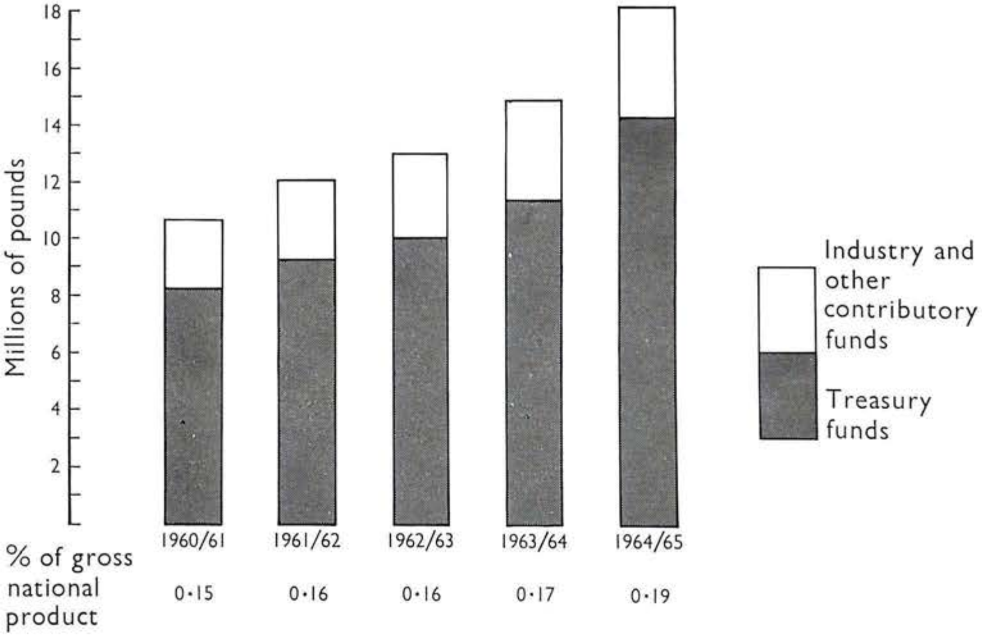
Approximately two-thirds of CSIRO's research expenditure relates to salaries and payments in the nature of salary. Maintenance, i.e. general running expenses, is the next most important item, as shown below.



(a) Salaries	£10,479,906
(b) Travelling	634,161
(c) Equipment	1,396,259
(d) Maintenance	2,904,465
	£15,414,791

Total Expenditure

The amounts expended by the Organization in each of the past five years are shown below.



A large part of the increases shown has been absorbed in rising costs, particularly as a result of salary and wage adjustments. During the period 1960/61 to 1964/65, staff numbers rose from 4212 to 5375, an increase of 27%. During the same period the cost of salaries increased from £6,077,000 to £10,480,000, an increase of 72%. At June 30, 1960, the average salary cost per staff member was £1443, while at June 30, 1965, this cost was £1950. There are several factors that affect the interpretation of these figures, including the relative proportions of more highly paid research staff to lower-paid supporting staff, but the figures presented illustrate the extent to which the costs of research have been increased by rises in salary rates.

Staff

The staffing of a research organization poses a number of special problems. At the research level it is important to maintain a continuous influx of new people with new ideas, and for this purpose some Divisions make considerable use of short-term appointments. Ways of extending this practice are being examined.

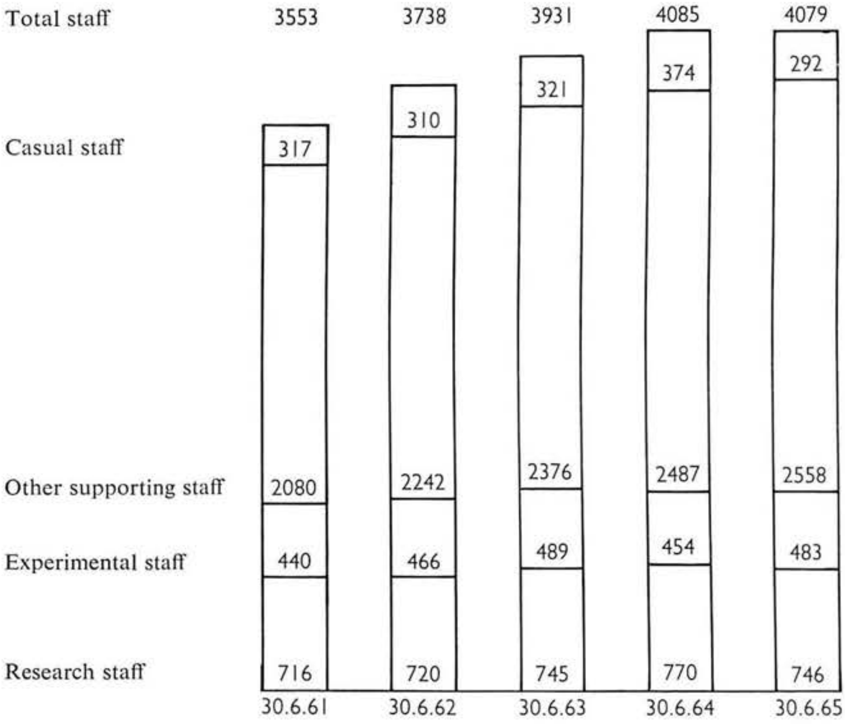
Changes within the research programme and the continuous introduction of new techniques for scientific research have brought a need for a greater proportion of supporting staff, particularly laboratory technicians. The growth in the supporting staff available to the Organization has not kept pace with changing needs and in some Divisions the numbers in this category fall considerably short of the optimum for efficient working. Apart from the appointment of research staff for specific new commitments, the Executive has for a number of years allocated most of the available increase in staff numbers to the recruitment of supporting staff, and for the present it is continuing this policy.

It is natural that a proportion of the professional scientific staff will so develop during the course of their work that their knowledge and abilities could be used to greater benefit in other avenues of employment, such as the universities, government advisory services, or industry. Conversely, the Organization needs to recruit a proportion of its staff from amongst those with specialized experience such as can be gained only from outside employment. Lack of transferability of superannuation rights has long been recognized as a very considerable barrier to this highly desirable mobility of professional staff *to* and *from* CSIRO. The problem has been accentuated by difficulties in some cases in which the Organization has sought to use to best advantage those provisions of the Commonwealth Superannuation Act designed specifically to permit limited participation in superannuation schemes having mobility of staff as one objective. This problem is currently being examined in CSIRO and in a number of other interested quarters.

The Executive devotes considerable attention to maintaining a high standard in the recruitment of research staff. Although the numbers currently required for new work and to replace wastage are not large, the Organization continues to be dependent on overseas countries for a large proportion of the research scientists recruited each year. It is, therefore, important that the Organization should have conditions that will be attractive on an international basis. Negotiations on the salaries of research scientists extending over several years culminated during the year in a short hearing before the Public Service Arbitrator, who handed down his judgment in Determination No. 97 of 1964, in September. The Executive retains some misgivings that the salaries available at the higher levels may make it difficult to recruit scientists of the desired ability and eminence to take charge of the Organization's laboratories.

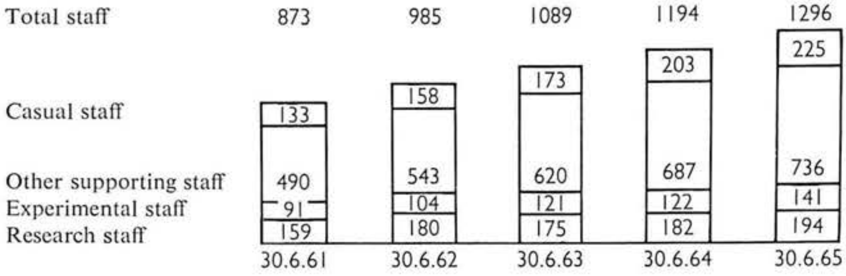
The number of staff employed in all categories, including casual employees, increased from 5279 to 5375 during 1964/65. There was a decrease of 6 in the staff financed by Treasury funds while staff financed by contributory funds increased by 102. Changes in staff numbers over the last five years are shown below.

Staff Financed by Treasury Funds



Staff Financed by Contributory Funds

A feature of the last five-year period has been that while staff supported from Treasury funds has increased by 18%, staff supported by contributions has increased by 70%. As a result the percentage of the Organization's staff supported from Treasury funds has fallen from 82% to 76% in this period.



Advisory Council and State Committees

The Advisory Council, which is established under the Science and Industry Research Act to advise the Executive, met twice during the year. The membership of the Council, consisting of the Executive itself, the Chairmen of the State Committees, and a number of co-opted members, covers a wide range of interests and disciplines from the universities, rural and manufacturing industries, and the government. Recently two Members of Parliament, Mr. C. R. Kelly and Mr. K. E. Beazley, have accepted invitations to join the Council.

In addition to reviewing the Organization's estimates and building programme, the Council at its two meetings during the year inspected the Division of Dairy Research and the National Standards Laboratory. The two principal topics discussed at its meetings were research in the service of the pastoral industry, and the respective roles of the universities and CSIRO in scientific and industrial research in Australia.

The Council has established a committee to report further on the latter subject. The Council also has committees working on research for the Australian mineral industries and on industry research associations.

The various State Committees set up under the Act to advise the Executive or the Advisory Council with respect to the general work of the Organization or any particular matter of investigation or research have been active during the year.

Expansion of the Kimberley Research Station

In December 1964, the Governments of the Commonwealth and Western Australia agreed on an expanded programme of research over the next five years at Kimberley Research Station, which is operated jointly by the CSIRO Division of Land Research and Regional Survey and the Department of Agriculture of Western Australia. The objective of this programme is to provide the scientific background for irrigated agriculture on the Ord River as well as information that will be applicable in other similar areas in northern Australia.

Experimental work at the Kimberley Research Station was commenced in 1947. There were many problems in establishing a research centre in such an isolated, undeveloped location, and with very limited resources the Station was faced with the major problem of developing agricultural practices in an area that had no previous history of agricultural development. It was also necessary to keep in mind that any commercial agriculture arising from the research would necessarily involve high-cost labour and a high degree of mechanization, and must aim at an acceptable Australian standard of living. Nowhere else in the world is this type of agriculture practised in this type of environment, and experience gained in similar environments in other countries was of little value. Exploratory trials were commenced with a wide range of crops and research has gradually been intensified on those crops that appeared to offer the best prospects for economic success.

The scientific staff on the Station has grown from four in 1957 to eight by 1964. The newly agreed programme allows for the appointment of a further five scientists to provide a balanced research unit. This unit will be capable of tackling promptly and efficiently the problems that will inevitably arise in a developing agriculture, in each of the main fields of agronomy, crop protection, cattle feeding and husbandry, and soil physics and chemistry.

The major crop being grown in the initial development phase on the Ord River is cotton. As a result of research, the average yield of cotton at Kimberley Research Station has already been raised to 1·7 bales of lint per acre (2200 lb seed cotton) and this figure is by no means a ceiling yield. Some commercial irrigation blocks should yield 2 bales per acre (3000 lb seed cotton) this season. Research on growth and fruiting potential indicates that yields of up to 3 bales of lint per acre should be possible in the future. The region has several natural advantages for growing cotton, including a very long growing season (long enough to permit "second cycle" cropping, in which picking of the mature crop is followed by re-irrigation for a second crop from the same plants within the same season) and a reliably dry harvesting period. From recent research work it seems likely that the naturally low nitrogen status of the soil may also be an advantage in permitting closer control of nitrogen supply to the crop through fertilizer application.

Other crops have been shown to be ecologically adapted to this area; these include rice, grain sorghum, wheat, oats, safflower, linseed, rape, sugar-cane, and forage crops. Some of the land on the research station has been under irrigation for 18 years and there is no evidence of major soil problems associated with continued irrigation. The major industry in the associated region at the present time is the raising of beef cattle and its chief problem is the acute protein deficiency of the dry standing pastures available during the dry season. Protein-rich by-products such as cotton seed would overcome this deficiency. Irrigation development could thus have considerable impact on the cattle industry through protein by-products and through the production of forage and grain crops. Other work has shown that it should be possible to develop improved Townsville lucerne pastures on some adjacent types of higher sandy country. The winters are sufficiently warm to grow tropical crops such as sugar-cane, sorghum, and rice, and multiple harvests from a single planting of the last two crops are now being examined. At the same time the winters are sufficiently cool to grow a wide range of temperate crops such as wheat, oats, and rape, and they are so dry that on unirrigated areas it should be possible to alleviate the dry-season protein shortage by utilizing Townsville lucerne as standing hay.

Many of these findings are still only experimental, but they are being vigorously extended into commercial cropping practices in order to develop forms of agriculture that make maximum use of the natural advantages of the dry monsoonal environment.

Head Office Move to Canberra

The Head Office of CSIRO and its predecessors has been located at its present address of 314 Albert Street, East Melbourne, since 1922. A proposal that it should be transferred to Canberra was approved by Cabinet during the year and details of the move are now being planned.

Organizational Changes

Fodder Conservation Section

The Fodder Conservation Section, which had laboratories at Highett, Melbourne, has now been disbanded. Early work of the Section centred on mechanical losses occurring during hay-making and the effect on silage of factors like crop maturity and ensiling temperature. It had become evident that little further progress could be made without a great deal of fundamental information about the processes involved. Some of the investigations have now been terminated, while some have been transferred to other groups where appropriate facilities are available.

Sugar Research Laboratory

The Sugar Research Laboratory, a unit of the Chemical Research Laboratories, located in the Russell Grimwade School of Biochemistry of the University of Melbourne, has been closed down and the staff transferred to other activities. This unit was formed to investigate derivatives of sugar as a possible means of using part of the large surplus of this commodity then produced by Australia. While terminating the present programme, the Executive is examining the desirability of participation in research on problems of production of raw sugar.

Division of Land Research and Regional Survey Coastal Plains Research Station

Formal arrangements have been made for the Coastal Plains Research Station at Humpty Doo, near Darwin, to function as a cooperative venture of CSIRO and the Northern Territory Administration. An Advisory Committee representing both organizations will be responsible for the work of the Station. Under the new arrangements basic studies will be carried out by CSIRO and research associated with application of results will be undertaken by the Agricultural Branch of the Northern Territory Administration.

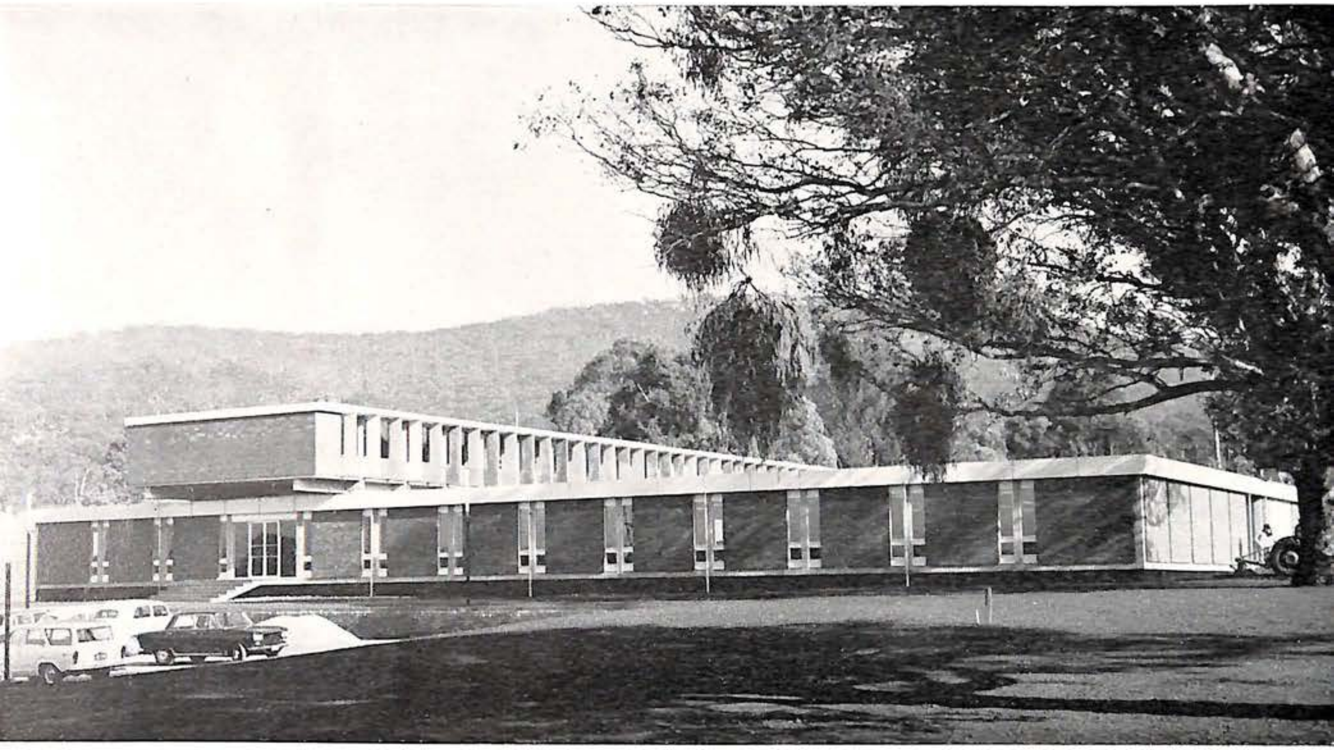
New Laboratory for Irrigation Research

A new two-storey wing for the Irrigation Research Laboratory at Griffith, N.S.W., was opened by the Governor-General, Lord De L'Isle, on November 19, 1964.

The new building houses a physics laboratory, a plant physiology laboratory, a series of rooms for studies of plant growth under controlled environments, a library, and a lecture and meeting room. It cost £70,000, and was designed by the Commonwealth Department of Works and built by Clark Constructions of Wagga Wagga, N.S.W.

Computer in Operation

The new laboratory for the Computing Research Section was officially opened by the Chancellor of the Australian National University, Sir John Cockcroft, on September 17, 1964. The laboratory, which is the headquarters of the Section, houses a Control Data 3600 computer and a wide range of subsidiary devices. This computer is the central installation in CSIRO's computing network, which includes three smaller Control Data 3200 computers in Sydney, Melbourne, and Adelaide. The laboratory



The Canberra headquarters building of the Computing Research Section. The building, which houses the Control Data 3600 Computer, was opened by Sir John Cockcroft on September 17, 1964.

was designed by the Commonwealth Department of Works and was built at a cost of £165,000 by Kennedy and Bird Pty. Ltd. The computer, together with electrical and mechanical plant rooms, administration areas, library, and staff amenities, is located on the ground floor. It is housed in a special air-conditioned dust-free room.

The computer network is now fully in operation, and work at the central installation was recently extended to one and a half shifts five days a week. At present 78% of the work-load of the network comes from CSIRO's own research work, 14% from other government authorities, and 8% from universities.

Overseas Liaison Offices

CSIRO has for many years maintained Liaison Offices in London and Washington. These offices facilitate exchanges and contacts between individuals and laboratories, serve as centres for Australian scientists and research students travelling abroad, and are important centres for the recruitment of scientific staff. The increasing governmental participation in science programmes, the international activities of grant-giving agencies and foundations, and the diversification and expansion of scientific institutions have placed increasing importance on their function as sources of information on the scientific policies and establishments of those countries within their respective spheres of operation.

Technical Assistance Programmes

CSIRO has continued to take part in Australia's activities in foreign aid and technical assistance programmes. The facilities of its laboratories and the knowledge of its staff are made available freely to trainees and fellows on visits from Asian and African countries. Officers of the Organization have also gone overseas on expert assignments and developmental projects, but some of the most effective contributions made by CSIRO to the promotion of science in developing countries are less formally associated with aid or technical assistance programmes. The Organization has provided discussion leaders and speakers at international conferences and symposia concerned with the scientific and technological problems of development. Members of the staff have thus established and maintained contact with research workers throughout Asia and Africa. These activities have been supplemented by membership of expert panels and working parties established by intergovernmental bodies and international scientific unions. Officers of the Organization travelling overseas also spend short periods en route to their destinations giving lectures and meeting scientists working in scientific institutions in the developing countries. The objective is to assist in the growth of self-sustaining scientific research establishments within these countries, and so lead to a situation wherein the developing country is able to undertake its own research on its problems of development.

Sir Frederick White (Chairman, CSIRO), Lord Casey (Member of the Executive), and Mr. G. B. Gresford (Secretary, CSIRO) represented Australia at the Third Meeting of the Commonwealth Scientific Committee, held in New Zealand in November and December 1964. The role of the Committee in technical assistance programmes was reviewed. Approaches are to be made to the various Governments within the Commonwealth to have scientific research and its application to social and economic development included in the programmes to be associated with the intended establishment of a Commonwealth Secretariat.

Mr. G. B. Gresford has continued to act as scientific adviser to Sir Ronald Walker (Australian Ambassador to France) in activities arising from Sir Ronald's membership of the U.N. Advisory Committee on the Application of Science and Technology for the Benefit of Less Developed Countries.

In November 1964, the Division of Fisheries and Oceanography, on behalf of F.A.O. and the Indo-Pacific Fisheries Council, conducted a Training Centre on Mackerel and Tuna Research at Cronulla. The Centre was attended by representatives of nine countries of the I.P.F.C. Region and took the form of a series of advanced seminars on sampling and stock assessment methods, the application of these methods, and the evaluation of data on mackerel and tuna stocks.

The Minister-in-Charge, Commonwealth Activities in Education and Research, Senator J. G. Gorton, who opened the Training Centre on Mackerel and Tuna Research, with Dr. V. Beerman, United Nations Technical Assistance Board representative in Australia and New Zealand, and Mr. J. S. Hynd, of the Division of Fisheries and Oceanography, examining a bluefin tuna on board the research vessel Marelda.

During the UNESCO General Conference in November last, Australia issued an invitation for UNESCO to hold within Australia a Seminar on Science Policy and Research Organization for the countries of south and south-east Asia. This invitation was accepted, and CSIRO will conduct the seminar on behalf of UNESCO in Sydney in August 1965.

Overseas Travel

Advances in scientific knowledge are the result of research work in laboratories throughout the world, and in his approach to any problem the research scientist draws heavily upon the work of others. Access to scientific publications is therefore important, but equally important to the research worker is contact with other scientists working in fields related to his own. The advances made as a result of direct exchange of ideas between scientists may cut years off the course of a research project.

Within Australia the research staff of CSIRO freely maintain contact with workers in other laboratories in the Organization, and with those in other government scientific institutions, in universities, and in industry. For Australian scientists, however, effective contact with other workers must to a large extent involve overseas travel. The Executive sends abroad each year a substantial number of the research staff on visits which vary in duration, according to need, from a few weeks to several months. Some seventy officers represented Australia at international conferences during 1964/65, including fifteen who were delegates to the Third International Conference on Wool Textile Research. A further fifty-nine officers visited one or more laboratories abroad to gain new ideas and techniques specific to their fields of research.

Many distinguished overseas scientists also visited CSIRO laboratories during the year. As in previous years, the Executive has actively encouraged such visits as an important means of direct contact with trends of thought and the latest developments in the leading laboratories throughout the world. There has been a great increase in inquiries from overseas scientists seeking to spend sabbatical and other forms of leave working within CSIRO laboratories.

Overseas Research Grants

For a number of years CSIRO has received grants from overseas organizations for specific research work of interest both to them and to Australia. The majority of these awards have come from agencies of the United Nations or the United States of America. Where necessary, special arrangements have been made to ensure that results of the work supported by the grant are not lost to Australia.

Only one new major grant was awarded this year, namely $25,000 from the United States National Bureau of Standards for work to be carried out by the Division of Physics on solar flares. Funds have also been provided for the continuation of several projects commenced in previous years.

Details of these grants are set out in Chapter 5.

Primary Industry Research Funds

CSIRO receives considerable financial support from the various industry research funds related to the primary industries. The Organization is represented on the following committees: Wool Production Research Advisory Committee, Wool Textile Research Advisory Committee, Wheat Industry Research Council, Dairy Produce Research Committee, Australian Cattle and Beef Research Committee, and Central Tobacco Advisory Committee.

These committees recommend the allocation of funds to support appropriate programmes of research being conducted by CSIRO, State departments, and universities. In addition to the meetings normally held, members of the Wool Production Research Advisory Committee visited a number of CSIRO laboratories and field stations during August 1964.

During the year, the Australian Dried Fruits Association and the Australian Dried Fruits Control Board made arrangements with the Commonwealth Government for the formation of the Dried Vine Fruits Research Committee, on which CSIRO is also represented. The first meeting of this Committee was held in May 1965. The possibilities of forming a fund to provide financial support for an expansion of research on agricultural machinery are also being explored.

Collaboration with Industry

The Executive encourages the collaboration of industry with the Organization on research and development projects. In some cases a number of firms join in collaborative investigations with CSIRO; in others, work is undertaken with individual firms or a public authority. In much of this joint activity the research is undertaken by CSIRO with financial support from the firms concerned. During the year under review the following new cooperative projects have been begun:

Project	*Division*	*Supported by*
Possible methods of improving the rheological characteristics of bentonite clay in the Upper Yarraman deposit, Queensland	Applied Mineralogy	Department of National Development
Research on aspects of the production of aluminium chloride and investigations of the application of a solar pond thermal energy collector for the production of salt by evaporation	Chemical Engineering	Conzinc Riotinto of Australia Ltd.
Investigations on the development of a size sensing element for the automatic control of grinding circuits in ore-dressing plants	Chemical Engineering	Australian Mineral Industries Research Association
Research on production of spectroscopic gratings	Chemical Physics	Techtron Pty. Ltd.
Investigations on the use of flexible film packages for the freezing and storage of egg pulp	Food Preservation	Australian Egg Board

Investigations on the feasibility of reprocessing stocks of canned meat	Food Preservation	Darling Downs Co-operative Bacon Association Ltd.
Research on sulphuring techniques and problems relating to white centres in apricots	Food Preservation	Australian Dried Fruits Association
Research on rice	Food Preservation	Australian Rice Marketing Board
Investigations of the solvent extraction of vegetable oils	Food Preservation	Ricegrowers' Co-operative Mills Ltd.
Research on nematodes	Horticultural Research Section	Australian Dried Fruits Association
Investigations on production of manganese dioxide	Mineral Chemistry	Electrolytic Zinc Company of Australasia
Investigations of new methods for the surveying of drill-holes	Mineral Chemistry	Conzinc Riotinto of Australia Ltd. and New Broken Hill Consolidated Ltd.
Nuclear Magnetic Resonance Service project	Organic Chemistry	Imperial Chemical Industries of Australia & New Zealand Ltd., and Monsanto Chemicals (Aust.) Ltd.
Research on thermal conductivity of soil	Plant Industry	Pipeline Technologists Pty. Ltd.
Investigations into the electrostatic charging of fabrics	Protein Chemistry	Royal Melbourne Hospital
Mineralogical investigations	Soils	Zinc Corporation Ltd. and Philips Electrical Pty. Ltd.

Collaboration with the Universities

Although the objectives of the universities and of CSIRO are different, there is, nevertheless, wide scope for collaboration between them, both in teaching and in research. Officers of the Organization assist in university lecturing and demonstrating, particularly in their specialized fields of knowledge. Conversely, CSIRO could profit considerably from the temporary presence of more young scientists, and would welcome opportunities to play a part in the training of post-graduate students in appropriate fields of study.

There is already much fruitful collaboration between research workers in CSIRO and university staff members on a range of research projects. There are also several joint laboratories such as the Microanalytical Laboratory in the Chemistry School of the University of Melbourne; Ore Dressing Investigations in the Mining Department of the same University; the Physical Metallurgy Section in the Metallurgy School, again in Melbourne; and the Plant Physiology Unit of the Division of Food Preservation in the School of Biological Sciences of the University of Sydney. There may well be scope for further expansion of these activities, and the CSIRO Advisory Council has recently appointed a Committee to examine further these interactions between the Organization and the universities.

In addition, grants have been made to support a number of university research programmes of particular interest to CSIRO. These include grants for the following purposes:

University of Melbourne:

Pollen research
International Biological Programme
International Conference on Electron Diffraction and Crystal Defects

University of Queensland:

Research Fellowship in Parasitology
Research Fellowship in Veterinary Anatomy

University of Sydney:

Colloid science research
Research on dairy beef production
Research on heat and mass transference
Post-doctoral Fellowship in Corrosion Research

University of New South Wales:

Investigations into the failure of concrete
Research at the School of Biological Sciences

University of New England:

Cloud physics research

Australian National University:

Research on marsupials
Study of the conduct of scientific research and development in Australia
Research on milk proteins

University of Adelaide:

Post-graduate training in biophysics
Research on evolution of marsupials
Representation at Sixth Symposium on Fruit Tree Viruses

University of Western Australia:

Establishment of an Institute of Arid Zone Biology

University of Tasmania:

Equipment grant for research associated with aluminium production
Biophysical research

CSIRO has continued its support to the Electrical Research Board, which made grants this year to the Universities of Sydney, Melbourne, Queensland, Western Australia, New England, Adelaide, and New South Wales, and Monash University.

The Radio Research Board, to which CSIRO is a major contributor, has made grants for research in radio science at the Universities of Sydney, Melbourne, Queensland, Adelaide, Tasmania, New England, and Western Australia, and Monash University.

CSIRO Post-graduate Studentships

The Organization has awarded a number of post-graduate studentships to graduates of Australian universities, as part of the Executive's policy of encouraging research training.

Support is also provided from the CSIRO Studentship Fund to supplement the 1851 Exhibition Scholarships, a number of which are made available to Australian science graduates each year for post-graduate training in Britain.

Junior Post-graduate Studentships

These are awarded, for one year only, to persons who have completed their studies at the undergraduate level in science, agricultural science, veterinary science, engineering, or in arts with mathematics as a major subject. There were 186 applications; 41 Studentships were awarded (12 were subsequently declined). The candidates who accepted are listed below with their universities:

Miss H. E. Bensley (New England)
M. J. S. Bowden (Queensland)
A. J. Bracken (Adelaide)
R. T. Brady (Sydney)
P. I. Brooker (Adelaide)
A. T. Calvert (Tasmania)
Miss A. J. Campbell (Adelaide)
B. W. Clare (Western Australia)
R. J. Clarke (Adelaide)
S. C. Clarke (Western Australia)
L. T. Cooper (Adelaide)
J. de Jersey (Queensland)
S. A. R. Disney (Adelaide)
P. D. Godfrey (Monash)
P. C. Harris (Sydney)
C. J. F. Harrop (Adelaide)
R. P. Henzell (Western Australia)
N. C. Hope (Tasmania)
M. B. Jackson (Adelaide)
B. W. Keck (Melbourne)
R. B. McFest (Adelaide)
R. G. A. R. Maclagan (Western Australia)
R. K. Norris (Sydney)
R. F. Pratt (Melbourne)
L. Radom (Sydney)
H. D. W. Saddler (Adelaide)
D. R. Smyth (Adelaide)
M. R. Walter (Adelaide)
L. J. Warren (Queensland)

In addition, Mr. G. M. Polya was awarded the Masson Memorial Scholarship of the Royal Australian Chemical Institute, an award which is supplemented from CSIRO sources.

Senior Post-graduate Studentships

These are awarded for two years initially to persons holding at least an Honours degree in the fields listed above. The period of the studentship may be extended for an additional year under special circumstances. There were 227 applications; 43 awards were made (4 were subsequently declined). The candidates who accepted are listed below:

J. R. McR. Badcock (Melbourne)
J. Baldas (Melbourne)
R. J. Blagrove (Adelaide)
P. H. Cannington (Melbourne)
B. A. Casey (Adelaide)
Miss J. A. Chessell (Western Australia)
D. Cook (Western Australia)
Miss S. Cory (Melbourne)

M. Craig (Sydney)
Miss J. E. Crawford (Sydney)
G. P. Deutsch (Melbourne)
P. W. Donovan (Sydney)
P. C. Drewer (Adelaide)
L. Dubicki (Melbourne)
R. H. Eather (New South Wales)
P. W. Ford (Monash)
R. A. Fox (Western Australia)
R. W. Gellie (Melbourne)
S. Harris (Sydney)
D. G. Hewitt (Western Australia)
D. G. Laing (New South Wales)
J. Lipa (Western Australia)
M. M. Ludlow (Queensland)
B. J. McAvaney (Adelaide)
D. J. Mackey (Melbourne)
R. G. Meyer (Melbourne)
C. J. Pearce (Western Australia)
Miss B. J. Pickford (Western Australia)
J. W. Redmond (Adelaide)
B. W. Ricketts (Sydney)
D. E. Robertson (Western Australia)
Miss E. Rudeberg (Western Australia)
B. R. Scoggins (Melbourne)
B. M. Smith (Adelaide)
R. H. Smith (Western Australia)
L. C. Stonehouse (Western Australia)
W. C. Summerfield (Adelaide)
Miss D. F. White (Sydney)
J. R. Zdysiewicz (Adelaide)

Overseas Studentships

These are awarded to post-doctoral scientists to enable them to proceed overseas for one year to work with leaders of research in their special field of interest. During the year 40 applications were received and 14 candidates were selected, 2 of whom subsequently declined:

N. L. Arthur (Adelaide)
L. C. Calder (Adelaide)
D. W. Cooper (Adelaide)
B. E. Davidson (Melbourne)
J. A. Elix (Adelaide)
I. R. Kennedy (Western Australia)
C. A. Sholl (Monash)
T. H. Spurling (Western Australia)
J. G. Steele (Queensland)
D. Wege (Adelaide)
M. J. Weidemann (Melbourne)
H. Weigold (Adelaide)

In addition, the following officer of CSIRO was judged of overseas studentship standard:

A. D. Warth (Division of Food Preservation, Sydney)

Science and Industry Endowment Fund

The Science and Industry Endowment Fund Act of 1926 provided for the establishment of a fund to assist persons engaged in scientific research and in the training of students for scientific research. During the year under review the Executive, as Trustees of the Fund, made grants to assist the following: Mr. N. W. Schleiger to publish his paper "Primary Scalar Bedding Features of the Siluro–Devonian Sediments of the Seymour District"; Mr. N. A. Wakefield to continue his studies on the fossil mammalian fauna of south-eastern Australia; Mrs. K. Southern to undertake a study of the small Australian fungus beetle; Mr. B. M. Moore to prepare his thesis on the geology of the Upper Yarra region; Dr. I. R. C. Bick for collecting plant material in New Caledonia in his study of the alkaloids of the Monimiaceae species; Dr. Mary Carver to continue her studies of the Australian aphid fauna; Miss F. V. Murray for her work on the life history studies of Victorian species of marine molluscs; Dr. R.

Kumar to continue his studies on Australian Hemiptera; Mrs. G. K. Crowcroft to purchase field equipment for her ecological work on the marsupial mouse, *Sminthopsis crassicaudata*; and Dr. W. D. L. Ride to continue a project concerned with the taxonomy of Australian mammals.

Grants were made towards the travelling expenses of members of the staff of the University of Adelaide to enable them to participate in a biological expedition to the Solomon Islands; Dr. W. H. Dawbin to visit New Zealand in connection with his studies on the tuatara (*Sphenodon punctatus*); Messrs. B. Phillips and J. Lucas for a collecting trip along the South Australian, Victorian, and New South Wales coasts in connection with their studies on the whelk *Dicathais* and estuarine crabs of the genus *Halicarcinus*; Mr. E. D. Gill to attend the Seventh International Congress of the I.N.Q.U.A.; Mr. H. G. Cogger for a visit to New Guinea for field work on reptile fauna; Dr. L. H. Smith to enable him to extend his visit to the U.S.A. in connection with his studies on the lyre-bird.

The Trustees also made grants to the A.C.T. Science Teachers' Association, the Science Teachers' Association of N.S.W., and the Science Teachers' Association of Victoria for annual school science awards; and to students and demonstrators of the Universities of Tasmania, Western Australia, Queensland, Adelaide, Melbourne, and New England, Monash University, and University College, Townsville, to enable them to attend the annual School of Marine Biology at the CSIRO Division of Fisheries and Oceanography, Cronulla, N.S.W.


The CSIRO Officers' Association has instituted the David Rivett Medal to honour the memory of the former Chief Executive Officer and, subsequently, Chairman of the Council for Scientific and Industrial Research. The medal is to be offered every two years for outstanding research by members of the Organization's research staff. The 1964 David Rivett Medal was awarded jointly to Dr. C. H. Gallagher (left), *of the Division of Animal Health, and Dr. E. O. P. Thompson* (right), *of the Division of Protein Chemistry.*

2

Research Activities

FOR THE PURPOSE of conducting its research work CSIRO is organized into 32 Divisions and a number of research Sections (research groups usually smaller in size than a Division or in an earlier stage of development). Some of the Divisions are grouped, three Divisions forming the Animal Research Laboratories, six Divisions the Chemical Research Laboratories, two Divisions the National Standards Laboratory, and three Divisions the Wool Research Laboratories. Each Division covers a broad area of research which may be based either on an industry (e.g. Forest Products) or on a scientific discipline (e.g. Chemical Physics). Laboratories in the latter group are concerned with research that will have application over a range of industries.

Since CSIRO's activities are Commonwealth-wide and often involve extensive field work, branch laboratories and field stations have been established in various parts of Australia. The more important of these are included in the following list.

Laboratories and Divisions

Animal Research Laboratories, consisting of the following three Divisions:

Animal Genetics, with headquarters in Sydney, laboratories in Sydney and in Rockhampton, Qld., and field stations at Badgery's Creek, N.S.W., Rockhampton and Cunnamulla, Qld., and Werribee, Vic.

Animal Health, with headquarters and laboratories in Melbourne, laboratories in Sydney and Brisbane, and field stations at Werribee, Vic., and Amberley, Qld.

Animal Physiology, with headquarters and main laboratories at Prospect, N.S.W., and a laboratory with field station at Armidale, N.S.W.

Chemical Research Laboratories, Melbourne, consisting of the following six Divisions:

Applied Mineralogy, with a branch laboratory in Perth,
Chemical Engineering,
Chemical Physics,
Mineral Chemistry,
Organic Chemistry,
Physical Chemistry,

and

Microanalytical Laboratory.

National Standards Laboratory, Sydney, consisting of the following two Divisions:

Applied Physics,
Physics.

Wool Research Laboratories, consisting of the following three Divisions:

Protein Chemistry, Melbourne,

Textile Industry, Geelong, Vic.,

Textile Physics, Sydney.

Other Divisions are:

Biochemistry and General Nutrition, with headquarters and laboratories in Adelaide and a field station at O'Halloran Hill, S.A.

Building Research, with headquarters in Melbourne and an office in Port Moresby, New Guinea.

Coal Research, Sydney.

Dairy Research, Melbourne.

Entomology, with headquarters and main laboratories in Canberra, laboratories in Sydney and Brisbane, and field stations at Albury, Trangie, and Wilton, N.S.W., and Cambridge, Tas.

Fisheries and Oceanography, with headquarters and main laboratories at Cronulla, N.S.W., and a laboratory in Melbourne.

Food Preservation, with headquarters and laboratories in Sydney and laboratories in Brisbane and in Gosford, N.S.W.

Forest Products, Melbourne.

Land Research and Regional Survey, with headquarters in Canberra and field stations and laboratories at Alice Springs, Katherine, and Darwin, N.T., and Kununurra, W.A.

Mathematical Statistics, Adelaide, with officers stationed at a number of Divisions and Sections and at the University of Melbourne.

Mechanical Engineering, Melbourne.

Meteorological Physics, Melbourne.

Plant Industry, with headquarters and main laboratories in Canberra, laboratories in Perth and Hobart and in Deniliquin, N.S.W., field stations and experimental farms at Canberra and Deniliquin and at Kelmscott, Kojonup, and Baker's Hill, W.A., and the Tobacco Research Institute at Mareeba, Qld.

Radiophysics, with headquarters and laboratories in Sydney, the Australian National Radio Astronomy Observatory at Parkes, N.S.W., and the Solar Physics Observatory at Culgoora, N.S.W.

Soils, with headquarters and laboratories in Adelaide and a laboratory in Canberra.

Tribophysics, Melbourne.

Tropical Pastures, with headquarters in Brisbane, main laboratories in Brisbane and Townsville, a laboratory at Lawes, Qld., and field stations at Samford and Woodstock, Qld.

Wildlife Research, Canberra.

Independent Sections

Computing Research Section, Canberra, with subsidiary installations at Adelaide, Melbourne, and Sydney.

Editorial and Publications, Melbourne.

Fodder Conservation, Melbourne.

Horticultural Research, Adelaide, and Merbein, Vic.

Irrigation Research Laboratory, Griffith, N.S.W.

Mineragraphic Investigations, Melbourne.

Ore Dressing Laboratory, Melbourne.

Physical Metallurgy, Melbourne.

Soil Mechanics, Melbourne.

Upper Atmosphere, Camden, N.S.W.

Wheat Research Unit, Sydney.

Regional Centres

Officers from a number of Divisions are located at:

Tasmanian Regional Laboratory, Hobart.

Western Australian Regional Laboratory, Perth.

Fields of Research

It is in the nature of the work of CSIRO that much of it has relevance not only to more than one problem, but also to problems affecting more than one industry. For example, work on such materials as soils and water has great significance for the cattle, sheep, and horticultural industries, and cannot be accurately apportioned amongst them. Conversely, the resources of several Divisions may at times be required to tackle a single problem. In order to bring the work of the Organization as a whole into perspective, it has been grouped below broadly under the headings outlined on page 24 at the beginning of this chapter.

Cattle

Beef production, already one of Australia's most important industries, promises to become even more important with the development of additional production areas in the north and the opening up of new export opportunities. Research into problems affecting cattle was begun early in the history of the Organization, and its value was quickly demonstrated by the development of reliable diagnostic techniques and a vaccination procedure which has led to the almost complete eradication of pleuropneumonia from Australia. Each of the *Animal Research Laboratories* now contributes to work on cattle at centres in Melbourne, Sydney, Brisbane, and Rockhampton. The *Division of Entomology* also has a laboratory in Brisbane largely concerned with cattle research, in particular with work on the major problem of the industry in the north, the cattle tick (see Pest Control). Much of the work of the *Division of Tropical Pastures* centred on Brisbane and Townsville (see Plant Production) and of the *Division of Food Preservation* in Brisbane (see also Food Processing) is directly related to beef production, as well as the developmental work of the *Division of Land Research and Regional Survey* (see also Land Development).

Some £800,000 of Commonwealth funds are expended directly on cattle research annually, and are now supplemented by substantial amounts from the Australian Cattle and Beef Research Trust Account and lesser amounts from the Dairy Produce Research Trust Account and other contributors.

The current cattle research programme of CSIRO is aimed at improvement in production through attack on several broad fronts. These include work basic to the development of cattle breeds for both beef and dairy purposes suited to the hot environment in the north; investigation and development of methods of control of diseases and pests; the development of new pasture species for the tropical and subtropical areas of Australia; and an investigation of the relation between poor nutrition and reproductive performance.

One of the factors retarding the development of beef production in the northern areas of Australia is the absence of suitable breeds to withstand tropical conditions. At present the *Division of Animal Genetics* is studying the physiology of heat tolerance of two British breeds (Hereford and Shorthorn) and their crosses with Zebu types as represented by Brahman and Afrikander breeds. The individual characters selected for examination include body temperature, sweating, coat and skin, digestion of food, and glandular activity. The inheritance of resistance to cattle tick is also being studied. A major programme of breeding Zebu–Jersey crossbreds and investigating the characters associated with adaptation of dairy cattle to a hot environment is centred on the McMaster Field Station, with the cooperation of a number of commercial milk producers at Wollongbar, N.S.W.

The *Division of Animal Health* is tackling a number of the more important diseases of cattle. In view of the ever-present danger of introduction of diseases from other countries, several exotic virus diseases and protozoan tick-borne diseases as yet unknown in this country are also being studied. Work on infectious diseases due to bacteria and viruses is centred mainly at the Melbourne Laboratory, and that on cattle parasites and protozoan diseases at Brisbane (see also Pest Control).

The *Divisions of Animal Physiology* and *Tropical Pastures* are cooperating in a study of the nutrition and reproduction of beef cattle on tropical and subtropical pastures. At present ecological studies are under way to determine the points at which reproduction is likely to fail under field conditions. The possibilities of artificial insemination under extensive grazing conditions are also being investigated.

The work within the three Divisions of the Animal Research Laboratories is coordinated through the Animal Research Committee, comprising the Chiefs of the Divisions. The Laboratories collaborate closely with State Departments of Agriculture, participating in refresher courses for extension workers and in the planning and conduct of field studies. By these and other means a continuing flow of information is made available for use by the beef and dairy cattle industries.

Research results of particular interest are outlined below.

Search for Improved Pleuropneumonia Vaccine

Contagious bovine pleuropneumonia may soon be eliminated from Australia. When this is achieved, the possibilities of export trade in live cattle will be greatly improved.

A major weapon in the campaign against this disease of cattle has been the CSIRO V5 strain vaccine, which is still being used after 28 years to protect cattle against the disease. At present the Animal Health Laboratory at Parkville is preparing $1\frac{1}{2}$ million doses of the vaccine annually. Although the V5 strain vaccine has been used with good effect for such a long time, it has some slight disadvantages. Occasionally it may be too virulent for some highly susceptible cattle and cause severe tail reactions. Also, it is a liquid living vaccine and there is some doubt whether it withstands exposure to the higher ambient temperatures of northern Australia. Therefore an even more efficient vaccine is being sought.

Recent experiments have shown that a freeze-dried vaccine prepared from a completely non-virulent African strain is just as effective as the V5 vaccine for the immunization of highly susceptible types of dairy cattle. Tests are now being carried out to determine whether it is equally protective for northern beef cattle. Meanwhile the V5 vaccine has been re-examined and the results are reassuring. It has been shown experimentally that its effectiveness is not reduced even after three months' storage at body temperature.—*Division of Animal Health.*

A technician in the Division of Animal Health dissecting tissues under a sterile hood. This is a first step in the preparation of monolayer cultures of animal cells, used in the study of a wide variety of animal diseases.

New Method of Utilizing Townsville Lucerne

The native pastures of the Katherine region are of very low quality in the dry season, and beef cattle grazing native pasture as their sole diet lose on the average about 20% of their body weight between May and November.

Work at the Katherine Research Station has shown that when given a concentrated protein supplement (e.g. peanut meal), cattle will gain weight satisfactorily on dry-season native pasture. The body weight response to supplementary protein was approximately proportional to the amount fed up to 0·8 lb/day digestible crude protein, which produced a gain of the order of 1 lb/head/day. Other experiments have shown that beef cattle grazing standover Townsville lucerne in the dry season kept gaining weight at a steady rate in excess of 1 lb/head/day from May to October. Periodic pasture sampling showed that the protein content of the lucerne remained relatively constant over the period of grazing.

These results suggested that standover Townsville lucerne could be used as a protein supplement to native pasture in the dry season in a complementary grazing system. The first experiment to test this idea was carried out in the 1964 dry season, with considerable success. Groups of beef cattle were grazed on Townsville lucerne and native pasture for a different number of days each week from May to October, and it was found that body-weight gains were approximately proportional to the number of days the cattle were on lucerne. The work is being continued, as by this method it should prove possible to adjust the proportion of legume supplement (and hence the acreage requirement per head) in accordance with the needs of different cattle husbandry systems.—*Division of Land Research and Regional Survey.*

New Technique for Ovarian Examination in Cattle

The Beef Cattle Research Unit at Brisbane has developed a new research technique that allows direct examination of ovaries in cattle continuously for periods up to two days or intermittently for some weeks. Direct examination of the ovary is necessary to study the effects of hormones and nutrition on ovarian function. In the past this has been done by surgical incision through the flank, but the ovary can be examined only a few times in this way. Also, no satisfactory technique has been developed for viewing the ovary through the incision.

With the new technique the flank is prepared by surgical removal of an area of muscle to allow the skin to adhere to the peritoneum. This provides a site which is relatively free of nerves and large blood vessels. After an incision is made under local anaesthesia, the ovaries are examined through a steel tube with an internal diameter of about 1½ inches that is fitted with light bulbs. Both ovaries can be examined through the one incision. When it is necessary to examine the ovaries directly for a continuing period, a plastic cannula is inserted in the flank. To make an examination the cap of the cannula is simply removed and the tube inserted.

The value of this technique is that ovaries can be viewed without recourse to slaughter, an extremely important point with such expensive experimental animals. The new method has made it possible to keep an actual count of Graafian follicles and numbers of ovulations and to observe the morphological changes in an ovary throughout an oestrous cycle. It will contribute greatly to current studies of nutrition and reproduction in beef cattle.—*Division of Animal Physiology.*

Tick-borne Diseases

A new complement-fixation blood test has been developed in an intensive programme of research on babesiosis or "red-water fever". It is now possible to detect infection in 95% of carrier animals that, although they appear healthy, are capable of spreading the disease. This improved test is being used in the campaign to eradicate babesiosis in tick areas of northern New South Wales. It has also been demonstrated that clinical attacks of this disease may be prevented in susceptible animals by inoculating them with serum from immune animals. This evidence suggests that a vaccine of killed organisms may protect against the disease and research on this aspect has been increased.

An essential part in any research on disease is the determination of the life cycle of the causal organism. This is almost completed for *Babesia argentina*, the more important of the two organisms responsible for babesiosis. The life cycle of another protozoan, *Theileria mutans*, which causes a disease much milder than babesiosis, is also being studied. Transmission of the disease could not be obtained with cattle tick (*Boophilus microplus*), although it has been recorded by others as a vector, but experiments with the tick *Haemaphysalis bispinosa* proved successful. Nevertheless, the incidence of *Theileria* infection is high in some areas where neither of these two ticks occurs and therefore it would appear that some other species of tick is responsible for transmission.—*Division of Animal Health.*

Chemical Manufacturing

The generally high technological level of the present-day Australian chemical industry makes its position in relation to CSIRO different from that of many other industries in which, for one reason or another, little scientific work may be done in the industry itself. As a result, CSIRO is rarely called upon to assist with trouble-shooting for the chemical industry, which brings short-term problems to the Organization only when it needs some specialized skill or equipment not available elsewhere. CSIRO research relevant to the chemical industry is predominantly concerned with problems that are specific to Australia and that, by their nature, are unlikely to be the subject of substantial research effort elsewhere.

Almost all industries use chemical processes at one or more stages in production, and work of a chemical nature is therefore significant to a wide range of industries. It forms a large part of the activities of the group of Divisions that form the Chemical Research Laboratories in Melbourne. In other Divisions, such as Plant Industry, Forest Products, Building Research, and Coal Research, work that is undertaken primarily in relation to their interests in other directions also has a close bearing on the chemical industry.

Within the Chemical Research Laboratories, the *Division of Organic Chemistry* is surveying the drugs contained in native plants found in Australia and New Guinea to define those which show physiological activity of potential value. Such work requires access to comprehensive screening facilities to allow testing over a range of activities of potential medical or veterinary use. This has been achieved by collaboration with the U.S. National Institutes of Health and an American manufacturing firm.

Other work on the synthesis and chemical reactions of organic derivatives containing phosphorus has resulted in compounds that have shown activity as insecticides, which are being developed in collaboration with an Australian manufacturer. Compounds having metal carbon bonds are being studied in a search for novel chemical processes for separating and purifying metals, especially those metals that are abundant in Australia.

Much of the work of the *Division of Chemical Engineering* on specific processes and chemical engineering operations is being carried out in collaboration with, or under the sponsorship of, chemical industry. In the *Division of Chemical Physics* work is centred on the application of physics to chemical problems, and has led to novel scientific instruments and new instrumental techniques for use in the chemical industry (see Engineering and Physics).

The development and application of ion exchange techniques to industrial processes, studies of the properties of matter at extremely high pressures, theoretical and experimental studies of the theory of fluids and solids, and the mechanism of crystal growth are being studied in the *Division of Physical Chemistry*. The Division's research on bush fires, on methods of retarding evaporation of water storages, and on ice nucleation in rain-making (see Water) is not directly aimed at developing the chemical industry but seems likely to create new markets or uses for its products.

Much of the work of the *Divisions of Mineral Chemistry* and *Applied Mineralogy* has a direct bearing on chemical industries, since many of the products of the mineral industry become the raw materials for the chemical industry. For example, research on the treatment of ilmenites is of particular importance to the paint industry, in which titanium pigments are widely used. Paint and other chemical problems of the building and timber industries are also investigated by the *Divisions of Building Research* and *Forest Products* (see Timber and Building).

The *Division of Forest Products* pioneered the use of Australian native timbers in pulp- and paper-making, and investigations of this type have continued in collaboration with industry.

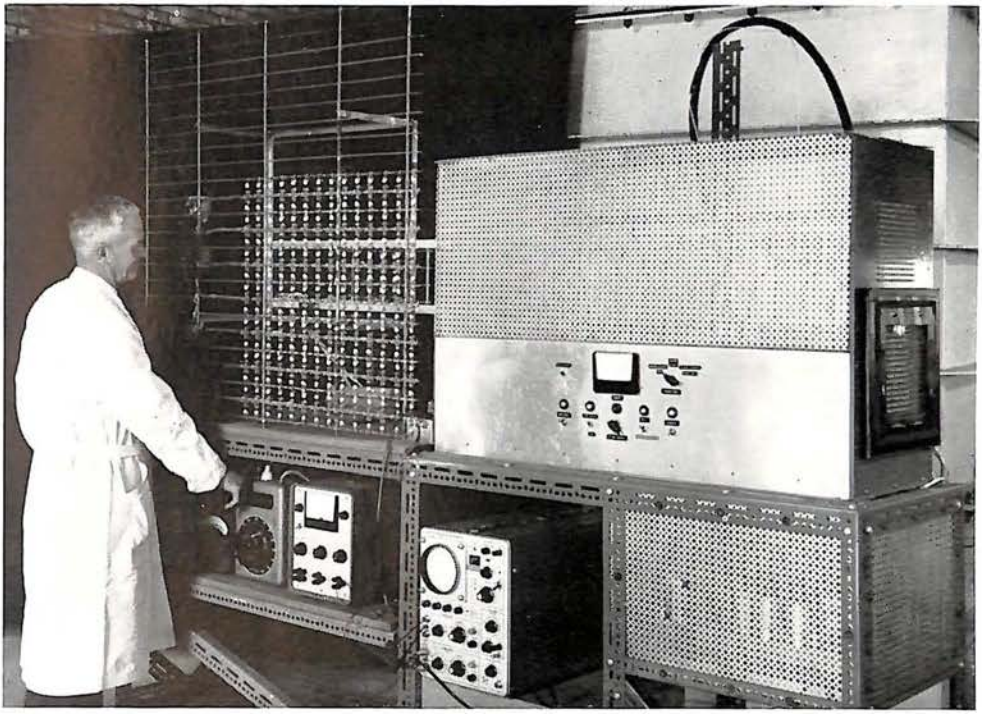
Developments during the year include the following.

Assistance for Industrial Research

A striking feature of modern chemical research is its increasing dependence on complex and expensive instruments. Access to these instruments is just as necessary for industrial research laboratories as it is for the universities and CSIRO, but the foreseeable volume of work often makes it difficult for an industrial firm to justify the initial capital outlay. Recognizing this as one aspect of the broader problem of how to utilize high-capital-cost equipment most efficiently, the Division of Organic Chemistry has, with the financial support of several manufacturers, taken the step of operating its nuclear magnetic resonance spectrometer on a two-shift basis, the second shift to meet the requirements of the firms concerned. If the experiment is successful, it may be desirable to extend this activity to three-shift operation and also to other techniques, such as mass spectrometry, which involve a high capital outlay. An important aspect of this project is the educational one: the research workers in industry can more fully appreciate the value of these new techniques when they are able to make direct use of them.—*Division of Organic Chemistry*.

Bubble Phenomena in Large-scale Gas Fluidized Bed Units

A fluidized bed of solids is formed when a gas is passed upwards through a mass of solid particles and the velocity of the gas is sufficient to cause the particles to become so mobile that the whole mass resembles a boiling liquid. Fluidized beds are of considerable industrial importance in processes such as catalysis and temperature-sensitive reactions that involve intimate contact between a gas and a solid under carefully controlled conditions of temperature.



The 14 × 14 bubble detection probe and associated visual display equipment being tested prior to insertion in a fluidized bed of silica sand.

The efficiency of gas-solid contact in a fluidized bed depends on the number and size of gas voids, or bubbles, present in the system. Although the behaviour of gas bubbles in small units has been studied and described in considerable detail, there is little available information on large-scale systems.

To study the bubble population in large-scale fluidized beds, an electronic bubble detection device, consisting of a 14 × 14 grid of light sources and matching grid of photosensitive detectors, has been immersed at various levels in fluidized beds whose depths have been varied from 2 feet to 8 feet. The presence of voids in the bed is shown on a bank of slave neon glow tubes and recorded with a cine-camera. This unit permits the determination of size and frequency of bubbles occurring in fluidized beds of up to 16 square feet cross-sectional area.

The results obtained have shown how the rate of bubble coalescence is affected by distance from the gas distributor and how the bubble population characteristics are affected by changing the fluidizing gas flow rate. This is giving a better understanding of the factors affecting performance and design of industrial fluidized bed units.—*Division of Chemical Engineering.*

Phytochemical Survey of Papua and New Guinea

A survey of the Australian flora that has been conducted for many years with the object of finding pharmacologically active materials of potential value to the pharmaceutical industry was extended in 1961 to the New Guinea flora. In collaboration with Smith, Kline and French Laboratories of Philadelphia, a three-year programme of plant collection and alkaloid screening was, with the assistance of the Administration, set up in Papua and New Guinea. This three-year field programme has now been completed and laboratory work is proceeding on the more promising plants selected from the total of about four thousand that were tested. Of the plants examined in the field, approximately 10% gave a positive test for alkaloids and warranted further investigation.

Selection of species for chemical examination has been based either on the results of pharmacological testing of total extracts or, in some instances, on the botanical relationship of the plant to species of proved pharmacological interest. In these latter cases, the individual alkaloids are isolated and perhaps identified prior to pharmacological assessment.

Because of its wide scope, the New Guinea survey has already led to the discovery of alkaloids in genera or families in which they were not previously known to occur, with, in consequence, a higher probability of finding alkaloids of novel type that have special chemical and chemotaxonomic interest and unusual pharmacological properties.—*Division of Organic Chemistry.*

Pulp and Paper from Western Australian Timbers

The potentialities of the Western Australian forests as a source of pulpwood for the possible development of a pulping industry are being assessed. The paper-making properties of three of the most plentiful hardwood species in Western Australia, viz. *Eucalyptus diversicolor*, *E. marginata*, and *E. calophylla*, have been investigated. Thinnings (6–12 in. diameter), old over-mature trees, and sawmill waste (excluding sawdust) have been used for this work. Plantation-grown trees of *Pinus pinaster* have also been included in the survey.

All the species examined could be pulped readily by the sulphate process, but the consumption of chemicals was higher for *E. marginata* and *E. calophylla* than for eucalypt pulpwoods from south-eastern Australia. All except *E. marginata* gave satisfactory neutral sulphite semi-chemical pulps. The properties of both the sulphate and neutral pulps from the three eucalypt species were not as satisfactory as those of commercial eucalypt pulps; this applied particularly to pulps made from over-mature wood and sawmill waste. Pulps from *P. pinaster* gave paper of good quality with high tearing strength. Papers with satisfactory strength properties could be made from a blend of eucalypt and pine pulps.—*Division of Forest Products.*

Heterogeneity of Paper

During the paper-making process the wood fibres tend to clump together, or flocculate, and the final sheet is thereby rendered more heterogeneous. Properties such as strength and printability are impaired as heterogeneity increases. In work aimed at understanding the factors controlling flocculation, and ultimately improving sheet uniformity, an instrument for measuring heterogeneity has been developed in collaboration with the Australian Atomic Energy Commission. The instrument consists essentially of a promethium-147 beta-ray source with a small aperture across which the paper strip is moved at a constant rate, and a radiation detector and its auxiliary equipment.

The proportion of radiation absorbed depends on the amount of material in the path, and a recorded trace of the transmitted radiation provides a mass profile for the test strip.—*Division of Forest Products.*

Solar Pond

In the absence of suitably located deposits of rock salt, sodium chloride and chemicals derived from it are more expensive to make in Australia than their counterparts overseas. It is of particular importance to be able to produce low-cost sodium chloride along the east coast of Australia, where there is the greatest concentration of chemical and allied industries. Economic production of salt by evaporation in conventional salt pans is difficult in these areas because of the climatic conditions, but a device such as the solar pond, which has been developed in Israel, may be a possible alternative.

The solar pond consists of a leak-proof tank about three feet deep. It is filled with layers of brine of varying concentration, the strongest and densest solutions on the bottom and fresh water on the top. When the pond is exposed to solar radiation, energy is absorbed in the form of heat and is trapped in the lower layers of brine, whose density distribution prevents the normal processes of convective circulation.

The experimental solar pond at Aspendale.

This heat can be usefully employed for evaporation of brine or the production of desalinated water by circulating the lowest layers of brine through suitable heat exchange equipment.

A solar pond was built in the grounds of the Division of Meteorological Physics at Aspendale, Vic., during the summer of 1965. The pond is lined with a patent plastic sheet to prevent losses of solution by leakage and is at present undergoing test.—*Division of Chemical Engineering.*

Engineering and Physics

The Organization entered into research in the fields of physics and engineering in 1938, with the establishment of the National Standards Laboratory in Sydney. During World War II several other groups were established to meet the war-time needs of rapidly developing Australian industries. The Division of Radiophysics in Sydney developed as an outcome of the work on radar undertaken during the war by a group of Australian scientists. The Division of Tribophysics, in Melbourne, began as a Section of Lubricants and Bearings, working on the problems of an industry often isolated from its usual sources of supply.

Work on physics and engineering now extends, in addition, into several other specialized branches. In Melbourne it is included in the programmes of the Divisions of Mechanical Engineering, Chemical Physics, Meteorological Physics, Building Research, and Forest Products, and the Soil Mechanics Section; in Sydney it features in the programmes of the Divisions of Food Preservation and Textile Physics, and the Upper Atmosphere Section.

Modern production engineering is critically dependent upon high standards of accuracy in measurement. The *Divisions of Physics* and *Applied Physics*, which together comprise the *National Standards Laboratory*, between them maintain the Australian Standards for the measurement of temperature, light, length, mass, time interval, electric current, and quantities derived from these. To meet the continuing trend towards greater accuracy in industrial measurements the Divisions undertake research on methods and equipment for more precise measurement. Associated with this work is research in various fields of physics that are related to precise measurement or make use of the techniques and equipment available in the Laboratory. To meet its obligations under the Weights and Measures (National Standards) Act 1960–1964, the Laboratory must also undertake a wide range of calibrations and tests.

The physics of solids, particularly of metals and other engineering materials, is the basis of work in the *Divisions of Physics*, *Tribophysics*, and *Chemical Physics*, and is centred on various aspects of the relation between structure and the properties of materials. A smaller unit, the *Physical Metallurgy Section*, is working in conjunction with the School of Metallurgy of the University of Melbourne on the changes which take place within metals in use or during deformation by the processes of fabrication.

The behaviour of the atmosphere surrounding us greatly affects our welfare.

The *Division of Meteorological Physics* is particularly concerned with differences between the pattern of general circulation in the Southern Hemisphere and that in the Northern. This has led to a special interest in the lowest hundred feet of the atmosphere, the region of greatest importance to life on the planet. By way of contrast, the *Upper Atmosphere Section* at Camden, collaborating with the Department of Supply and the National Aeronautics Space Administration, U.S.A., is studying the ionosphere (by which all long-distance radio communication is achieved), the emission of electromagnetic radiations from the higher atmosphere, and the electric currents that are responsible for fluctuations in the magnetic field of the Earth.

Australia occupies a special place in observations of outer space in that we can see a part of the sky that cannot be observed from the Northern Hemisphere, including a large part of the Sun's galaxy, on which greatest interest is naturally centred. The *Division of Radiophysics* has played a pioneering role in the development of radio astronomy and is recognized as one of the world's leading research centres both in this field and in rain and cloud physics research (see Water). It operates the *Australian National Radio Astronomy Observatory* at Parkes, and with this and other facilities is studying radio sources within the Sun's galaxy as well as distant galaxies and radio emission from the Sun itself. The chromosphere of the Sun and its effects on the Earth are also the subject of studies in the *Division of Physics*. A substantial part of this work is supported by grants from the National Aeronautics and Space Administration, U.S.A.

The widespread importation of fully developed technologies led to rapid establishment of many manufacturing industries in Australia. Such copied technology does not provide a basis for substantial export of manufactured goods, for which a country must have something distinctive to offer, such as a new product or a known product made by a new, improved, or cheaper method. It is on this basis that the Organization undertakes work in several Divisions on novel processes and instruments. The *Division of Chemical Physics* of the *Chemical Research Laboratories* in Melbourne is making a series of basic studies of molecular structure and is applying the results to the development of new instruments, some of which have found wide application in chemical, metallurgical, and other industries and are now manufactured in Australia (see also Chemical Manufacturing). The *Division of Mechanical Engineering* in Melbourne is working to develop improved methods of air-conditioning and refrigeration, and is also examining possibilities of making greater direct use of energy from the Sun for these and other purposes. The Divisions engaged on research related to a particular industry undertake research in the areas of engineering and physics appropriate to their special interests. For example, the *Division of Dairy Research* is investigating the mechanization of cheese-making and other dairy manufacturing processes (see Food Processing). The *Division of Forest Products* devotes considerable attention to the physics of timbers and the development of novel structures (see Timber and Building). Other Divisions are concerned with new processes in chemical manufacturing, minerals and mineral processing, and wool textiles.

Most of the Divisions concerned with research in engineering and physics devote a substantial portion of their resources to direct service to industry.

In addition to measurements of load using a specially devised thin load cell the Divisions of Radiophysics and Applied Physics have developed an instrument for measuring the shape of the reflecting dish of the 210-ft radio telescope at Parkes. Small survey targets are placed at measured radial distances from the centre of the dish, and their positions are recorded by a telescopic camera installed at the centre.

Design for Production

The "design for production" stage is the stage in the development of an engineering product where, with the functional model proved, the design is to be made ready for production. Skilful analysis needs to be made of the shape and geometric relations of the components of the product to check their suitability for production by the facilities available. It is at this point, too, that the required quality of workmanship is assessed, and modifications can be made to the original design details to secure the best compromise between satisfactory performance and cost of production. Australia's ability to compete at home or abroad in selling engineering products will depend on the ability of our designers to make good quality compatible with low cost.

The Division of Applied Physics has been endeavouring to establish techniques that will allow a logical and systematic approach to the search for the best solutions to such design problems. A design manual has been prepared for publication. It sets out the general principles of these techniques in relation to common design topics of everyday occurrence in engineering design offices. It is intended not only for the teaching of undergraduate engineers but also for use by designers and draughtsmen in industry.—*Division of Applied Physics.*

Thin Load Cell

A new kind of load cell in the form of a thin plate has potentially wide application for the experimental investigation of engines, machinery, and structures. The need for a thin load cell arose in the course of a dynamic study of the 210-foot radio telescope of the Division of Radiophysics, where it was necessary to measure dynamic load changes up to about 200 tons under various conditions of loading. As the gap available between the faces where the load was to be applied was only one-tenth of an inch, it would have been impossible to accommodate any of the existing types of load cell.

The thin load cell devised is in the form of two metal plates with shallow recesses containing electrodes, which form an electrical capacitor when the plates are closed together. The loaded area is 2 inches by 2 inches centred over the capacitor, and the total thickness is less than one-tenth of an inch. The repeatability of the load cell in calibrations on a testing machine is better than $\pm 5\%$ over the range 20–200 tons.—*Division of Applied Physics.*

Night-time Visibility of Painted Road-lines

Lines painted on road pavements are often insufficiently conspicuous under headlamp illumination, and special techniques are required to increase their brightness. The most common method is to "reflectorize" the lines by partial immersion of small spherical glass beads in the paint. This procedure is very successful in dry weather but is almost completely ineffective during rain because a surface film of water upsets the optical behaviour of the beads.

A laboratory examination of this problem has shown that an alternative treatment, though less effective than the beads in dry weather, is little affected by rain. It involves giving the narrow strip of road to be painted a rough-textured surface, such as that produced by surface-dressing the strip with half-inch stone chippings. Many of the facets are then almost perpendicular to the headlamp beam and are illuminated much more strongly than horizontal surfaces.

Best results for dry or wet conditions are obtained by a combination of the two methods, in which the surface to be painted is given a rough texture and glass beads are applied to the inclined facets. This procedure retains the advantages of both individual methods, and the effect of rain on bead performance is greatly reduced because of the draining action.—*Division of Physics.*

Automatically Controlled Interferometers

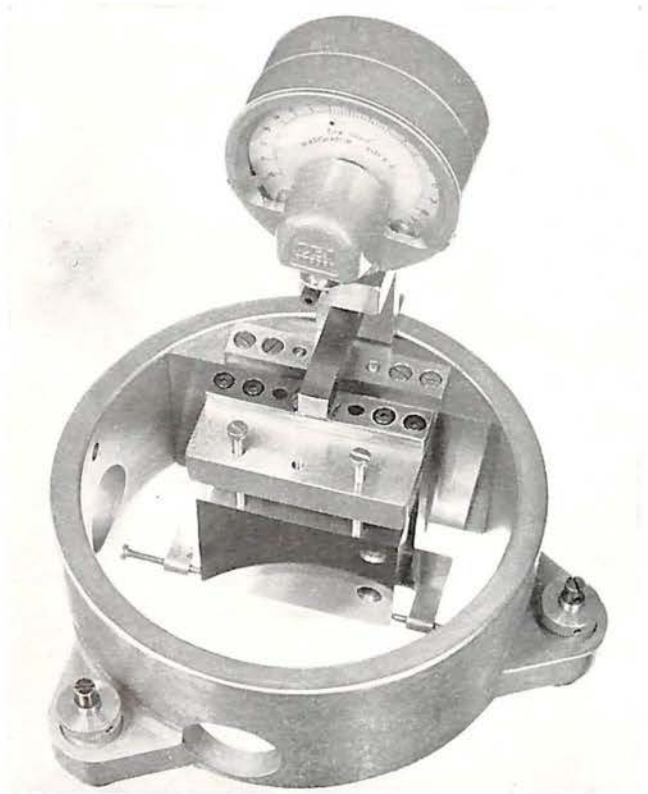
Fabry–Pérot interferometers are used widely in optics, astronomy, metrology, chemical analysis, and elsewhere as instruments of the highest spectroscopic resolution. They are based on the properties of a pair of highly reflecting parallel plates which, in combination, transmit very narrow bands of wavelengths whose band widths and separations depend on the spacing of the plates. The problem of maintaining these plates precisely parallel and at a given spacing, as is essential for a versatile interferometer, has been solved by the development of suitable servo-controls. Patent applications have been lodged in Australia, the United States of America, and Great Britain.

An optical instrument manufacturer in Adelaide has been licensed to manufacture instruments using these innovations, and the first two have already been exported to Germany. Servo-controlled interferometers are also being incorporated in a filter of completely adjustable wavelength capable of giving variable pass bands down to 0·01 Å or less, for use in studying solar magnetic fields. This development is being carried out under contract with the National Aeronautics and Space Administration, U.S.A.—*Division of Physics.*

Radio Heliograph

Good progress has been made in the erection at Culgoora, N.S.W., of a radio heliograph, an instrument developed by the Division of Radiophysics to provide virtually continuous "pictures" of the Sun based on the radio waves it emits at a frequency of 80 megacycles per second.

The huge aerial system of the radio heliograph consists of 96 separate parabolic aerials spaced equally around the perimeter of a circle nearly 2 miles in diameter. Each aerial is 43 feet across, mounted independently and individually driven so that it can track the Sun across the sky. An extensive network of transmission lines connects the aerials to the radio observatory at the centre of the circle. A special computer programmes the interconnections between the aerials in such a way that the Sun is scanned in successive strips, in much the same way as a television image is produced. Design, development, and production of the many complex pieces of electronic equipment involved in the radio heliograph are being carried out at the Radiophysics Laboratory. The installation of all major equipment at the site will be completed late in 1965 and it is expected that, after an initial period of testing and tuning up, the instrument will come into regular operation during 1966.—*Division of Radiophysics.*



Universal Lapping Fixture

A problem that frequently arises in metrological work is to obtain an accurately flat surface in a specified relationship with cylindrical or flat surfaces to within very fine limits of the order of a microinch.

To meet these requirements a fixture has been developed incorporating some novel features including non-wearing locating surfaces, automatic feed of the work while maintaining the setting to the required precision, and continuous measurement of the amount removed during lapping.—*Division of Applied Physics.*

Lasers

Lasers are brilliant sources of radiation of extremely narrow spectral line width, with potentialities in communication, length measurement, micro-welding, and other fields. Following their development in the United States of America some four years ago, they have been the subject of research and development in a large number of commercial and research laboratories.

The Division of Physics has been concerned in establishing optimum conditions for the construction of helium–neon gas lasers of lengths down to 5 centimetres, with the aim of achieving sufficient wavelength stability for them to be used in precision metrology. This work has, *inter alia*, resulted in a design for a portable laser 22 centimetres in length which is now being manufactured commercially. Designed primarily for lecture demonstrations, it has found research applications as well. It sells for approximately half the price of its nearest imported rival.—*Division of Physics.*

Explosive Fastening

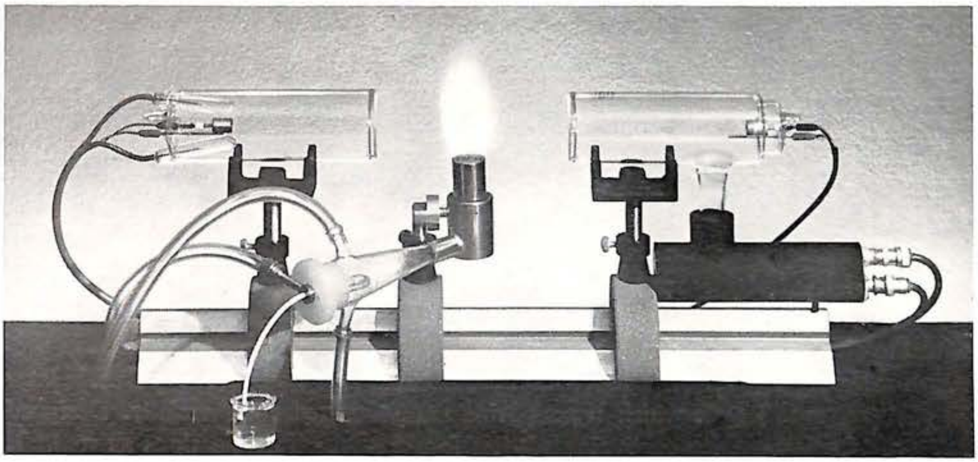
The mechanism of adhesion of hardened steel bolts fired into mild steel plate by the explosive fastening method has been investigated. The results show clearly that the friction between bolt and plate during penetration causes the surfaces to seize together. If the surface finish of the bolt is smoother, more intimate contact with the plate is achieved, and the force that the bolt will stand without pulling out is increased.

In the limit with a highly polished bolt the adhesion is such that the bolt will break in tension before it will pull out. On the other hand, the application of a suitable lubricant increases the penetration of the bolt into the plate but reduces the adhesion and the withdrawal force.—*Physical Metallurgy Section.*

Hot Flames for Atomic Absorption Spectroscopy

In chemical methods of analysis based on atomic absorption spectroscopy, the metallic constituents of the analytical solution must be converted to free atoms in the flame. Air–coal gas or air–acetylene flames satisfactorily atomize many metals, but with calcium, strontium, barium, molybdenum, and tin, atomization is far from complete. With beryllium, aluminium, vanadium, tantalum, tungsten, and silicon, which are of great importance to the mining and metallurgical industries, virtually no free atoms are produced and thus it has not hitherto been possible to determine these elements by atomic absorption methods. High-temperature flames such as those produced by burning acetylene in air enriched with oxygen give better results but require specially prepared gas mixtures and are potentially hazardous.

It has now been shown that use of the nitrous oxide–acetylene flame avoids these difficulties and makes it possible to determine the metals mentioned in a wide range of materials. The special burners required for nitrous oxide–acetylene flames are now incorporated in the atomic absorption spectrophotometers manufactured in Australia.—*Division of Chemical Physics.*



An atomic absorption spectrophotometer incorporating a resonance monochromator. The solution for analysis is sprayed into the flame. The lamp on the left emits the spectrum of the element to be determined and its intensity is attenuated by passage through the flame. The degree of attenuation is measured by the resonance monochromator on the right, and from this measurement the concentration of the element can be determined.

A resonance monochromator for a given element produces an atomic vapour of that element by cathodic sputtering. This vapour can only absorb radiation characteristic of that element, and this absorbed energy is subsequently re-emitted and detected by the photo-electric cell beneath the resonance monochromator.

Resonance Monochromators

In 1959 the Division of Chemical Physics suggested that for many purposes, and particularly for atomic absorption spectroscopy, it should be possible to isolate radiation of particular wavelengths with monochromators in which the required wavelengths are first selectively absorbed by atomic vapours and then re-emitted.

The Division has now produced several such "resonance monochromators" which have a much higher optical performance than any conventional monochromator. The new instruments will be produced under licence in Australia and the United States of America. Whilst their first applications will undoubtedly be in atomic absorption spectroscopy, it is believed that they will permit many important fundamental investigations of spectroscopic phenomena.

An essential component for the use of the new monochromator is a high-intensity atomic spectral lamp of the type described in last year's Annual Report and now produced in Australia and the United States of America under licence.—*Division of Chemical Physics.*

Fisheries and Oceanography

Although fisheries products represent a relatively small part of Australian food production, they have been making an increasing contribution in recent years, especially to overseas earnings, and exports have risen from £4 million in 1959/60 to over £8 million in 1963/64. CSIRO research in this field is centred on the *Division of Fisheries and Oceanography* at Cronulla and is broadly based on investigations into the nature of the environment (oceanography) and the extent and nature of the resources (fisheries). The current budget for the Division is a little over £300,000, all of which is provided from government sources.

The main emphasis of the Division's fisheries work is on stock assessment, which is a necessary prelude to catching and prediction studies. The extent of CSIRO research on fisheries is largely governed by the degree of industrial and State government participation that can be obtained. Fishermen are the basic source of catch and effort data, while the States are responsible for collecting these statistics and for much of the market measuring data. Both types of information are essential for resource assessment. As in other fields, the computer has revolutionized the analysis of fisheries data.

Oceanographical research is conducted in conjunction with the Royal Australian Navy, using the facilities of the frigates "Diamantina" and "Gascoyne". Work has centred on the biology and ecology and the productivity of marine animals and plants along the 110°E. meridian in the Indian Ocean, and on bottom sediments, plankton, and other organisms on the continental shelf and slope around Australia. The East Australian Current, which has important effects on navigation, fisheries, meteorology, and waste disposal, is also the subject of long-term studies. The findings of these cruises have application in such diverse areas as fisheries assessment, submarine defence, and the accessibility of minerals.

Items of current interest include the following.

Below decks in H.M.A.S. Gascoyne. *A CSIRO analyst is measuring the oxygen content of sea water.*

New Anti-corrosion Anti-fouling System

The growth of marine organisms on ships' hulls has been a vexing problem for both naval and merchant vessel operations over many years. Six months' growth of such organisms on a vessel in temperate waters is often sufficient to increase fuel consumption up to 40%.

In cooperation with the Royal Australian Navy, the Division of Fisheries and Oceanography has been investigating this problem. Conventional treatment of the hull with cuprous oxide anti-fouling paint, while effective in reducing fouling, was found to increase corrosion. There was a galvanic reaction between the paint and the iron of the hull. A solventless epoxy resin has now been developed as an anti-corrosive layer. Over this is painted a thick coat of a soluble matrix type of cuprous oxide. After a 16-month trial of this preparation on the hull of an Australian ship, divers have reported no sign of corrosion or fouling.—*Division of Fisheries and Oceanography.*

Prawn Survey of Gulf of Carpentaria

The overseas market for prawns has expanded considerably in recent years, particularly in Japan and the United States of America. A growing local market has added incentive to production. Since July 1963, the Division of Fisheries and Oceanography has been conducting a survey of the prawn potential of the Gulf of Carpentaria, with the cooperation of the Queensland Department of Harbours and Marine and under the sponsorship of the Queensland and Commonwealth Governments.

The survey, to be concluded in July 1965, has shown the presence of over 22 species of prawns, of which at least seven are present in commercial quantities. In addition to the survey operations, considerable information has been gained about the general biology of the prawn, with particular emphasis on its feeding and reproductive behaviour.—*Division of Fisheries and Oceanography.*

Western Crayfish

A stock assessment programme, conducted jointly with the Western Australian Department of Fisheries and Fauna during the last three years, has shown a significant degree of over-fishing in the western crayfish industry, currently worth about £5 million annually. Further work to determine the extent of over-fishing will continue, with particular attention to the "recruit" stage of the life cycle. Recent findings point toward the value of further recruitment, transplantation, and hatchery studies, but the work would require the provision of more equipment and laboratory facilities.—*Division of Fisheries and Oceanography.*

Food Processing

With an annual production of perishable foodstuffs valued at more than £500 million, it is important for Australia that food storage and processing methods should be efficient. CSIRO work in this field is directed towards the development of improved methods for storing and handling fresh foods, preservation techniques such as canning, freezing, and drying, novel methods for producing manufactured food products, quality control, and the development of new food forms, particularly those making use of products at present largely wasted. Research on the handling and storage of meat was begun nearly 40 years ago, followed a few years later by investigations on the storage of fresh fruit. The scope of the research programme was greatly increased during World War II, especially in relation to processes such as canning, freezing, and drying. Research on dairy products began over 30 years ago and it also has expanded considerably in recent years.

Food processing investigations in CSIRO are mainly centred in the *Division of Food Preservation*, Sydney, concerned with the handling, storage, and transport of fresh fruit and vegetables, meat, fish, and eggs, and with preservative processes, and the *Division of Dairy Research*, Melbourne, which is investigating methods for improving the quality and variety of dairy products and developing novel methods of manufacture. The *Horticultural Research Section*, Merbein, is investigating various aspects of processing vine fruits.

Of the current total annual expenditure of about £800,000 on food research, approximately £175,000 is provided by industry and other sources outside CSIRO, including some £80,000 from the Dairy Produce Research Trust Account derived from a levy on dairy products, with a matching Commonwealth contribution.

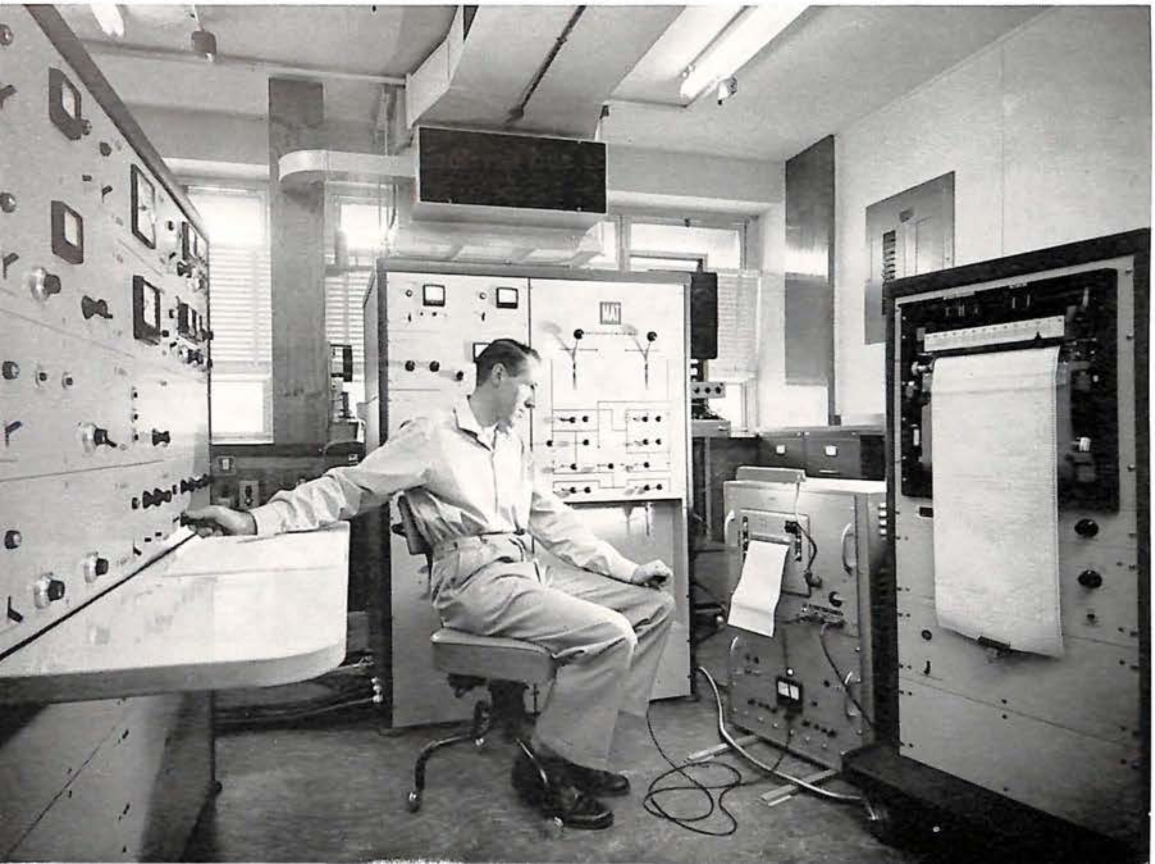
Much of CSIRO's research on food processing is concerned with commercial processes, and the Divisions maintain close contact with industry, with which they collaborate in some investigations. The Division of Dairy Research has, in addition, collaborated with machinery manufacturers in the development of equipment for mechanized production, especially of cheese. Potential users are informed of the results of research work through publications, conferences, and demonstrations.

Research directed at the solution of manufacturing problems is backed by more basic investigations on the foodstuffs themselves and on the phenomena associated with handling and processing. In the *Division of Food Preservation*, the factors influencing quality, storage life, and suitability for processing of a range of foods are being studied. This includes work on the nature and behaviour of micro-organisms that can cause spoilage during processing and storage. The changes occurring in foods during and after processing are being studied with a view to achieving retention of higher quality. A programme concerned with the handling of meat especially for export is being expanded with support from the Cattle and Beef Research Trust Account. The *Division of Dairy Research* has already developed equipment for the mechanization of cheese manufacture that is widely used for some stages of manufacture. Considerable progress is being made towards complete mechanization. Other work of the Division has the object of increasing the use of Australian dairy products in Asia. The programme includes investigations on the physical chemistry of the constituents of milk and dairy products, and chemical studies on the substances influencing flavour. Some items of current interest are reported below.

New equipment and new techniques are more than ever before the keynote of effective scientific research. Although often expensive to install, such equipment can save years of effort in the collection of data required for research, and it may provide the only means of investigation of a problem.

The Division of Food Preservation has recently installed a mass spectrometer in its laboratories at North Ryde, N.S.W. Coupled with a gas chromatograph it is being used to study changes in quality of foods during ripening, storage, and processing. It allows the quick examination of samples that is essential to any investigation of flavour changes.

The photograph shows, from left to right, the electronics console, analyser unit, direct writing oscillograph recorder, and mass recording console.



Water Damage to Canned Foods

Water damage to containers is a problem that may be encountered at any time during the world-wide distribution of canned foods. Cartons become discoloured or mouldy or may collapse, can labels become wrinkled, discoloured, and mouldy, and the cans themselves may rust. Water damage of this kind is usually due to moisture from the atmosphere condensing on the cold cans. The incidence of water damage in Australian canned fruits shipped to Britain reached alarming proportions in 1962 and 1963, amounting to as many as 9000 damaged cartons in a single shipment, and the Australian Canned Fruits Board made a substantial grant to the Division of Food Preservation towards the cost of an investigation.

Since water damage chiefly affected Melbourne shipments, three experimental shipments of canned fruits were despatched from Melbourne during the winter of 1964, and ten other ships were inspected at loading and discharge. Instruments were installed in each experimental shipment to record the temperature of the cargo, the humidity in cargo spaces and within the cartons, and the dampness of the cartons and labels throughout the voyage. This one season's work has already pointed the way to means for alleviating the problem. Further experimental shipments have been planned for the winter of 1965.—*Division of Food Preservation.*

Quality of Fresh and Preserved Berry Fruits

Berry fruits such as currants, strawberries, and raspberries are important raw materials for jams, preserves, and canned fruit products. The total annual production in Tasmania and elsewhere in Australia is well over a million bushels.

Work in the Tasmanian Regional Laboratory directed at determining the origin of microorganisms that ferment raspberries after picking has revealed the cause of inferior quality in the processed berries. The large increase in numbers of fermenting organisms in the fruit after picking was traced to contamination of the freshly picked fruit by residues left in containers from previous pickings. Raspberries held in containers that were properly cleaned and dried before use had an appreciably longer pre-processing storage life, which could be further extended by prompt cooling after picking. Work on the preservation of strawberries by freezing has also shown the need for strict hygiene in handling.

The effects of the many factors involved in processing and storage on the quality of canned berries have been closely studied. Detailed recommendations can now be made for the processing of berry fruits to give products of optimal quality. Further work is being done on the influence of the raw material and storage temperature on the stability of the natural colour of the product.—*Division of Food Preservation.*

Separating Microstructures of Biological Cells

Living cells have a highly complex internal organization and the electron microscope reveals membranous structures and numerous kinds of particulate bodies within them. Very little is known of the composition of these microstructures and their function is not fully understood. Information about them could contribute greatly to work on a wide range of problems, but has been unavailable because of lack of techniques for their separation from cells in quantities adequate for detailed examination.

A relatively new technique known as density gradient electrophoresis has recently been adapted to the problem, and the method promises to be a powerful new tool for isolating and characterizing cell components. The separation is effected by applying an electrical force through a liquid medium that serves as a carrier for the material. The particles migrate through the medium at a rate determined by their characteristic surface charges, and thus separate into distinct zones.

The technique has been used on liver cells and is now being applied to microstructures in muscle to follow the changes that take place *post mortem* in studies of the factors affecting meat quality.—*Division of Food Preservation.*

"Seaminess" in Cheese

In the final stages of the manufacture of Cheddar cheese, small rectangular strips of curd are held under pressure for 15–20 hours to form a homogeneous mass of cheese. Sometimes the junctions of the curd strips remain distinctly visible as an outline of lighter colour. This "seaminess" is not regarded as a defect of any significance in cheese in Great Britain or Australia, but in some markets of the United States, particularly with artificially coloured cheese, it is of commercial importance. The Bell–Siro cheese-making machines, two of which are in use in the United States, tend to produce cheese with this defect more frequently than it occurs in hand-made cheese and this has operated against the wider use of the machines.

An investigation of the nature and causes of "seaminess", which had hitherto been attributed to a fat layer between the protein surfaces, has led to the finding that it is due to the presence of crystals of calcium orthophosphate dihydrate at the curd junction. During the salting of the curd before pressing, whey containing calcium and phosphate ions forms a layer on the curd surface and the calcium phosphate crystallizes out within a day or so. This understanding of the nature of "seaminess" has provided the essential first step towards its control and the Bell–Siro cheese-making machines in the United States are now being suitably modified.—*Division of Dairy Research.*

Recombined Dairy Products in Asia

Two commercial plants are now operating in Asia producing sweetened condensed milk from Australian butter fat and dried skim milk. Established by the Australian Dairy Produce Board in conjunction with local firms in Singapore and Bangkok, both plants use a process developed in the Division of Dairy Research. The equipment was also designed in the Division and manufactured in Australia.

The recombination process makes it possible to manufacture high-quality products in Asia from materials that can be shipped economically from Australia. This creates an opportunity for Australian producers to win a far larger share of this important market than was possible previously. At the same time, the establishment of the processing plants is an important step in the development of manufacturing activities and employment opportunities in these countries. The operation of the two plants will require about 4000 tons of butter fat and 8000 tons of dried skim milk annually, the total annual value of these materials being about £2½ million.—*Division of Dairy Research.*

Processing Aids for Dried Fruit

The glossy appearance and free-running character of dried grapes are important quality factors, and they are usually imparted by adding a small amount of paraffin during the final stage of processing. Recently some countries have banned the use of paraffin oil as a food additive and other consuming countries may soon do likewise. A suitable alternative processing oil is therefore required and it has been found that several oils of animal or plant origin can be used. Their ability to overcome stickiness and to promote glossiness has been confirmed under a wide range of storage conditions. They have no adverse effect on the flavour or quality of the fruit, but are slightly more costly than paraffin.—*Horticultural Research Section.*

Land Development

Unlike most countries with a European population and Western culture, Australia still has a developing agricultural frontier. Many square miles of land remain either uncultivated or as yet undeveloped for stocking at high intensities, particularly in the northern areas of the continent.

The task of sponsoring land development rests primarily with the State governments. There are, however, some notable exceptions where private companies have used the results of research to open up large tracts of sparsely settled land. The role of CSIRO in these efforts has been largely one of taking stock of natural resources so that development can be planned in a logical sequence and undertaking research to provide solutions to the intrinsic problems that would otherwise remain barriers to effective development. Development projects require many types of information and it should be stressed that CSIRO is only one contributor among many in this field of work.

At the end of World War II, enthusiasm for land development projects rose sharply, partly to rehabilitate ex-servicemen and partly to hasten the settlement of northern Australia. Extensive surveys of the natural resources of northern Australia and the Territory of Papua–New Guinea were commenced, and the growth of this work led to the establishment of the *Division of Land Research and Regional Survey* with its land survey groups and field stations in the north. This was followed by the formation of the *Division of Tropical Pastures* for work in the north-eastern sector of Australia.

It would be difficult to state in precise terms the amount of money spent on research work directed towards land development, which is, of course, the general aim of most of the biological research programmes of the Organization. Irrespective of the narrowness of definition one takes, it is considerable. For example, the budget in the past year for soil surveys in the Division of Soils was approximately £100,000, while the Division of Land Research and Regional Survey received £500,000 from the Commonwealth Treasury, of which £132,000 was provided through the Department of Territories.

At an early stage the *Division of Land Research and Regional Survey* developed an efficient and rapid method for surveying large areas of land using aerial photographs and limited field sampling. These surveys are used to subdivide the land surface into "land systems", each of which has its own scope or problems for development. Currently the Division is conducting surveys in Papua–New Guinea and in the Fitzroy area of Queensland, while the more intensive phases of land development are being studied at field stations at Kununurra on the Ord River and Katherine and Humpty Doo in the Northern Territory.

The region of eastern Australia lying north of 30° latitude and east of the 20-inch rainfall isohyet contains over 200 million acres of generally poor soils dominated by pastures of low-yielding native grasses. The pastoral industry is based on extensive grazing systems, with low densities of slow-maturing stock and a consequent low level of productivity. Early studies by the *Division of Tropical Pastures* showed the native grasses had little scope for improvement and the Division has concentrated on developing new legume–grass associations based on more productive species obtained by selection, breeding, and introduction from overseas. The work involves defining the broad ecological regions for pasture research, and selecting a few key experimental sites within these to test the reactions of new species and strains to important variations in climate and soil. As a result it is now becoming possible to determine the plants that should be used in sown pastures in each region and to specify the general principles of pasture management (see Plant Production).

CSIRO is not equipped to implement developmental work and the results of its research are made available to other organizations which are concerned more directly with such projects. CSIRO provides through its Agricultural Liaison Unit a link to transmit research information to Commonwealth authorities and State departments. It is also represented on joint committees such as the Agricultural Development Advisory Committee of the Northern Territory Administration.

Survey of Fitzroy Area of Central Queensland

For the past three years the regional survey teams of the Division of Land Research and Regional Survey have been working, at the request of the Queensland Department of Primary Industries, in the Fitzroy area of central Queensland, where they have mapped and described the environments of 77,000 square miles. In the past the area has been used mainly for extensive grazing, but it contains large areas of brigalow country which is being developed rapidly for semi-intensive beef production and cropping.

The teams have divided the area into over 100 land systems. From the development viewpoint the results can be summarized briefly as follows:

(1) An estimated 3 million acres are suitable for arable farming.

(2) 12 million acres are suitable for the establishment of permanent improved pastures with minor cropping.

(3) 48 million acres are likely to continue to be used for extensive grazing with low-cost pasture improvement.

(4) 12 million acres of poor country are virtually useless for agriculture or grazing.

When published next year the maps and reports will assist in the subdivision of the land and in the location of roads. They will also enable future experimental plots to be located on land typical of extensive environments and will assist in the extrapolation of research results over the whole area.

The definition of the environments in the area is only a first step and a great deal of agricultural research by the Division of Tropical Pastures and the Queensland Department of Primary Industries is needed before the region can be developed to its full potential.—*Division of Land Research and Regional Survey.*

Discovery of Valuable Agricultural Land in Papua

The coastal plains between the Musa River and the Hydrographers Range in the Northern District, Papua, have been considered in the past as worthless swamp country. Investigations during the land resources survey of the Safia–Pongani area (2700 square miles), based on close cooperation between a plant ecologist, a pedologist, and a geomorphologist, have dispelled this belief and led to the discovery of a complex of nearly 200 square miles of potentially highly productive agricultural land. Air-photo interpretation of the forests suggested marked differences in drainage

A survey team from the Division of Land Research and Regional Survey discussing field observations on Bougainville Island, Territory of Papua–New Guinea.

conditions, with a strong predominance of well-drained land. This interpretation was confirmed by field observations of the vegetation and the soils, fertile alluvial silts and clays. These observations were made over a short period on a small number of preselected sites in poorly accessible country. Confidence in their reliability for the assessment of the whole area is based on two considerations: the extrapolation of the data by vegetation mapping and the geomorphic evidence for recent slight upfaulting of the plains, which resulted in cessation of flooding and deposition and in lowering of the water-table.—*Division of Land Research and Regional Survey.*

Use of Helicopter in Land Resources Survey

In 1964 on Bougainville Island, New Guinea, a small helicopter was used for the first time on a reconnaissance land resources survey. The unavailability of carriers and inadequacy of the road system virtually precluded a survey based on ground traverses. Helicopter traverses based on air-photo interpretation had to be planned in great detail, because of the need for the most economical use of flying time and because of the scarcity of landing sites. The practical possibilities of using a helicopter in largely forested terrain exceeded expectations. It enabled the field party to increase considerably the number of field observations per unit of time, and resulted in an unusually good distribution of sampling sites, even though landing in some mountain areas proved too hazardous or impossible. The use of the helicopter reduced the total survey time from 12 weeks to 7. The ability of the helicopter to fly slowly or hover at low altitude was very helpful in correlating ground observation data on vegetation and land forms with air-photo patterns.—*Division of Land Research and Regional Survey.*

Minerals and Mineral Processing

Industries based on mining have played a major part in the development of Australia and our future will depend upon expanded use of our mineral resources. However, for a variety of reasons Australian government agencies are not carrying out research for the mining industries on a scale in keeping with their importance to the economy. The attention currently directed to the need to increase Australia's export income has again emphasized our over-dependence on wool exports as a major earner of foreign currency. The mining industry represents a promising means for both short and long-term expansion of industrial production and of exports. This expansion would be hastened if the level of research for the mining and mineral processing industries was increased, and it could yield results of great economic importance to the country as a whole. A committee set up by the Advisory Council of CSIRO is at present examining research needs in this area, in consultation with the other government agencies concerned.

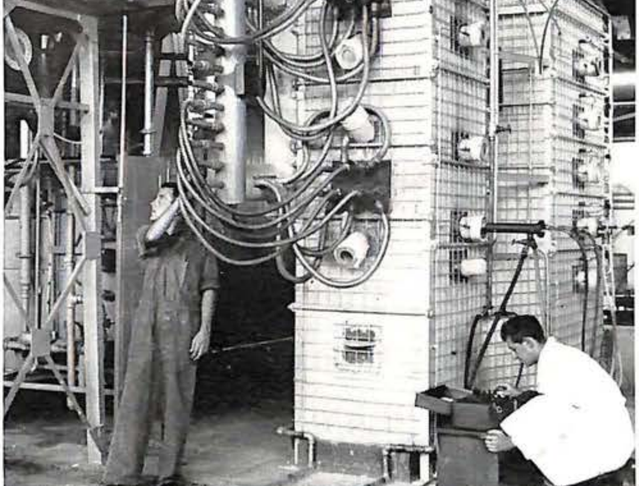
Among the agencies operated or supported by the Commonwealth government to carry out research and provide scientific and technical information for the mining industry are the Bureau of Mineral Resources, CSIRO, and the Australian Mineral Development Laboratories. A considerable amount of research and development is being carried on, by both CSIRO and industry, for the mineral processing industries.

Current expenditure by CSIRO is about £800,000 per annum and that by industry over £1 million. It is now planned that some promising lines of CSIRO research on mineral treatment in the *Division of Mineral Chemistry* should be substantially expanded in the forthcoming year. In addition, the *Divisions of Applied Mineralogy* and *Coal Research* and the *Mineragraphic Investigations* and *Ore Dressing Investigations* are fully engaged in research on utilization and processing of minerals. The *Division of Chemical Engineering* also devotes a substantial proportion of its research effort to development of mineral processing.

The *Division of Mineral Chemistry* is carrying out research on the chemical basis for the better utilization and processing of Australian minerals. Particular attention is being paid to studies of minerals that are abundant in Australia and have considerable potential for increased exploitation.

The research programme of the *Division of Applied Mineralogy* is concerned mainly with the nature and industrial application of mineral products, especially the non-metallics. A major part of the Division's programme is devoted to research on production and utilization of cement. Studies of industrial refractories and engineering ceramics are also being made.

A major aim of the *Division of Coal Research* is to promote the effective use of coal through research into the processes of combustion, gasification, and carbonization. This work ranges from basic studies of the kinetics of the processes involved in combustion and gasification to studies of problems that have arisen in operating boilers in large power stations. Examination and recording of the characteristics of Australian coals from all known deposits are another important activity of the Division.



The carbonization of coal to form gas, coke, and tar products has scarcely deviated from the well-tried method of high-temperature distillation for more than a century. Recently several new techniques have been developed to the experimental stage, and the Division of Coal Research has been investigating one of these, fluidized-bed carbonization, for several years to evaluate the possibilities of the method in relation to Australian coals. The photograph shows the plant rigged for investigating the production of finely divided coke for metallurgical purposes.

In the *Division of Chemical Engineering* projects of particular interest to the mineral industry include studies of mineral grinding, fluidized bed techniques, and high-pressure reactions in carbon and coal gasification. The *Mineragraphic Investigations* laboratory has become a general reference point in CSIRO for examination of minerals and for advice on problems concerning their nature and origin. The *Ore Dressing Investigations* laboratory, which is under the joint control of CSIRO and the University of Melbourne, has continued to serve industry on problems arising from the processing of Australian minerals. In addition, it is collaborating with interested firms in long-term studies on the chemistry of flotation pulps and assessment of the grindability of Australian ores.

All CSIRO groups taking part in mineral research are in close contact with industry. Several projects are currently being developed by collaboration between CSIRO and Australian firms and the stage has now been reached where a significant proportion of the Organization's mineral research is carried on with funds provided by industry. For example, the Division of Mineral Chemistry received over £25,000 for additional research in the 1964/65 year, making an increase of 25% in the research expenditure of the Division. Even more significant has been the contribution by industry to the developmental stage of collaborative projects with the Division of Mineral Chemistry. Industry contributed sums of the order of £100,000 during 1964/65 for larger-scale study of processes that originated from research in the Division. Subjects studied in collaboration with sponsoring bodies included production of thorium, chlorination of tin, recovery of alumina from low-grade deposits, and cyanidation of gold. Work still in progress covers such investigations as the reduction of ilmenite, construction of a prototype fuel cell, and applications of neutron activation analysis to mineral surveys.

Items of special interest include the following.

Phosphate Resources

On present indications the supply of phosphate rock from island deposits will not be maintained at the current rate and quality for many more years. Alternative supplies might be obtained from phosphatic deposits within Australia, but as yet none of the known deposits appears likely to provide an answer to this problem.

In some parts of the world extensive banks of fine granular calcium phosphate occur off-shore, where upwellings of ocean waters containing greater than normal amounts of dissolved phosphate encounter continental shelf conditions which promote deposition. To check whether such sources could be readily located around the Australian coastline, the most favourable regions were selected by examining oceanographic data and prospected by shore and bottom sampling, with assistance from the Royal Australian Navy.

Results from two traverses around the north-west coastline from Darwin to Port Hedland have not been encouraging, although theory had indicated that favourable areas should exist in this region. Mineralogical and chemical data showed only traces of granular phosphate in most samples. It is possible that other types of phosphate, such as nodule beds, exist around the continental shelf, but no simple lead is available to direct the search for such materials.—*Mineragraphic Investigations* and *Division of Fisheries and Oceanography*.

CSIRO Alumina Process in Argentina

While the first object of CSIRO research is to assist Australian industry, the possibility of obtaining additional rewards from overseas patent applications is followed up wherever possible. A South American company recently negotiated an agreement with CSIRO for the right to produce alumina by a process that originated in the Division of Mineral Chemistry. The process had been developed and patented under the sponsorship of an Australian mining company. For Australian ores the process at its present stage was found not to offer a clear economic advantage over the conventional process; however, it does provide a means of treating low-grade ores, such as occur in Argentina, that cannot be treated by the conventional method. A small pilot-plant unit has functioned successfully in Santa Fé and large-scale development is being planned. The project, which has the financial support of the Argentine government, could help to make South American countries self-sufficient with regard to alumina; it could also result in substantial royalty payments to both the sponsoring company and the Commonwealth.—*Division of Mineral Chemistry.*

Soil Microorganisms aid Oil Exploration

Microbiological oil exploration depends on measuring the numbers or activities of certain types of soil bacteria that can grow on traces of hydrocarbon gases that have seeped up in minute quantities from deep oil and gas pools. From the distribution of these bacteria and after consideration of local geological and geophysical evidence, predictions can be made of the location of an oil reservoir. Bacteria growing on petroliferous gas must be distinguished from other bacteria also capable of utilizing hydrocarbons, but whose presence in the soil is due to organic matter. To avoid errors due to this cause, soils are sampled at different levels at each site, since soils overlying oilfields, in contrast to soils in non-petroliferous areas, contain a distinctive zone of high microbial activity towards hydrocarbons, and this zone is below and separate from the organic matter zone.

Interpretation of results can be complicated if the bacterial population in soil is limited by other variable factors of the soil environment, even when petroliferous gas is present. To account for variations due to this cause, bacterial activities (i.e. the rate of utilization of hydrocarbons) are measured over a number of sampling sites. Assay methods using radio-isotopes and gas chromatography have been developed to measure these activities in a variety of soils, and the effects of soil factors that influence the growth of the bacteria have been determined.

Seven surveys have been conducted in recommended areas in Australia. Although high rates of hydrocarbon utilization have been found in some samples, no large area of high activity has so far been discovered.—*Division of Soils.*

Coal Utilization

The efficiency of operation of coal-burning equipment, particularly with certain types of coal, is impaired by the fireside fouling of metal heat-transfer surfaces by deposits arising from the mineral and inorganic constituents of the coals burned. This is an important area of research, and with the encouragement and support of electricity generating authorities the Division of Coal Research is investigating this problem of deposit formation in order to devise means of preventing or minimizing fouling and thus increasing the efficiency of power generation.

Laboratory investigations have indicated that the manner in which air and pulverized coal are introduced through the burners into the furnace of a power station boiler have a marked influence on the conditions prevailing in the furnace and hence on the transfer of heat to the furnace wall tubes. Subsequent tests on a power station boiler confirmed that the burner settings did have a significant effect on the distribution of radiant heat at the furnace walls and on the pattern of deposition of inorganic solids over the walls.

Other investigations have established that the sodium content of the coal is probably the most important contributory factor where fireside fouling problems are currently being experienced in Australian power station boilers. The harmful effect of sodium is alleviated to some extent by an increase in the amount of ash relative to sodium in the coal. Experiments with coal blends have established a critical sodium-to-ash ratio below which the rate of fireside fouling is considerably minimized. This has provided the first practical guide to the preparation of the coal blends used.—*Division of Coal Research.*

Hydrogenation of Coals

Treatment of coals with hydrogen under pressure and at high temperatures produces gas of high calorific value, due to an increased yield of hydrocarbons, chiefly methane. A study of the chemical processes involved has shown that there are two concurrent reactions. One is fast, and involves the volatile matter in the coal; the second is a slow reaction that gasifies the residual carbon. The first of these has been studied in detail, and it has been found that the formation of hydrocarbons is directly associated with the oxygen content of the original coal, and that coals containing little oxygen give poor yields of hydrocarbon. Since the amount of volatile matter and the reactivity of the char produced during hydrogenation are vital to economic production of hydrocarbons—and hence of cheap high-calorific gases—further experiments are being done with black coal and Victorian brown coal to clarify these effects.—*Division of Chemical Engineering.*

Pest Control

The potential immediate financial gains to individual landholders and to the national income from the practical solution of important pest control problems are probably greater than from any other current major research activity. For instance, one insect alone—the sheep blowfly—currently costs graziers about £10 million per year, and the rabbit once cost us tens of millions of pounds annually. Every rural industry is plagued by pests of one kind or another. Some, such as kangaroos and foxes, are large animals, while at the other end of the scale microscopic nematode worms take a very great but often insidious toll of livestock, crops, and pastures.

A wide variety of pests is being studied in CSIRO, in the *Division of Animal Health* (internal and external parasites of livestock), the *Division of Wildlife Research* (rabbits and a range of native fauna known to cause economic loss), the *Division of Forest Products* (pests of timbers), the *Horticultural Research Section* (plant nematodes with particular reference to irrigated crops), and the *Division of Entomology* (sheep blowfly, cattle tick, phasmatids, sirex wasps, and many others). It is probable that at least £1,100,000 is now being spent annually on research into pest problems, including some £200,000 of moneys from the Wool Research Trust Fund and over £150,000 from other contributors.

Problems are chosen for investigation in the light of such factors as the economic threat presented by the pest, the effectiveness and cost of any current methods of control, the probability that more basic knowledge could provide leads to practical control measures, and the availability of the specialist staff to undertake work in the various fields of research. The emphasis is generally on how the pests function and how they live and reproduce. Such knowledge is necessary to expose vulnerable points around which practical control strategies can be developed.

The threat to certain food exports, including beef, lamb, and dairy products, arising from possible contamination of the livestock environment with insecticides, and the increasing international disquiet about the effects of such poisons on desirable wildlife and on man himself, have prompted the Organization to increase the resources allotted to entomological research, with the ultimate object of devising alternative, safer control measures for important insect pests. The concept of pest control by management has been inherent in the research programme of the *Division of Entomology* since its inception in 1928. In handling any major pest problem, the procedure has been to acquire a detailed understanding of the ecology of the species concerned. That knowledge, interpreted in the light of the principles governing population changes that have been derived from basic studies carried out within the Division and elsewhere, has in almost every case suggested ways in which the pest could be attacked at some points where its biology or behaviour rendered it vulnerable. The CSIRO contributions to the control of the sheep blowfly, the Australian plague locust, and the cattle tick are all of this general nature. The entomologist now has at his disposal a number of important new weapons, some biological, some physical, and some chemical, which could revolutionize the control of many pests. The current research programme is being directed increasingly towards exploiting these new developments.

The *Division of Animal Health* work on sheep parasites is conducted mainly at the McMaster Laboratory in Sydney (see Sheep and Wool Production), while work on cattle parasites is centred on Brisbane (see Cattle).

Several species of mammals and birds are studied by the *Division of Wildlife Research*. A large part of the programme is directed towards control of the rabbit, where it is clear that any new major advances will emerge from improvement in tactics and strategy, for which we require a detailed knowledge of the animal's entire life and of its reaction to different environments. The Division also studies a number of other animals and birds whose role in relation to the country's economy is not clear and needs to be defined (see also Wildlife).

The translation of the results of this research into practical control measures generally calls for cooperation between the Organization and State instrumentalities.

An understanding of the principles underlying recommended pest control practices is sometimes essential for their effective application and the educational aspects of liaison are therefore particularly important in this field.

Current work of interest includes the following items.

Predicting Locust Outbreaks

A recent analysis of the history of plague locust outbreaks in Australia showed that widespread swarming activity in the Channel Country of south-western Queensland and in New South Wales west of the Darling River was associated with major locust outbreaks in central and south-western New South Wales, Victoria, and South Australia.

Regular surveys of far western New South Wales and south-western Queensland showed that the development of locust swarms in the Channel Country depended on general breeding of resident non-swarming locusts under the favourable conditions that follow flooding. However, in order to predict outbreaks of the locust it was essential to find out how these non-swarming locusts managed to survive during the long intervals between floods. Accordingly the London Anti-Locust Research Centre and the Division of Entomology undertook a cooperative project during the summer of 1965. The results will add substantially to our understanding of the factors that lead to the development of locust outbreaks.

It was found that locusts can persist for relatively long periods after the vegetation available to them has dried out. For example, locusts that were adult in November 1964 were still present in very dry areas along Coopers Creek and the Wilson River in March 1965. However, not only were these locusts unable to breed, but the populations consisted of greater numbers of males than of females.

Isolated thunderstorms are characteristic of the summer rainfall of this region and in places the run-off from storms results in the growth of green vegetation which forms locally favourable conditions for locust breeding. It is due to the occurrence of these areas that the locust is able to persist. Increases in locust populations in these isolated favourable areas appear to be checked by the many predators that feed on locusts. When generally favourable conditions return, the growth of populations to swarm levels and thence to outbreak proportions is relatively slow.—*Division of Entomology*.

Bacterial Disease of Apple Moth

The microbial pathogen *Bacillus thuringiensis* shows promise of being a valuable element in the development of integrated programmes for the control of insect pests in orchards. Highly concentrated suspensions of spores of the bacterium are sprayed on infested plants, causing a deadly septicaemia in larvae that eat the contaminated foliage. *B. thuringiensis* is harmless for vertebrates, even after concentrated applications, and is therefore a safe and selective means of reducing populations of insect pests.

The control of light-brown apple moth by conventional spraying procedures is becoming increasingly difficult in parts of south-eastern Australia. The insecticides currently used in orchard spray programmes seriously reduce the numbers of valuable natural enemies of the pest. Preliminary tests conducted by the Division of Entomology some years ago suggested that *B. thuringiensis* might be helpful. With special permission from the quarantine authorities, field tests were made in 1963/64 and again in 1964/65. These tests indicated that two applications of an improved commercial formulation of *B. thuringiensis* at normal concentrations can depress potentially injurious populations of light-brown apple moth to a level at which natural enemies can contain them effectively.—*Division of Entomology.*

Control of Fruit Fly in Country Towns

Chemical lures are receiving increasing attention as a means of limiting the toxic hazards of insecticides. Control methods based on attracting the insect to the poison have achieved greater acceptance during the past decade or so, partly because of the discovery of more efficient lures and partly because of recent demonstrations that the principle is most effective when implemented on a large scale and aimed at entire breeding populations of the pest species.

Relatively isolated breeding populations of the Queensland fruit fly exist in most of the larger towns in central and northern New South Wales. Several attractants for this species are known. The most powerful is a derivative of phenylbutanone, which attracts males only. The best general lure, attracting both females and males, is a solution of hydrolysed protein. The potentialities of both of these attractants for the control of fruit fly have been investigated by the Division of Entomology in a series of experiments begun in 1961.

The first phase of the work involved 12 towns in western New South Wales, extending from Condobolin in the south to Bingara in the north. In three of the towns lures of the male attractant (plus an insecticide) were used; in three the protein hydrolysate (plus an insecticide) was used; in three others lures of both types were used; and the remaining three were left untreated. The use of an insecticide with these attractants proved so successful that the Division instituted similar experiments under the more difficult conditions of the northern coastal districts of New South Wales, where the infestations are less isolated and the fruit fly populations more vigorous. In both experiments:

excellent control of fruit fly was achieved when the insecticide was used in a mixture of the two lures;

adequate control of fruit fly followed the use of an insecticide plus protein hydrolysate alone;

although male attractant plus the insecticide reduced fly infestation to some extent, this particular treatment did not provide adequate control.

A most important feature of the experiments was that control was achieved without the indiscriminate distribution of toxic materials. The use of lures with considerable specificity protected beneficial insects in the treated areas, while the carefully controlled methods of application avoided such problems as residues on crops and danger to birds or domestic animals. The experiments showed clearly that economic methods are now available for the control of Queensland fruit fly in towns in country areas of New South Wales.—*Division of Entomology.*

Percussion kills Grain Weevil

Overseas buyers are demanding that wheat be completely free from insect pests. The current practice of the industry is to apply chemical protectants and insecticides on a very large scale. The possible development of insect resistance to the few chemicals that can be added to grain, together with the problem of chemical residues in the grain, are two of the more obvious disadvantages of this approach.

In the search for other methods that might be used, experiments in the Division of Entomology have shown that the immature stages of the grain weevil *Sitophilus granarius* are extremely sensitive to mechanical disturbance of the grain in which they live. Dropping the grain a distance of only 18 inches onto a hard surface each day during the weevil's developmental stages causes 60% mortality. Other combinations of drop height and frequency produce mortalities as high as 100%.

When very high forces are used, one drop is sufficient to kill the insects and in these instances the cause of death is physical damage to the organism. However, this is not true for the much lower forces involved in drops of only a few inches or feet. For example, if the same total disturbance is given to the insects on the one occasion, i.e. a series of drops on the one occasion, instead of spreading the "percussion effect" over the entire developmental period, a very much lower mortality is produced.

In view of this, the spacing of the treatments would seem to be important to get the maximum "percussion effect" and research is currently being undertaken to find out why this is so. If the actual cause of death can be determined, a physical treatment of grain for the control of grain insects may become practicable.—*Division of Entomology*.

Worm Parasites of Rabbits

The role of worm parasites in regulating rabbit populations is being investigated and early results suggest that certain of the worm parasites already present in this country may exert a population-regulating influence in some areas. A number of parasites are native to the rabbit in Europe, but these have not found their way into Australia.

Of the three species of worm parasites of rabbits in Australia, only *Passalurus ambiguus* is common in all areas studied. The other two species do not spread into the hotter and drier areas. Only in the wetter areas of southern Australia do these parasites reach large numbers, and so it is only in these areas that rabbit populations are likely to be affected. It is not thought likely that the ubiquitous *Passalurus* is harmful to rabbits, despite its occurrence at times in very large numbers.

The numbers of worm parasites appear to be regulated by the reproductive physiology of the host. All parasite species reach a peak in does during the breeding season, whereas in bucks, and in does during the non-breeding season, parasite burdens remain very much lower. The consequence of this may be that the principal harmful effect of the parasites on a rabbit population is exerted on the does during the breeding season and is expressed as a lowered birth rate. This aspect is being studied.—*Division of Wildlife Research*.

Aeration saves Stored Wheat

Aeration could play an increasingly important role in the preservation of grain in Australia. Experiments have been made in a 100,000-bushel wheat storage at Melton, Vic., on a process that can eliminate surface mould and limit insect numbers to a very low level without any treatment with pesticides. The grain bulk is cooled by forcing large quantities of cold air through it, thus inhibiting insect reproduction, mould activity, and other causes of deterioration.

To design the aeration system it was necessary first to determine the air-flow rate required to achieve optimum results under the particular climatic conditions. Methods of controlling fan operation, selection of suitable fans, and the design of the perforated ducts through which the air flows into the grain were also studied.

The designs evolved from this research were used as a basis for large systems recently installed at Beulah and Murtoa, Vic. The operation control panels for the installations incorporate a method of simultaneously displaying the temperature profiles in all storage bins, which greatly assists in their efficient operation.—*Division of Mechanical Engineering.*

Plant Production

Research in CSIR on crops and pastures was initially concentrated mainly in the Division of Plant Industry, with smaller independent laboratories dealing with irrigation problems of the Murrumbidgee Irrigation Areas at Griffith and with the sultana and other horticultural crops at Merbein. In 1950, increasing interest in the problems of the undeveloped northern half of the continent led to the establishment of the Section (later Division) of Land Research and Regional Survey. Similarly, in 1959 pasture research in the subtropics and tropics was split off from the Division of Plant Industry when the Division of Tropical Pastures was formed.

Currently, work on plant production is undertaken by the *Division of Plant Industry* with main centres in Canberra, Perth, Deniliquin, and Mareeba, the *Horticultural Research Section* (Adelaide and Merbein), the *Irrigation Research Laboratory* (Griffith), the *Division of Land Research and Regional Survey* (Canberra, Katherine, Kununurra, and Darwin), and the *Division of Tropical Pastures* (Brisbane and Townsville). Each of these groups controls one or more experiment stations and uses many other experimental sites, either in collaboration with State agricultural authorities or on private properties. A considerable proportion of the work is supported by primary industry research funds. Thus the whole of the cost of the Tobacco Research Institute at Mareeba is a charge on the Tobacco Industry Trust Account, and pasture investigations at various centres are financed from the Wool Research Trust Fund. Because of its interactions with other programmes it is difficult to estimate the overall expenditure on research on pastures and crops in CSIRO, but some idea of its magnitude may be gained from the fact that the budget for 1964/65 for the Division of Plant Industry alone amounted to £1,489,000, of which £993,000 was provided from government sources, £352,000 from the Wool Research Trust Fund, and £144,000 by other contributors.

The broad aim of CSIRO's work in this area is to increase the productivity of Australia's crops and pastures. In the production of crops and pastures there is a complex interaction between soil nutrients, plants, pests and diseases, water, and solar energy, to form the net product. Further, this product must be processed or preserved for direct use as food or, in the case of pastures, must be converted by grazing livestock to meat or wool.

A study of any of these complex systems and processes calls for the services of scientists in many fields working in close collaboration. Thus, in the Divisions of Plant Industry and Tropical Pastures there are not only scientists concerned with the various phases of pasture growth, from agronomy and ecology to genetics and biochemistry, but also representatives of the animal sciences who help to relate pasture plants and pasture systems to the productivity and health of the grazing animal. Moreover, there is a great deal of consultation and collaboration between CSIRO Divisions. For example, the toxicity to stock of the important grass *Phalaris tuberosa* is being studied jointly by the Divisions of Animal Health, Animal Genetics, Biochemistry and General Nutrition, Plant Industry, and Organic Chemistry.

The *Division of Plant Industry*, at its headquarters laboratories in Canberra, is concerned primarily with basic studies and the development of new principles. This work is supported and supplemented in the regional laboratories and by associated experiments in the field aimed at the adaptation of new and existing scientific knowledge to practical problems. The translation of theory into practice is greatly facilitated by "CERES", the controlled-environment research laboratory in Canberra, in which plants can be grown in a diversity of climates. Not only is this important unit proving valuable in providing precise control of climatic factors in basic studies, but it is already giving useful leads to the practical application of research findings and is promoting more efficient use of the field stations. For example, it has been used to obtain a better understanding of blue mould lesion development in tobacco, of growth and flowering in several tropical grasses and legumes, and of the nature of the oestrogen content in subterranean clover, leading to more precise plant breeding objectives.

Pasture research in the temperate southern half of Australia is increasingly concerned with improving the efficiency of use and maintaining the productivity of the 30–40 million acres of improved pastures established over the past 50 years. In contrast, the development of leguminous pastures for large areas of the subtropics and tropics is still in the pioneering phase, with the initial emphasis on finding more productive species, particularly legumes with which to improve the native grassland. After many years of effort and in the face of scepticism both in Australia and abroad, the *Division of Tropical Pastures* has developed suitable pasture legumes by introduction and by breeding. Concurrent work on soil fertility has enabled the Division to establish highly productive experimental pastures in central and southern Queensland. A new regional laboratory in Townsville has the objective of extending the results of pasture research in the subtropics into the harsher environment further north. The *Division of Land Research and Regional Survey* has investigations in progress at Katherine in the Northern Territory and at the Kimberley Research Station in Western

Australia which complement this work. These centres together cover a broad pattern of crop and pasture research aimed at providing the technical background for increased rural production in northern Australia.

Research on field crops is confined mainly to specific disease and quality problems in tobacco at Canberra and Mareeba, to cotton production on the Ord River and in the Murrumbidgee Irrigation Areas, to rice in the Northern Territory and on the Ord River, to irrigated horticultural crops, particularly sultanas and citrus, and to limited projects on such crops as soybean and safflower. However, much of the general research on plant problems has potential application to crop problems and the results of research programmes on the fertility of soils will ultimately lead to increased yields of crops as well as pastures.

Work of particular current interest is reported below.

Higher-quality Townsville Lucerne

Although the immense potential value of Townsville lucerne (*Stylosanthes humilis*) has been recognized—it has been called the "subterranean clover of the north"—it does not yet occupy large areas or have a major effect on the production of beef. The first scientific work on the species was a long-term study of its productivity commenced at Rodd's Bay, Qld., in 1945. The study has shown that the output of beef per acre can be increased up to tenfold by sowing Townsville lucerne and applying appropriate fertilizers. These results and those of the Division of Land Research and Regional Survey at Katherine, N.T., led to further research on the species. This has already produced valuable information on its responsiveness to nutrients, and demonstrated that a range of different types exists within Australia.

Early interest in Townsville lucerne centred on its value as a pasture legume for soils of low fertility, but recent field, glasshouse, and controlled-environment experiments have shown that it can also respond well to favourable conditions. Protein levels in the growing plant were raised from 15 to 21% by applying molybdenized superphosphate. This transformation from a low- to a high-quality legume indicates that the low protein levels commonly found in Townsville lucerne under field conditions could be substantially raised by applying appropriate fertilizers. Further information is being accumulated on changes in chemical composition in response to various nutrients, as part of a physiological study of the basis of the adaptability of Townsville lucerne to favourable conditions and to environmental stress.

A study of plants grown from seed collected throughout the area of distribution of the species in northern Australia has shown important variations in flowering time and in physical characters such as plant diameter, growth habit, stem colour, and degree of hard-seededness. This indication that there are several distinct types within the species is being further checked by investigating the distribution of maturity types in relation to climate and by studying the performance of different types at a range of localities. The range of maturity types parallels the range of varieties of subterranean clover in southern Australia, and may be of similar importance in developing new varieties for pastures in the north.—*Division of Tropical Pastures.*

Superphosphate helps Spread Skeleton-weed

Recent work has indicated that applications of superphosphate encourage the spread of skeleton-weed by seed. It has been shown experimentally that relatively high levels of exchangeable calcium and available phosphorus are essential for normal growth and root development of skeleton-weed seedlings. Deficiency symptoms may appear even in the cotyledon stage and retarded root growth renders seedlings vulnerable to desiccation. Superphosphate provides both these elements and thus assists establishment of the weed.

Experiments have also shown that cultivation, a complete cover of subterranean clover, or spraying with selective herbicides will destroy the young rosettes during the winter months. Thus, pasture leys and fallow cultivation, together with spraying of the young wheat crop, should prevent new infestation.

For continued production of wheat where skeleton-weed is established, reliance must be placed on improved chemical control and/or the introduction of pasture leys into the cereal rotation.—*Division of Plant Industry.*

Improved Pastures stand up to Drought

A fear of the consequences of drought has been an important factor inhibiting graziers from establishing improved pastures and from fully utilizing their increased carrying capacity. It is widely but erroneously believed that abnormally dry conditions will reduce the yield and quality of improved pastures to those of native pastures, so that pasture improvement and the accompanying stock increases would tend to accentuate the risk of serious losses through drought.

The performance of cattle on experimental pastures at Rodd's Bay, Qld., in the last two seasons is therefore of particular significance. The rainfall during the 1963/64 growing season was the lowest since records began in 1931, and 1964/65 has been the second consecutive summer with less than half the long-term average rainfall. Throughout this period, fertilized Townsville lucerne–spear grass and Rhodes grass–Siratro pastures have carried cattle at a beast to 2 acres, compared with the normal stocking rate of a beast to 9 acres on unimproved native pasture. Annual liveweight gains on the improved pastures, which are 460–490 lb per head in normal seasons, were reduced to about 160 lb per head in these exceptionally dry conditions (the same level as on unimproved pasture). However, the important fact is that the increased stock numbers have been successfully carried through this adverse period, and the improved pastures still produced four and a half times the liveweight gain per acre.

Important legume species showing drought resistance in pastures at a number of experiment centres in the dry 1963/64 and 1964/65 summers were Townsville lucerne, Siratro, and *Leucaena leucocephala*. At various centres grasses within the genera *Panicum*, *Cenchrus*, *Chloris*, and *Paspalum* all showed good drought resistance. In these genera, varieties of buffel grass and green panic were outstanding in the driest localities.

Siratro was able to establish in brigalow country despite dry conditions in marked contrast to temperate lucerne, which showed little seedling resistance to drought. Siratro showed this advantage when sown by ground equipment into cultivated land and when sown from the air into ash following the burning of brigalow scrub.—*Division of Tropical Pastures.*

Siratro, bred at the Division of Tropical Pastures from two varieties of Phaseolus atropurpureus, *was released in 1960 and quickly showed promise over a wide area of northern Australia. It has now shown considerable resistance to drought in experimental pastures at Rodd's Bay, Qld.*

Cotton on the Ord River

Many potential crops have been investigated at the Kimberley Research Station on the Ord River since its establishment in 1947, but from 1960 onwards cotton has held pride of place. The adoption of cotton as the main commercial crop of the developing Ord River irrigation area has repaid concentration of research on it.

The major tasks have been to select varieties suitable to both mechanized agriculture and a tropical environment, to determine the optimum time of sowing in relation to productivity and economic harvesting, to define the rather exacting nitrogen fertilizer requirements of the crop, to examine the influence of the environment and of cultural practices on lint quality, and to evolve chemical methods of weed and insect control.

As a result of progress in these fields of research, the average yield of seed cotton at Kimberley Research Station has risen from 1500 lb per acre for the period 1955/56–1958/59 to 2200 lb per acre for the period 1959/60–1963/64. The first commercial crop on the Ord River, 218 acres, was grown in 1962/63; in 1963/64, 1613 acres were grown; and in the current season about 5500 acres have been sown. All the 1963/64 crop met or exceeded the grade and staple requirements of Australian cotton spinners.

Many tasks still face the research workers on the Ord, including the evolution of crop rotations based on cotton, more effective control of insect pests, and the development of a more economic irrigation regime. A breeding programme to develop varieties more closely adapted to the Kimberley environment and cultural system will begin in the coming season.—*Division of Land Research and Regional Survey.*

Cotton growing at the Ord River.

Hastening Field Curing of Hay

Basic studies of the physical nature of hay drying suggest that air movement is all-important in the early stages of curing, but that atmospheric temperature is the main factor maintaining a satisfactory rate of water loss in the later stages.

There is a progressive decrease of drying rate during field curing of mown pasture. This lengthens the exposure period and often results in serious loss of nutrients through damage by rain or sun. The paths and mechanisms of moisture movements during the whole drying process have been investigated as part of a programme aimed at hastening field curing.

For a few hours after mowing, moisture is lost quickly through the stomatal pores of the leaf and stem surfaces, but these pores soon close and further drying involves the passage of water vapour through the surface cuticle of the leaves and stems. Moisture loss is then much slower. Accordingly, the wind speed required to prevent build-up of water vapour at the surfaces of individual plant units decreases. Air movement must still be sufficient to ensure ventilation of the air spaces within the bulked material lying in the field as swaths or wind-rows and, even in early stages of curing, slow winds may need to be supplemented by turning or tossing of the material.

Movement of moisture to the surfaces of the individual units progressively decreases. After loss of some 50% of the total moisture, the rate of drying is controlled largely by this movement within the plant rather than by movement through or away from the surfaces. Maintenance of a satisfactory rate then depends on sufficient radiant energy being available at least to maintain, and preferably to increase, the tissue temperature.—*Fodder Conservation Section.*

Cultivation reduces Phosphorus Availability

Because of the importance of superphosphate in maintaining the productivity of most of our improved pastures, any process that causes a decline in the availability of the soil phosphorus is of considerable agricultural significance. It has been found that one such process is the cultivation of pasture soils for weed control, pasture renovation, or cropping.

As a result of top-dressing with superphosphate, a zone of residual fertilizer phosphorus accumulates at the soil surface under the pasture. This is because (in most soils) the water-soluble phosphate is rapidly immobilized.

Although the accumulation of a phosphorus-rich layer at the soil surface has certain disadvantages, it also has distinct advantages in terms of efficient build-up and utilization of available phosphorus. For instance, this surface concentration allows the saturation of those sorption sites in the soil that hold the phosphate in forms that are unavailable to plants, and so permits the accumulation of the remainder of the applied phosphate in forms that plants can absorb.

Experiments have shown that cultivation of the soil disperses this accumulated phosphorus throughout the ploughed depth and so exposes the available phosphorus to fresh sorption sites in the subsurface soil. This leads to a general lowering of the phosphorus availability.

Temporary waterlogging, such as may occur during periods of heavy rainfall, has been found to cause further lowering of the availability of this phosphate.

It is clear that shallow ploughing is one means of minimizing these adverse effects, since the reduction in phosphorus availability has been shown to be proportional to the depth of mixing. For pasture renovation, chisel ploughing could be an effective means of reducing this effect.—*Division of Plant Industry.*

New Kind of Plant Growth Regulator

A new chemical class of plant growth regulator has been developed. Derivatives of phenylurea, at concentrations less than 0·1 part per million, can cause a variety of developmental phenomena in plants. These include the induction of division in mature cells that normally would never divide, the delay of ageing of leaves, and the initiation of growth in dormant buds. Almost 500 different compounds related to phenylurea have been synthesized and about 300 of these show biological activity. The derivatives of phenylurea that are biologically active are readily and cheaply synthesized and have a potential as a new class of agricultural chemicals for the control of some phases of plant development. One use under investigation is the preservation of plant tissues that are marketed green, such as fresh green leaf vegetables and flowers.—*Division of Plant Industry.*

Lucerne sensitive to Soil Aluminium

Quite low concentrations of aluminium (0·027 part per million) are almost lethal to lucerne but only slightly toxic to subterranean clover, even though the clover takes up more aluminium. Adding aluminium salts to nutrient solutions reduces plant growth, root elongation, and uptake of calcium and phosphate, and produces leaf symptoms resembling those of phosphorus deficiency. It is common to refer to these effects as "aluminium toxicity", but they can also be produced by acidity and phosphate deficiency. Hence it has been questioned whether aluminium additions affect the plant directly, as a clear-cut toxicity, or merely indirectly, through making the medium acid and phosphorus-deficient.

The ranges of acidity and phosphate concentration that are high enough to permit normal growth of lucerne plants but low enough to allow an aluminium concentration of about 0·027 part per million to be maintained have now been defined experimentally. It has been shown, for instance, that the plants can grow normally at a pH as acid as 4·0–4·2 if calcium is high enough and that at this pH phosphate can be varied widely without inducing chemical combination of aluminium with the phosphate and without inducing phosphate deficiency. It is clear, therefore, that aluminium is directly toxic to lucerne and its primary effects are not due to interference with uptake of either calcium or phosphate.—*Division of Plant Industry.*

Fertilizers for Pine Forests

The failure of pine plantations, particularly *P. radiata* in several localities and on a variety of soils in southern Australia, has prompted a search for possible causes. Although moisture has proved to be important to the growth of such plantations, particularly during the summer, lack of water is apparently not the main cause of poor growth.

Research has shown that the growth of *P. radiata* is most often restricted by inadequate supplies of phosphorus in the soil. However, once this need is met by application of superphosphate, other nutrient deficiencies may become apparent. For instance, at one site in South Australia pines responded to dressings of nitrogen, nickel, and copper after a total of about 12 cwt of superphosphate had been applied.

Potassium deficiency has been found to occur in trees growing on a number of soils in eastern Victoria, and sufficient information accumulated to allow the diagnosis of this deficiency by analysis of the foliage. This method is now being used commercially in deciding when to apply potassium fertilizers. The levels of nitrogen, phosphorus, and potassium have been determined in needles of varying age from different parts of the trees throughout the seasonal growth cycle. This has shown how these levels change during periods of maximum growth, and so has helped to define the most suitable time for foliage sampling. Although sampling errors are large from tree to tree, the results obtained so far have also enabled limits for phosphorus and nitrogen to be defined, thus determining when fertilizers containing these nutrients should be used in the forest. This technique is now being applied in the field by the South Australian Department of Woods and Forests.—*Division of Soils.*

Sheep and Wool Production

The significance of sheep and wool production to Australia is reflected in the large, diverse, but coordinated programme of research conducted by CSIRO on problems of the industry. In addition, there is a large programme of work on wool as a textile fibre (see Wool Textiles) and much of the work covered in other sections of this Report is directly or indirectly of benefit to the sheep and wool industry (see for example Plant Production, Pest Control, Soils, and Water). CSIRO conducts research closely related to sheep and wool production in the *Divisions of Plant Industry* (pasture plants and pastures, nutrition, and grazing efficiency and management), *Animal Health* (diseases and parasites), *Animal Physiology* (reproduction and growth, and grazing efficiency), *Animal Genetics* (genetics and breeding), *Entomology* (insect pest control), *Wildlife Research* (pests and predators), *Biochemistry and General Nutrition* (nutrition), and *Soils* (soil fertility), and in the *Wool Research Laboratories* (handling and processing of wool), the *Chemical Research Laboratories* (poison plants, water, bush fires), and elsewhere.

A large proportion of the finance for this programme is derived from the Wool Research Trust Fund, administered by the Australian Wool Board, amounting to approximately £1,500,000 in 1964/65. Of this the sheep and wool industry contributes one-third, or £500,000, and the Commonwealth government £1,000,000. In addition the Commonwealth finances the programme directly to the extent of a further £1,400,000, and some £10,000 is derived from other sources.

Sheep diseases and parasites rank high in importance in the current research programme despite the large amount of work that has already been done. Investigations, mainly in the *Division of Animal Health*, now relate to internal parasites, foot-rot, mycotic dermatitis, posthitis, external parasites and disease vectors, and virus diseases. Metabolic disorders such as those caused by minor element deficiencies, chronic copper poisoning, pregnancy toxaemia, and the toxicity for sheep of carbon tetrachloride, sporidesmin, and *Phalaris tuberosa* pastures, are being studied in a number of laboratories.

In Australian flocks sheep rarely approach the maximum possible reproductive rate. The factors leading to low lamb-marking percentages being studied in the *Division of Animal Physiology* include poor ram fertility, failure of either the ram or the ewe in mating, a low proportion of multiple ovulations, failure of fertilization or implantation, abortions, and lamb deaths. This Division and several others are contributing to work on the oestrogenic substances found in some legumes, particularly certain strains of subterranean clover. The approaches to this problem include the selection of strains of clover low in oestrogenic activity and the isolation and synthesis of the active substances. In other laboratories the inheritance of multiple births and fertility, and the effect of the time of breeding on lambing percentages, are being studied.

The approach to increased wool and meat production has been partly through genetic research and partly through attention to many aspects of nutrition. The *Division of Animal Genetics* has been studying selection for wool production since 1947 and the programme has now been extended to cover selection for increases in lamb and meat production. It is also seeking to evaluate the contribution to production made by environment, fleece components, and characteristics of the individual sheep. Each of the main stages in the conversion of pasture into wool is being studied in the *Division of Animal Physiology*, with the overall aim of increasing the efficiency of food conversion. Because of the importance of sulphur-containing amino acids in wool, much of the work is aimed at providing an understanding of the role of sulphur in the animal and in the wool follicle. Studies of the effects of climate on wool growth also form part of the Division's long-term programme related to the physiology of wool production. Other Divisions are working on the effect of parasites.

Many problems of growth and nutrition of sheep are being studied in the *Division of Plant Industry* at Canberra, at Deniliquin, N.S.W., and at the Yallanbee Experiment Station, near Perth. These include comparisons of the nutritive value of grasses, factors affecting the uptake of roughage, the effect of management, especially of stocking rate, on the productivity of pastures and on animal production, and the effect on wool growth of such factors as pregnancy and lactation. The effects of stock movement and stocking rates, the productiveness of different strains and species of pasture plants in terms of year-long animal output, fodder conservation, fodder crops, and other aspects of management are being studied in a carefully integrated programme at the *Pasture Research Laboratory*, Armidale. Considerable attention is also being given to the feeding of sheep during drought in an attempt to devise ways in which this may be done economically without loss in wool production.

Many of the developments in animal production are, of course, based on developments in pasture production. Much of the work of the *Division of Plant Industry* on the introduction of new species of grasses and legumes, on plant breeding, soil fertility and plant nutrition, the control of weeds, and pasture establishment and management, is therefore directly related to improvements in sheep and wool production (see Plant Production). Work on the control of sheep blowfly and insect pests of pastures, by the *Division of Entomology*, and on predators of the sheep and on the rabbit by the *Division of Wildlife Research* (see Pest Control), also has the same objective. In addition, the research programmes of other Divisions, notably those concerned with work on soils and water, are providing background knowledge that will lead to other developments for the benefit of the sheep and wool industries.

A selection of items of research of current interest is given below.

Toxicity of *Phalaris tuberosa*

Several Divisions have been collaborating in studies on the toxicity of *Phalaris tuberosa*, the valuable perennial pasture grass that occasionally causes "staggers" and "sudden death" of sheep grazing it. Substantial progress has been achieved.

The Division of Organic Chemistry has found that *P. tuberosa* contains three alkaloids closely related to the indole compound, serotonin, which is a pharmacologically active, naturally occurring substance thought to be associated with the transmission of nerve impulses in some parts of the nervous system. When these alkaloids are administered to sheep and to small laboratory animals they produce diseases closely resembling "sudden death" and the acute form of "staggers". A disease with the residual abnormalities characteristic of chronic "staggers" has not yet been reproduced. The alkaloids exert their acute effects by pharmacological mechanisms in competition with serotonin. Damage to the intracellular membrane systems may disrupt the enzyme systems associated with the mobilization of glycogen, thus leading to its deposition in the liver, kidney, lung, and elsewhere.

Other lines of investigation have included studies of the climatic factors influencing the alkaloid composition of *P. tuberosa* and related species, using the controlled environment research laboratory (CERES) at Canberra. Correlations between high alkaloid concentrations and diurnal temperature, high nitrogen, and, particularly, shaded conditions have already been established. The work will be extended to bring in plant biochemists and plant geneticists. Further collaborative studies should lead to a complete understanding of this disease and could produce a new approach to its control.—*Divisions of Animal Health, Animal Genetics, Plant Industry, Organic Chemistry, and Biochemistry and General Nutrition.*

Effects of Poisons from Plants Dangerous to Livestock

Work on the liver-damaging effects of pyrrolozidine alkaloids derived from poison plants has been referred to in previous Annual Reports. One of the characteristic features of chronic poisoning is a great enlargement of liver cells and their nuclei, while the total number of liver cells may be reduced. These observations suggest that these alkaloids may have some effect on the processes of cell division. In a normal liver, cells are comparatively rarely found in the process of dividing, but under abnormal conditions, such as loss of tissue by death of cells or by surgical removal, the remaining cells can divide more speedily, so that the lost tissues are replaced within a short period. The effect of one of the alkaloids on this capacity of the liver to replace tissue removed surgically has been studied with special techniques. The results showed that one effect of the alkaloid was to prevent cell division. When cell division did occur it was usually only in the outer two-thirds of the liver lobule. It thus seems that in poisoning with this alkaloid cells are lost mostly from the central area of the liver lobules and can no longer be replaced by division of the outer cells. The extent to which enlargement of cells can compensate for reduced numbers is limited, and many of the enlarged cells may die and not be replaced.

This inhibition of cell division is not the only harmful effect of the pyrrolozidine alkaloids on the liver, but it is probably one of the main factors in the production of the characteristic pathological changes on which the diagnosis of chronic poisoning in sheep is based.—*Division of Animal Health.*

Oestrogenic Pastures and Sheep Infertility

Some types of clover pasture in Australia are responsible for a depression of fertility in sheep that is of considerable economic importance. The clovers have been found to contain quite large quantities of weakly oestrogenic compounds known as isoflavones, but the correlation between isoflavone content of the pasture and its effect on grazing ewes is often poor. In an attempt to clarify this situation large batches of these compounds have been synthesized and fed to ewes. The oestrogenic activity of each of the three isoflavones found in clovers was found to be similar and to be about one-millionth of that of stilboestrol administered intramuscularly.

In contrast, the evidence obtained from feeding ewes different varieties of subterranean clover indicates that the three isoflavones have very different activities when eaten in plant material. The reason for this discrepancy appears to lie in the way the sheep metabolizes the compounds. Radioactively labelled isoflavones have been used to establish the major metabolic pathways and a sensitive chemical technique has been developed for measuring the levels of the isoflavones present in the blood of grazing sheep. Results indicate the importance of the processes occurring in the rumen. An understanding of the way these vary between clover strains and species may make possible the development of methods of diagnosis and control of "clover disease".—*Division of Animal Physiology.*

New Approaches to Breeding Sheep for Production

Most aspects of productivity in sheep, such as fleece weight, body weight, or number of lambs born, are controlled by a large number of gene pairs, so that selection to raise production, though effective, may be a slow process. Selection experiments along these lines are continuing, but other genetic means of raising production are also being sought. One of these uses the fact that in any population the frequency of a characteristic that is controlled by a single pair of genes can sometimes be changed rapidly through selection. If such a characteristic can be shown to be associated with some aspect of productivity, then a short cut to improvement may be provided.

Two such characteristics in sheep are under investigation and show some promise.

Two types of haemoglobin (A and B) can readily be distinguished in sheep, and are simply inherited. Animals carrying both gene types (AB) can be distinguished from those carrying only one (A or B). Work in collaboration with the University of New England has shown that in sheep flocks at Cunnamulla and Deniliquin, the haemoglobin type of a ewe is associated with the number of lambs which she bears and rears. Type B and AB ewes are similar, but type A ewes are poorer in reproductive performance. The difference between the two groups of ewes increases with the general level of reproduction in the flock, and at Deniliquin in a flock selected for high twinning rate, the difference between type A and types B and AB has been as much as 27 lambs weaned per 100 ewes joined.

As the haemoglobin type can be readily measured, even early in life, this could be an important selection tool. However, the difference in reproduction rate is so great that type A ewes must have other advantages or they would not occur as often as they do. Other aspects, therefore, need to be investigated before the tool can be recommended for general use.

In another group of selection experiments at Cunnamulla (CSIRO) and Trangie (N.S.W. Department of Agriculture), increases in clean wool weight per head have been found to be accompanied by increases in the number of wool follicles per square inch of skin. This has focused attention on the follicles and their structure. Previous work has been done largely on horizontal skin sections, but an examination of vertical sections has shown that follicles are of two main types, "straight", which lie straight and parallel to each other, and "tangled", which curve in various directions from the bulb to the skin surface. "Straight" follicles lie at a greater depth than "tangled" follicles.

Skin samples from flocks at Cunnamulla selected for high clean wool weight showed 50–60% with "straight" follicles, compared with 0–20% in flocks without selection or selected for low clean wool weight. Similar results were obtained at Trangie.

The inheritance of the "tangled" and "straight" follicles is being investigated in the hope that it may prove a useful indicator of wool production.—*Division of Animal Genetics.*

Mechanisms of Wool Growth

Sheep differ markedly in their efficiency at converting food into wool. After digestion and absorption, the nutrients are conveyed to the wool follicle where the fibres are made of hardened and cemented cells. The rate of wool production is determined by three separate factors: the number of cells that the follicles produce in a given time; the proportion of these cells channelled into the growing fibre (15–30%) and the proportion going to waste (70–85%) in forming the inner root sheaths of the follicles; and the increases in size (threefold) and weight (fifteenfold) of the cells of the wool fibres as they grow and cornify.

Efficiency of wool production therefore depends on maximal production of cells, minimal wastage of cells, and maximal growth of cells. Current experiments are concerned with the relative importance of these three pathways in wool production, the ways they can be combined, and the degree to which they are affected by nutrition. Results to date indicate that highly efficient sheep have higher rates of cell production and lower wastage rates than sheep of low efficiency. Such information will provide a deeper understanding of the pathways to efficient wool growth and may lead to the development of practical methods of increasing this efficiency.—*Division of Animal Physiology.*

New Pituitary Hormone affecting Wool Growth

The pituitary gland at the base of the brain regulates growth, metabolism, and reproduction as well as protecting the animal against environmental stress. Removal of the pituitary gland from sheep causes a complete cessation of wool growth. Research has been undertaken to identify the pituitary hormones responsible for maintaining wool growth in the normal sheep. It was found that injections of pituitary thyrotrophic hormone, which stimulates the thyroid gland to secrete thyroxine, would partially restore wool growth in animals from which the pituitary gland had been removed. Similar results were obtained by injections of thyroxine. It has now been discovered that a similar effect may be obtained by another substance extracted from pituitary glands and that it is effective in the absence of the thyroid gland. The substance has not yet been prepared in pure form but pituitary extracts containing it do not contain any of the known pituitary hormones.

During these investigations it has been necessary to develop methods for the isolation and characterization of sheep pituitary hormones. These methods have now been applied to the preparation of hormones from human pituitary tissue, and have been found to give greatly improved yield and potency of growth hormone and follicle-stimulating hormone compared with those obtained by methods in current use overseas.—*Division of Animal Physiology.*

Feeding of Ewe Lambs

A long-term experiment to determine the effects of poor feeding of ewe lambs on their subsequent productivity has been running since 1958 at Armidale.

Ewe lambs were run on unimproved natural pastures in the first or second half of their first 14 months of life, while others were run on the best available improved pastures. The different pastures caused immediate and predictable differences in liveweight and wool growth. All the ewes were placed in one flock when they were 14 months of age and have been run together ever since on improved pastures. The differences in liveweight and wool growth disappeared quite rapidly but differences in reproductive performance were still apparent at the fifth lambing. The differences lay largely in the proportion of the lambing ewes that produced twins.

Little difference shows between ewes fed poorly in the first half and those fed poorly in the second half of their first 14 months of life. However, when all the poorly fed ewes are compared with the ewes well fed during their early life, it is found that the latter produce twice as many twins. For example, in 1964 the well-fed ewes produced 29 pairs of twins per 100 ewes that lambed whilst the poorly fed ewes produced 14. It must be stressed that "well fed" and "poorly fed" refers to feeding in 1958–59; subsequent feeding has been the same for all sheep. The implications from these observations are clear. Poor feeding of young ewes results not only in an immediate penalty in wool growth, but also in permanent reduction in reproductive ability.—*Division of Animal Physiology.*

Effects of Subdivision and Management on Breeding-ewe Performance

In grazing experiments with breeding Merino ewes at Ginninderra Experimental Station, Canberra, subdivision and rotational grazing have conferred no advantage, but rather a slight disadvantage, as compared with set stocking, at a stocking rate of 5 ewes per acre. At 7 ewes per acre there was a distinct advantage in favour of rotational grazing. At 12 ewes per acre there was a substantial decrease in reserve dry feed in late spring and summer.

These results are interpreted as follows. At low stocking rates, sheep on a rotational system are presented with a limited grazing area and are prevented from grazing selectively. As a result the quality of the diet is adversely affected and performance suffers. At the intermediate stocking rates rotational grazing permitted higher plant production in winter and enabled the perennial grasses to persist, with favourable effects on animal production. At the highest stocking rates the effect of very heavy grazing pressure during winter on the rotationally grazed plots caused a substantial decrease in spring growth. This seemed to be largely due to suppression of annual species which contribute most to reserve dry feed at high stocking rates. This decrease in reserves is important in a summer when rainfall is inadequate for pasture growth.—*Division of Plant Industry.*

New Light on the Complex Relationship between Pasture and Animal Production

Pasture can be visualized as a "living storehouse" from which sheep and cattle draw their daily food. What is seen or measured at any one time is merely a momentary "balance-in-store", resulting from numerous transactions up to that time. These transactions can be grouped under four headings: plant growth, which adds quantity and quality; plant ageing, which reduces quality; plant breakdown, which reduces quantity; and intake by the stock, reducing both quantity and quality. Additions to this store by growth are discontinuous. There are often long periods of no growth, and when growth does occur it may be slow or fast. On the other hand, removals from the store by ageing, breakdown, and intake are continuous. All four transactions not only influence, but are influenced by, the current status of the "storehouse", which in itself is the outcome of previous transactions.

The most important part of the pasture on any one day is that consumed by the livestock, and attempts are being made at the Pastoral Research Laboratory, Armidale, to examine the day-by-day transactions within a pasture and to relate these to the animal production being achieved. One method being used is to take photographs of very small fixed areas at daily intervals, and thus acquire a record of the growth, ageing, breakdown, and intake of individual plants and plant parts. This has revealed that breakdown of pasture is a continuous feature under the wide range of conditions so far examined. The proportion of the pasture never consumed by stock is considerable. Again, it has been shown that even at high stocking rates under continuous stocking, individual plants are grazed rotationally; in one situation the mean defoliation rate per plant, in a paddock carrying seven ewes per acre, was once in three weeks.

These studies are giving a clearer picture of the complex mechanisms at work in pasture under ordinary grazing conditions. They help explain why some pasture treatments do not give the animal production expected of them; and they will help to determine the relative value of new or already accepted practices in a variety of different environments.—*Division of Animal Physiology*.

Soils

The failure of many early land development projects in Australia pointed to the need for better information on soils as a prelude to sound planning of land use. Research on Australian soils was initiated by CSIR in 1927 in cooperation with the Waite Agricultural Research Institute of the University of Adelaide; the establishment of the Division of Soils followed in 1930.

The soils of the Australian continent are complex and range from the fertile black clays of the Darling Downs to sandy wastes, as in the Simpson Desert. Some of them also are very old, geologically, and have no counterparts in other countries. Even the younger groups reflect the peculiarities of the Australian climate which helped to fashion them from parent rocks and sediments. Early work was directed at devising a system of soil classification within which the salient soil features could be described and used to assess the distribution of soil types in the country.

The principal centres of research of the *Division of Soils* are now in Adelaide, Canberra, Brisbane, Townsville, Hobart, and Perth. In addition, the *Division of Land Research and Regional Survey* (Canberra) is surveying regions in the interior and north of Australia and in Papua–New Guinea. Various aspects of soils in relation to plants are studied in the *Divisions of Plant Industry* (Canberra, Deniliquin, and Perth) and *Tropical Pastures* (Brisbane and Townsville) (see Plant Production), while problems of drainage and movement of water in soil are studied in the *Division of Plant Industry* (Deniliquin) and the *Irrigation Research Laboratory* (Griffith) (see Water). The effect of the grazing animal on soil minerals is being studied by the *Division of Animal Physiology* at Armidale, and the breakdown of animal droppings by insects by the *Division of Entomology* at Canberra. Minor element deficiencies are widespread in Australian soils, and work on the role of these elements in plant and animal nutrition is done in many Divisions, notably the *Division of Biochemistry and General Nutrition* (Adelaide). The support of structures such as buildings and roads on soils is the concern of the *Soil Mechanics Section* (Melbourne) (see Timber and Building).

Some £600,000 was expended in 1964/65 on soils research, of which approximately 90% came from Commonwealth government sources.

Information on the formation and distribution of major soil types is still being accumulated. In the more settled areas of Australia the pioneering phases of soils investigations have provided a solid basis of knowledge about the nature and extent of the more important groups, and opened the way to more detailed studies. Current work is being directed increasingly towards soil fertility problems. Potassium deficiencies are widespread and often develop under current land-use practices. The rate of release of this element from soil minerals is being studied under various conditions. Areas of soils deficient in minor elements continue to be discovered, and work in this field is concerned with the distribution of these elements in soils and the factors affecting their binding and release. Toxic factors in soils, arising from the decomposition products of some crops, are being studied. Work on soil water and on soil–water–plant relationships is widespread, and arises as an essential part of many problems concerning plant growth, whether under irrigation or natural rainfall (see also Plant Production). Some items of soils research of current interest are reported below.

Soil Tests predict Top-dressing Needs

For certain areas in south-eastern Australia, recent work has shown that a chemical soil test has considerable promise in predicting the phosphorus needs of wheat crops. The present work indicates that, although pasture presents an even more complex situation, soil tests can be used to predict the potential response of pastures to phosphorus, provided care is taken to ensure that other factors are not limiting.

Many past attempts to establish such a relation under Australian conditions have been disappointing, largely because of the lack of understanding of the other factors concerned in the response to superphosphate. For example, restriction in the growth of some pastures caused by molybdenum deficiency and by ineffective nodulation of clovers has undoubtedly weakened the relation between soil test value and response to phosphorus. Also the significance of sulphur in fertilizers has been overlooked until comparatively recently. Thus good responses to superphosphate were found on certain soils where the phosphorus status was high because sulphur in the fertilizer overcame a sulphur deficiency.—*Division of Plant Industry*.

Measuring the Hardness of Soils

There is increasing awareness of the problem that the normal development of plant root systems might be restricted under some conditions by the mechanical strength of the soil. The root systems of fruit-trees, for example, are often confined to a shallow layer of soil; and the roots of sugar-cane do not seem able to utilize some soils below the layer loosened by ploughing. The problem could become important in cereal farming where highly developed mechanization allows farming operations to be carried out when the soil is susceptible to compaction. Agriculturalists require some method that will allow them to detect whether soil strength is limiting productivity.

The use of fine metal probes as penetrometers to measure soil hardness, together with a knowledge of the force exerted by plant roots, has given anomalous results, indicating that more information should be sought on the mechanism of penetration.

A theoretical analysis has been made of the stresses acting on a fine metal probe as it penetrates soil. The theory predicts that up to 40% of the point resistance to a metal probe is accounted for by frictional resistance on the end of the probe. The ability of plant roots to penetrate soils having high probe resistance values may be explained on the basis that they possess some mechanism for overcoming this frictional resistance. Furthermore, observations that root growth is stopped in unsaturated clay materials that have much lower probe resistances could be explained by the soil–metal friction being reduced in such materials by release of water at the base of the probe.

It is hoped that a soundly based test for compacted soils will result from this work.—*Division of Soils.*

Cobalt Availability in Soils

The results of two apparently unrelated investigations have been used to give an understanding of the factors controlling the availability of cobalt in soils.

In Tasmania, in connection with cobalt deficiency in sheep, studies in the field, glass-house, and laboratory have been made on a variety of soils to determine their ability to supply native cobalt and to fix cobalt applied as fertilizer. The behaviour of the soils was erratic and unpredictable, apparently identical soils differing greatly in their ability to supply and to fix cobalt. The variations could not be explained in terms of clay content, organic matter content, pH, or type of clay minerals.

Separate studies at Adelaide on the mineralogy and chemistry of the manganese oxide minerals in soils have revealed that these minerals are exceptionally high in cobalt, and that in many soils most of the cobalt is present in the manganese minerals. This close association of cobalt with manganese suggested that the manganese minerals might be responsible for the erratic behaviour of the Tasmanian soils with respect to cobalt, and subsequent investigations confirmed this.

Two conclusions about the uptake of cobalt by plants are suggested by this work. In the first place, the ability of the soils to fix applied cobalt was shown to depend on soil manganese content and pH, these two factors accounting for all the variability of the soils. Secondly, the ability of many of the soils to supply native cobalt depended on their cobalt : manganese ratio.

Prior to this work the intimate association of cobalt and manganese in soils was not suspected and it is of interest in that the behaviour of the soil with respect to cobalt is controlled largely by an element which itself is often present as only a trace.—*Division of Soils.*

Gypsum on Light-textured Irrigated Soils in the Riverina

Both the light-textured soils (red-brown earths) and heavy clay soils (grey and brown soils of heavy texture) that are irrigated in the Riverina often suffer from the disadvantages of poor water characteristics. The amount of water stored in these soils following an irrigation may be as low as one inch or less, and very frequent irrigations are necessary to attain reasonable pasture production.

The heavy clay soils were markedly improved with gypsum dissolved in the initial irrigation water or broadcast on the soil surface. The light soils failed to respond to dissolved gypsum, but good results have now been achieved by heavy applications (4 to 5 tons per acre) of broadcast gypsum. This was the result of increased water storage in the soil, and whereas irrigation was necessary twice weekly without gypsum, it was necessary only once weekly with gypsum. Furthermore, the greatest yield of pasture with gypsum was more than twice that without gypsum even though only half the number of irrigations was required. Increases in yields from broadcast gypsum have, at this stage, occurred on two red-brown earth soil types and it appears promising for improving those light soils for which water penetration is a problem.—*Division of Plant Industry.*

Statistics and Computation

Most scientific work is of a quantitative nature. In such fields as animal breeding, plant nutrition, oceanography, or cloud physics hundreds of experiments must be done, simultaneously or serially, to yield a single result. Very often a single experiment will produce a great mass of numerical data which must be converted to a significant and meaningful form. The design of experiments and the statistical interpretation of results are thus an important component of scientific research, and CSIRO set up a mathematical statistics group for this type of work 30 years ago. The *Division of Mathematical Statistics* now has headquarters in Adelaide and officers stationed in Melbourne, Sydney, Canberra, Brisbane, Perth, and Adelaide.

The development of modern instruments capable of making thousands of measurements and observations in a short time has also confronted scientists with an enormous quantity of information. The new radio heliograph of the Division of Radiophysics at Narrabri, for example, will record a radio wave image of the Sun once every second. CSIRO established a *Computing Research Section* in 1962 to meet its needs for computer services. The Section has a Control Data 3600 computer at its headquarters laboratory in Canberra, and subsidiary computers and staff in Adelaide, Melbourne, and Sydney.

A measure of the importance of statistical and computing work to CSIRO research is the annual budget of about £350,000. The statistical and computing groups both combine basic research with service to other laboratories. The *Division of Mathematical Statistics* does research in theoretical and meteorological statistics, and the *Computing Research Section* is seeking to extend the application of computer techniques to research problems. The services of these two groups are used by most other CSIRO laboratories and also by other organizations.

Timber and Building

Until about 40 years ago a large proportion of the materials used in building construction in Australia was imported, as was much of the timber used for furniture and similar purposes. Early attempts to use Australian hardwoods were based on seasoning practices established for overseas species and many difficulties resulted. Research into these problems was begun by CSIR in 1928. The scope of the research undertaken in CSIRO has been enlarged and the *Division of Forest Products* in Melbourne now deals with problems of timber utilization through all stages from milling to building construction, the manufacture of furniture, the construction of fencing, power, and telephone lines, and paper manufacture. In 1945 research into problems of building was extended with the creation of a new laboratory now known as the *Division of Building Research*, Melbourne. Specialized work of interest to the building industry is also being done by the *Division of Applied Mineralogy* and the *Soil Mechanics Section*, both with headquarters in Melbourne.

The greater part of the work of these laboratories is financed from Commonwealth funds, but substantial contributions have also been made by individual firms and industry associations. Expenditure on timber and building research in the past year amounted to some £900,000, of which £50,000 was contributed from outside sources.

The emphasis in the research programme is on work aimed at exploiting the special properties of local materials and at providing answers to problems specific to the Australian industries. The broad aims of the *Division of Forest Products* are to achieve more effective use of our timber resources, to improve the quality of woods in the forests of the future, and to study the basic principles underlying problems in the timber, plywood, and pulping industries. Problems in the seasoning of Australian timbers are particularly important and the scope of research in this field has recently been extended by the use of a large low-velocity wind tunnel. An indication of the magnitude of the economic implications of this work is the £25 million worth of timber at any given time in air-drying yards throughout Australia. Surface roughness of rotary peeled veneer, a major problem in the plywood industry, is being studied experimentally using extremely slow-speed peeling and photographic recording. Timber roof trusses and other engineered building components are being used increasingly by the building industry, and the characteristics of various types of jointing media are being studied with the object of improving the design of timber structures.

In addition to timber and its products, other building materials being studied include concrete, clay products, and gypsum, in the *Division of Building Research*, which also has research groups working on problems in acoustics, thermal control in buildings, and structural design. Recently the research programme has been extended to include an analysis of the special problems of building in tropical conditions, and work on building operations and economics is just being commenced. The properties and behaviour of soils under load are being investigated by the *Soil Mechanics Section*, and problems arising in the use of cement and concrete by the *Division of Applied Mineralogy*.

Several other Commonwealth government agencies are concerned with building research and advisory services, and CSIRO cooperates with these through the Building Research and Development Advisory Committee of the Department of Works, and the Building Research Committee. The latter Committee is composed of representatives of all relevant Divisions of CSIRO and Commonwealth agencies, and examines programmes of work in detail to ensure proper integration of activities.

A feature of CSIRO work on timber and building problems is the active interest shown by all the associated industries, which make considerable use of the information and advisory services available. Thus the Divisions of Forest Products and Building Research between them handle some 20,000 inquiries annually in addition to holding regular meetings and conferences with a number of trade associations.

Reports of current research of interest include the following.

Protection of Mill Logs during Storage

Hardwood logs may develop serious end and barrel splits when held through the summer for milling in winter. Similarly, softwood logs may develop severe blue stain despite preventive treatment. The amount of sawn timber recovered from green logs can thus be reduced by more than 10%, which represents an industry loss of about 60 million super feet of timber per annum, valued at some £900,000.

A series of log protection studies has been carried out under laboratory and industry conditions over a two-year period to examine the effect of various treatments. These included treating ends with moisture barriers, coating exposed stack surfaces with grease compounds, protecting stacks with weather shields, completely covering them with a plastic film, and using water sprays to keep the entire pile wet. Water spraying gave best protection, reducing storage losses to less than half that for unprotected logs. Softwood logs developed marked blue stain or barrel checking within a short time of piling when stored in accordance with normal industry practice, even after a preliminary fungicide treatment, whereas those stored under water sprays remained free of both defects for at least 7½ months. An average sawmill holding some 2 million super feet of logs valued at £30,000 could use the method to save some £3500 per annum after providing for the cost of spraying. A simple water reticulation system from a small, excavated, farm-type dam, which would normally fill during winter rains, was found to be adequate as a water source.—*Division of Forest Products.*

Timber Flooring

New developments such as end-matching, finger-jointing of tongued and grooved boards, and the possible use of sheet materials such as plywood and particle board have underlined the need for an Australian standard for testing flooring materials. The results of tests conducted over many years have now been analysed and the critical requirements for a satisfactory floor have been determined. It is now possible to formulate tests to determine whether a flooring material has the necessary structural characteristics for domestic use, and the resulting specification should eventually become an Australian Standard. In addition, a simple field test has been devised. This will enable manufacturers and others to establish the acceptability of a particular parcel of flooring.—*Division of Forest Products.*

Assessment of Wood Quality for Tree Breeding

A method has been developed whereby trees to be used for breeding may be selected for wood quality in addition to desirable external characteristics. Using small specimens, a comprehensive picture of wood quality can be obtained from an examination of a limited number of features, such as cell length, basic density, and spiral grain. With young material, quantitative measures of heritabilities have been calculated for these important wood characteristics, and there are indications of useful gains through selection. Mature wood is now being examined to enable estimates of heritability to be made for trees nearer harvestable age. Older material is also being used to supplement a preliminary investigation of the effect of environmental factors on wood characteristics of young trees.—*Division of Forest Products.*

Wood and Water

The behaviour of wood and wood products in service is very dependent on the quantity of moisture that the wood holds. The moisture content of wood is usually determined by drying it. Recent research has shown that this is a much more difficult problem than had been recognized. By a series of precise measurements it has been found that wood sometimes holds on tenaciously to some of the water in it but at other times, under exactly the same drying conditions, it releases this water comparatively easily. The ease of removal of the water is now known to depend upon the length of time the wood has been exposed to any atmosphere containing water vapour, longer exposure making removal harder. However, if the wood is wetted by immersion in water before drying, any water that was previously difficult to remove comes out very easily. The reasons for this unexpected behaviour are still being studied.—*Division of Forest Products.*

Soil Structural Analysis

Structurally, soils are very complex systems. The mechanical properties of the three major components—sand and silt grains, clay particles, and air- and/or water-filled pores—are generally orders of magnitude apart, in contrast to the components of most other engineering materials. Quantitative methods have been designed and are now being tested to describe the complex structural patterns of soils in terms of grain-contact frequencies and, particularly, the geometrical characteristics of soil pore patterns. The influence of load conditions on the structural pattern of a series of soils of different composition is also being studied. The methods that have been developed will enable the alterations in the structural patterns to be measured quantitatively. The results of current experiments are expected to lead to a better understanding of such problems as mode of failure of soils under load and of certain aspects of soil stabilization.—*Soil Mechanics Section.*

Prop Forces in Multi-storey Flat-plate Construction

A knowledge of the loads imposed on flat-plate floors and supporting props during construction of multi-storey reinforced concrete buildings is necessary to enable the most efficient construction cycle to be selected. A more rational design approach is now possible following theoretical and experimental investigations. In many cases the number of levels of propped floors supporting newly placed floors can be reduced without increasing the loads sustained. Direct savings in material and indirect benefits in accessibility are possible.—*Division of Building Research.*

New Ceramic Materials

Two new ceramic materials, one based on basalt and the other on lightweight aggregate, have been developed in the Division of Building Research. For the first of these, waste basalt fines are bonded with a clay slip, cast in plaster moulds, and fired in the normal way. When fired at 1100 to 1200°C the product is comparable with cast basalt in many of its properties, but is superior in its resistance to thermal and mechanical shock and can be produced at a fraction of the cost. Its refractoriness and resistance to abrasion can be increased by incorporating zircon in the body, and its resistance to slip by adding the mineral merely in the surface layer. The new material has many applications, such as flooring for food factories and for chemical, metallurgical, and industrial plants, linings for blast furnaces, coke ovens, industrial chimneys, high-temperature ducts, ash sluices for boilers and coal and ore hoppers, and a surface layer for ceramic tunnel kiln cars. When fired at lower temperatures of 950 to 1050°C, bodies are produced with properties comparable with those of heavy clay products suitable for bricks, blocks, flooring tiles, and ornamental pottery.

A new lightweight ceramic material has been made by firing a mixture of powdered glass and lightweight aggregate from shale or clay at temperatures of 900 to 950°C. Artificial glasses may be partly replaced by basalt or similar rock fines but temperatures about 100°C higher are required to give a satisfactory product. The material takes ceramic glazes readily and has the added advantage that it can be nailed. Bricks, blocks, and panels made in this way are attractive, light, have good thermal insulation, and can have a variety of finishes.—*Division of Building Research.*

Concrete Admixtures

In making concretes it is becoming increasingly common in Australia to add small amounts of organic chemicals at the mixer to control the behaviour of the material and make most efficient use of it under any given conditions of emplacement. Since the properties of concretes are strongly influenced by the organic admixtures, every factor must be considered if costly failures of structures are to be avoided. These have occurred in recent years, and a detailed investigation is being made of the mode of action and side effects of admixtures. One unsuspected factor has already been isolated. Some chemicals have been found to have a more severe retarding influence on setting if added after the mixing water than if they are dissolved in it. A delay of a few minutes in the addition of admixture can result in many hours' delay in setting. The sequence of addition at the mixer must therefore be specified if the concretes are to have a predictable behaviour. This finding was quickly put into practice by industry after it had confirmed that this had been one of the unrecognized causes of anomalies in concrete practice.—*Division of Applied Mineralogy.*

Water

In comparison with other large land masses of the world, Australia is an arid continent, and water is the limiting factor to production over almost all its area. The pastoral industry in particular has suffered serious set-backs as a result of droughts. For example, it took thirty years for sheep numbers to recover to former levels after the disastrous droughts of 1902 onwards. Although changed conditions and increased development may reduce such losses now, we have had a reminder again this year that the threat still remains. Work on problems in which water is a factor therefore appears in the research programmes of many Divisions in CSIRO. This work falls broadly into two approaches. The first and most direct is aimed simply at increasing the amount of water available, as, for example, in the cloud physics and experimental cloud-seeding work of the *Division of Radiophysics*. The second has the objective of making better use of the water we have, and enters into the programmes of many Divisions. The sum expended on research in these two fields exceeds £600,000 annually.

The experiments in cloud seeding by the *Division of Radiophysics* to see if rainfall can be increased economically are well known in Australia. The difficulties and the exacting laboratory studies behind these experiments are probably not as well understood. Much work has been done on the origin and nature of the nuclei of condensation and ice formation in clouds, and on the processes whereby the initial exceedingly small droplets grow to raindrop size. On the basis of this knowledge, experiments have been planned and the results statistically evaluated so as to cope with the great natural variability of rainfall data. Much has been learnt in the past few years, but a fuller understanding of the processes at work is necessary before the possibilities of modifying weather in a desired direction can be realistically assessed.

Another approach of great promise lies in the possibilities of producing fresh water from saline waters. Desalination by the use of ion-exchange absorbants is being investigated in the newly formed Water Purification Research group of the *Division of Physical Chemistry*. Novel processes involving distillation techniques are being developed in the *Division of Chemical Engineering*, while the *Division of Mechanical Engineering* is working on the use of solar energy to reduce the salt content of inland water supplies where these are too brackish for direct use. An experimental solar still is in operation at Muresk Agricultural College in Western Australia. Other Divisions are examining the possibilities of reducing losses from dams by evaporation and seepage.

Those planning agricultural research projects are constantly confronted with the challenge to produce more from the water available. Patterns of run-off and infiltration in different types of country are being studied in climates ranging from alpine to near desert. The *Divisions of Land Research and Regional Survey* and *Meteorological Physics* have made considerable progress with the development of long-term recorders to measure run-off in isolated areas. Other groups in several Divisions, and the *Irrigation Research Laboratory* at Griffith, are studying the amount of water used by growing crop and pasture plants. The movement of water in soils under different crops and climatic conditions is also receiving attention, while problems of rising saline water-tables in irrigation areas are being studied at Merbein, Deniliquin, and Griffith.

The preceding paragraphs indicate the wide pattern of activity taking place in CSIRO in relation to water. The Organization is not alone in this work and many contacts with other governmental and private organizations have been developed in recent years. Perhaps the most important step to coordinate and stimulate studies on water has been the formation of the Australian Water Resources Council. This body, with representatives from Commonwealth and State governments, has done much to formulate and coordinate policy. Through its Standing Committee and Advisory Panels, CSIRO gets advice and transmits information throughout the Commonwealth.

Current items of water research of particular interest are reported below.

The Basis of Ice Nucleation

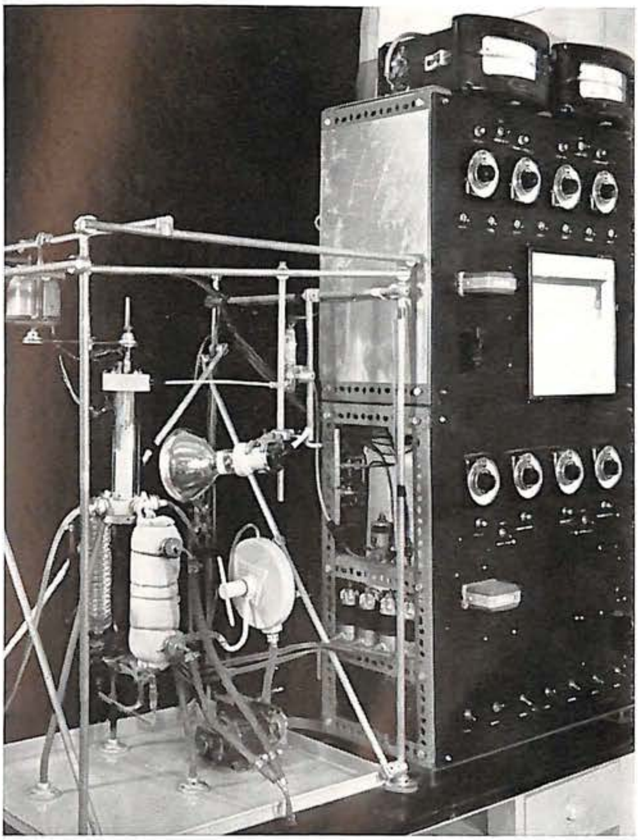
Associated with the cloud-seeding operations of the Division of Radiophysics, a fundamental study has been made of the factors that govern the nucleation of ice in supercooled water, the aim being to improve the effectiveness of silver iodide in cloud seeding and if possible to find a more effective material than silver iodide.

It has long been suspected that both the electrical state of the surface of a nucleating material and the geometrical arrangement of its crystal lattice might be important, but only recently have experiments been devised to allow the influences of the two factors to be studied independently. First, it has been shown that the negative charge that silver iodide particles possess in pure water tends to inhibit nucleation and the particles are most effective at their isoelectric point, where they carry no charge. Second, the importance of geometrical fit between the nucleating lattice and the ice lattice has been convincingly demonstrated by a study of the nucleation of the high-pressure phases of ice. Silver iodide continues to form normal ice (Ice I) even in the pressure-temperature region where a dense form of ice (Ice III) is the only stable form. A practical outcome of these theoretical studies has been the correct prediction that the organic compound phloroglucitol is an excellent nucleating material for ice.—*Division of Physical Chemistry.*

Solar Distillation

In many of the arid areas of Australia the supplies of bore water available are frequently too saline for use even for watering stock. In these areas, which in general receive large daily supplies of solar energy, solar distillation can now provide a simple means of producing fresh water, at a cost of the order of 30*s* per thousand gallons. Following experimental work a prototype still was erected at the Muresk Agricultural College, Northam, W.A., and has been in operation since December 1963. This still has an effective area of 4500 square feet and operates on brackish water from the adjacent Avon River, which has a salinity ranging from 1500 to 15,000 parts per million according to the time of year.

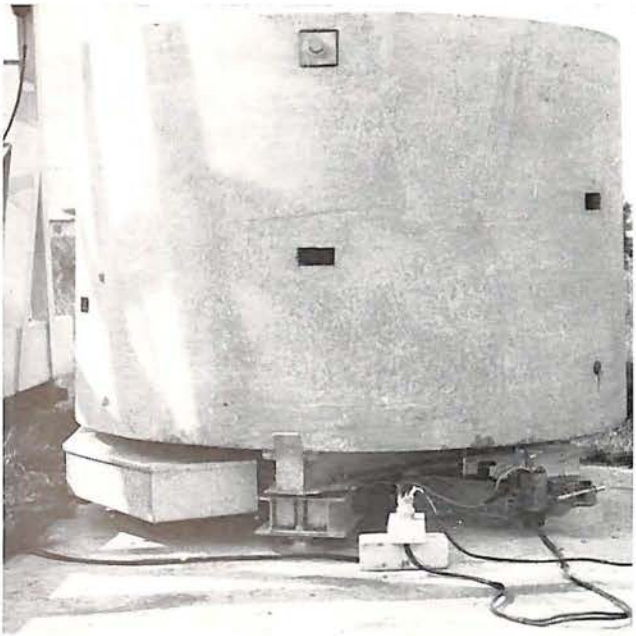
During the first twelve months of operation the still produced 73,000 gallons of fresh water, the highest daily output being 375 gallons. In the summer of 1965 daily figures of up to 426 gallons were recorded. No serious operating problems have been encountered, and the still has proved remarkably immune to the effects of rain, hail, and high winds. The prototype installation has aroused considerable interest among potential users, and preliminary talks are being held with manufacturers with a view to its commercial production.—*Division of Mechanical Engineering.*



An apparatus developed in the Division of Physical Chemistry as part of the Sirotherm programme of water demineralization. It automatically subjects ion-exchange resins to many thousands of successive cycles of heating and cooling. The resins are treated in the glass cylinder at the left of the photograph and their chemical and physical properties are periodically checked for signs of deterioration.

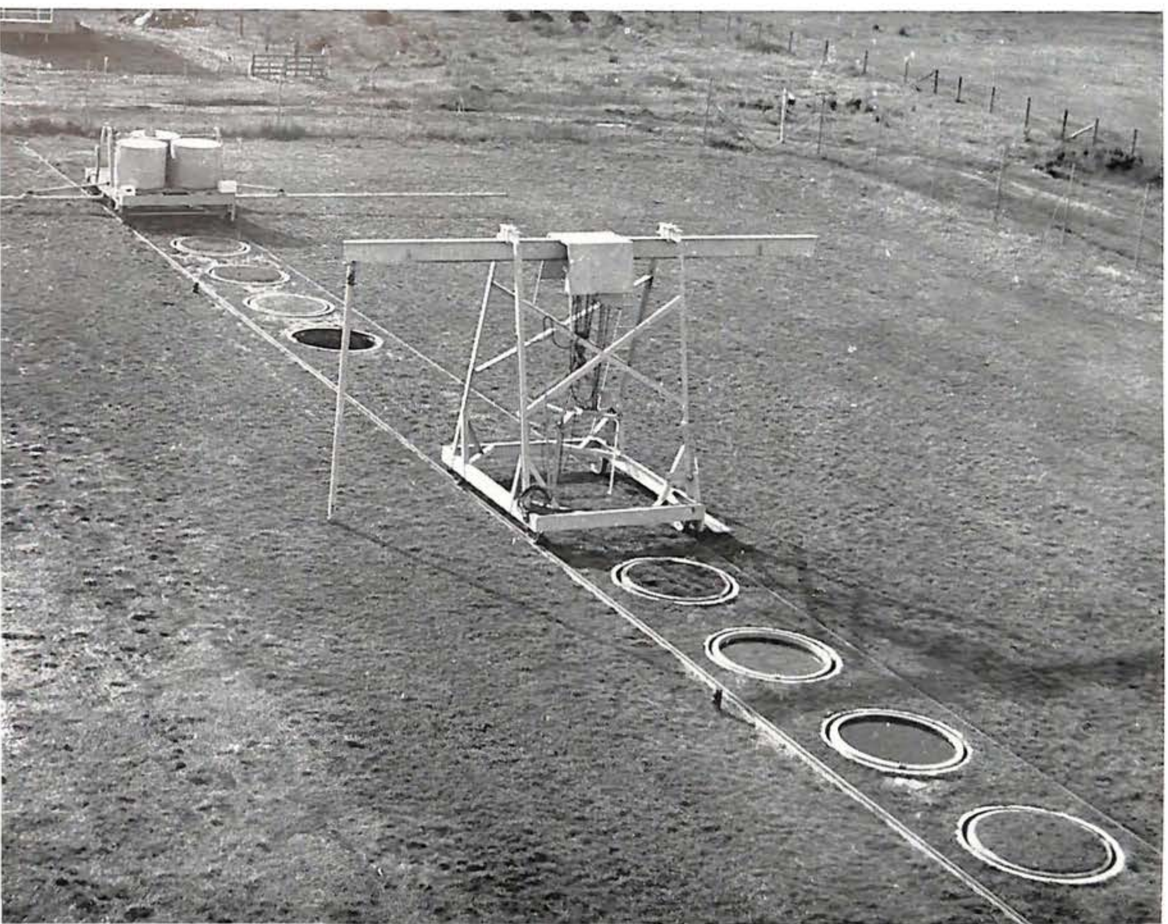
Novel Method for Desalting Water

In some parts of Australia the local water supplies contain as much as 500 parts per million of dissolved salts, which make them unsuitable for many industrial purposes. It is costly to remove the salts by conventional methods and for that reason some manufacturing industries cannot be established in areas where the water is of poor quality. Even in regions where the salinity is at present at an acceptable level, the level is likely to rise in the future as the re-use of water becomes more common practice. Eventually, some form of inexpensive treatment will be needed to correct the salinity of municipal waters for domestic as well as industrial use. The usual methods using ion-exchange resins are expensive because they require chemicals to regenerate the spent materials. An important advance has been made by the discovery of a method for regenerating resins by heat rather than by chemicals. In this process, termed the "Sirotherm" process, salts are absorbed at normal temperature and the resins are then regenerated by washing with a small quantity of the feed water heated to 80°C. Since low-grade heat is considerably cheaper than chemicals, the Sirotherm process promises a major reduction in the cost of water treatment. The process is now at an advanced stage of laboratory development, but further work is needed to achieve a practical operating plant.—*Division of Physical Chemistry.*



A lysimeter pot removed from its position in the ground. The soil is held in the concrete pot, which sits on the sensitive recording balance mechanism.

The battery of lysimeters at Aspendale.



Measurement of Natural Evaporation

One of the most important factors in successful agriculture is the effective use of water by vegetation. At Aspendale, Vic., evaporation is being studied under natural conditions, principally by means of large weighed lysimeters. These are massive blocks of soil complete with vegetation, representative of their surroundings but isolated from them so that small weight changes can be detected. They may be used to measure the gain or loss of water resulting from rain, irrigation, or dewfall on the one hand, or evaporation on the other.

A battery of lysimeters ranging up to 7 tons in weight, with highly sensitive automatic continuous recording balances, has now been in operation for six years. Results have shown that the potential evaporation rate for a typical irrigated pasture mixture is on the average about 20% higher than that for a water surface and 40% higher than that for a bare soil surface, under the same weather conditions. Further, the energy used in the process is greater than the local net radiant energy supply from sun and sky. This is believed to be typical of many of Australia's irrigated areas. By allowing the soil to dry out over several summer periods, the effect of soil moisture on evaporation has been studied at all stages from field capacity to near wilting point. Recently, half the experimental area has been changed over to potatoes, permitting a comparison between two quite different types of vegetation.—*Division of Meteorological Physics.*

The Pye Lysimeter at Katherine

A rugged and sensitive weighing lysimeter has been developed for studies of evaporation under difficult operating conditions, using funds donated to CSIRO by Mr. F. C. Pye. The lysimeter measures the changes of weight in a five-foot column of soil weighing up to nine tons, isolated from the surrounding soil in a container. The container is supported by three hydraulic capsules which transmit changes in weight to a remote high-precision pressure recorder developed for this installation.

During the 1964/65 wet season at Katherine in the Northern Territory the lysimeter has been used to record evaporation from a Townsville lucerne pasture. An interesting result was obtained during the dry spell in February. Towards the end of the dry spell the average daily evaporation rate from the pasture fell to as low as one-seventh of the January figure. This installation is now playing an important part in the research being carried out at Katherine to study the processes of plant production in the field.—*Division of Land Research and Regional Survey.*

Rapid Processing of Water Resources Data

The present demand for accurate water resources information makes it essential that large volumes of hydrologic data be processed by computer. The bulk of Australian data on rainfall and river levels is recorded as ink traces on strip or drum charts, and the task of transferring the data manually to punched cards or paper tape is extremely time-consuming.

These difficulties have been considerably reduced by the development of a specially designed strip chart conversion unit. The chart record is fed past an illuminated screen and an operator maintains a pointer in coincidence with the trace, transferring the information automatically onto paper tape which can be fed directly into a

Measuring water stress in a cotton plant. A leaf is maintained at constant temperature in a spherical apparatus, and the relative humidity of the air in equilibrium with the leaf is then recorded.

computer. The computer is programmed to check the information for possible errors and to scale and correct it and write it on magnetic tape. This will make possible large-scale detailed analysis of water resources data, leading to advances in planning and design.

Constituent authorities of the Australian Water Resources Council have tested the prototype conversion unit and encouraged its commercial development. In addition to water resources data, the conversion unit has possible applications to such items as power station records, geophysical data from oil-well logs, micro-climatology research, star spectral analysis, soil profile data, tidal records, and other data recorded on strip charts.—*Division of Land Research and Regional Survey.*

Controlling Seepage from Farm Dams

Small farm dams constructed in Australia are usually built without close control of the water content of the soil or the degree of compaction and, in the absence of proper attention to these details, may fail through seepage or tunnelling. Simple tests have now been devised which group the soils according to the type of bonding between the particles of clay within them. One of the soil groups, for example, is identified in the field by the complete dispersion of dry crumbs of the soil when immersed in water. Such a soil, if used dry to form a dam wall, will lead to failure by tunnelling should the dam fill rapidly. Other groups of soils can be identified as needing special compaction or chemical treatments. The effectiveness of the tests has been extensively checked in the past five years, largely in cooperation with the Department of Agriculture, South Australia.—*Division of Soils.*

New Measurement of Plant Water Stress

Studies of the water economy of plants require a knowledge of the energy level of the water in the plants. Previously, plant–water stress could be measured directly only in detached parts of plants, but a technique has been developed whereby it is possible to make measurements on leaves that remain attached to plants. The leaf is enclosed in an apparatus in which the temperature is controlled, and the relative humidity of the air in equilibrium with the leaf is measured continuously. This is related directly to the plant water stress in the stem of the plant. The measurements are being used to study the uptake of water by plants when insufficient is available and the effect of water stress on plant growth.—*Irrigation Research Laboratory*.

Controlling Dangerous Water-tables in Rice Lands

The grey and brown soils of heavy texture in the Murrumbidgee Irrigation Areas are used for rice growing in a 5–7 year rotation with pasture. Permanent water-tables, which are somewhat saline, are now general and in some places lie at dangerously shallow depths. The movement of water within the soils is slow, making tile or deep ditch drainage uneconomic, and it is not practicable to pump from the underlying sand beds. The results of experiments over four years have shown that water-tables can be lowered by vegetative drainage. This is accomplished by adjusting cropping and management between rice crops to get the maximum water usage by plants and the minimum accumulation of water through irrigation or rainfall. Efficient irrigation is important in this. Rice soils crack deeply on drying and at the next irrigation lose much water directly to the water-table. The usual practice of infrequent heavy irrigations thus not only wastes water, but also contributes to water-table problems. Accurate grading of land will allow smaller increments of water to be applied sufficiently often to prevent cracking and to maintain growth. It is then possible, by following the rice crop immediately with wheat (which requires no further irrigation) and then sowing perennial pasture, to lower and stabilize water-tables more effectively than by the usual pasture rotation.—*Irrigation Research Laboratory*.

Wildlife

Various representatives of the wildlife of Australia are being studied by the *Division of Wildlife Research*, Canberra. The species investigated include those that are obviously pests, such as the rabbit, and those about whose true status there may be some doubt, such as kangaroos. Others are being studied on the basis of their importance to an industry, such as the mutton bird, or to meet our national obligation for their conservation as unique members of the Australian fauna, such as the lyre-bird. The work of the Division is directed at assessing the status and basic biology of the animals. Any successful programme of control or conservation of an animal must be based on a sound knowledge of its ecology and behaviour and on a thorough assessment of its true place in the economy.

Apart from work on the rabbit (see Pest Control), a large part of the Division's work is on various species of kangaroo, whose position is particularly complex. There are species that are undoubted pests in some places while in others they are potentially a valuable resource. Other species are in urgent need of conservation.

Current work is directed mainly at establishing the economics of the position of the two major species, the red and the grey kangaroo, and at the same time accumulating the basic knowledge on reproduction, movement, growth, and so on that will be needed if control or conservation is found to be necessary. Other species being investigated include foxes, dingoes, ravens, native hens, emus, and ibises.

Much of the work of the Division is in the field, remote from Canberra, and these investigations would be impossible without the assistance of individual landholders. The Division collaborates closely with the State authorities responsible for vermin control and fauna conservation and with the universities. It also joins with the Antarctic Division of the Department of External Affairs in conservation studies, particularly on Macquarie Island.

Banding a baby lyre-bird near Canberra.

The elephant seal is now fully re-established on Macquarie Island.

Antarctic Conservation Studies

Faunal surveys and population studies of birds and seals are being made in collaboration with the Antarctic Division, Department of External Affairs, and advice is being given on the measures being drafted by the Antarctic Treaty Powers for conservation of the living resources of the Antarctic region. The main field studies are located at Macquarie Island, where several species have been exterminated or greatly reduced in numbers during sealing operations.

The elephant seal, *Mirounga leonina*, was periodically decimated by indiscriminate killing throughout last century, but has regained its full numbers since sealing ceased in 1919. The self-contained population at Macquarie Island is now stable at about 110,000 individuals, and consists of 36,000 breeding cows, up to 4000 harem bulls, 35,000 pups weaned each year, and immatures. Banding of 7768 pups during 1951–64 has established details of the annual cycle and seasonal behaviour of each age and sex. Rational exploitation could be effected without depleting the capital stock by harvesting a high percentage of the fat newly weaned pups, taking more males than females.

The recolonization of Macquarie Island by the New Zealand fur seal, *Arctocephalus forsteri*, has been documented since 1948. The original population of several hundred thousand was exterminated in a few years after its discovery in 1810, but after an absence of well over a century almost 500 fur seals are now present and several pups have been born since 1955. This has provided an unusual opportunity to study a natural large-scale population increase until it reaches stability, and it emphasizes the conservation principle that a species can recover so long as its habitat and food supply remain unimpaired.—*Division of Wildlife Research.*

Wool Textiles

Despite the importance of wool to Australia, research on wool textiles was not commenced by CSIRO until 1949. At that stage, although large sums were being spent on synthetic fibres by other sectors of industry, mainly overseas, little work had been done on wool anywhere in the world. Early research in CSIRO was directed mainly at finding new ways to improve the efficiency of wool processing and to stimulate demand by conferring special qualities on wool. It quickly produced results, sometimes on a spectacular scale, such as the Siroset process for producing permanent crease effects in wool fabrics. Many other processes developed since 1949 are now in regular commercial use.

Wool textile research in CSIRO is carried out in the *Divisions of Protein Chemistry* (Melbourne), *Textile Physics* (Sydney), and *Textile Industry* (Geelong), known jointly as the CSIRO *Wool Research Laboratories*. Their work is financed partly by woolgrowers (about £400,000 in 1964/65) and partly by the Commonwealth government (about £800,000 in 1964/65) through allocations from the Australian Wool Board, advised by the Wool Textile Research Advisory Committee.

Integration of the research activities of the Divisions is maintained by the Wool Research Laboratories Committee, comprising the Chiefs of the Divisions, who also ensure that the resources of the Laboratories are employed on investigations directed in the best interests of the wool industry. Interchange of ideas between the three Divisions is, naturally, continuous.

The current research programme is aimed at obtaining a more complete knowledge of the chemical and physical structure of wool, developing improved properties in wool fabrics, and achieving higher efficiencies in the handling, measuring, and processing of wool. New uses for wool are being sought continuously. Of particular importance to the programme as a whole are the basic studies on the wool fibre. Information from these investigations is being used in work on problems such as improved methods of shrinkproofing, the causes and prevention of yellowing, and improvements in setting processes. Another valuable development arising directly from basic work, on the mode of action of formic acid on wool proteins, has been a greatly improved method of dyeing wool. Originally applied to the printing of names and small designs on wool fabric, it is now being developed for use in the dyeing of wool tops.

Recently, increased attention has been given to problems in handling the wool clip. Work on contamination by jute from the wool bale has led to vacuum-pressing techniques, and this work is being extended to include a detailed investigation of the dumping process.

Since a large proportion of Australia's wool is exported for processing overseas, it is important that the results of the work of the Laboratories should be promoted into the industry on a world basis. This is effected largely through the International Wool Secretariat. New processes are patented where this is necessary to assist their adoption by industry.

Within Australia, close contact is maintained with all sections of the wool textile industry. Detailed reports of developments are made direct to industry and are given publicity in publications of the Laboratories and in trade journals. In November 1964, a conference was held at the Division of Textile Industry with the Australian Association of Stud Merino Breeders. It provided an opportunity for sheep breeders to obtain detailed knowledge on the processing of wool and properties of the fibre that are important to the wool textile manufacturers. In October 1964 a colloquium on wool scouring was held. It was attended by some 120 representatives from industry, teaching and research organizations, the Australian Wool Board, and the International Wool Secretariat.

Work of particular interest during the current year includes the following items.

New Methods for Dyeing Wool

A new technique for dyeing wool has been developed which permits the use of lower temperatures and shorter times, thereby reducing damage to the fibre during dyeing. The new process is based on the observation that practically all types of dyes generally used on wool can penetrate the fibres and give level fast dyeings in slightly acid solutions below the boil if about 1% of a certain type of detergent is added; proprietary products of this type are cheap and readily available. Satisfactory dyeings can usually be obtained in about half an hour below the boil compared with well over an hour at the boil by the normal method. This method is being adopted by Australian mills where its obvious advantages have been rapidly realized.—*Division of Textile Industry.*

Shrinkproofing Wool

A method of shrinkproofing wool has been developed in which wool tops or carded sliver can be continuously treated. In mill trials, the treated wool is being spun and knitted and shrinkage assessment has been carried out on the final fabric. The degree of shrinkage reduction can be controlled by altering the temperature in the treatment solution where time of treatment is of the order of 20 seconds.

As the process does not harshen the wool, the method could have useful application in knitted and woven outerwear, particularly in garments where the handle of the wool is an important consideration.—*Division of Textile Industry.*

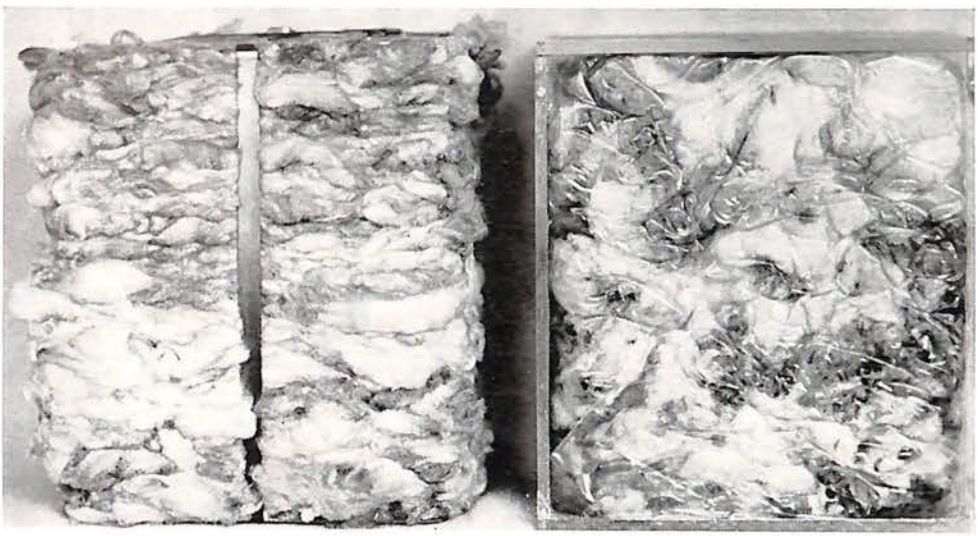
Yellowing of Wool

When wool is exposed to light, particularly light high in ultraviolet radiation, marked yellowing of the fibre can occur. Until recently it has been difficult to study the problem, as little information has been available on the chemical composition of the yellow substances formed. Like all proteins, wool proteins are long-chain polymers of amino acids and their chemical and physical properties are determined by the nature of the different amino-acid residues and the order in which they occur along the length of the molecule. About 20 different types of amino-acid residues occur in natural proteins, but until recently the only model compounds available for protein research have been synthetic polymers containing a single type of residue. Recently polymers containing known sequences of residues have been synthesized. It may now be possible to use these sequential amino-acid polymers to look further into the factors responsible for the yellowing of wool, particularly if specific sequences of amino-acid residues are involved, and to suggest ways in which yellowing can be prevented.—*Division of Protein Chemistry.*

Dumping Vacuum-pressed Wool

The vacuum-pressing method of packing wool was outlined in an earlier Report (1961–62). The wool is enclosed in an air-tight plastic bag and the air pumped out. Atmospheric pressure outside the bag compresses the wool into a rectangular block which can then be enclosed in a normal jute pack. When air is re-admitted to the plastic bag, a bale of normal appearance is obtained. The method is simple and was received with great interest both by the producer and by the wool handler, but in spite of its great promise there remained one serious drawback—wool packed by this method could not be dumped successfully.

All wool, before export, is dumped (or compressed) in a hydraulic press, and banded so that its volume is reduced by about one-third. Except for very heavy bales, normally pressed bales survive this process, but vacuum-pressed bales invariably burst. A study of wool in the bales showed that conventionally pressed wool is layered, because it is compressed in one direction only, whereas vacuum-pressed wool is randomly oriented by being compressed in all directions. When vacuum-pressed wool is dumped it expands sideways more than normally pressed wool and the bale bursts.



Model bales pressed by normal method (left) showing layering of wool and by vacuum method (right) showing random orientation of the fleeces.

This led to the conclusion that restraining the sides of the bale during dumping would successfully prevent bursting. Vacuum-pressed bales dumped in a suitably modified press have not burst; in fact, they have emerged more nearly rectangular in shape than conventionally dumped bales. Further, although only about half the normal force was applied in the experimental dump, the shipping volume of the dumped bales was appreciably smaller than normal.—*Division of Protein Chemistry.*

Formic Acid Dyeing Process

Since the original discovery in 1961 that wool takes up suitable dyes rapidly from formic acid solutions, work on possible applications has proceeded in two directions.

A process for the rapid printing of wool has been developed and passed over to the trade. It has a number of advantages over other processes, including greater simplicity of equipment.

In conjunction with the Division of Chemical Engineering, a machine has been developed for a continuous process for dyeing tops. The dyeing is achieved in a 75% formic acid solution at 50°C and the new process is complete in 4 minutes. After dyeing, the wool must be washed and dried, and equipment for this is now being built and tested.—*Division of Protein Chemistry.*

Measurement of Regain of Wool

Knowledge of the moisture content, or regain, of wool is of great importance both in commercial transactions and in manufacturing processes, and an instrument that will indicate regain quickly and accurately under industrial conditions is needed. A type of balance known as the CSIRO Direct Reading Regain Tester has been developed and patented. The theory of balances of this type has now been fully worked out. Other industrial uses could follow in addition to the Regain Tester, for which sales in Australia and overseas now approach 200.

Immediately after drying, the sample is hot (105°C), and for its weight to be measured accurately it must either be allowed time to cool in a sealed enclosure or be weighed in an expensive and bulky enclosure uniformly heated to the same temperature as itself. An analysis has been made of the causes of error when weighing a hot sample in the open. Correction factors have been worked out to allow true weight to be determined to 0·1%, a quite sufficient accuracy. In the CSIRO Direct Reading Regain Tester the correction factors are now incorporated automatically in the regain indication.—*Division of Textile Physics.*

Patents aid Promotion of Wool Use

Recently the International Wool Secretariat accepted the responsibility for promoting the industrial use of new wool textile processes developed by CSIRO, under conditions that will lead to the maximum benefit for the Australian wool industry. The Secretariat has formed a non-profit company, International Wool Development Company Pty. Ltd., to hold patents and trade marks that are being used as promotional aids for wool. CSIRO has agreed to transfer to this company control of the overseas patents and trade marks relating to the Siroset process for permanent pleating and a general agreement is being negotiated with the company to cover future research developments to further the objectives towards which the CSIRO wool textile research programme is directed.

3

Services and Publications

THE RESULTS of research in CSIRO become accessible to other scientists through publication in scientific journals and each year form a substantial contribution to world science. This in itself is not enough and it is of major importance to Australia that new knowledge available as the result of the Organization's work should become known to industry and be used to maximum benefit as rapidly as possible. In the agricultural industries there is usually much work to be done before the practical significance of research results can be assessed and advice to the producer formulated on a regional or local basis. For this purpose the States have set up departments concerned with research and advisory services. In the secondary industries no such service is available, nor would it be practicable, and each enterprise is usually dependent on its own technical staff to assess the significance of new developments in relation to its activities. In the absence of such technical staff, any effort aimed at communicating the results of research to industry must be largely ineffective.

In the circumstances, the measures taken by CSIRO to secure the application of the results of its research are many and varied, and are largely dictated by the capabilities of the industry concerned. In the sphere of the primary industries the Organization maintains active programmes of liaison work to aid the interchange of scientific information between its Divisions and Sections and the State agricultural research and extension services. Other means are used to encourage the rapid distribution of research results to secondary industry. Where appropriate, applications are made for patents covering discoveries arising from CSIRO research, essentially as an aid to their adoption by industry. To bring new information from research for the secondary industries to the attention of those who might use it, many Divisions maintain advisory services and issue publications describing new developments and discussing possible applications. The publications range from detailed technical reports to periodicals designed to keep readers informed on the work of the laboratories. The Organization's extensive holdings of library material are made available to both research and industrial users. Instructional films are produced to demonstrate new processes and, in some cases, to assist in the training of operators.

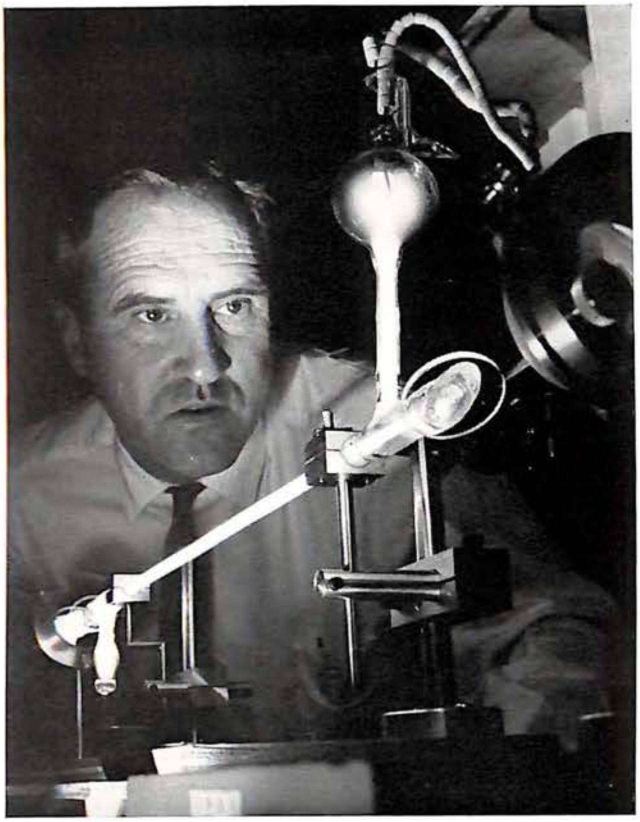
Agricultural Liaison Activities

CSIRO does not undertake agricultural extension work of its own accord but makes the results of its work available to the State government authorities. The research and extension staffs of these authorities use their detailed knowledge of local problems to assist producers to make the most effective use of information arising from their own and CSIRO research as well as from research in universities and overseas. Contact with the State authorities is maintained in a variety of ways, prominent among them being the use of liaison publications (see page 106). The quarterly, "Rural Research in CSIRO", now has a circulation of about 25,000 copies.

Technical conferences are a valuable means of interchange of scientific information between research workers, extension workers, and representatives of industries. Such conferences are organized by CSIRO usually on behalf of the Australian Agricultural Council, and those arranged during the past year covered the following areas of research activity: plant nutrition; vermin control; tobacco; fruit and vegetable storage.

In addition, seminars and other specialist meetings arranged by CSIRO laboratories are attended by State extension and research staff. Field days and demonstrations are organized in collaboration with local Department groups, while less formal links include interchange of staff, joint use of laboratory and field facilities, and personal discussions. Several agricultural industries are now making large contributions to support CSIRO research, and the committees associated with the use of these funds are providing a valuable link with producers.

As part of the J. D. Stewart refresher course on "Infertility in Sheep" organized by the Post-Graduate Committee for Veterinary Science at the University of Sydney, more than 30 veterinary surgeons took part in talks at the Division of Animal Physiology's Ian Clunies Ross Animal Research Laboratory at Prospect in March 1965. Participants in the course included property owners, private practitioners, State Department of Agriculture officers, and university staff from four States. Dr. B. A. Panaretto, of the Division of Animal Physiology, is shown here with a group of the visiting veterinary surgeons in the operating theatre of the Ian Clunies Ross Laboratory.



A continuous-wave helium–neon laser developed by the Division of Physics in collaboration with an Australian company which is now marketing the laser.

Contact with Secondary Industry

Those Divisions which are associated directly with an industry naturally maintain close contact with the firms concerned. Even closer collaboration is achieved through sponsorship of investigations in CSIRO laboratories by firms or associations, where provision is made for regular exchange of information. Active information and advisory services are maintained, and in one Division the inquiries handled exceed 12,000 a year. Other laboratories are concerned with a branch of science rather than with a particular industry, and their work therefore spreads over the interests of a range of industries. These also provide advice and assist in development, for example in the commercial production of instruments and devices developed in the laboratories.

The facilities of many CSIRO laboratories are used to provide specialized services to industry and other scientific institutions. The National Standards Laboratory, which maintains Australia's standards of measurement, undertakes calibrations of working standards where a high level of precision is necessary and the required facilities are not available elsewhere. It also undertakes tests on instruments and materials in fields for which its special equipment is necessary. The microanalytical services sponsored by the Division of Organic Chemistry and the University of Melbourne are available not only to other CSIRO laboratories but also to chemists in university and industrial laboratories. The Division of Chemical Engineering makes an extensive range of chemical process equipment available to firms that wish to undertake pilot experiments or to produce small quantities of special chemicals as part of their development programmes.

Patents

CSIRO uses patents primarily as an aid to the industrial application of its research results and patents are taken out and licensed in whatever way will lead to the most effective application of its inventions. Most CSIRO patent applications are sought under one of the following five aspects of public interest:

(1) When there is a danger that others may obtain patents covering the Organization's research results.

(2) When it is desirable for the Organization to maintain some measure of control over the quality and technical efficiency of production.

(3) When it is likely that an invention will not be developed and exploited commercially unless covered by a patent.

(4) Where an invention may assist in maintaining or extending the use of Australian products overseas.

(5) Where substantial royalties may be earned, especially from industry overseas.

Too much stress should not be placed on income from royalties overseas. For Australia to receive the maximum return from CSIRO research, this research must be applied in Australian industry. A wide range of benefits can follow, including improvements in efficiency of production, a stronger position on competitive export markets, increased employment, larger-scale production, lower manufacturing costs, reduction of imports, and so on. By comparison, the returns obtained from overseas patent licensing are generally of a much lower order.

A major obstacle to be overcome is the inability of a large section of Australian industry to handle its own development work. While there may be some need to take development further in CSIRO, this cannot be a complete answer to the problem. It happens too often that overseas industry is the first to apply CSIRO research results that, were it not for the problems of local industry, might have been applied to greater benefit in Australia.

For these reasons CSIRO has consistently supported proposals aimed at strengthening the research and development effort of Australian industry. In many overseas countries, notably Britain, Canada, the United States of America, and Japan, government incentives for research by industry play an important part in stimulating improved technology. Among such incentives are substantial tax remissions for industry's research and development expenditure, research and development contracts placed by government with industry, and cost sharing of promising research projects in industrial laboratories.

Specific instances of benefits arising from patented processes are to be found in Chapter 2 of this Report. A list of patents granted in Australia and overseas during 1964 is given below.

Division of Applied Mineralogy

Walker, G. F.—Carbon-silicate complexes. Aust. Pat. 248,015. Brit. Pat. 947,123.

Williams, L. S.—Improvements in or relating to compacts and seals. Aust. Pat. 247,495. Brit. Pat. 955,675.

Williams, L. S., and Garrett, W. G.—Production of articles of ceramic ware from magnesium oxide. U.S. Pat. 3,133,134.

Division of Biochemistry and General Nutrition

Marston, H. R.—Cobalt pellets. Argent. Pat. 138,794. Germ. Pat. 1,164,813. Braz. Pat. 70,067.

Division of Building Research

Hoffman, E., and Saracz, A.—Treatment of plaster products to increase their water resistance. Aust. Pat. 248,381.

Ridge, M. J., and Hoffman, E.—Water-resistant plaster products. Aust. Pat. 249,423.

Division of Chemical Engineering

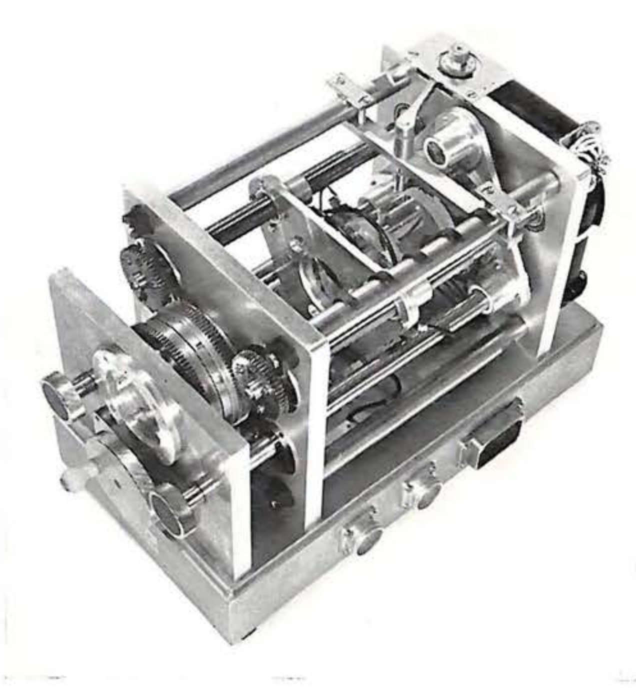
Kelsall, D. F.—Cyclone elutriator. Can. Pat. 689,275. Germ. Pat. 1,160,381. Aust. Pat. 250,915.

Division of Chemical Physics

Walsh, A., and Jones, W. G.—Improvements in or relating to atomic spectral lamps. U.S. Pat. 3,089,054.

Division of Coal Research

Brooks, J. D., and Harrison, R. J.—Method and apparatus for treatment of organic compounds. Aust. Pat. 250,126.



General view of the automatically controlled interferometer made by an Australian company under licence from CSIRO. The control console is not shown.

Division of Dairy Research

Czulak, J.—Apparatus for adding one substance to another in controlled proportions. Aust. Pat. 248,181. Brit. Pat. 954,503.

Czulak, J.—Improved method and apparatus for manufacturing Cheddar, Cheshire or like cheese. Sth. Afr. Pat. 63/1321.

Czulak, J., and Freeman, N. J.—Improved press. U.S. Pat. 3,133,492.

Division of Forest Products

Johanson, R., and Tamblyn, N. E.—Dry-mix preparation for the preservation of timber. Aust. Pat. 246,298. N.Z. Pat. 128,723.

Division of Mechanical Engineering

Griffiths, H. J.—A method of and means for measuring temperatures at a plurality of positions in material in bulk storages. Aust. Pat. 244,951.

Kalecki, E.—Silencing of reciprocating compressors. Aust. Pat. 250,447.

Kalecki, E., and Morse, R. N.—Radiant cooling method and apparatus. Aust. Pat. 250,840.

Riordan, R. H. S.—Improvements in and relating to noise elimination in telemetry receivers. Brit. Pat. 952,198.

Riordan, R. H. S.—Proximity relay. Aust. Pat. 249,580.

Division of Mineral Chemistry

Scott, T. R.—Improvements in and relating to the production of alumina. Certificate of Registration Brit. Honduras (no number given). N.Z. Pat. 124,342. Argent. Pat. 136,699. Moroc. Pat. 11,233.

Division of Plant Industry

Dudman, W. F.—Sorbic acid derivatives. Belg. Pat. 624,535. French Pat. 1,332,149. Sth. Afr. Pat. 62/2217. Norw. Pat. 104,199. Portug. Pat. 39,692.

Division of Protein Chemistry

Garrow, C.—Method and apparatus for pressing materials having entrained fluids. French Pat. 1,327,946. Peruv. Pat. 6631.

Tugen, R. G.—Moulded felt and the manufacture thereof. Can. Pat. 693,946. U.S. Pat. 3,148,435.

Division of Textile Physics

Burgmann, V. D., and Baird, K.—Apparatus for measuring the relaxation shrinkage of textile fabrics and similar materials. Jap. Pat. 428,928.

Roberts, N. F.—Pressure coring devices. Aust. Pat. 245,370.

Division of Textile Industry

Knothe, W. E. O.—Apparatus for transferring fibrous material. French Pat. 1,341,671. U.S. Pat. 3,134,482.

Morgan, W. V.—Method and apparatus for the removal of burrs and other foreign matter from fibres. French Pat. 1,333,355.

Walsh, J., and Sinclair, J. F.—Method and apparatus for forming a substantially uniform layer of textile fibres. Germ. Pat. 1,152,922.

Publications for Industry

In view of the importance of securing rapid and effective application in industry of the results of research, a wide range of publications is prepared directly for industry use. Several Divisions issue regular newsletters covering developments within their sphere of interest, while *CSIRO Industrial Research News* and *Rural Research in CSIRO* cover the work of the Organization on a broader scale. In addition, many reports are issued in printed or roneoed form to give industry the information necessary for technical assessment of new developments.

A list of publications issued in 1964–65 specifically for industry is appended.

Division of Building Research

Building Information: A Review of the Current Literature on Building for the Designer, Manufacturer and User. Nos. 1–2 (1964).

Fibrous Plaster Research Notes. No. 10 (1964).

Ready Research References. No. 3 (1964)–No. 7 (1965).

Tropical Building Research Notes. No. 4 (1964)–No. 9 (1965).

CSIRO Division of Building Research Open Days (1965).

Technical Papers

13. The tensile strength of bituminous roofing fabrics. K. G. Martin. (1964.)
14. Calculation of solar positions for building purposes. J. W. Spencer. (1965.)
15. Estimation of solar radiation in Australasian localities on clear days. J. W. Spencer. (1965.)

Division of Coal Research

Coal Research in CSIRO. No. 23 (1964)–No. 26 (1965).

Technical Communication

47. The analysis of bituminous and brown-coal ashes and related materials (some recent developments and a comparison of revised CSIRO and B.S. procedures). R. A. Durie, H. N. S. Schafer, and D. J. Swaine. (1965.)

Open Days are an effective means of demonstrating the range of activities of a laboratory. The Division of Building Research held Open Days on March 24 and 25, 1965. The exhibits covered a number of fields, including acoustics, bituminous materials, building operations and economics, ceramics, concrete, fibrous plaster, glass, gypsum, joints and sealants, masonry, mineralogy and crystallography, mortar, paint, solar radiation, stone, surfacing materials, thermal investigations, and tropical building research.

The Rt. Hon. the Lord Casey addressed visitors on the opening day. The dais was specially designed and built to demonstrate that advances in technology through research can extend and enlarge the uses of everyday materials. The concrete blocks in the walls are glued together with epoxy resin instead of being laid in mortar. The cantilevered folded plate roof is in autoclaved asbestos cement.

Division of Dairy Research

The Manufacture and Packaging of Rindless Cheese for Export. J. Conochie. (1964.)

Division of Entomology

Technical Paper

6. Notes on the screw-worm fly, *Chrysomya bezziana* (Diptera: Calliphoridae) as a pest of cattle in New Guinea. K. R. Norris and M. D. Murray. (1964.)

Division of Fisheries and Oceanography

Technical Paper

18. Techniques for measuring oceanic primary production using radioactive carbon. N. Dyson, H. R. Jitts, and B. D. Scott. (1965.)

Reports

38. Australian whaling 1963—catch results and research. J. L. Bannister. (1964.)
39. F.R.V. "Derwent Hunter"—scientific reports of cruises 1950–56. (1965.)

Division of Food Preservation

CSIRO Food Preservation Quarterly. Vol. 24 (1964).
Foodpres News. No. 10 (1964)–No. 12 (1965).

Division of Forest Products

Forest Products Newsletter. No. 309 (1964)–No. 319 (1965).

Technological Papers

31. Geometrical determination of lateral back bevel angle (top bevel angle) for circular saws. R. L. Cowling. (1964.)
32. The strength of Australian pole timbers. IV. Radiata pine poles. J. D. Boyd. (1964.)
33. The mechanical properties of King William pine. E. Bolza. (1964.)
34. Minimum strength and stiffness necessary for wooden floors in houses. J. D. Boyd, with an Appendix by N. H. Kloot. (1964.)
35. The establishment of working stresses for groups of species. R. G. Pearson. (1965.)

Irrigation Research Laboratory

Australian Needs in Irrigation—Proceedings of the Two-day Conference held at CSIRO Irrigation Research Laboratory, Griffith, N.S.W., on 2nd–3rd June, 1964. (1965.)

Division of Land Research and Regional Survey

Technical Paper

25. Arable crop variety trials at Katherine, N.T., 1957–63. L. J. Phillips and M. J. T. Norman. (1964.)

Land Research Series

9. General report on lands of the West Kimberley area, W.A. N. H. Speck, R. L. Wright, G. K. Rutherford, K. Fitzgerald, F. Thomas, Jennifer F. Arnold, J. J. Basinski, E. A. Fitzpatrick, M. Lazarides, and R. A. Perry. (1964.)
10. General report on lands of the Buna–Kokoda area, Territory of Papua and New Guinea. H. A. Haantjens, S. J. Paterson, B. W. Taylor, R. O. Slatyer, G. A. Stewart, and P. Green. (1964.)
11. General report on lands of the Leichhardt–Gilbert area, Queensland, 1953–54. R. A. Perry, J. R. Sleeman, C. R. Twidale, C. E. Pritchard, R. O. Slatyer, M. Lazarides, and F. Collins. (1964.)
12. General report on lands of the Wanigela–Cape Vogel area, Territory of Papua and New Guinea. H. A. Haantjens, E. A. Fitzpatrick, B. W. Taylor, and J. C. Saunders. (1964.)

13. General report on lands of the Tipperary area, Northern Territory, 1961. N. H. Speck, R. L. Wright, R. H. M. van de Graaff, E. A. Fitzpatrick, J. A. Mabbutt, and G. A. Stewart. (1965.)
14. Lands of the Port Moresby–Kairuku area, Territory of Papua and New Guinea. J. A. Mabbutt, J. R. McAlpine, and E. A. Fitzpatrick. (1965.)

Division of Mechanical Engineering

Circular

2. Solar water heaters—principles of design, construction, and installation. (1964.)

Engineering Development (E.D.) Report

8. Bulk storage of grain—A summary of factors governing control of deterioration. H. J. Griffiths. (1964.)

National Standards Laboratory

Test Pamphlet

3. Tests and measurements: electricity and magnetism. (1965.)

Technical Papers

19. A survey of fundamental aspects of the drilling process. R. A. Williams and A. V. Gibson. (1964.)
20. Tool-life exponents in the light of regression analysis. R. T. Leslie and G. Lorenz. (1964.)
21. Vibration isolation. J. A. Macinante. (1964.)

Division of Physical Chemistry

Prototype survival tent for forest firefighters. A. R. King. (1965.)

Division of Plant Industry

Field Station Record. Vol. 3 (1964).
Plant Introduction Review. Vol. 1, No. 3 (1964); Vol. 2, No. 1 (1965).

Division of Radiophysics

Radiophysics Laboratory, CSIRO, Sydney, Australia. (1964.)

Division of Soils

Soil Publications

21. The soils of the central portion of the New England region, New South Wales. R. W. Jessup. (1965.)
22. Soil development associated with stranded beach ridges in south-east South Australia. G. Blackburn, R. D. Bond, and A. R. P. Clarke. (1965.)

Soils and Land Use Series

45. The soils of Counties Macdonnell and Robe, South Australia. G. Blackburn. (1964.)
46. Soils and land use in the Dorrigo–Ebor–Tyringham area, New South Wales. W. M. McArthur. (1964.)
47. Soils of portion of the Coleambally Irrigation Area, New South Wales. D. C. van Dijk and T. Talsma. (1964.)

Soil Mechanics Section

Technical Report

4. Some chemical aspects of a small-scale field trial of lime stabilization. O. G. Ingles. (1964.)

Division of Tropical Pastures

Technical Papers

2. Chromosome numbers in some introduced and indigenous legumes and grasses. A. J. Pritchard and K. F. Gould. (1964.)
3. Frost and low night temperatures as limitations to pasture development in subtropical eastern Australia. R. G. Coleman. (1964.)

Division of Wildlife Research

CSIRO Wildlife Research. Vol. 9 (1964).

Technical Papers

6. A natural history reconnaissance of Barrow and Montebello Islands, 1958. D. L. Serventy and A. J. Marshall. (1964.)
7. Ninth annual report of the Australian bird-banding scheme, July 1962 to June 1963. W. B. Hitchcock. (1964.)
8. The use of mist nets in Australia. S. J. Wilson, S. G. Lane, and J. C. McKean. (1965.)

Wool Research Laboratories

CSIRO Wool Textile News. No. 6 (1964)–No. 8 (1965).

Liaison Publications

CSIRO Industrial Research News. No. 46 (1964)–No. 51 (1965).
Rural Research in CSIRO. No. 47 (1964)–No. 51 (1965).
CSIRO Research Index 1964—Agriculture and Related Sciences. (1964.)
A Manual of Techniques. Field Investigations with Sheep. G. R. Moule. (1965.)
Australian Weeds Conference Handbook. (1965.)
CSIRO Cunningham and Townsville Laboratories. (1965.)
CSIRO and Engineering in Industry. (1964.)

Miscellaneous

Scientific Serials in Australian Libraries. (1964, 1965.)
Australian Science Index. Vols. 8–9. (1964, 1965.)
Scientific and Technical Research Centres in Australia. (1964.)
List of Publications. (1965.)
CSIRO Abstracts. Vols. 12–13. (1964, 1965.)
CSIRO Divisions and Sections. (1965.)
CSIRO 210 Foot Radio Telescope. (1964.)
CSIRO Film Productions. (1964.)
CSIRO Research for Australia. (1965.)

Libraries

The CSIRO library system is based on a large number of decentralized specialist working collections located in the various centres of research and made effective by a range of centralized service activities undertaken by the Central Library at Head Office. Together these libraries make up by far the most comprehensive collection of scientific and technical material in Australia. Current expenditure on libraries throughout the Organization is of the order of £300,000 annually.

The Central Library's functions lie mainly in obtaining library material and in making it readily accessible to users both within CSIRO and in universities and industry. The Organization's *Scientific Serials in Australian Libraries* covers all libraries in Australia and, almost uniquely amongst the world's union catalogues of this nature, is kept up to date so that new acquisitions are recorded at most within a few months.

CSIRO libraries, in common with other scientific libraries, face increasing problems of housing the great quantities of information required by research workers. The increased holdings of the various libraries have made urgent the exploration of means to conserve space. The deposit collection of less-used and non-specific material held by the Central Library on behalf of the working collections is growing rapidly and a substantial additional area of building for its storage and management will soon be required. Even more important is the problem of ensuring that the material is readily available. In a number of overseas countries this problem is at present being tackled by using automated systems of documentation. There are at present between 50 and 60 different systems in use but sufficient experience with them has not yet been obtained to demonstrate conclusively their real effectiveness. Work on these systems has largely been concentrated on storage and retrieval problems, but research has already shown that, in addition, the mechanization of reading, of abstracting, and of coding may also be achieved. In CSIRO a committee of senior librarians and the senior librarian of the Weapons Research Establishment of the Department of Supply are examining mechanization systems and working towards the application of procedures suited to the Organization's needs. The material received by CSIRO by subscription, gift, and exchange from overseas institutions has now been listed and entered into the computer system, as a first step towards making computer-based comparisons with the large overseas catalogues and union lists.

The library service both within and outside CSIRO has continued to increase and loans from the Central Library alone now average more than 1000 a week. Exchange arrangements have been extended and many of the gaps in the Australian scientific and technical periodical holdings have been filled. As a result, many inquiries which previously had to be referred overseas can now be dealt with in Australia with a minimum of delay.

Many of the publications held in the libraries are in foreign languages, and written and oral translations are undertaken by staff located in centres in Melbourne, Canberra, Sydney, and Adelaide. The Organization also acts as the Australian depository for the *Commonwealth Index of Translations* of the Commonwealth Scientific Office, supplying details of translations on request.

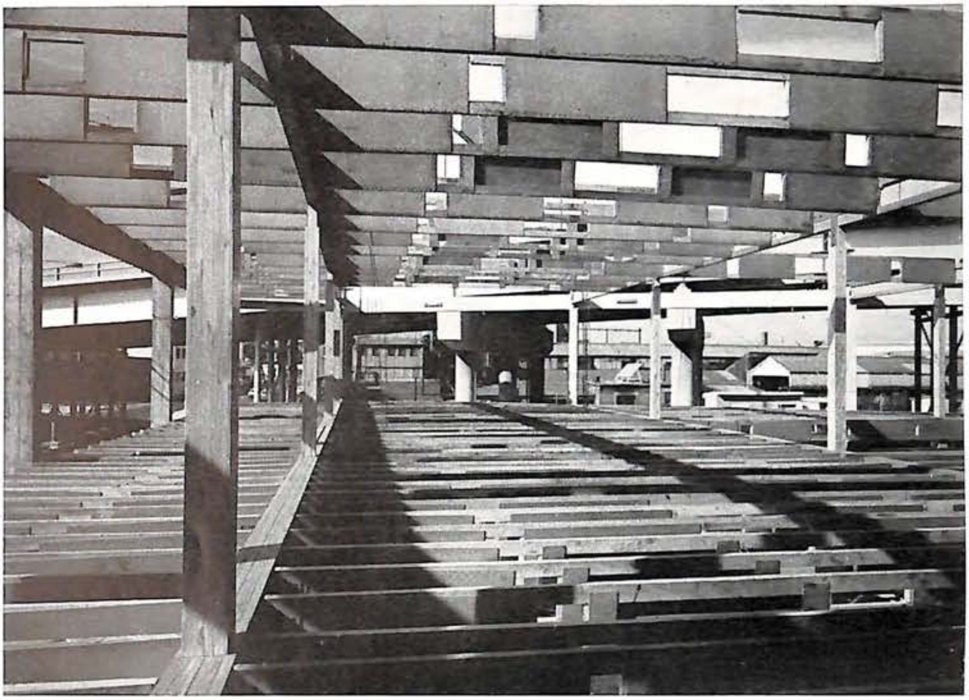
Towards the end of 1964 a revised edition of *Scientific and Technical Research Centres in Australia* was published. The demand for this booklet has been heavy and already another revision is in course of preparation.

The first four sections of *CSIRO Published Papers* (Author index) have been completed, but copies are available to CSIRO libraries only.

In January 1965, entries for monographs in the Central Library *Union Catalogue* were photographed by the National Library for inclusion in the *Retrospective Union Catalogue of Monographs.*

Films

CSIRO maintains a Film Unit which produces 16-mm scientific films for a variety of purposes. In the past, films have been largely directed at specialist audiences for educational purposes, as an aid to communication between scientists, or for extension purposes. Many of these films have found use in television programmes, and recently there has been some movement towards the production of films specifically for use on television.



A still from the film "An Engineered Timber Building" made by the CSIRO Film Unit. The construction of a new laboratory for the Division of Forest Products in Yarra Bank Road, South Melbourne, provided an opportunity of demonstrating the use of modern design in light-weight timber construction. The columns and main beams of the building are laminated mountain ash and radiata pine, while the flooring joists which span 24 feet are of green hardwood flanges and hardboard webs.

Although the Film Unit is small, with an annual expenditure on film production of only £22,000, it consistently achieves recognition for the quality of its productions. During the year under review the film "Approach to Science" won an award in the teaching section of the 1965 Australian Film Award competition, and this film and several others have been selected for showing at international scientific film exhibitions.

Films are distributed to CSIRO Film Libraries in Melbourne, London, and Washington, and the National Film Library in Canberra. Prints are made available to State Film Centres throughout Australia on a half-cost basis, and to other approved users at the net cost of printing. Distribution of some films is also undertaken in the U.S.A. and Britain by a commercial distributor on a royalty basis.

Television stations continue to make use of CSIRO films in rural and educational programmes. The Australian Broadcasting Commission used excerpts of four films in programmes "For Schools" and others were included in the University of the Air series on "Conservation". In addition, 20 films were transmitted in their entirety over commercial television networks.

The indexed catalogue of film productions has been brought up to date and re-issued under the title *CSIRO Film Productions 1964.*

The following films were completed during the year:

"*Approach to Science*"—16 mm, colour, sound, screening time 30 min.

Dedicated to the memory of Sir Ian Clunies Ross, this film shows the importance to scientists of a sound basic training, an inquiring mind, a lively imagination, and a painstaking capacity to examine and sift evidence. Two examples of scientific endeavour are used to illustrate the points: a post-graduate research student studying superconductivity in metal crystals and a research scientist tackling the practical problem of man's survival in bush fires. The film was made in cooperation with the Physics Department of Monash University and the CSIRO Officers' Association.

"*The Computer CSIRAC*"—16 mm, black and white, sound, screening time 15 min.

A scientific record film of the world's earliest automatic, electronic, digital computer, made just before it was transferred from the University of Melbourne to the Applied Science Section of the National Museum in Melbourne.

"*An Engineered Timber Building*"—16 mm, colour, sound, screening time 10 min.

This film demonstrates the versatility of timber in the construction of large buildings, using for an example the construction of a new laboratory for the Division of Forest Products. It was sponsored by the Timber Development Association of Australia.

"*Window into Space—The Parkes Radio Telescope*"—16 mm, colour, sound, screening time 20 min.

The giant radio telescope at Parkes in New South Wales is one of the most efficient in the world. The film explains how this telescope works and the contribution it is making to the science of radio astronomy.

Scientific Journals

The publication of the results of research in scientific journals is an essential feature of the exchange of information between scientists whereby advances in knowledge anywhere in the world become available for application elsewhere. CSIRO publishes a series of scientific journals, the Australian Academy of Science cooperating with the Organization in maintaining high standards. Editorial policy is decided by a Board of Standards appointed jointly by the Academy and CSIRO. Advisory Committees are appointed by the Board for each individual journal and members of the Board serve on the appropriate journal committees.

The journals published by the Organization are: *Australian Journal of Agricultural Research*, *Australian Journal of Biological Sciences*, *Australian Journal of Botany*, *Australian Journal of Chemistry*, *Australian Journal of Marine and Freshwater Research*, *Australian Journal of Physics*, *Australian Journal of Soil Research*, and *Australian Journal of Zoology*.

Publication of the *Australian Journal of Applied Science* has been discontinued as from the December 1964 issue. There is no longer a need for this journal, as most of the material suitable for it is now being published in other specialist journals.

Contributions to these journals are not limited to the staff of CSIRO but are accepted from research workers irrespective of their affiliations. Many papers by university staff are published and a small number is received from overseas workers. CSIRO officers also contribute many research papers to other scientific journals, both in Australia and overseas.

CSIRO also publishes research results in technical papers and other special publications (see "Publications for Industry").

Published Papers

The following papers were published during the year ended December 31, 1964.

ANIMAL RESEARCH LABORATORIES

DIVISION OF ANIMAL GENETICS

ALLEN, T. E., BENNETT, J. W.,[1] DONEGAN, SUSAN M., and HUTCHINSON, J. T. D.[1]—Moisture in the coats of sweating cattle. *Proc. Aust. Soc. Anim. Prod.*, 1964, **5**, 167.

ASHTON, G. C.[2]—Serum albumin polymorphism in cattle. *Genetics*, 1964, **50**, 1421.

ASHTON, G. C.,[2] FALLON, G. R.,[3] and SUTHERLAND, D. N.[4]—Transferrin (β-globulin) type and butterfat production in dairy cows. *J. Agric. Sci.*, 1964, **62**, 27.

BARKER, J. S. F.,[5] and NAY, T.—A study of sweat gland characters and their relationships to adaptation in Jersey cattle. *Proc. Aust. Soc. Anim. Prod.*, 1964, **5**, 173.

BOBR, L. W., LORENZ, F. W., and OGASAWARA, F. X.—Distribution of spermatozoa in the oviduct and fertility in domestic birds. I. Resident sites of spermatozoa in oviducts of fertile fowl. *J. Reprod. Fert.*, 1964, **8**, 39.

BOBR, L. W., LORENZ, F. W., and OGASAWARA, F. X.—Distribution of spermatozoa in the oviduct and fertility in domestic birds. II. Resident sites of spermatozoa in oviducts of fertile fowl. *J. Reprod. Fert.*, 1964, **8**, 49.

DOLLING, C. H. S., and BROOKER, M. C.—Cryptorchism in Australian Merino sheep. *Nature, Lond.*, 1964, **203**, 49.

DUNLOP, A. A., and TALLIS, G. M.[6]—The effects of length of oestrus and number of inseminations on the fertility and twinning rate of the Merino ewe. *Aust. J. Agric. Res.*, 1964, **15**, 282.

GRIGG, G. W.—Efficiency of sperm transport and fertility. *Nature, Lond.*, 1964, **201**, 570.

GRIGG, G. W.—Observations on competitive suppression in bacteria. *Microb. Genet. Bull.*, 1964, **21**, 6.

GRIGG, G. W.—Radiation-induced reversion of transition mutants. *Aust. J. Biol. Sci.*, 1964, **17**, 907.

GRIGG, G. W.—The detection of small mutagenic effects in the presence of high background frequencies of prototrophics. *Microb. Genet. Bull.*, 1964, **21**, 8.

HAYMAN, R. H.—The exercise of mating preference by a Merino ram. *Nature, Lond.*, 1964, **203**, 160.

HAYMAN, R. H., and COOPER, D. W.—The inheritance of black pigmentation in a family of inbred Peppin Merinos. *Aust. J. Agric. Res.*, 1964, **15**, 453.

HAYMAN, R. H., and TRIFFITT, L. K.—Eradication of footrot from flocks of experimental sheep. *Aust. Vet. J.*, 1964, **40**, 300.

KINDRED, B. M.—Effects of genotype on radiosensitivity of vibrissae. *Radiat. Res.*, 1964, **22**, 703.

MORRIS, J. A.—Estimates of genetic parameters relevant in selection for certain aspects of egg quality. *Aust. J. Agric. Res.*, 1964, **15**, 719.

MYKYTOWYCZ, R.,[7] and NAY, T.—Studies of the cutaneous glands and hair follicles of some species of Macropodidae. *CSIRO Wildl. Res.*, 1964, **9**, 200.

NAY, T., and JENKINSON, D. MCE.—Skin structure and milk production of British dairy cattle. *J. Dairy Res.*, 1964, **31**, 53.

PAN, Y. S.—Variation in hair characters over the body in Sahiwal, Zebu, and Jersey cattle. *Aust. J. Agric. Res.*, 1964, **15**, 346.

PENNYCUIK, PAMELA R.—The effect on rats of chronic exposure to 34°C. I. Dietary requirements for growth and survival of young. *Aust. J. Biol. Sci.*, 1964, **17**, 208.

[1] Division of Animal Physiology, CSIRO.
[2] Present address: Department of Genetics, University of Hawaii, Honolulu.
[3] Veterinary School, University of Queensland.
[4] Queensland Department of Agriculture and Stock, Brisbane.
[5] Department of Animal Husbandry, University of Sydney.
[6] Division of Mathematical Statistics, CSIRO.
[7] Division of Wildlife Research, CSIRO.

PENNYCUIK, PAMELA R.—The effect on rats of chronic exposure to 34°C. II. Growth. *Aust. J. Biol. Sci.*, 1964, **17**, 220.

PENNYCUIK, PAMELA R.—The effect on rats of chronic exposure to 34°C. III. Appetite and the efficiency of food conversion. *Aust. J. Biol. Sci.*, 1964, **17**, 236.

PENNYCUIK, PAMELA R.—The effect on rats of chronic exposure to 34°C. IV. Reproduction. *Aust. J. Biol. Sci.*, 1964, **17**, 245.

PENNYCUIK, PAMELA R., and FRASER, A. S.[8]—Variation in scutellar bristle number in *Drosophila*. II. Effects of temperature. *Aust. J. Biol. Sci.*, 1964, **17**, 764.

SHELDON, B. L., and BARKER, J. S. F.[5]—The effect of temperature during development on mutation in *Drosophila melanogaster*. *Mutat. Res.*, 1964, **1**, 310.

SHELDON, B. L., RENDEL, J. M., and FINLAY, D. E.—The effect of homozygosity on developmental stability. *Genetics*, 1964, **49**, 471.

TALLIS, G. M.,[6] TURNER, HELEN NEWTON, and BROWN, G.—The relationship between live measurements and edible meat in Merino wethers. *Aust. J. Agric. Res.*, 1964, **15**, 446.

TURNER, H. G.—Coat characters of cattle in relation to adaptation. *Proc. Aust. Soc. Anim. Prod.*, 1964, **5**, 181.

TURNER, HELEN NEWTON.—Relationships between important characteristics in the Australian Merino. *Wool Technol. Sheep Breed.*, 1964, **11**, 95.

TURNER, HELEN NEWTON.—The role of genetics in animal production. *Proc. Aust. Soc. Anim. Prod.*, 1964, **5**, 21.

YOUNG, S. S. Y.—Multi-stage selection for genetic gain. *Heredity, Lond.*, 1964, **19**(I), 131.

DIVISION OF ANIMAL HEALTH

ADLER, H. E.,[1] and ETHERIDGE, J. R.—Contagious bovine pleuropneumonia: a comparison of two slide agglutination blood tests with the complement fixation test. *Aust. Vet. J.*, 1964, **40**, 38.

BORAY, J. C.—Studies on the ecology of *Lymnaea tomentosa*, the intermediate host of *Fasciola hepatica*. I. History, geographical distribution, and environment. *Aust. J. Zool.*, 1964, **12**, 217.

BORAY, J. C.—Studies on the ecology of *Lymnaea tomentosa*, the intermediate host of *Fasciola hepatica*. II. The sexual behaviour of *Lymnaea tomentosa*. *Aust. J. Zool.*, 1964, **12**, 231.

BORAY, J. C., and ENIGK, K.[2]—Laboratory studies on the survival and infectivity of *Fasciola hepatica*- and *F. gigantica*-metacercariae. *Z. Tropenmed. u. Parasit.*, 1964, **15**, 324.

BREMNER, K. C.—Studies on haptoglobin and haemopexin in the plasma of cattle. *Aust. J. Exp. Biol. Med. Sci.*, 1964, **42**, 643.

CARRICK, R.,[3] and MURRAY, M. D.—Social factors in population regulation of the silver gull, *Larus novaehollandiae* Stephens. *CSIRO Wildl. Res.*, 1964, **9**, 189.

DINEEN, J. K.—Sources of immunological variation. *Nature, Lond.*, 1964, **202**, 101.

DIXON, K. E.—The relative suitability of sheep and cattle as hosts for the liver fluke, *Fasciola hepatica* L. *J. Helminth.*, 1964, **38**, 203.

DONALD, A. D., DINEEN, J. K., TURNER, J. H.,[4] and WAGLAND, B. M.—The dynamics of the host–parasite relationship. I. *Nematodirus spathiger* infection in sheep. *Parasitology*, 1964, **54**, 527.

DYCE, A. L.—An observation of mosquitoes biting an echidna. *J. Ent. Soc. Qd.*, 1964, **3**, 83.

FARRINGTON, K. J.[5]—The syntheses of compounds related to 2-thienylmethyl 2-(2-imidazolinyl) sulphide. *Aust. J. Chem.*, 1964, **17**, 230.

FRENCH, E. L.—Evidence of freedom of Australian flocks from infection with Newcastle disease virus. *Aust. Vet. J.*, 1964, **40**, 119.

[8] University of California, Davis, Calif., U.S.A.

[1] University of California, School of Veterinary Medicine, Davis, Calif., U.S.A.
[2] Institute of Parasitology and Veterinary Medical Zoology, Veterinary College, Hanover.
[3] Division of Wildlife Research, CSIRO.
[4] Present address: Beltsville Parasitological Laboratory, Animal Disease and Parasite Research Division, U.S.D.A., A.R.C., Beltsville, Md., U.S.A.
[5] Parke, Davis & Co., Caringbah, N.S.W.

FRENCH, E. L., and SNOWDON, W. A.—Mucosal disease in Australian cattle. *Aust. Vet. J.*, 1964, **40**, 99.

GALLAGHER, C. H.—Effects of carbon tetrachloride administered into the trachea or the rumen of sheep. *Aust. Vet. J.*, 1964, **40**, 229.

GALLAGHER, C. H.—Skin lesions of sheep caused by sporidesmin. *Nature, Lond.*, 1964, **201**, 1293.

GALLAGHER, C. H.—The effect of sporidesmin on liver enzyme systems. *Biochem. Pharmac.*, 1964, **13**, 1017.

GALLAGHER, C. H., KOCH, J. H., MOORE, R. M.,[6] and STEEL, J. D.[7]—Toxicity of *Phalaris tuberosa* for sheep. *Nature, Lond.*, 1964, **204**, 542.

GORDON, H. McL.—Studies of anthelmintics for sheep: thiabendazole. *Aust. Vet. J.*, 1964, **40**, 9.

GORDON, H. McL.—Studies on resistance to *Trichostrongylus colubriformis* in sheep: influence of a quantitative reduction in the ration. *Aust. Vet. J.*, 1964, **40**, 55.

HUDSON, J. R.—Contagious bovine pleuropneumonia: laboratory work in relation to the eradication campaign. *Aust. Vet. J.*, 1964, **40**, 95.

HUDSON, J. R.—The present incidence and distribution of contagious bovine pleuropneumonia in Australia. *Bull. Off. Int. Épizoot.*, 1964, **61**, 37.

KEITH, R. K.—Subcutaneous injection of an organic phosphorus compound as an anthelmintic procedure for cattle. *Aust. Vet. J.*, 1964, **40**, 402.

MCKERN, H. H. G.,[8] and PARNELL, I. W.[9]—The larvicidal effect of various chemical compounds and plant products on the free-living stages of *Haemonchus contortus* Rud. (Nematoda). *J. Helminth.*, 1964, **38**, 223.

MAHONEY, D. F.—Bovine babesiosis: an assessment of the significance of complement fixing antibody based upon experimental infection. *Aust. Vet. J.*, 1964, **40**, 369.

MURRAY, M. D.—Ecology of the ectoparasites of seals and penguins. Proc. 1st Symp. on Antarctic Biol., Paris, 1962. p. 241. (Hermann: Paris 1964.)

MURRAY, M. D., and CARRICK, R.[3]—Seasonal movements and habitats of the silver gull, *Larus novaehollandiae* Stephens, in south-eastern Australia. *CSIRO Wildl. Res.*, 1964, **9**, 160.

NEWSAM, I. D. B., and PETERSON, J. E.—Persistence of *Vibrio fetus* in the genital tract of experimentally infected heifers. *Br. Vet. J.*, 1964, **120**, 223.

NORRIS, K. R.,[10] and MURRAY, M. D.—The screw-worm problem. *Aust. Vet. J.*, 1964, **40**, 148.

PARNELL, I. W.[9]—A modified technique for preliminary screening of compounds for anthelmintic activity against eggs and larvae of bursate nematodes of sheep. *J. Helminth.*, 1964, **38**, 47.

PARSONSON, I. M.—Infectious pustular vulvovaginitis in dairy cattle in Victoria. *Aust. Vet. J.*, 1964, **40**, 257.

PETERSON, J. E., and NEWSAM, I. D. B.—The histopathology of genital vibriosis in virgin heifers. *Br. Vet. J.*, 1964, **120**, 229.

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[6] Division of Plant Industry, CSIRO.
[7] Faculty of Veterinary Science, University of Sydney.
[8] Museum of Applied Arts and Sciences, Sydney, N.S.W.
[9] Present address: Carrington Hill, Gorebridge, Midlothian, Scotland.
[10] Division of Entomology, CSIRO.

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[12] Laboratory of Parasitic Diseases, National Institutes of Health, Bethesda, Md., U.S.A.
[13] Division of Mathematical Statistics, CSIRO.
[14] Present address: McGarvie Smith Institute, Ingleburn, N.S.W.

[1] Division of Animal Genetics, CSIRO.
[2] Department of Physiology, Veterinarhogskolan, Stockholm, Sweden.
[3] Division of Neurological Diseases, U.S. Public Health Service.
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[6] Department of Veterinary Pathology, University of Sydney.
[7] Sub-Department of Veterinary Surgery, University of Sydney.
[8] School of Rural Science, University of New England, Armidale, N.S.W.
[9] Department of Agriculture Veterinary Research Station, Glenfield, N.S.W.
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[12] Division of Tropical Pastures, CSIRO.
[13] Department of Experimental Pathology, John Curtin School of Medical Research, Australian National University, Canberra.
[14] School of Anatomy, University of New South Wales, Sydney.
[15] Division of Wildlife Research, CSIRO.
[16] Dermatology Department, Boston University, Boston, Mass., U.S.A.

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DIVISION OF APPLIED PHYSICS

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[17] Institute of Agriculture, University of Western Australia, Perth.
[18] Department of Animal Husbandry, Cornell University, Ithaca, N.Y., U.S.A.

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[3] Fats Research Laboratory, Department of Scientific and Industrial Research, Wellington, New Zealand.
[4] Division of Organic Chemistry, CSIRO.
[5] Division of Food Preservation, CSIRO.
[6] Department of Chemistry, Talan Sultan, Petaling Taya, Kuala Lumpur, Malaysia.
[7] School of Physics, University of New South Wales, Sydney.
[8] Department of Biology, University of California, San Diego, La Jolla, Calif., U.S.A.
[9] Present address: Bell Telephone Laboratories Inc., Murray Hill, N.J., U.S.A.
[10] Department of Pure Chemistry, National Research Council, Ottawa, Canada.
[11] Glen Walker & Co. Pty. Ltd., Collingwood, Victoria.

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[4] Smith Kline & French Laboratories, Philadelphia, Pa., U.S.A.
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[1] University of Melbourne.
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[1] Present address: Department of Geology, University College, Wollongong, N.S.W.
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[6] Fruit Research Division, D.S.I.R., Auckland, N.Z.
[7] Chemistry Division, D.S.I.R., Petone, N.Z.
[8] Present address: Department of Organic Chemistry, University of Sydney.
[9] Department of Organic Chemistry, University of Sydney.
[10] Twyford Laboratories, London, England.

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[5] Forestry and Timber Bureau, Canberra.
[6] Department of Botany, Australian National University, Canberra.
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[1] Present address: California State College at Los Angeles, Calif., U.S.A.
[2] Pennsylvania State University, Penn., U.S.A.
[3] Postgraduate Medical School, London, England.
[4] Present address: University of Bristol, Bristol, England.

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[2] Division of Tropical Pastures, CSIRO.
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[2] Division of Animal Health, CSIRO.
[3] Department of Genetics, University of Adelaide.
[4] 105 Middle Harbour Road, Lindfield, N.S.W.
[5] Division of Animal Physiology, CSIRO.
[6] School of Anatomy, University of New South Wales, Kensington, N.S.W.
[7] Dermatology Department, Boston University, School of Medicine, Boston, Mass., U.S.A.
[8] Museum of Comparative Zoology, Cambridge, Mass., U.S.A.
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[11] Department of Zoology, University of Adelaide.

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[2] Division of Textile Industry, CSIRO.
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[5] Caulfield Hospital, Melbourne.
[6] Peter MacCallum Clinic, Melbourne.
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[8] Present address: Department of Biochemistry, University of Adelaide.
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Ch. 4. Plant ecology. pp. 37–48. J. E. Coaldrake.
Ch. 5. Soil survey and soil assessment. pp. 49–59. G. D. Hubble, A. E. Martin, R. F. Isbell, R. S. Beckwith, and G. B. Stirk.
Ch. 6. Plant introduction. pp. 60–78. R. J. Williams.
Ch. 7. Plant breeding and genetics. pp. 79–92. E. M. Hutton.
Ch. 8. Mineral nutrition of plants. pp. 93–101. C. S. Andrew and E. F. Henzell.
Ch. 9. Legume bacteriology. pp. 102–17. D. O. Norris.
Ch. 10. Plant physiology. pp. 118–22. C. T. Gates.
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Ch. 12. The nutritive value of pasture plants. pp. 144–53. R. Milford.
Ch. 13. Plant chemistry. pp. 154–8. M. P. Hegarty.
Ch. 14. Statistics in pasture research. pp. 159–69. K. P. Haydock.
Ch. 15. Methods used in ecological surveys. pp. 170–72. J. E. Coaldrake.
Ch. 16. Techniques in plant nutrition and the soil fertility survey. pp. 173–85. C. S. Andrew and I. F. Fergus.
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4

Personnel

Obituary

Dr. H. E. Dadswell, D.Sc., Chief of the Division of Forest Products, died suddenly at his home in Melbourne in December 1964, at the age of 61.

After he graduated M.Sc. from the University of Sydney in 1927 his entire professional career was associated with CSIRO. He was selected as one of the first CSIR overseas Research Students and spent two years at the U.S. Forest Products Laboratory at Madison, Wisconsin. On his return to Australia he joined the Division of Forest Products, where he remained until his death.

He became a world authority on the structure, properties, and identification of Australian timbers, and during his career he published more than a hundred papers on this and related fields of research.

Dr. Dadswell was awarded the D.Sc. degree of the University of Melbourne in 1941, and in 1955 he served as the Walker-Ames Professor of Forestry at the University of Washington, Seattle.

He was President of the Royal Australian Chemical Institute in 1961–62.

Executive Appointment

Mr. H. B. Somerset, C.B.E., M.Sc., has been appointed to the Executive.

After graduating M.Sc. from the University of Melbourne, Mr. Somerset spent seven years with I.C.I.A.N.Z. Ltd. In 1937 he joined Associated Pulp and Paper Mills Ltd., and was appointed managing director of the company in 1948.

Mr. Somerset was President of the Australasian Institute of Mining and Metallurgy in 1958, and was awarded a C.B.E. in 1961. From 1956 to 1960 he was closely associated with CSIRO as a member of the Advisory Council.

Mr. Somerset is Chancellor of the University of Tasmania and a director of several leading industrial companies.

Retirements and Resignations

Sir Arthur Coles retired from the Executive after being a part-time member for nine years. Before joining the Executive he had combined a distinguished business career with an equally notable career of public service. He had served, *inter alia*, as Lord Mayor of Melbourne, as a Member of Parliament, and as Chairman of the Australian National Airlines Commission.

As a member of the Executive he travelled widely in Australia to familiarize himself with the Organization's research activities. He became involved in many important negotiations on behalf of the Executive, and the high degree of cooperation between CSIRO and Control Data Corporation, which supplied the Organization's computer network, is due in no small measure to his personal efforts. He also played a leading role in negotiations with the Western Australian Government for acquisition of the land in Perth on which CSIRO's new laboratories are now being built.

One of his special interests was the Commonwealth Agricultural Bureaux, and he attended the CAB Review Conferences in London in 1960 and 1963 as a member of the Australian delegation. At the 1960 Conference he was appointed Chairman of the Finance Committee and was able to bring his considerable financial acumen to bear on the complex problems of Commonwealth cooperation.

Dr. A. B. Wardrop, D.Sc., Ph.D., of the Division of Forest Products, has been appointed Professor of Botany, University of Tasmania.

Mr. L. J. Lynch, B.Agr.Sc.(Hons.), Senior Principal Research Scientist in the Division of Food Preservation, retired after 30 years' service to the Organization.

New Chief of Division

Dr. A. T. Dick, O.B.E., D.Sc., F.A.A., has been chosen to succeed Dr. H. R. Marston, D.Sc., F.R.S., F.A.A., as Chief of the Division of Biochemistry and General Nutrition. He will take up his new post when Dr. Marston retires in August, 1965.

Dr. Dick graduated B.Sc. with honours from the University of Melbourne in 1932 and M.Sc. from the same University in 1938. He joined the CSIR Division of Animal Health and Production in 1933 and worked at Townsville on contagious bovine pleuropneumonia. In 1936 he transferred to Melbourne where he became leader of the Division's chemical pathology group. He was awarded the degree of Doctor of Science by the University of Melbourne in 1954 for his studies on toxaemic jaundice of sheep.

Dr. Dick was awarded the David Syme Research Prize of the University of Melbourne in 1954. He was elected a Fellow of the Australian Academy of Science in 1964 and was appointed an Officer of the Most Excellent Order of the British Empire in 1965.

Posthumous Honour

The Australian Academy of Science has created a special medal to commemorate the distinguished contribution to physics of the late Dr. J. L. Pawsey, who pioneered Australia's work in radio astronomy. Dr. Pawsey, who died in 1962, was a Foundation Fellow of the Academy and Assistant Chief of CSIRO's Division of Radiophysics.

Honours and Awards

Mr. C. S. Andrew, Division of Tropical Pastures: Australian Medal of Agricultural Science.

Professor G. M. Badger, Member of the Executive: President of the Royal Australian Chemical Institute; and Professor Emeritus, University of Adelaide.

Dr. F. K. Ball, Division of Meteorological Physics: Doctor of Science, University of Melbourne.

Dr. A. B. Beck, Division of Plant Industry: Doctor of Science, University of Adelaide.

Mr. J. G. Bolton, Division of Radiophysics: Fellow, Australian Academy of Science.

Dr. W. Boas, Chief, Division of Tribophysics: Einstein Memorial Lecturer, Australian Institute of Physics.

Mr. W. W. Bryan, Division of Tropical Pastures: Fellow, Australian Institute of Agricultural Science.

Dr. I. A. M. Cruickshank, Division of Plant Industry: Doctor of Science, University of New Zealand.

Dr. C. C. J. Culvenor, Division of Organic Chemistry: Doctor of Science, University of Melbourne.

Dr. J. Griffiths Davies, Chief, Division of Tropical Pastures: Britannica Australia Award.

Dr. A. T. Dick, Division of Animal Health: Officer of the Most Excellent Order of the British Empire.

Miss B. C. L. Doubleday, Chief Librarian: Foundation Fellow, Library Association of Australia.

Dr. R. A. Duncan, Upper Atmosphere Section: Doctor of Science, University of Adelaide.

Dr. J. E. Falk, Chief, Division of Plant Industry: Archibald D. Olle Prize, Royal Australian Chemical Institute.

Dr. O. H. Frankel, Member of the Executive: Fellow of the World Academy of Art and Science.

Dr. C. H. Gallagher, Division of Animal Health: David Rivett Medal, CSIRO Officers' Association (shared).

Dr. R. C. Gifkins, Physical Metallurgy Section: Honorary Member, Iron and Steel Institute of Japan.

Mr. H. McL. Gordon, Division of Animal Health: Gilruth Prize, Australian Veterinary Association.

Dr. E. G. Hallsworth, Chief, Division of Soils: Doctor of Science, University of Leeds.

Mr. G. Loftus Hills, Chief, Division of Dairy Research: President of the Australian Society of Dairy Technology.

Dr. I. G. Jarrett, Division of Biochemistry and General Nutrition: Doctor of Science, University of Adelaide.

Miss B. E. Johnston, Division of Food Preservation: Foundation Fellow, Library Association of Australia.

Mr. F. J. Lehany, Chief, Division of Applied Physics: President of the Australian Institute of Physics.

Dr. F. K. McTaggart, Division of Mineral Chemistry: Doctor of Science, University of Melbourne.

Dr. T. J. Marshall, Division of Soils: Fellow, Australian Institute of Agricultural Science.

Dr. D. Martin, Division of Plant Industry: Associateship of Honour, Royal Horticultural Society of London.

Dr. T. Mole, Division of Organic Chemistry: Rennie Medal, Royal Australian Chemical Institute.

Mr. L. L. Muller, Division of Dairy Research: Silver Medal, Australian Institute of Dairy Technology.

Dr. A. L. G. Rees, Chief, Division of Chemical Physics: Secretary (Physical Sciences), Australian Academy of Science.

Dr. J. M. Swan, Division of Organic Chemistry: H. G. Smith Memorial Medal, Royal Australian Institute of Chemistry (shared).

Dr. E. O. P. Thompson, Division of Protein Chemistry: David Rivett Medal, CSIRO Officers' Association (shared).

Mr. A. J. Vasey, Division of Animal Health (on secondment as Executive Secretary of the Commonwealth Scientific Committee): Member of the Most Excellent Order of the British Empire.

Dr. I. W. Wark, Member of the Executive: Fellow of University College, London.

Dr. C. H. Williams, Division of Plant Industry: Doctor of Science, University of Adelaide.

Advisory Council

Executive

Sir Frederick White, K.B.E., M.Sc., Ph.D., F.A.A. (*Chairman*)

C. S. Christian, B.Agr.Sc., M.S.

I. W. Wark, C.B.E., Ph.D., D.Sc., F.A.A.

O. H. Frankel, D.Sc., D.Agr., F.A.A., F.R.S.

J. Melville, M.Sc., Ph.D.

The Rt. Hon. the Lord Casey, P.C., C.H., D.S.O., M.C., M.A.

E. P. S. Roberts

H. B. Somerset, C.B.E., M.Sc.

Chairmen of State Committees

New South Wales—W. Sloan

Queensland—W. J. D. Shaw

South Australia—Professor E. A. Rudd, A.M., B.Sc.

Tasmania—V. G. Burley, B.E.

Victoria—L. W. Weickhardt, M.Sc.

Western Australia—E. H. Lee-Steere, C.B.E.

Coopted Members

K. E. Beazley, B.A., M.H.R.

Sir Arthur Coles, Kt.

Professor Sir John Crawford, Kt., C.B.E., M.Ec.

Professor C. M. Donald, M.Agr.Sc., H.D.A.

Professor Sir John Eccles, Kt., M.A., M.B., B.S., D.Phil., Sc.D., F.A.A., F.R.S.

Professor C. W. Emmens, D.Sc., Ph.D., F.A.A.

R. A. Irish, O.B.E., F.C.A.

Charles R. Kelly, M.H.R.

Colin R. Kelly, B.Agr.Sc.

P. J. Lawler, O.B.E.

C. G. McGrath, O.B.E.

J. A. L. Matheson, M.B.E., M.Sc., Ph.D.

W. M. Morgan, B.E.

J. P. Norton, O.B.E.

Professor S. A. Prentice, M.E.E., B.Sc.

Professor R. T. Prider, B.Sc., Ph.D.

F. M. Read, M.Agr.Sc.

P. Ryan, I.S.O., B.Agr.Sc.

G. Sheil, B.Sc., B.C.E., B.M.E.

Professor V. M. Trikojus, D.Sc., D.Phil., F.A.A.

Emeritus Professor Sir Samuel Wadham, Kt., M.A., LL.D., Agr.Dip.

H. P. Weber, M.Sc.

P. J. Young, B.Ag.Sc.

State Committees

New South Wales State Committee

W. Sloan (*Chairman*)
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Professor H. N. Barber, M.A., Ph.D., F.A.A.
F. S. Bradhurst, D.Sc.
Professor H. R. Carne, D.V.Sc.
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R. G. C. Parry-Okeden, C.B.E., D.Sc.
A. R. Penfold
L. A. Pockley, B.V.Sc.
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Professor J. W. Roderick, M.A., Ph.D., F.A.A.
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Emeritus Professor W. L. Waterhouse, C.M.G., M.C., D.Sc.Agr., D.I.C., F.A.A.
A. J. Higgs, B.Sc. (Hons.) (*Secretary*)

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H. H. Harvey
C. P. Haselgrove
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G. Hall, B.Sc.
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D. Martin, D.Sc. (*Secretary*)

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R. A. Hunt, D.S.O., B.C.E.
C. R. Kelly, B.Agr.Sc.
N. S. Kirby, B.E.
P. S. Lang, B.Agr.Sc., Ph.D.
A. O. P. Lawrence, B.Sc., Dip.For.
Professor G. W. Leeper, M.Sc.

C. G. McGrath, O.B.E.
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J. A. L. Matheson, M.B.E., M.Sc., Ph.D.
Sir Maurice Mawby, Kt., C.B.E., D.Sc.
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D. E. Thomas, D.Sc.
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Professor J. S. Turner, M.A., M.Sc., Ph.D., F.A.A.
Emeritus Professor Sir Samuel Wadham, Kt., M.A., LL.D., Agr.Dip.
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Professor M. J. D. White, D.Sc., F.A.A.
J. P. Shelton, M.Sc., A.B.S.M. (*Secretary*)

Western Australian State Committee

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G. K. Baron-Hay, M.C., C.B.E., B.Sc.
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Professor N. S. Bayliss, C.B.E., B.A., B.Sc., Ph.D., F.A.A.
K. E. Beazley, B.A., M.H.R.
L. C. Brodie-Hall, A.W.A.S.M.
C. R. Bunning, B.C.E.
Professor C. J. Birkett Clews, B.Sc., Ph.D.
Professor K. L. Cooper, B.Sc., M.A.
D. M. Cullity, B.Sc.
T. C. Dunne, B.Sc. (Agric.), Ph.D.
K. W. Edwards, O.B.E.
L. E. Elvey
Air Chief Marshal Sir Basil Embry (R.A.F. retired), G.C.B., K.B.E., D.S.O. (3 bars), D.F.C., A.F.C.
Professor B. J. Grieve, M.Sc., Ph.D., D.I.C.
A. C. Harris, B.Sc.
J. H. Hohnen
N. G. Humphries, A.A.S.A.
P. B. Lefroy
J. P. Norton, O.B.E.
Professor R. T. Prider, B.Sc., Ph.D., F.G.S.
Professor J. P. Quirk, B.Sc.Agr., Ph.D.
W. T. Richards
F. J. Robinson
Emeritus Professor A. D. Ross, C.B.E., M.A., D.Sc., Dip.Ed.
W. J. Russell
L. W. Samuel, B.Sc., Ph.D.
F. L. Shier, B.Sc.Agr.
D. O. Temby, B.E.
E. E. Tomlinson
Professor E. J. Underwood, C.B.E., B.Sc. (Agric.), Ph.D., F.A.A.
W. R. Wallace, Dip.For.
Professor H. H. Waring, D.Sc., F.A.A.
J. P. Brophy (*Secretary*)

Staff

The following is a list of professional and senior administrative staff of the Organization as at June 30, 1965

OFFICE OF THE EXECUTIVE

Headquarters: A.M.P. Building, Hobart Place, Canberra, A.C.T.

Chairman—Sir Frederick White, K.B.E., M.Sc., Ph.D., F.A.A.
Member of the Executive—C. S. Christian, B.Agr. Sc., M.S.
Member of the Executive—O. H. Frankel, D.Sc., D.Agr., F.A.A., F.R.S.
Member of the Executive—Emeritus Professor G. M. Badger, Ph.D., D.Sc., F.A.A.
Assistant Secretary — A. F. Gurnett-Smith, B.Agr.Sc.
Scientific Assistant to Member of Executive—P. F. Butler, M.Ag.Sc.

HEAD OFFICE

Headquarters: 314 *Albert Street, East Melbourne, Vic.*

Member of the Executive—I. W. Wark, C.B.E., Ph.D., D.Sc., F.A.A.

SECRETARIAT BRANCH

Secretary—G. B. Gresford, B.Sc., A.R.M.T.C.
First Assistant Secretary—L. G. Wilson, M.Sc.
Assistant Secretary—D. T. C. Gillespie, M.Sc.
Scientific Services Officer—A. K. Klingender, B.Sc.
Scientific Services Officer—C. D. Kimpton, B.Agr.Sc.
Officer for International Cooperation—L. G. Peres, B.Ec.(Hons.)
Safety Officer—J. W. Hallam, Dip.App.Chem.
Archives Officer—W. F. Evans, B.Sc.

Finance

Finance Manager—R. W. Viney, A.A.S.A., A.C.I.S.
Deputy Finance Manager—R. C. McVilly, F.A.S.A., A.C.I.S.
Senior Finance Officer (Contracts and Stores)—D. J. Bryant, A.A.S.A.
Senior Finance Officer—M. F. Combe
Budget Officer—I. F. Carrucan, A.A.S.A., R.C.A.
Officer-in-Charge, Accounting Section—K. L. Hodges
Scientific Services Officer—N. F. Clark, B.E. (Civil), B.Com.

Staff

Assistant Secretary (Staff)—J. Coombe
Scientific Services Officer—W. M. Balding, B.Sc.
Registrar—P. Knuckey
Staff Officer—P. J. Kelly, LL.B., D.P.A.
Staff Officer—G. D. McLennan, B.Com.
Staff Officer—M. J. Rolfs
Administrative Assistant—H. C. Crozier, B.A. (Hons.), Dip.Ed.

Buildings

Assistant Secretary (Works and Buildings)—B. Beresford Smith, B.Sc., B.E.
Architect—W. R. Ferguson, B.E.
Architect—R. L. Brooks, Dip.Arch.Des., Dip. Build.Cons.
Architect—J. V. Dunn, Dip.Arch.
Architect—R. B. Fuller, Dip.Arch.
Architect—P. G. A. Relf
Engineer—B. G. Gibbs, B.E.

Library

Chief Librarian—Miss B. C. L. Doubleday, M.A., F.L.A.A.
Scientific Services Officer—Miss M. J. Dunstone, B.Sc., Dip.Ed.
Senior Librarian—Miss J. A. Conochie, B.Sc., A.L.A.A.
Senior Librarian—Miss L. J. Davey, B.Sc., A.L.A.A.
Librarian—Miss J. Eliott, A.L.A.A.
Librarian—Mrs. K. Gruzewski, A.L.A.A.
Librarian—Mrs. J. I. Korn, A.L.A.A.
Librarian—Miss I. W. McNamara, B.A., A.L.A.A.
Librarian—Miss V. J. Shone, A.L.A.A. (*on leave*)
Librarian—Miss F. B. South, B.A., A.L.A.A.

Translation Unit

Translator-in-Charge—A. L. Gunn
Translator—M. M. Fremt, B.Ag.Sc.
Translator—P. A. Kazakov, LL.B.
Translator—Mrs. B. Bergmanis, B.A.

Film Unit

Officer-in-Charge—S. T. Evans, B.Sc.
Scientific Services Officer—A. M. Evans, B.Ag.Sc.

Liaison Overseas

London

Chief Scientific Liaison Officer—W. Hartley, B.A., Dip.Agr.
Liaison Officer—J. I. Platt, B.Sc.(Econ.)

Washington

Scientific Attaché—C. S. Elliot, B.Sc.

AGRICULTURAL AND BIOLOGICAL SCIENCES BRANCH

Associate Member of the Executive—W. Ives, M.Ec.
Assistant Secretary—B. F. McKeon, B.Ag.Sc. (Hons.)
Irrigation Adviser—F. Penman, M.Sc.

Agricultural Liaison Unit (372 *Albert Street, East Melbourne, Vic.*)

Assistant Secretary (Agricultural Liaison)—R. D. Croll, B.Agr.Sc.(Hons.)
Scientific Services Officer—A. C. Doery, B.Agr.Sc.
Scientific Services Officer—K. Loftus Hills, M.Agr. Sc.
Scientific Services Officer—R. N. Farquhar, B.Agr. Sc., M.S., Ed.D.
Scientific Services Officer—E. A. Jackson, B.Agr. Sc.
Scientific Services Officer—J. J. Lenaghan, B.Agr. Sc., M.Sc.
Scientific Services Officer—N. L. Tyshing, B.Agr. Sc.
Scientific Services Officer—H. S. Hawkins, B.Agr. Sc.(Hons.)
Scientific Services Officer—R. E. Churchward, B.V.Sc., H.D.A. (*at Department of Agriculture, Sydney*)
Scientific Services Officer—D. V. Walters, M.Agr. Sc. (*seconded to N.S.W. Department of Agriculture, Sydney*)
Librarian—Miss J. Mooney, A.L.A.A.

INDUSTRIAL AND PHYSICAL SCIENCES BRANCH

Executive Officer—L. Lewis, B.Met.E.
Assistant Secretary—J. P. Shelton, M.Sc., Dip. App.Chem.
Scientific Services Officer—R. L. Aujard, B.Sc.
Scientific Services Officer—J. S. Wells, B.El.Eng.
Scientific Services Officer—J. F. H. Wright, B.Sc.

REGIONAL ADMINISTRATIVE OFFICES

Regional Administrative Office, Canberra

Headquarters: A.M.P. Building, Hobart Place, Canberra

This office provides accounting, staffing, and purchasing services for Divisions and Sections in the Australian Capital Territory

Regional Administrative Officer—K. J. Prowse
Accountant—V. J. Taylor, B.Com., A.A.S.A.

Regional Administrative Office, Melbourne

Headquarters: 314 *Albert Street, East Melbourne, Vic.*

This office provides accounting, staffing, and purchasing services for Divisions and Sections in Victoria, Western Australia, South Australia, Tasmania, and Northern Territory

Regional Administrative Officer—A. P. Patterson, F.A.S.A.
Accountant—W. C. Hosking, A.A.S.A., A.C.I.S.

Regional Administrative Office, Sydney

Headquarters: Grace Bros. Building, Broadway, Sydney

This office provides accounting, staffing, and purchasing services for Divisions and Sections in New South Wales and Queensland

Regional Administrative Officer—F. J. Whitty, F.A.S.A., A.C.I.S.
Accountant—T. C. Clark, A.A.S.A., A.C.I.S.

ANIMAL RESEARCH LABORATORIES

Animal Research Committee

J. M. Rendel, B.Sc., Ph.D., F.A.A. (*Chairman*)
T. S. Gregory, D.V.Sc., Dip.Bact.
I. W. McDonald, B.V.Sc., B.Sc., Ph.D.
D. F. Stewart, D.V.Sc., Dip.Bact.
A. Packham, B.V.Sc., A.A.S.A. (*Secretary*)

DIVISION OF ANIMAL GENETICS

Headquarters: Delhi Road, North Ryde, N.S.W.

Administration

Chief—J. M. Rendel, B.Sc., Ph.D., F.A.A.
Research Assistant to the Chief—A. Packham, B.V.Sc., A.A.S.A.
Administrative Officer—K. J. Turner, B.Com.
Librarian—Miss E. Ahearn

At Animal Genetics Laboratory, University of Sydney

Officer-in-Charge—J. M. Rendel, B.Sc., Ph.D., F.A.A.
Senior Principal Research Scientist—P. J. Claringbold, B.V.Sc., Ph.D.
Principal Research Scientist—G. W. Grigg, M.Sc., Ph.D.
Principal Research Scientist—H. J. Hoffman, M.Sc., Ph.D.
Principal Research Scientist—W. R. Sobey, B.Sc., Ph.D.
Senior Research Scientist—T. Nay
Senior Research Scientist—A. H. Reisner, A.B., Ph.D.
Senior Research Scientist—B. L. Sheldon, B.Sc. Agr.(Hons.), Ph.D.
Research Scientist—J. F. Eadie, M.Sc.(Hons.)
Research Scientist—Miss B. M. Kindred, M.Sc.
Experimental Officer—K. M. Adams
Experimental Officer—E. J. Burnett, B.Sc.
Experimental Officer—Miss D. I. Conolly, Dip. Sc.
Experimental Officer—D. E. Finlay, B.Sc.Agr.
Experimental Officer—P. G. Johnston, B.Agr.Sc.
Experimental Officer—Miss J. Lockhart, B.Sc.
Experimental Officer—Miss J. McDougall, B.Sc.
Experimental Officer—B. J. J. McHugh, B.Sc.
Experimental Officer—Mrs. H. Macindoe, B.Sc. (Hons.)
Experimental Officer—J. H. O'Keefe, B.Sc.
Experimental Officer—Miss P. R. Pennycuik, M.Sc., Ph.D.
Experimental Officer—Miss J. Stuckey, B.Sc.
Experimental Officer—N. H. Westwood, M.Sc.

At Animal Breeding Section, McMaster Laboratory, Sydney

Senior Principal Research Scientist—Miss H. Newton Turner, B.Arch.
Principal Research Scientist—A. A. Dunlop, M.Agr.Sc., Ph.D.
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Senior Research Scientist—D. McG. McBean, B.Sc.
Experimental Officer—A. A. Johnson, A.S.T.C.
Experimental Officer—J. I. Pitt, M.Sc., A.S.T.C.

Freezing of Fruit and Vegetables

Senior Research Scientist—J. Shipton, B.Sc.Agr.
Research Scientist—F. B. Whitfield, M.Sc., Ph.D., A.S.T.C.
Experimental Officer—J. H. Last, A.S.T.C.

Animal Products Section

Chief—J. R. Vickery, M.Sc., Ph.D.
Principal Research Scientist—A. R. Johnson, B.Sc.(Hons.), Ph.D.
Experimental Officer—A. C. Fogerty, M.Sc.

Experimental Officer—W. A. Montgomery, A.S.T.C.
Experimental Officer—Mrs. J. A. Pearson, M.Sc.
Experimental Officer—F. S. Shenstone, A.S.T.C.

Meat Investigations

Chief Research Scientist (Leader of Investigations) —W. J. Scott, B.Sc.Agr., D.Sc.
Principal Research Scientist—R. P. Newbold, M.Sc., Ph.D.
Research Scientist—R. K. Scopes, B.A., Ph.D.
Experimental Officer—C. A. Lee, M.Sc.

At Cannon Hill, Qld.

Principal Research Scientist (Officer-in-Charge)—A. Howard, M.Sc.
Principal Research Scientist—G. Kaess, Dr.Ing.
Research Scientist—F. Grau, M.Sc., Ph.D.
Experimental Officer—P. E. Bouton, B.Sc.
Experimental Officer—L. E. Brownlie, B.Sc.Agr.
Experimental Officer—N. T. Russell, D.I.C.
Experimental Officer—M. K. Shaw, B.Sc.(Hons.) (*overseas*)
Experimental Officer—J. F. Weidemann, B.Sc.
Administrative Officer—J. I. Menzies, B.Econ.

At Division of Animal Physiology, Prospect, N.S.W.

Research Scientist—W. R. Shorthose, B.Sc. (Hons.), Ph.D.

At Department of Mechanical Engineering, University of Sydney

Experimental Officer—G. G. Swenson, M.Sc.

At Botany School, University of Sydney

Plant Physiology Investigations

Principal Research Scientist—A. B. Hope, B.Sc., Ph.D.
Principal Research Scientist—R. M. Smillie, M.Sc., Ph.D.
Senior Research Scientist—C. J. Brady, M.Sc.Agr., Ph.D.
Senior Research Scientist—J. Giovanelli, B.Sc. Agr., Ph.D.
Research Scientist—G. P. Findlay, B.Sc.(Hons.), Ph.D. (*overseas*)
Research Scientist—D. Graham, B.Sc.(Hons.), Ph.D.
Experimental Officer—Miss R. S. Mullens, M.Sc.
Experimental Officer—P. B. Price, B.Sc.
Experimental Officer—N. F. B. Tobin, B.Sc. (Hons.)
Scientific Services Officer—J. Smydzuk, Ing.de Ch.

At Atomic Energy Research Establishment, Lucas Heights, N.S.W.

Food Irradiation Investigations

Senior Research Scientist—J. J. Macfarlane, M.Sc.

At Tasmanian Regional Laboratory, Hobart

Processing Investigations

Experimental Officer—D. G. James, B.Sc.
Experimental Officer—S. M. Sykes, B.Sc.Agr., M.Sc.

DIVISION OF FOREST PRODUCTS

Headquarters: 69 Yarra Bank Road, South Melbourne, Vic.

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Technical Secretary—F. A. Priest, A.S.A.S.M.
Information Officer—A. P. Wymond, M.Sc.
Senior Librarian—Miss A. Forbes, A.L.A.A.
Librarian—Mrs. J. Henderson, A.L.A.A.
Engineer—L. Santer, M.Mech.E., Dip.Ing.

Special Investigations

Senior Principal Research Scientist—W. E. Cohen, D.Sc. (*Section Leader*)

Wood and Fibre Structure Section

Principal Research Scientist—D. E. Bland, M.Sc. (*Acting Section Leader*)
Principal Research Scientist—W. E. Hillis, M.Sc., A.G.Inst.Tech.
Principal Research Scientist—G. Scurfield, B.Sc., Ph.D.
Senior Research Scientist—H. D. Ingle, B.For.Sc.
Senior Research Scientist—J. W. P. Nicholls, M.Sc.
Research Scientist—R. C. Foster, B.Sc., Ph.D.
Research Scientist—T. Inoue, D.Sc.
Research Scientist—D. S. Skene, B.Sc., Ph.D.
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Wood Chemistry, Pulp, and Paper Section

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Principal Research Scientist—R. C. McK. Stewart, D.Sc.
Principal Research Scientist—A. J. Watson, F.R.M.I.T.
Senior Research Scientist—Mrs. J. F. Melvin, M.Sc.
Research Scientist—A. J. Michell, B.Sc.(Hons.), Ph.D.
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Principal Research Scientist—G. N. Christensen, M.Sc., Ph.D.
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Experimental Officer—H. F. A. Hergt, A.R.M.T.C.
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Senior Research Scientist—P. Rudman, B.Sc., Ph.D., Dip.Microbiol. (*on leave*)
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HORTICULTURAL RESEARCH SECTION

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Research Scientist—M. S. Buttrose, B.Ag.Sc. (Hons.), M.Sc., Dr.sc.nat.
Research Scientist—M. G. C. Mullins, B.Sc., Ph.D., Dip.Agric.(Cantab.)
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Research Scientist—R. C. Woodham, B.Ag.Sc.
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Research Scientist—H. D. Barrs, B.Sc., Ph.D.
Research Scientist—H. Greenway, Ir.Agr.
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Survey Leader—R. A. Perry, M.Sc.

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Principal Research Scientist—R. Story, D.Sc.
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Experimental Officer—A. D. L. Hooper, M.Sc.
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Environmental Biology Group

Senior Principal Research Scientist—R. O. Slatyer, D.Sc.Agr.

Plant-Soil-Water Relations

Senior Principal Research Scientist—R. O. Slatyer, D.Sc.Agr.
Senior Research Scientist—J. E. Begg, B.Sc. (Hons.), Ph.D.
Senior Research Scientist—E. A. Fitzpatrick, M.A.
Senior Research Scientist—C. W. Rose, B.Sc., B.E., Ph.D.
Senior Research Scientist—W. R. Stern, M.Sc.Agr., Ph.D.
Research Scientist—P. G. Jarvis, B.A.(Hons.), Ph.D.
Experimental Officer—G. F. Byrne, B.Sc.

Nitrogen Biology

Senior Research Scientist—R. Wetselaar, Ing.Agr. (*at Kimberley Research Station*)

Soil Agronomy

Senior Research Scientist—W. Arndt, M.Sc.Agr.

Agricultural Assessment

Principal Research Scientist—J. J. Basinski, M.A., B.Sc.
Experimental Officer—H. A. Nix, B.Agr.Sc.

Regional Research Stations

At Canberra

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At Katherine Research Station, N.T.

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Administrative Officer—L. R. Smith
Experimental Officer—M. J. Fisher, B.Agr.Sc.
Experimental Officer—I. M. W. Wood, B.Sc., B.Agr.Sci.

At Kimberley Research Station, W.A.

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Research Scientist—D. W. Robinson, B.Sc., Ph.D.
Research Scientist—P. J. van Rijn, Ing.Agr.
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Experimental Officer—P. Jakobsen, B.Sc.Agr., Dip.Appl.Chem.
Experimental Officer—D. H. McKenzie, B.Agr.Sci.
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At Coastal Plains Research Station, Darwin

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DIVISION OF MATHEMATICAL STATISTICS

Headquarters: University of Adelaide

At University of Adelaide

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Principal Research Scientist—G. W. Hill, M.Sc., Ph.D.
Principal Research Scientist—N. S. Stenhouse, M.Sc.
Principal Research Scientist—G. N. Wilkinson, M.Sc.
Senior Research Scientist—A. G. Constantine, B.Sc.(Hons.), Ph.D.
Experimental Officer—K. M. Cellier, B.Sc.
Experimental Officer—L. G. Veitch, B.Sc.

At Division of Animal Health, Sydney

Research Scientist—G. M. Tallis, M.Sc., Ph.D. (*on leave*)

At Division of Animal Physiology, Prospect, N.S.W.

Principal Research Scientist—H. Weiler, Lic.ès Sc., M.Sc.

At Division of Building Research, Highett, Vic.

Senior Research Scientist—R. Birtwistle, B.Sc.

At Division of Fisheries and Oceanography, Cronulla, N.S.W.

Experimental Officer—J. D. Kerr, B.Sc.(Hons.)
Experimental Officer—A. E. Stark, B.A.

At Division of Food Preservation, North Ryde, N.S.W.

Principal Research Scientist—G. G. Coote, B.A., B.Sc.
Experimental Officer—E. A. Roberts, B.Sc.Agr.
Experimental Officer—S. L. Sherlock, B.Sc.

At Division of Forest Products, South Melbourne

Experimental Officer—Miss N. Ditchburne

At National Standards Laboratory, Chippendale, N.S.W.

Principal Research Scientist—R. T. Leslie, M.A., B.Sc., Ph.D.
Experimental Officer—D. Culpin, B.Sc.(Hons.)
Experimental Officer—D. E. Shaw, B.Sc.

At Division of Plant Industry, Canberra

Senior Principal Research Scientist—G. A. McIntyre, B.Sc.(Hons.), Dip.Ed.
Senior Research Scientist—M. L. Dudzinski, B.Sc., B.Ec.(Hons.)
Research Associate—Miss S. M. Green, M.A.
Experimental Officer—P. J. Pahl, B.Sc.(Hons.)

At Pastoral Research Laboratory, Armidale, N.S.W.

Senior Research Scientist—P. F. May, B.Sc.Agr. (Hons.)

At Tasmanian Regional Laboratory, Hobart

Experimental Officer—A. Grassia, B.A., Dr.Ma. & Phys.

At Division of Tropical Pastures, St. Lucia, Qld.

Senior Research Scientist—K. P. Haydock, B.Sc. (Hons.)

At School of Agriculture, University of Melbourne

Senior Research Scientist—A. M. W. Verhagen, Cand.Nat.Phil., B.A.(Hons.), Ph.D.

At Western Australian Regional Laboratory, Nedlands, W.A.

Senior Principal Research Scientist—D. W. Goodall, Ph.D., D.Sc.
Experimental Officer—C. A. P. Boundy, B.E.

At Wool Research Laboratories: Division of Protein Chemistry, Parkville, Vic.

Senior Research Scientist—W. B. Hall, B.A.

DIVISION OF MECHANICAL ENGINEERING

Headquarters: Graham Road, Highett, Vic.

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Administrative Officer—J. A. Pattison, A.A.S.A.

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Librarian—Miss M. E. Olley

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Research Scientist—D. J. Close, B.E., M.Eng.Sc.
Experimental Officer—J. T. Czarnecki, Dip.Ing.
Experimental Officer—R. C. R. Johnston, B.Mech. E., M.Eng.Sc.
Experimental Officer—D. J. Norris, A.M.T.C.

Refrigeration and Air Conditioning

Principal Research Scientist—J. J. Kowalczewski, Dip.Ing., Dr.sc.techn.
Senior Research Scientist—Mrs. Esther Kaletzky, B.E., M.Eng.Sc.
Experimental Officer—D. W. Cunliffe, F.M.T.C.
Experimental Officer—D. Pescod, Dip.Mech. Eng., Dip.Elec.Eng.
Experimental Officer—K. A. Robeson, B.Mech. Eng.

Electronics

Principal Research Scientist—M. Kovarik, Ing.
Senior Research Scientist—R. H. S. Riordan, B.E.E.
Experimental Officer—P. Milner, B.Mech.E.

Agricultural Machinery

Senior Research Scientist—P. A. Taylor, B.Sc.

Grain Moisture Studies

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Experimental Officer—W. B. Elder, Dip.Mech. Eng.
Experimental Officer—J. W. Sutherland, B.Sc.

Engineering Development

Sectional Engineer—W. R. W. Read, Dip.Mech. Eng.
Experimental Officer—H. L. Chapman, Dip. Mech.Eng.
Experimental Officer—P. Pott, Ing.

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Senior Principal Research Scientist—E. L. Deacon, B.Sc.
Principal Research Scientist—F. K. Ball, D.Sc.
Principal Research Scientist—A. F. A. Berson, Dr.Phil.
Principal Research Scientist—R. H. Clarke, B.A., M.Sc.
Principal Research Scientist—A. J. Dyer, M.Sc., Ph.D.
Principal Research Scientist—R. J. Taylor, M.Sc.
Senior Research Scientist—D. E. Angus, B.Sc., Ph.D.
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Senior Research Scientist—I. C. McIlroy, B.Sc.
Senior Research Scientist—W. Shepherd, B.Sc., M.Ag.Sc.
Senior Research Scientist—E. K. Webb, B.A. (Hons.), B.Sc.
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Experimental Officer—A. C. Dilley, B.Sc.
Experimental Officer—B. B. Hicks, B.Sc.
Experimental Officer—R. H. Hill, B.E., Dip.E.E.
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Experimental Officer—F. J. Maher, A.R.M.T.C.
Experimental Officer—C. J. Sumner, A.M.S.E.
Experimental Officer—A. J. Troup, B.Sc.
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Principal Research Scientist—J. McAndrew, M.Sc., Ph.D.
Research Scientist—P. L. C. Grubb, B.Sc., Ph.D.
Research Scientist—J. A. McDonald, M.Sc., Ph.D.
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DIVISION OF MINERAL CHEMISTRY

See Chemical Research Laboratories

NATIONAL STANDARDS LABORATORY

Headquarters: University Grounds, Chippendale, N.S.W.

National Standards Laboratory Committee

F. J. Lehany, M.Sc.
R. G. Giovanelli, D.Sc., F.A.A.

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Librarian—Miss M. McKechnie, B.A., A.L.A.A.
Librarian—Miss J. M. Cook, B.A.(Hons.), A.L.A.A.
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Senior Principal Research Scientist—J. S. Dryden, M.Sc., Ph.D., D.I.C.
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Principal Research Scientist—L. U. Hibbard, B.Sc., M.E., Ph.D.
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Senior Research Scientist—L. Medina, M.E., Dip.Ing.
Senior Research Scientist—Miss M. G. I. Pearce, M.Sc.
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Senior Research Scientist—H. A. M. Ross, A.S.T.C.
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Research Scientist—J. S. Cook, M.Sc.
Research Scientist—J. C. Macfarlane, B.Sc., Ph.D.
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Research Associate—V. T. Morgan, B.Sc.(Eng.)
Engineer—J. C. Coles, B.A., A.S.T.C.
Experimental Officer—R. W. Archer, A.S.T.C.
Experimental Officer—D. B. Armitage, B.Sc., B.E.
Experimental Officer—H. Bairnsfather
Experimental Officer—G. E. Beard, B.Sc.(Tech.)
Experimental Officer—J. W. Bell
Experimental Officer—D. E. Brown, A.S.T.C.
Experimental Officer—F. C. Brown, A.S.T.C.
Experimental Officer—G. J. A. Cassidy, B.E.E.
Experimental Officer—A. L. Clarke, B.Sc.
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- Research Scientist—H. Doing, D.Agr.Sc., Ph.D.
- Research Scientist—P. W. Michael, B.Agr.Sc. (Hons.), Ph.D.
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At Wagga Agricultural Research Institute (New South Wales Department of Agriculture)

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At Pastoral Research Laboratory, Armidale, N.S.W.

Pasture Investigations

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At Waste Point (Kosciusko State Park)

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At Riverina Laboratory, Deniliquin, N.S.W.

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Plant Introduction

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At University of Queensland

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At Cunningham Laboratory, Brisbane

Plant Introduction

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At Tasmanian Regional Laboratory, Hobart

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At Tobacco Research Institute, Mareeba, Qld.

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Scientific Services Officer—A. R. P. Clarke, B.Tech.

Soil Zoology Section

Principal Research Scientist—K. E. Lee, D.Sc.

Soil Physics Section

Chief Research Scientist—T. J. Marshall, M.Ag. Sc., Ph.D.
Principal Research Scientist—W. W. Emerson, B.A., Ph.D.
Principal Research Scientist—E. L. Greacen, B.Sc. Agr., Ph.D.
Principal Research Scientist—J. W. Holmes, M.Sc.
Senior Research Scientist—C. G. Gurr, B.Sc.
Research Scientist—J. S. Colville, M.Sc.
Research Scientist—D. A. Farrell, B.C.E., Ph.D

Soil Microbiology Section

Senior Principal Research Scientist—R. J. Swaby, M.Sc., M.Ag.Sc., Ph.D.
Principal Research Scientist—A. D. Rovira, B.Ag. Sc., Ph.D.
Senior Research Scientist—G. D. Bowen, M.Sc. (*overseas*)
Senior Research Scientist—J. R. Harris, M.Sc.
Senior Research Scientist—J. N. Ladd, M.Sc., Ph.D.
Research Scientist—R. W. L. Kimber, B.Sc., Ph.D.
Research Scientist—Miss B. M. McDougall, M.Sc., Ph.D.
Experimental Officer—P. G. Brisbane, B.Sc.Agr.
Experimental Officer—J. H. A. Butler, B.Sc. (*overseas*)
Experimental Officer—R. B. Jackson, M.Sc.
Experimental Officer—C. Theodorou, B.Ag.Sc.
Experimental Officer—Miss M. I. Vitolins, B.Sc.
Research Associate—T. B. Paltridge, B.Sc.

Mineralogy Section

Senior Principal Research Scientist—K. Norrish, M.Sc., Ph.D.
Principal Research Scientist—J. T. Hutton, B.Sc., A.S.A.S.M.
Principal Research Scientist—A. C. Oertel, D.Sc.
Principal Research Scientist—E. W. Radoslovich, M.Sc., Ph.D.
Research Scientist—T. Kato, M.Sc., Ph.D.
Research Scientist—C. B. Wells, M.Ag.Sc.
Experimental Officer—J. B. Giles, B.Sc.
Experimental Officer—E. St. A. Jordine, M.Sc.
Experimental Officer—R. M. McKenzie, B.Tech.
Experimental Officer—T. R. Sweatman, M.Sc.
Experimental Officer—R. M. Taylor, M.Sc.

At Cunningham Laboratory, Brisbane

Soil Survey and Pedology Section

Principal Research Scientist—G. D. Hubble, B.Ag.Sc.
Senior Research Scientist—G. G. Beckmann, M.Sc., Ph.D.
Senior Research Scientist—R. F. Isbell, M.Sc. (*at Townsville*)
Research Scientist—T. R. Paton, M.Sc.
Experimental Officer—C. H. Thompson, Q.D.A.

Soil Physics Section

Senior Research Scientist—G. B. Stirk, B.Sc.
Experimental Officer—R. E. Prebble, B.Sc.

Soil Chemistry Section

Senior Principal Research Scientist—A. E. Martin, D.Agric.Sc.
Senior Research Scientist—R. S. Beckwith, B.Sc. (*extended leave*)
Research Scientist—B. J. Crack, M.Sc. (*at Townsville*)
Experimental Officer—I. F. Fergus, B.Sc.
Experimental Officer—I. P. Little, B.Sc.Agr.
Experimental Officer—R. Reeve, Dip.Ind.Chem.
Experimental Officer—P. J. Ross, B.Sc.

Soil Microbiology Section

Senior Research Scientist—A. W. Moore, M.Sc., Ph.D.

At Canberra

Soil Survey and Pedology Section

Senior Principal Research Scientist—B. E. Butler, B.Sc.(Agric.)
Senior Research Scientist—D. C. van Dijk, Ing. Agr., D.Sc.
Senior Research Scientist—W. H. Litchfield, B.Sc. Agr.
Senior Research Scientist—J. Loveday, M.Ag.Sc., Ph.D. (*at Irrigation Research Laboratory, Griffith, N.S.W.*)
Senior Research Scientist—P. H. Walker, M.Sc. Agr. (*overseas*)

Soil Chemistry Section

Senior Research Scientist—J. D. Colwell, B.Sc. Agr., Ph.D. (*overseas*)
Scientific Services Officer—H. J. Beatty, Dip.Ind. Chem.

Soil Physics Section

Senior Research Scientist—D. S. McIntyre, M.Sc., Ph.D.
Experimental Officer—D. R. Scotter, B.Sc.Agr. (*overseas*)

Soil Micropedology Section

Senior Principal Research Scientist—R. Brewer, D.Sc.
Senior Research Scientist—J. R. Sleeman, B.Ag. Sc.
Experimental Officer—Miss M. P. Green, B.Sc.

At Perth

Soil Survey and Pedology Section

Principal Research Scientist—M. J. Mulcahy, B.Sc., Ph.D.
Senior Research Scientist—E. Bettenay, M.Sc. (Agric.)
Senior Research Scientist—H. M. Churchward, M.Sc.Agr.
Senior Research Scientist—W. M. McArthur, M.Sc.

Soil Chemistry Section

Research Scientist—J. Keay, B.Sc., Ph.D.
Experimental Officer—G. A. Dean, B.Sc., Ph.D.
Experimental Officer—F. J. Hingston, M.Sc.
Experimental Officer—A. G. Turton, B.Sc.

Soil Physics Section

Research Scientist—A. V. Blackmore, M.Sc., Ph.D. (*overseas*)
Experimental Officer—D. R. Williamson, B.Sc. Agr.

At Tasmanian Regional Laboratory, Hobart

Soil Survey and Pedology Section

Principal Research Scientist—K.D. Nicolls, B.Ag. Sc., B.Sc.
Research Scientist—G. M. Dimmock, B.Sc.

Soil Chemistry Section

Experimental Officer—A. M. Graley, B.Sc.
Experimental Officer—J. L. Honeysett, B.Sc.

SUGAR RESEARCH LABORATORY

See Chemical Research Laboratories

TASMANIAN REGIONAL LABORATORY

Headquarters: Stowell Avenue, Hobart

The services of this office are common to Divisions and Sections represented in Tasmania

Officer-in-Charge—D. Martin, D.Sc.
Administrative Officer—M. H. F. Bennett, A.F.I.A.

DIVISION OF TEXTILE INDUSTRY

See Wool Research Laboratories

DIVISION OF TEXTILE PHYSICS

See Wool Research Laboratories

DIVISION OF TRIBOPHYSICS

Headquarters: University of Melbourne, Parkville, Vic.

Chief—W. Boas, M.Sc., D.Ing., F.A.A.
Administrative Officer—W. A. Daunt
Senior Principal Research Scientist—L. M. Clarebrough, B.Met.E., M.Eng.Sc., Ph.D.
Senior Principal Research Scientist—A. K. Head, B.A.(Hons.), D.Sc., Ph.D.
Principal Research Scientist—D. Michell, B.E.E.
Principal Research Scientist—A. J. W. Moore, B.Sc., Ph.D.
Principal Research Scientist—J. F. Nicholas, B.A. (Hons.), B.Sc.
Principal Research Scientist—G. J. Ogilvie, B.Met.E., M.Eng.Sc., Ph.D.
Principal Research Scientist—J. V. Sanders, B.Sc. (Hons.), Ph.D.
Principal Research Scientist—G. W. West, B.E.E., B.Sc.
Senior Research Scientist—A. J. Davis, B.Eng.
Senior Research Scientist—M. H. Loretto, B.Met. (Hons.)
Senior Research Scientist—J. A. Spink, M.Sc.
Research Scientist—J. G. Allpress, M.Sc.
Research Scientist—B. G. Baker, B.Sc., Ph.D. Dip.Ed.
Research Scientist—Miss L. A. Bruce, B.Sc. (Hons.), Ph.D.
Research Scientist—P. Humble, B.Sc.(Hons.), Ph.D.
Research Scientist—A. Lawson, B.Sc., Ph.D.
Research Scientist—P. D. Mercer, B.Sc. (Hons.), Ph.D.
Research Scientist—H. G. Scott, B.A., Ph.D.
Research Scientist—R. L. Segall, M.Sc., Ph.D.
Experimental Officer—R. J. Esdaile, B.Sc.
Experimental Officer—R. L. Gully, A.R.M.I.T.
Experimental Officer—H. Jaeger, A.R.A.C.I.
Experimental Officer—A. M. B. Lewis, M.Sc. (*on leave*)
Experimental Officer—G. R. Perger, F.R.M.T.C.
Experimental Officer—R. G. Sherwood, A.R.M.T.C.
Experimental Officer—A. P. Smith, A.R.M.I.T.
Experimental Officer—I. J. Spark, B.Sc.
Experimental Officer—A. J. White, A.R.M.T.C.

DIVISION OF TROPICAL PASTURES

Headquarters: Cunningham Laboratory, St. Lucia, Qld.

At Cunningham Laboratory

Administration

Chief—J. Griffiths Davies, Ph.D., D.Sc.
Assistant Chief—E. M. Hutton, B.Agr.Sc., D.Sc.
Laboratory Secretary—A. G. Eyles, B.Sc.(Agric.)
Administrative Officer—D. B. Thomas
Librarian—Miss K. M. O'Brien

Agrostology

Chief—J. Griffiths Davies, Ph.D., D.Sc.
Principal Research Scientist—W. W. Bryan, M.Agr.Sc.
Principal Research Scientist—J. E. Coaldrake, M.Sc.
Principal Research Scientist—R. Roe, B.Sc. (Agric.)
Principal Research Scientist—N. H. Shaw, B.Agr. Sc.(Hons.)
Senior Research Scientist—J. S. Russell, B.Agr. Sc., Ph.D.
Research Scientist—R. L. Hall, B.Sc.(Agric.), Ph.D.
Research Scientist—R. J. Jones, B.Sc.(Agric.) (Hons.), D.T.A.(Trin.)
Research Scientist—L. 't Mannetje, Ir.(Wageningen)
Experimental Officer—T. R. Evans, B.Sc.(Agric.), D.T.A.(Trin.)

Plant Breeding and Genetics

Senior Principal Research Scientist—E. M. Hutton, B.Agr.Sc., D.Sc.
Senior Research Scientist—A. J. Pritchard, B.Sc. (Hons.), D.T.A.(Trin.)
Research Scientist—R. A. Bray, B.Agr.Sc., Ph.D.
Research Scientist—J. B. Hacker, B.Sc.(Agric.) (Hons.), Ph.D.
Experimental Officer—D. E. Byth, B.Agr.Sc. (Hons.) (*overseas*)
Experimental Officer—S. G. Gray, M.Sc.Agr.

Plant Nutrition and Soil Fertility

Principal Research Scientist—C. S. Andrew, M.Agr.Sc.
Senior Research Scientist—E. F. Henzell, B.Agr. Sc.(Hons.), Ph.D.
Research Scientist—R. E. White, B.Agr.Sc., Ph.D.
Experimental Officer—V. R. Catchpoole, B.Agr. Sc.(Hons.), M.Sc.
Experimental Officer—I. Vallis, B.Agr.Sc.(Hons.)

Plant Physiology

Principal Research Scientist—C. T. Gates, M.Sc. (Agric.)
Research Scientist—P. C. Whiteman, B.Agr.Sc. (Hons.), Ph.D.
Research Scientist—J. R. Wilson, M.Sc.(Agric.), Ph.D.

Plant Chemistry

Senior Research Scientist—M. P. Hegarty, M.Sc., Ph.D.
Experimental Officer—R. D. Court, B.Sc.
Experimental Officer—M. F. Robins, B.Sc. (Agric.)

Ecology

Principal Research Scientist—J. E. Coaldrake, M.Sc.
Research Scientist—J. C. Tothill, B.Agr.Sc., Ph.D.

Legume Bacteriology

Senior Principal Research Scientist—D. O. Norris, D.Sc.(Agric.)

At Cooper Laboratory, Lawes, Qld.

Pasture Evaluation and Animal Nutrition

Senior Research Scientist—R. Milford, B.Agr.Sc. (Hons.), Ph.D.
Senior Research Scientist—D. J. Minson, B.Agr. Sc.(Hons.), Ph.D.

Agrostology

Senior Research Scientist—C. A. Smith, M.Agr. Sc.
Experimental Officer—M. J. Russell, B.Sc.(Agric.), D.T.A.(Trin.)

At Pastoral Research Laboratory, Townsville, Qld.

Officer-in-Charge—L. A. Edye, B.Agr.Sc.(Hons.), M.Sc.

Agrostology

Senior Research Scientist—L. A. Edye, B.Agr.Sc. (Hons.), M.Sc.
Research Scientist—P. Gillard, B.Sc.(Hons.), Ph.D.
Experimental Officer—D. A. Cameron, B.Agr.Sc. (Hons.)

Plant Nutrition

Research Scientist—R. K. Jones, B.Agr.Sc. (Hons.), Ph.D.

Pasture Evaluation

Research Scientist—M. J. Playne, B.Agr.Sc. (Hons.), Ph.D.

At Lansdown Pasture Research Station, Woodstock, Qld.

Experimental Officer—J. B. Ritson, B.Agr.Sc.

UPPER ATMOSPHERE SECTION

Headquarters: Carrington Road, Camden, N.S.W.

Officer-in-Charge—D. F. Martyn, D.Sc., Ph.D., F.A.A., F.R.S.
Principal Research Scientist—E. B. Armstrong, B.Sc., Ph.D.
Senior Research Scientist—R. A. Duncan, B.Sc. (Hons.)
Experimental Officer—D. G. Cartwright, B.Sc. (Hons.)
Experimental Officer—K. Yano, B.Sc.

WESTERN AUSTRALIAN REGIONAL LABORATORY

Headquarters: University Grounds, Nedlands, W.A.

The services of this office are common to Divisions and Sections represented in Western Australia

Officer-in-Charge—M. J. Mulcahy, B.Sc., Ph.D.
Administrative Officer—J. P. Brophy

WHEAT RESEARCH UNIT

Headquarters: Epping Road, North Ryde, N.S.W.

Officer-in-Charge—E. E. Bond, A.R.M.T.C.
Leader of Unit—M. V. Tracey, M.A.
Senior Research Scientist—J. Wilson Lee, B.Sc. (Hons.), Ph.D.
Research Scientist—D. J. Winzor, B.Sc.(Hons.), Ph.D.
Experimental Officer— Mrs. I. C. Barnes, B.Sc.
Experimental Officer—J. K. Raison, B.Sc.(Hons.), Ph.D. (*seconded to Division of Plant Industry*)
Experimental Officer—J. A. Ronalds, B.Sc.
Experimental Officer—M. Wootton, B.Sc.
Experimental Officer—Mrs. P. M. Wrench, M.Sc.
Experimental Officer—C. W. Wrigley, M.Sc. (*on leave*)

DIVISION OF WILDLIFE RESEARCH

Headquarters: Barton Highway, Canberra

Administration

Chief—H. J. Frith, D.Sc.Agr.
Administrative Officer—P. E. R. Magi, B.A.
Librarian—Mrs. J. F. Bland

Marsupial Biology

Senior Principal Research Scientist—G. B. Sharman, D.Sc.
Senior Research Scientist—J. H. Calaby, Dip. Appl.Chem.
Senior Research Scientist—W. E. Poole, B.Sc. (Hons.)
Experimental Officer—P. T. Bailey, B.Sc., Dip. Agric.Ent.
Experimental Officer—Miss M. J. Clark, B.Sc. (Hons.)
Experimental Officer—D. L. McIntosh

Rabbit Biology

Principal Research Scientist—K. Myers, B.Sc. (Hons.)
Senior Research Scientist—R. Mykytowycz, D.V.M.
Research Scientist—J. D. Dunsmore, B.V.Sc., Ph.D.
Research Scientist—P. J. Fullagar, B.Sc.(Hons.), Ph.D.
Research Scientist—R. L. Hughes, B.Sc.(Hons.)
Experimental Officer—D. K. Casperson, B.Sc. (Hons.)
Experimental Officer—B. S. Parker, B.Sc.

Rabbit Control

Scientific Services Officer—B. V. Fennessy, B.Agr. Sc.

Field Ecology

Principal Research Scientist—D. L. Serventy, B.Sc. (Hons.), Ph.D. (*at Perth*)
Senior Research Scientist—M. G. Ridpath, B.Sc. (Hons.)
Senior Research Scientist—I. C. R. Rowley, B.Agr. Sc.
Research Scientist—G. F. van Tets, M.A., Ph.D.
Experimental Officer—L. W. Braithwaite, B.Sc.

Experimental Officer—S. J. J. F. Davies, B.A. (Hons.) (*at Perth*)
Experimental Officer—F. N. Robinson, B.A. (Hons.)

Bird Population Studies

Senior Principal Research Scientist—R. Carrick, B.Sc.(Hons.), Ph.D.
Experimental Officer—Miss S. E. Ingham, B.A. (Hons.)

Animal Physiology

Principal Research Scientist—M. E. Griffiths, D.Sc.

WOOL RESEARCH LABORATORIES

Wool Textile Research Committee

F. G. Lennox, D.Sc. (*Chairman*)
V. D. Burgmann, B.Sc., B.E.
M. Lipson, B.Sc., Ph.D.
C. Garrow, M.Ag.Sc., B.Com., D.P.A. (*Secretary*) (*overseas*)

DIVISION OF PROTEIN CHEMISTRY

Headquarters: 343 *Royal Parade, Parkville, Vic.*

Chief—F. G. Lennox, D.Sc.
Assistant Chief—W. G. Crewther, M.Sc.
Laboratory Secretary—C. Garrow, M.Ag.Sc., B.Com., D.P.A. (*overseas*)
Librarian—Miss M. M. Clippingdale, B.A., A.L.A.A.
Senior Principal Research Scientist—R. D. B. Fraser, Ph.D., D.Sc.
Senior Principal Research Scientist—H. Lindley, B.A., Ph.D.
Senior Principal Research Scientist—P. Mason, M.Sc., Ph.D.
Principal Research Scientist—J. M. Gillespie, D.Sc.
Principal Research Scientist—B. S. Harrap, M.Sc., Ph.D.
Principal Research Scientist—M. A. Jermyn, M.Sc., Ph.D.
Principal Research Scientist—S. J. Leach, B.Sc. Tech., Ph.D.
Principal Research Scientist—I. J. O'Donnell, M.Sc.
Principal Research Scientist—T. A. Pressley, B.Sc., Ph.D.
Principal Research Scientist—W. E. Savige, M.Sc., Ph.D.
Principal Research Scientist—E. O. P. Thompson, M.Sc., Ph.D., Dip.Ed.
Principal Research Scientist—E. F. Woods, M.Sc.
Senior Research Scientist—A. S. Inglis, M.Sc.
Senior Research Scientist—J. A. Maclaren, M.Sc., Ph.D.
Senior Research Scientist—T. P. MacRae, M.Sc.
Senior Research Scientist—B. Milligan, B.Sc., Ph.D.
Senior Research Scientist—J. G. Scroggie, M.Sc., Ph.D.
Senior Research Scientist—F. H. C. Stewart, B.Sc., Ph.D.
Senior Research Scientist—J. F. K. Wilshire, B.Sc., Ph.D.
Research Scientist—M. G. Dobb, B.Sc., Ph.D.
Research Scientist—G. W. Evans, B.Sc., Ph.D.
Research Scientist—R. Frater, B.Sc., Ph.D.
Research Scientist—S. H. Laurie, B.Sc., Ph.D.
Research Scientist—R. Ledger, B.Sc.(Hons.), Ph.D.
Research Scientist—A. Miller, B.Sc.(Hons.), Ph.D.
Research Scientist—B. G. Newsom, B.Sc., Ph.D.
Research Scientist—E. Suzuki, B.Eng.
Research Scientist—B. J. Sweetman, M.Sc., Ph.D.
Research Scientist—M. A. W. Thomas, B.Sc., Ph.D.
Research Scientist—J. R. Yates, M.A., Ph.D.
Engineer—E. P. Lhuede, B.Mech.E.
Experimental Officer—P. J. Beck, A.R.M.I.T.
Experimental Officer—J. B. Caldwell, B.Sc.
Experimental Officer—L. M. Dowling, B.Sc.
Experimental Officer—Miss J. E. Eager, B.Sc. (Hons.)
Experimental Officer—G. F. Flanagan, F.R.M.T.C.
Experimental Officer—I. H. Leaver, B.Sc.
Experimental Officer—A. B. McQuade, B.Sc.
Experimental Officer—D. E. Rivett, A.B.T.C.
Experimental Officer—R. J. Rowlands, B.Sc.
Experimental Officer—C. M. Roxburgh, B.Sc., Ph.D.
Experimental Officer—I. W. Stapleton, B.Sc.
Experimental Officer—K. I. Wood, A.R.M.T.C.
Experimental Officer—Miss A. Woodcock, B.Sc. (Hons.)
Scientific Services Officer—J. P. E. Human, M.Sc., Ph.D.

DIVISION OF TEXTILE INDUSTRY

Headquarters: Princes Highway, Belmont, Geelong, Vic.

Chief—M. Lipson, B.Sc., Ph.D.
Administrative Officer—J. H. G. Watson, A.A.S.A.
Librarian—Miss L. A. MacGowan
Senior Principal Research Scientist—G. W. Walls, B.Sc.
Principal Research Scientist—J. Delmenico, B.Sc., Ph.D.
Principal Research Scientist—A. J. Farnworth, M.B.E., M.Sc., Ph.D., A.G.Inst.Tech. (*seconded to Australian Wool Board*)
Principal Research Scientist—J. R. McPhee, B.Sc., D.Phil.
Principal Research Scientist—D. S. Taylor, B.A., B.Sc., Ph.D.
Principal Research Scientist—G. F. Wood, B.Sc., Ph.D.
Senior Research Scientist—C. A. Anderson, B.Sc., Ph.D.
Senior Research Scientist—R. E. Belin, M.Sc.
Senior Research Scientist—D. E. Henshaw, B.Sc.
Senior Research Scientist—W. V. Morgan, B.Sc.
Senior Research Scientist—V. A. Williams, B.Sc., Ph.D.
Research Scientist—J. H. Brooks, M.Sc., Ph.D.
Research Scientist—A. J. Pratt, M.Sc., Ph.D.
Engineer—B. B. Beard, A.G.Inst.Tech.
Experimental Officer—G. M. Abbott, B.Sc. (*overseas*)
Experimental Officer—T. Akbar, M.Sc.
Experimental Officer—L. A. Allen, B.Sc.

Experimental Officer—I. B. Angliss, A.G.Inst. Tech.
Experimental Officer—J. R. Cook, A.G.Inst. Tech.
Experimental Officer—B. C. Ellis, A.M.C.T.
Experimental Officer—H. D. Feldtman, A.G.Inst. Tech.
Experimental Officer—E. O. Firth, G.I.Mech.E.
Experimental Officer—G. N. Freeland, A.G.Inst. Tech.
Experimental Officer—R. G. Ganly, A.G.Inst. Tech.
Experimental Officer—R. J. Hine, A.G.Inst.Tech.
Experimental Officer—H. J. Katz, B.Sc., Ph.D.
Experimental Officer—B. O. Lavery, Nat.Cert. in Mech.Eng.
Experimental Officer—J. D. Leeder, A.G.Inst. Tech.
Experimental Officer—B. G. Parnell, G.I.Mech.E.
Experimental Officer—D. E. A. Plate, B.Sc. (*overseas*)
Experimental Officer—C. P. Pritchard, A.G.Inst. Tech.
Experimental Officer—M. A. Trewhella, B.Sc.
Experimental Officer—J. L. Woo, M.Sc.
Scientific Services Officer—J. M. Preston, D.Sc.
Scientific Services Officer—G. C. West, A.G.Inst. Tech.

DIVISION OF TEXTILE PHYSICS

Headquarters: 338 *Blaxland Road, Ryde, N.S.W.*

Chief—V. D. Burgmann, B.Sc., B.E.
Administrative Officer—R. D. Whittle
Librarian—Miss H. G. Barr, B.A., A.L.A.A.
Senior Principal Research Scientist—J. G. Downes, B.Sc.
Senior Principal Research Scientist—M. Feughelman, B.Sc., A.S.T.C.
Principal Research Scientist—Mrs. K. R. Makinson, M.A.
Senior Research Scientist—K. Baird, M.Sc., Ph.D.
Senior Research Scientist—E. G. Bendit, B.Sc. (Eng.), M.Sc.
Senior Research Scientist—H. G. David, B.Sc.
Senior Research Scientist—A. R. Haly, M.Sc.
Senior Research Scientist—H. W. Holdaway, B.Sc., B.E.
Senior Research Scientist—J. F. P. James, M.Sc.
Senior Research Scientist—D. T. Liddy, B.Sc.
Senior Research Scientist—P. Nordon, B.Sc., Ph.D., A.S.T.C.
Senior Research Scientist—I. M. Stuart, M.Sc.
Senior Research Scientist—I. C. Watt, M.Sc., Ph.D.
Research Scientist—M. W. Andrews, B.Sc., Ph.D.
Research Scientist—E. F. Denby, B.Sc., Ph.D., D.I.C.
Research Scientist—B. H. Mackay, B.Sc., A.S.T.C.
Research Scientist—B. J. Rigby, M.Sc., A.S.T.C.
Engineer—H. W. Lunney, B.Sc., B.E.
Engineer—Z. B. Laicans, B.Sc.
Experimental Officer—J. E. Algie, B.E., M.Sc., A.S.T.C.
Experimental Officer—N. W. Bainbridge, B.Sc.
Experimental Officer—P. G. Burton, B.Sc. (*overseas*)
Experimental Officer—B. M. Chapman, B.Sc.
Experimental Officer—R. L. D'Arcy, B.Sc., A.S.T.C.
Experimental Officer—R. A. F. Foulds, B.Sc.
Experimental Officer—Miss J. C. Griffith, M.Sc., Ph.D., A.S.T.C.
Experimental Officer—O. Holmwood, B.Sc., B.E.
Experimental Officer—Miss D. R. McKelvie, B.Sc.
Experimental Officer—G. B. McMahon, B.Sc.
Experimental Officer—R. K. Mann, B.Sc.(Hons.)
Experimental Officer—T. W. Mitchell, A.S.T.C.
Experimental Officer—A. McD. Richardson, B.E.
Experimental Officer—K. D. Sinclair, A.S.T.C.
Experimental Officer—L. J. Smith, A.S.T.C.
Experimental Officer—A. E. Stearn, B.Sc.
Experimental Officer—G. L. Stott, A.S.T.C.

UNATTACHED OFFICERS

International Scientific Expert—F. G. Nicholls, M.Sc. (*seconded to United Nations Programme of Technical Assistance*)

Senior Principal Research Scientist—W. L. Greenhill, M.E. (*seconded to Thailand*)

Senior Principal Research Scientist—G. H. Munro, D.Sc. (*seconded to Electrical Engineering Department, University of Sydney*)

Senior Principal Research Scientist—A. J. Vasey, M.B.E., B.Agr.Sc. (*seconded to British Commonwealth Scientific Committee*)

Senior Principal Research Scientist—D. B. Williams, B.Sc.Agr., B.Com., Ph.D. (*seconded to University of Melbourne*)

Principal Research Scientist—J. C. M. Fornachon, B.Agr.Sc., M.Sc. (*seconded to Australian Wine Research Institute*)

Principal Research Scientist—L. A. Thomas, M.Sc. (*seconded to Queensland Department of Agriculture*)

Experimental Officer—A. C. Blaskett, B.Sc. (*on leave*)

Experimental Officer—L. Heisler, B.Sc. (*seconded to Electrical Engineering Department, University of Sydney*)

Experimental Officer—T. E. Treffry, B.Agr.Sc. (*on leave*)

5

Finance

A summary of the Organization's receipts and expenditure from July 1, 1964 to June 30, 1965 has been given on pages 5–9. Details are given below:

Expenditure

	£	£	£
SALARIES AND CONTINGENCIES*			**758,066**
INVESTIGATIONS			
Animal Research Laboratories			
Gross Expenditure		1,699,936	
Animal Genetics			
Gross Expenditure		502,889	
LESS Contributions from—			
Wool Research Trust Fund	163,622		
Cattle and Beef Research Trust Account ..	15,431		
General Donations	600		
Special Revenue Fund—"Belmont" Field Station ..	18,009		
†U.S. National Institutes of Health	5,027		
Total Contributions		202,689	
Net Treasury Expenditure			300,200

* The main items of expenditure under this heading are salaries of the administrative staff at Head Office; salaries and expenses of officers at the Liaison Offices in London and Washington; staff and upkeep of State Committees; travelling expenses of Head Office staff; and general office expenditure.

† Overseas organization.

	£	£	£
Animal Health			
Gross Expenditure		564,602	
LESS Contributions from—			
Wool Research Trust Fund..	89,104		
Alexander Fraser Memorial Fund	299		
Cattle and Beef Research Trust Account ..	15,126		
Dairy Produce Research Trust Account ..	7,460		
Ian McMaster Bequest	4,524		
Merck, Sharp & Dohme (Aust.) Pty. Ltd. ..	1,789		
Total Contributions		118,302	
Net Treasury Expenditure			446,300
Animal Physiology			
Gross Expenditure		632,445	
LESS Contributions from—			
Wool Research Trust Fund..	531,281		
Burdekin Bequest (Drought Feeding)	2,480		
Cattle and Beef Research Trust Account ..	26,892		
Total Contributions		560,653	
Net Treasury Expenditure			71,792
Plant Research			
Gross Expenditure		1,903,479	
Plant Industry			
Gross Expenditure		1,496,944	
LESS Contributions from—			
Wool Research Trust Fund	336,334		
Australian Apple and Pear Board	732		
Australian Fertilizers Ltd. and Sulphide Corporation Pty. Ltd.	176		
Cattle and Beef Research Trust Account ..	8,535		
Dairy Produce Research Trust Account ..	7,539		
Department of Primary Industry	15,821		
†Fisons Pest Control and J. R. Geigy	21,678		
†Foundation for International Potash Research ..	57		
Legacy of the late J. O. Holston	256		
National Capital Development Commission ..	16		
North Queensland Tobacco Growers' Co-operative Association	465		
†Rockefeller Foundation	101		
†Sulphur Institute of America	544		
Tobacco Industry Trust Account	69,176		
†U.S. National Institutes of Health	565 Cr.		
Wheat Research Trust Account	11,592		
Total Contributions		472,457	
Net Treasury Expenditure			1,024,487

† Overseas organization.

	£	£	£
Tropical Pastures			
Gross Expenditure		406,535	
LESS Contributions from—			
A.C.F. & Shirleys Fertilizers Ltd.	1,320		
Cattle and Beef Research Trust Account ..	51,653		
Dairy Produce Research Trust Account ..	6,440		
Imperial Chemical Industries of Australia & New Zealand Ltd.	1,696		
Special Revenue Fund—Samford Farm ..	4,739		
Total Contributions		65,848	
Net Treasury Expenditure			340,687

Entomology

Gross Expenditure		637,722	
LESS Contributions from—			
Wool Research Trust Fund	19,445		
Cattle and Beef Research Trust Account ..	26,130		
Department of Health	44,397		
Department of Primary Industry	3,581		
General Donations	516		
River Murray Commission and Snowy Mountains Hydro-Electric Authority and Kosciusko State Park Trust	2,728		
†U.S. National Institutes of Health	4,772		
Wheat Research Trust Account	142		
†World Health Organization	625		
Total Contributions		102,336	
Net Treasury Expenditure			535,386

† Overseas organization.

	£	£	£
Soils and Irrigation			
Gross Expenditure		1,018,774	
Soils			
Gross Expenditure		537,405	
LESS Contributions from—			
Wool Research Trust Fund	5,052		
Australian Fertilizers Ltd., A.C.F. & Shirleys Fertilizers Ltd., and Imperial Chemical Industries of Australia & New Zealand Ltd.	600		
Bureau of Mineral Resources	464		
Commonwealth Fertilizers & Chemicals Ltd., Australian Fertilizers Ltd., Cuming Smith and Mt. Lyell Farmers Fertilizers Ltd.	1,820		
†Rockefeller Foundation	3,887		
S. Aust. Woods and Forests Department, W.A. Forests Department, and Australian Paper Manufacturers Ltd.	6,097		
Wheat Research Trust Account	11,579		
Zinc Corporation Ltd. and Philips Electrical Industries Pty. Ltd.	409		
Total Contributions		29,908	
Net Treasury Expenditure			507,497
Soil Mechanics			
Gross Expenditure		133,075	
LESS Contributions from—			
Department of the Army	11,504		
S. Aust. Housing Trust	440		
Tasmanian Department of Health	41		
Water Research Foundation of Australia ..	1,832		
Total Contributions		13,817	
Net Treasury Expenditure			119,258
Horticultural Research Section, Merbein, Vic.			
Gross Expenditure		154,832	
LESS Contributions from—			
Australian Dried Fruits Association	239		
Australian Wine Board and Department of Primary Industry	3,334		
Dried Fruits Control Board	186		
Packing Companies and Co-operative Dried Fruit Sales Pty. Ltd.	1,795		
Special Revenue Fund—Coomealla, N.S.W. ..	4,000		
Total Contributions		9,554	
Net Treasury Expenditure			145,278

† Overseas organization.

	£	£	£
Irrigation Research Laboratory, Griffith, N.S.W.			
Gross Expenditure		193,462	
LESS Contributions from—			
N.S.W. Water Conservation and Irrigation Commission	10,276		
Special Revenue Fund—Irrigation Research Laboratory, Griffith, N.S.W.	10,462		
Total Contributions		20,738	
Net Treasury Expenditure			172,724
Food Preservation			
Gross Expenditure		543,334	
LESS Contributions from—			
Australian Apple and Pear Board	515		
Australian Banana Growers' Council	3,452		
Australian Canned Fruits Board	2,968		
Australian Dried Fruits Association and Department of Primary Industry	276		
Australian Egg Board	264		
Australian Dried Fruits Board	156		
Australian Meat Board	500		
Banana Research Fund	16		
Broken Hill Pty. Ltd.	715		
Cattle and Beef Research Trust Account ..	12,272		
Darling Downs Co-operative Bacon Association ..	184		
Department of Primary Industry	3,592		
Metropolitan Meat Industry Board of N.S.W. ..	532		
N.S.W. Department of Agriculture	4,631		
Rice Marketing Board	499		
†U.S. Department of Agriculture	11,551		
Various Contributors	8,037		
Total Contributions		50,160	
Net Treasury Expenditure			493,174
Forest Products			
Gross Expenditure		546,536	
LESS Contributions from—			
Australian Paper Manufacturers Ltd. Associated Pulp and Paper Mills Ltd. Australian Newsprint Mills Pty. Ltd. New Zealand Forest Products Ltd. ..	5,807		
Australian Plywood Board	14,686		
†Department of Forestry, Fiji	1,640		
Department of Territories	4,438		
General Donations	743		
Total Contributions		27,314	
Net Treasury Expenditure			519,222

† Overseas organization.

	£	£	£
Mining and Metallurgy			
Gross Expenditure		88,803	
LESS Contributions from—			
Australasian Institute of Mining and Metallurgy ..	2,574		
Broken Hill Mine Managers' Association ..	536		
General Donations	6,306		
State Electricity Commission of Victoria ..	560		
Total Contributions		9,976	
Net Treasury Expenditure			78,827
Radio Research			
Gross Expenditure		95,548	
Upper Atmosphere Section			
Net Treasury Expenditure			48,550
Radio Research Board Activities			
Gross Expenditure		46,998	
LESS Contributions from—			
Postmaster-General's Department, Australian Broadcasting Control Board, and Overseas Telecommunications Commission	24,548		
Total Contributions		24,548	
Net Treasury Expenditure			22,450
Research Services			
Gross Expenditure		646,869	
Mechanical Engineering			
Gross Expenditure		166,445	
LESS Contributions from—			
†University of Wisconsin	552		
Wheat Research Trust Account	16,741		
Total Contributions		17,293	
Net Treasury Expenditure			149,152
Other Services			
Gross Expenditure		480,424	
LESS Contributions from—			
Wool Research Trust Fund..	21,477		
Total Contributions		21,477	
Net Treasury Expenditure			458,947

† Overseas organization.

	£	£	£
Chemical Research Laboratories			
Gross Expenditure		1,455,693	
LESS Contributions from—			
Wool Research Trust Fund	22,147		
Australian Mineral Industries Research Association	1,468		
Cattle and Beef Research Trust Account ..	4,847		
Cement and Concrete Association of Australia ..	11,477		
Colonial Sugar Refining Co. Ltd.	2,427		
Conzinc Riotinto of Australia Ltd.	13,219		
Conzinc Riotinto of Australia Ltd. and Monsanto Chemicals	800		
Conzinc Riotinto of Australia Ltd. and Southern Portland Cement Ltd.	1,488		
General Donations	6,729		
Mary Kathleen Uranium Ltd.	256		
Murphyores Pty. Ltd.	1,612		
†Population Council Inc.	14		
Reserve Bank of Australia	2,680		
†Smith, Kline, and French Laboratories (U.S.A.) ..	6,160		
State Electricity Commission of Victoria, Gas & Fuel Corporation of Victoria, and Australian Paper Manufacturers Ltd.	13		
Techtron Pty. Ltd.	117		
Union Carbide Australia Ltd.	3,847		
†U.S. National Institutes of Health	4,482		
W.A. Chamber of Mines	4,393		
Total Contributions		88,176	
Net Treasury Expenditure			1,367,517
Fisheries and Oceanography			
Gross Expenditure		355,905	
LESS Contributions from—			
Department of Harbours and Marine	12,008		
Department of the Navy	4,445		
Department of Primary Industry	1,929		
Department of Primary Industry and Tasmanian Department of Agriculture	22,783		
Fisheries Development Trust Account ..	9,856		
Total Contributions		51,021	
Net Treasury Expenditure			304,884

† Overseas organization.

	£	£	£
Mathematical Statistics			
Net Treasury Expenditure			150,929
National Standards Laboratory			
Gross Expenditure		1,004,240	
LESS Contributions from—			
Length Measurement Research Fund	125		
†U.S. Air Force	619		
†U.S. National Aeronautics and Space Administration	15,139		
†U.S. National Bureau of Standards	7,703		
Total Contributions		23,586	
Net Treasury Expenditure			980,654
Tribophysics			
Gross Expenditure		161,343	
LESS Contributions from—			
Union Carbide Australia Ltd.	1,412		
Total Contributions		1,412	
Net Treasury Expenditure			159,931
Building Research			
Gross Expenditure		294,458	
LESS Contributions from—			
Associated Fibrous Plaster Manufacturers of Australia, Australian Plaster Industries Ltd., and Colonial Sugar Refining Co. Ltd.	4,344		
Cement and Concrete Association of Australia ..	635		
General Donations	625		
Housing Commission of Victoria, State Electricity Commission of Victoria, Victorian Railways Department	2,612		
Whitelaw Monier Pty. Ltd.	791		
Total Contributions		9,007	
Net Treasury Expenditure			285,451
Biochemistry and General Nutrition			
Gross Expenditure		224,985	
LESS Contributions from—			
Wool Research Trust Fund	82,291		
Total Contributions		82,291	
Net Treasury Expenditure			142,694

† Overseas organization.

	£	£	£
Fodder Conservation			
Net Treasury Expenditure			35,784
Radiophysics			
Gross Expenditure		679,962	
LESS Contributions from—			
Queensland Government	4,213		
†U.S. National Aeronautics and Space Administration	21,978		
Total Contributions		26,191	
Net Treasury Expenditure			653,771
Metallurgical Research			
Net Treasury Expenditure			24,203
Computing Research			
Net Treasury Expenditure			185,333
Meteorological Physics			
Gross Expenditure		181,711	
LESS Contributions from—			
Tobacco Research Trust Account	613		
Total Contributions		613	
Net Treasury Expenditure			181,098
Dairy Research			
Gross Expenditure		204,740	
LESS Contributions from—			
Dairy Produce Research Trust Account ..	70,751		
Total Contributions		70,751	
Net Treasury Expenditure			133,989
Wool Research			
Gross Expenditure		1,111,604	
LESS Contributions from—			
Wool Research Trust Fund	1,081,656		
Blanket Freight Equalization Fund	335 Cr.		
Leather Research Fund	1,120		
Wool Buying and Selling Account	9,877		
Total Contributions		1,092,318	
Net Treasury Expenditure			19,286

† Overseas organization.

	£	£	£
Fuel Research			
Gross Expenditure		412,397	
LESS Contributions from—			
Electricity Trust of South Australia	10,938		
General Donations	5,205		
State Electricity Commission of Victoria ..	3,174		
Total Contributions		19,317	
Net Treasury Expenditure			393,080
Wildlife Research			
Gross Expenditure		266,764	
LESS Contributions from—			
Wool Research Trust Fund	78,139		
Cattle and Beef Research Trust Account ..	180		
Department of Civil Aviation	10,015		
Various (Fauna Survey)	225		
Total Contributions		88,559	
Net Treasury Expenditure			178,205
Land Research and Regional Survey			
Gross Expenditure		517,772	
LESS Contributions from—			
Cattle and Beef Research Trust Account ..	8,427		
Department of National Development	5,154		
Department of Territories	64,107		
F. C. Pye Research Fund	5,431		
Northern Territory Administration	57,966		
W.A. Department of Agriculture	5,989		
Total Contributions		147,074	
Net Treasury Expenditure			370,698

	£	£	£
Miscellaneous			
Patent Fees		8,898	
Extra-mural Investigations		47,310	
Furlough and Compensation		52,574	
Unattached Officers		18,976	
Wheat Research		40,024	
Grants to Scientific Workers		799	
Australian Mineral Development Laboratories ..		25,810	
Bloat Research		601	
Various		12,909	
Gross Expenditure		207,901	
LESS Contributions from—			
Science and Industry Endowment Fund ..	799		
Wheat Research Trust Account	34,324		
Cattle and Beef Research Trust Account ..	601		
Total Contributions		35,724	
Net Treasury Expenditure			172,177
TOTAL TREASURY EXPENDITURE—INVESTIGATIONS			**11,173,615**
OTHER SERVICES			
Research Associations—Grants			
Bread Research Institute	21,250		
Wine Research Institute	5,000		
Coal Association (Research) Ltd.	25,000		
Australian Leather Research Association ..	10,000	61,250	
Overseas Research Studentships		154,428	
Other Grants			
Commonwealth Agricultural Bureaux	78,462		
Standards Association of Australia	119,000		
National Association of Testing Authorities ..	25,800		
Minor International Associations	10,090	233,352	
TOTAL OTHER SERVICES			**449,030**
TOTAL SALARIES AND CONTINGENCIES, INVESTIGATIONS, AND OTHER SERVICES			**12,380,711**
LESS receipts from sales of equipment, publications, etc., and revenue earned by Divisions and Sections, details of which are shown on page 214			178,300
TOTAL TREASURY EXPENDITURE			**12,202,411**

Contributions

This section shows receipts and disbursements during the year 1964–65 of the funds provided by contributors and recorded in a special account entitled "Specific Research Trust Fund". It includes transactions financed from wool funds, details of which appear on pages 212–4. Of the total expenditure of £3,902,914 recorded in this Fund, £3,483,110 refers to normal research activities and £419,804 to capital works. The following table summarizes the sources of these funds and the activities on which they are expended.

SOURCE OF FUNDS	ACTIVITY		TOTAL
	Investigations	*Capital Works*	
	£	£	£
Wool Research Trust Fund	2,430,547	153,670	2,584,217
Contributions (other than Wool)	1,052,563	266,134	1,318,697
	3,483,110	419,804	3,902,914

The details are as follows:

	Receipts 1964–65 & *Balances brought forward* 1963–64 £	*Expenditure* 1964–65 £
Wool Research Trust Fund (*details are shown on pages 212–4*)	2,639,504	2,584,217
Animal Research Laboratories		
Alexander Fraser Memorial Fund—*Fluke Investigations* ..	485	299
Beef Cattle Nutrition Account (Animal Physiology) ..	89	NIL
Burdekin Bequest—*Drought Feeding Investigations* ..	2,934	2,480
Cattle and Beef Research Trust Account—*Genetic Studies* ..	23,798	24,002*
Cattle and Beef Research Trust Account—*Virological Diseases of Cattle*	69,773	42,891
Cattle and Beef Research Trust Account—*Acquisition of Property at Jimboomba for Cattle Tick Investigations* ..	9,000	5,384
Cattle and Beef Research Trust Account—*Nutritional Studies*	30,201	29,367
Dairy Produce Research Trust Account—*Infertility in Dairy Cattle*	4,122	3,643
Dairy Produce Research Trust Account—*Virus Diseases of Dairy Cattle*	2,437	2,371
Dairy Produce Research Trust Account—*Endoparasites of Dairy Cattle*	2,000	1,446
Estate of the late Captain Ian McMaster—*Scholarship* ..	4,406	4,524*
General Donations—*Myxomatosis Investigations* ..	672	600
General Donations (Animal Health)	13	NIL
Merck, Sharp & Dohme (Aust.) Pty. Ltd.—*Anthelmintics Research*	7,056	1,789
†Population Council Inc.—*Studies on Induced Infertility* ..	19	NIL
Special Revenue Fund—"*Belmont*" *Field Station, Rockhampton, Qld.*	34,396	18,009
†U.S. National Institutes of Health—*Chemical, Physical, and Genetic Studies of Myxoma Virus*	6,196	5,027
†U.S. National Institutes of Health—*Visit of Dr. Druger* ..	25	NIL

* Expenditure on this work in excess of receipts will be recovered in 1965–66.
† Overseas organization.

	Receipts 1964–65 *& Balances brought forward* 1963–64 £	*Expenditure* 1964–65 £
Plant Research		
Acquisition and Development of Baker's Hill Field Station	16,240	13,537
Apple and Pear Board—*Contribution to Expenses of Experimental Shipment to U.K.*	805	732
Australian Fertilizers Ltd. and Sulphide Corporation Pty. Ltd.—*Phosphate Soil Testing*	380	176
Australian Tobacco Research Trust—*Tobacco Research Institute, Mareeba, Qld.*	77,339	64,010
Australian Tobacco Research Trust—*Blue Mould Investigations, Canberra*	5,540	5,166
A.C.F. & Shirleys Fertilizers Ltd.—*Trial work at Rodd's Bay, Qld.*	2,420	1,656
Cattle and Beef Research Trust Account—*Pasture Plant Physiology*	8,300	7,145
Cattle and Beef Research Trust Account—*Pasture Development and Plant Nutrition Investigations*	33,379	33,816*
Cattle and Beef Research Trust Account—*Genetic Breeding Investigations*	9,716	9,775*
Cattle and Beef Research Trust Account—*Pasture Nitrogen Project*	12,968	13,047*
Cattle and Beef Research Trust Account—*Plant Introduction Testing Station*	10,000	4,409
Cattle and Beef Research Trust Account—*Pasture Plant Collecting and Testing*	6,500	6,719*
Colonial Sugar Refining Co.—*Genetics Research* ..	2	NIL
Dairy Produce Research Trust Account—*Nutrition of Dairy Pastures in W.A.*	7,583	7,539
Dairy Produce Research Trust Account—*Pastures of Coastal Plains, Southern Queensland*	7,449	6,440
Department of Primary Industry—*Biochemical Studies of Weed Killers*	10,760	7,982
Department of Primary Industry—*Ecology of Skeleton Weed*	9,273	7,839
Estate of J. O. Holston—*Alpine Ecology*	350	256
†Fisons Pest Control and J. R. Geigy—*Chemical and Plant Anti-fungal Investigations*	42,830	21,678
F. C. Pye Research Fund—*Laboratory at Black Mountain* ..	7,333	7,333
Foundation for International Potash Research—*Potassium Status of Clover Pastures*	892	57
Imperial Chemical Industries of Australia & New Zealand Ltd.—*Nitrogen Grazing Experiments*	1,622	1,696*
International Atomic Energy Agency—*Measurement of Mutation Rates in Plants*	3	NIL
National Capital Development Commission—*Cotter River Catchment Investigations*	339	16
North Queensland Tobacco Growers' Co-operative Association Ltd.—*Investigations in Burdekin Valley* ..	544	465
Pipeline Technologists Pty. Ltd.—*Thermal Conductivity Investigations*	400	NIL

* Expenditure on this work in excess of receipts will be recovered in 1965–66.
† Overseas organization.

	Receipts 1964–65 & Balances brought forward 1963–64 £	Expenditure 1964–65 £
Plant Research (continued)		
†Rockefeller Foundation—*Contribution towards Overseas Visit to U.S.A. of Dr. D. J. Cosgrove*	374	101
Special Revenue Fund—*Grazing Trials, Samford Farm* ..	5,517	4,739
†Sulphur Institute of America—*Plant Nutrient Element Deficiencies*	1,086	544
†U.S. National Institutes of Health—*Genetic Studies* ..	2,203	565 Cr.
Western Australian Golf Association—*Research on Grasses*	50	NIL
Wheat Research Trust Account—*Plant Breeding Investigations*	8,579	8,916*
Wheat Research Trust Account—*Lucerne Investigations* ..	2,150	1,987
Wheat Research Trust Account—*Protein Synthesis in Wheat Grain*	1,000	689
Various Contributors—*Soya Bean Harvester*	198	NIL
Entomology		
Australian Cattle and Beef Research Committee—*Acquisition of Land at Amberley, Qld., for Cattle Tick Investigations* ..	57	1,630*
Cattle and Beef Research Trust Account—*Tick Survival* ..	27,677	21,541
Cattle and Beef Research Trust Account—*Acaricide Problems*	17,803	15,688
Cattle and Beef Research Trust Account—*Biological Control of Buffalo Fly*	4,400	2,883
Dairy Produce Research Trust Account—*Black Beetle Investigations*	463	NIL
Department of Health—*Sirex Wasp Investigations* ..	46,626	47,951*
Department of Primary Industry—*Ecological Studies* ..	3,031	2,257
Department of Primary Industry—*Locust Outbreak Analysis*	3,834	1,324
General Donations (Entomology)	1,501	516
Snowy Mountains Hydro-Electric Authority and River Murray Commission—*Phasmatid Investigations*	4,022	2,728
Special Revenue Fund—*Cattle Tick Investigations, Amberley, Qld.*	1,569	NIL
†U.S. National Institutes of Health—*Multiplication of Insect Polyhedron Virus*	9,275	4,549
†U.S. National Institutes of Health—*Fellowship of Dr. M. S. Lea*	223	222
Wheat Research Trust Account—*Experimental Silo* ..	1,000	40
Wheat Research Trust Account—*Aeration of Stored Grain* ..	368	102
†World Health Organization—*Insecticide Resistance of House-flies*	1,380	625
Soils and Irrigation		
Australian Dried Fruits Association—*Research in Nematology*	1,000	239
Australian Fertilizers Ltd., A.C.F. & Shirleys Fertilizers Ltd., and Sulphide Corporation Pty. Ltd.—*Contribution towards Overseas Visit of J. D. Colwell*	600	600
Australian Mineral Industries Research Association—*Purchase of X-Ray Spectrograph*	86	NIL
Bureau of Mineral Resources—*Microbiological Prospecting for Oil*	1,171	464

* Expenditure on this work in excess of receipts will be recovered in 1965–66.
† Overseas organization.

	Receipts 1964–65 & *Balances brought forward* 1963–64 £	*Expenditure* 1964–65 £
Soils and Irrigation (continued)		
Commonwealth Fertilizers and Chemicals Ltd., Cuming Smith and Mt. Lyell Farmers Fertilizers Ltd., and Australian Fertilizers Ltd.—*Bacterial Fertilizers*	1,819	1,820*
Department of the Army—*Soil Stabilization Project* ..	6,400	4,638
Department of the Army—*Terrain Evaluation Survey* ..	15,000	6,866
Department of Primary Industry and Australian Wine Board—*Wine Grape Crop Forecasting*	5,910	3,334
Dried Fruits Control Board—*Dried Fruits Investigations* ..	1,968	186
Ground Water Salt and Reclamation Revenue Account ..	553	NIL
†International Atomic Energy Agency—*Tritium Research* ..	2,206	NIL
N.S.W. Water Conservation and Irrigation Commission (Griffith Research Station)	10,955	10,276
Nyah–Woorinen Dried Fruits Inquiry Committee—*Dried Fruits Investigations*	92	NIL
Packing Companies and Co-operative Dried Fruits Sales Ltd.—*Dried Vine Fruit Investigations*	2,161	1,795
†Rockefeller Foundation—*Interactions of Plant Roots and Micro-organisms*	6,329	3,887
S. Aust. Housing Trust—*Research in Soil Mechanics and Land Use in Urban Areas*	3,270	440
S. Aust. Woods and Forests Department, Australian Paper Manufacturers, W.A. Department of Forests—*Problems of Growth*, Pinus radiata	5,375	6,097*
Special Revenue Fund—*Coomealla, N.S.W.*	6,470	4,000
Special Revenue Fund—*Irrigation Research Laboratory, Griffith, N.S.W.*	10,269	10,462*
Tasmanian Department of Health—*Foundation Investigations in Tasmania*	1,101	41
Water Research Foundation of Australia—*Water Retention in Earth Dams*	1,828	1,832
Wheat Research Trust Account—*Soil Tillage Studies* ..	4,262	4,250
Wheat Research Trust Account—*Fertilizer Requirements of Wheat*	2,231	1,335
Wheat Research Trust Account—*Effect of Decomposition of Wheat Straw on Fertilizer*	5,951	5,994*
Zinc Corporation Ltd., and Philips Electrical Industries Pty. Ltd.—*Mineralogical Research*	800	409
Food Preservation		
Australian Apple and Pear Board—*Experimental Shipment of Apples and Pears*	508	381
Australian Apple and Pear Board—*Apple and Pear Investigations*	1,883	134
Australian Banana Growers' Council—*Banana Research, Alstonville, N.S.W.*	2,731	3,452*
Australian Canned Fruits Board—*Damage through Condensation on Cans of Export Fruits*	3,529	2,968

* Expenditure on this work in excess of receipts will be recovered in 1965–66.
† Overseas organization.

	Receipts 1964–65 & *Balances brought forward* 1963–64 £	*Expenditure* 1964–65 £
Food Preservation (continued)		
Australian Dried Fruits Association—*Visit to Australia of Professor M. W. Miller*	200	156
Australian Dried Fruits Association and Department of Primary Industry—*Dried Tree Fruits Investigations* ..	1,250	276
Australian Egg Board—*Egg Investigations*	540	150
Australian Egg Board—*Packaging of Egg Pulp*	770	114
Australian Meat Board—*Contribution towards Cost of Physical Chemistry Laboratory*	7,643	6,001
Australian Meat Board—*Meat Investigations*	500	500
Banana Research Fund—*Banana Transport Investigations* ..	32	16
Broken Hill Pty. Ltd.—*Research on Tinplate Containers* ..	715	715
Cattle and Beef Research Trust Account—*Problems on Beef Quality*	22,181	16,038
Darling Downs Co-operative Bacon Association—*Re-processing Stocks of Canned Meats*	250	184
Department of Primary Industry—*Fruit Fly Commodity Treatment of Citrus Fruits and Pears*	7,494	3,575
Department of Primary Industry—*Fruit Fly Investigations* ..	18	18
Metropolitan Meat Industry Board of New South Wales—*Meat Investigations*	532	532
N.S.W. Department of Agriculture—*Fruit and Vegetable Storage Investigations*	5,801	4,631
Rice Marketing Board—*Rice Research*	1,000	499
†U.S. Department of Agriculture—*Study of Differences in the Chemical Structure of Albumin and* S-*Ovalbumin* ..	3,921	3,368
†U.S. Department of Agriculture—*Investigations into the Cyclopropenoid Compounds found in Cotton Seed*	10,992	8,183
Various Contributors (Food Preservation)	15,372	8,037
Forest Products		
Australian Plywood Board—*Veneer, Gluing, and Plywood Research*	14,968	14,686
Department of Territories—*Development of Pulp and Paper Industry in New Guinea*	5,541	4,438
General Donations (Forest Products)	7,212	743
†Government of Fiji—*Timber Research in Fiji*	3,375	1,640
Paper Companies and New Zealand Forest Products—*Paper Pulp Investigations*	8,262	5,807
Mining and Metallurgy		
Australasian Institute of Mining and Metallurgy—*Mineragraphic Investigations*	5,904	2,574
Broken Hill Mine Managers' Association—*Contribution towards Salary of Dr. S. M. Richards*	158	536*
General Donations (Ore Dressing)	7,200	6,306
Miscellaneous Contributors (Mineragraphic Investigations)	847	NIL
State Electricity Commission of Victoria—*Geological Consultations*	1,402	560

* Expenditure on this work in excess of receipts will be recovered in 1965–66.
† Overseas organization.

	Receipts 1964–65 & *Balances brought forward* 1963–64 £	*Expenditure* 1964–65 £
Radio Research		
Postmaster-General's Department, Australian Broadcasting Control Board, and Overseas Telecommunications Commission—*Radio Research Board Activities*	24,789	24,548
Research Services		
General Donations	519	NIL
Miscellaneous Contributors—*Construction of Forced Circulation Solar Hot Water Service*	410 Dr.	NIL
†University of Wisconsin—*Oversea Visit of D. J. Close* ..	1,347	552
Wheat Research Trust Account—*Powered Wheels* ..	8,334	8,405
Wheat Research Trust Account—*Grain Moisture Studies* ..	9,416	8,336
Chemical Research Laboratories		
Australian Mineral Industries Research Association—*Study of Breakages in Continuous Mills*	3,150	860
Australian Mineral Industries Research Association—*Development of Size Sensing Element*	1,350	607
Cattle and Beef Research Trust Account—*Study of Plant Alkaloids*	5,100	4,846
Cement and Concrete Association of Australia—*Cement Investigations*	10,842	11,477*
Colonial Sugar Refining Co. Ltd.—*Sugar Research* ..	1,361	872
Colonial Sugar Refining Co. Ltd.—*Sugar Fire Research* ..	1,941	1,554
Conzinc Riotinto of Australia Ltd.—*Sodium Aluminate Project*	6,000	4,216
Conzinc Riotinto of Australia Ltd.—*Development of Solar Pond*	2,600	2,331
Conzinc Riotinto of Australia Ltd.—*Aluminium Chloride Project*	5,900	1,625
Conzinc Riotinto of Australia Ltd. and New Broken Hill Consolidated Pty. Ltd.—*Neutron Irradiation Project* ..	4,898	800
Conzinc Riotinto of Australia Ltd.—*C.R.A.S.O. Project* ..	5,006	5,046*
Conzinc Riotinto of Australia Ltd. and Southern Portland Cement Ltd.—*Development of Coarse Batch Sizer* ..	1,500	1,488
Electrolytic Zinc Co. Ltd.—*Electrolytic Studies*	4,100	NIL
Mary Kathleen Uranium Ltd.—*Water Evaporation Control*	353	256
Miscellaneous Contributors (Chemical Research Laboratories)	15,211	6,729
Murphyores Pty. Ltd.—*Ilmenite Reduction Project* ..	1,612	1,612
†Population Council Inc.—*Studies on Induced Infertility* ..	665	14
Reserve Bank of Australia—*Fuel Cell Project*	18,129	2,680
Ricegrowers Co-operative Mills Ltd.—*Vegetable Oil Extraction Investigations*	200	NIL
†Smith, Kline, and French Laboratories, U.S.A.—*Phytological Survey and Drug Plant Collection*	6,705	6,160
State Electricity Commission of Victoria, and Gas & Fuel Corporation of Victoria—*Clinkering of Brown Coal Ash*	13	13
Techtron Pty. Ltd.—*Optical Gratings Development Project* ..	1,250	117
Union Carbide (Aust.) Ltd.—*Semi-polymers*	3,986	3,847
†U.S. National Institutes of Health—*Plant Alkaloids* ..	2,016	4,482*
Western Australian Chamber of Mines (Inc.)—*Cyanidation of Gold*	5,042	4,393

* Expenditure on this work in excess of receipts will be recovered in 1965–66.
† Overseas organization.

	Receipts 1964–65 & Balances brought forward 1963–64 £	Expenditure 1964–65 £
Fisheries and Oceanography		
Department of Harbours and Marine—*Gulf Prawn Survey* ..	11,628	12,008*
Department of the Navy—*Marine Fouling Investigations* ..	6,000	4,445
Department of Primary Industry—*Tuna Search, N.S.W. and S. Aust.* ..	1,913	1,929*
Department of Primary Industry and Tasmanian Department of Agriculture—*Tuna Survey, Tasmania* ..	10,000	22,783*
Electricity Commission of N.S.W.—*Fly Ash Programme* ..	373	NIL
Fisheries Development Trust Account—*Sperm Whale Investigations* ..	10,503	9,856
Mathematical Statistics		
Miscellaneous Contributors—*Mathematical Statistics* ..	5	NIL
National Standards Laboratory		
General Donations (Applied Physics) ..	509	NIL
†Machinability Donations Account (Metrology) ..	114	NIL
†U.S. Air Force—*Thermal Expansion of Solids at Low Temperatures* ..	NIL	619*
†U.S. National Aeronautics and Space Administration—*Cinematograph Study of Solar Magnetic Fields* ..	3,778	15,139*
†U.S. National Bureau of Standards—*Solar Flare Patrol* ..	NIL	7,703*
Various Contributors—*Length Measurement Research Fund*	768	125
Tribophysics		
Union Carbide (Aust.) Ltd.—*Catalytic Oxidation of Olefins*	10,409	1,412
Building Research		
Associated Fibrous Plaster Manufacturers of Australia, Australian Plaster Industries, and Colonial Sugar Refining Co. Ltd.—*Fibrous Plaster Research* ..	4,952	4,344
Cement and Concrete Association of Australia—*Concrete Research* ..	6,813	635
General Donations (Building Research) ..	9,592	5,961
Housing Commission of Victoria, Victorian Railways Department, State Electricity Commission of Victoria—*Mould Infestation in Dwellings* ..	2,612	2,612
Jaywoth Besser Ltd.—*Efflorescence on Concrete Blocks* ..	1	NIL
Whitelaw Monier Pty. Ltd.—*Research into Cement Tiles* ..	1,082	791
Radiophysics		
†Ford Foundation—*Construction of Radio Heliograph* ..	163,678	145,236
General Donations ..	25	NIL
Queensland Government—*Cloud Seeding for Drought Relief*	4,061	4,213*
†U.S. National Aeronautics and Space Administration—*Radio Astronomy* ..	34,238	21,978
Various Contributors—*Rain and Cloud Physics Research* ..	8,000	NIL

* Expenditure on this work in excess of receipts will be recovered in 1965–66.
† Overseas organization.

	Receipts 1964–65 & Balances brought forward 1963–64 £	*Expenditure 1964–65* £
Meteorological Physics		
Australian Tobacco Research Trust—*Meteorological Observations* ..	750	613
Dairy Research		
Dairy Produce Research Trust Account—*Dairy Research* ..	81,260	70,751
Wool Research Laboratories		
Associated Woollen and Worsted Textile Manufacturers of Australia—*Blanket Freight Equalization Fund* ..	721	335 Cr.
Donations for Worsted Processing Research	1,520	NIL
General Donations (Protein Chemistry)	141	NIL
General Donations (Textile Industry)	279	NIL
General Donations (Textile Physics)	2	NIL
Leather Research—*Residual Funds of Australian Leather Research Association*	5,601	1,120
Wool Buying and Selling Account	16,168	9,877
Coal Research		
Colonial Sugar Refining Co. Ltd.—*Purchase of Special Equipment for Coal Research*	54	NIL
Electricity Trust of S. Aust.—*Investigations into Boiler Gas Path Problems*	23,038	10,938
General Donations	10,343	5,205
State Electricity Commission of Victoria—*Brown Coal Investigations*	5,912	3,176
Wildlife Research		
Cattle and Beef Research Trust Account—*Dingo Studies* ..	2,000	1,480
Department of Civil Aviation—*Investigations into Bird Fouling of Jet Aircraft*	11,793	10,015
Petfoods Ltd.—*Food for Budgerigars*	79	NIL
Various—*Fauna Survey on Cape York Peninsula* ..	225	225
Land Research and Regional Survey		
Cattle and Beef Research Trust Account—*Investigations in Northern Territory High-rainfall Areas*	8,500	8,603*
Cattle and Beef Research Trust Account—*Beef Cattle Research, Katherine, N.T.*	7,301	5,033
Department of National Development—*Kimberley Research Station*	7,200	5,154
Department of Territories—*Resources Survey in Papua and New Guinea*	67,550	64,106
F. C. Pye Research Fund—*Installation of Lysimeter, Katherine, N.T.*	5,431	5,431
Northern Territory Administration—*Rice Research* ..	64,300	57,966
W.A. Department of Agriculture—*Cattle and Beef Research Project, Kimberley*	715	5,989*

* Expenditure on this work in excess of receipts will be recovered in 1965–66.

	Receipts 1964–65 & Balances brought forward 1963–64 £	Expenditure 1964–65 £
Miscellaneous		
Bureau of Mineral Resources, and Australian Mineral Industries Research Association—*Baas-Becking Biological Group*	4,901	NIL
Cattle and Beef Research Trust Account—*Bloat Research* ..	2,000	601
David Rivett Memorial Fund	1,312	NIL
Science and Industry Endowment Fund	799	799
Sundry Contributors (Commonwealth Scientific and Industrial Research Organization)	183	NIL
Wheat Research Trust Account—*Quality Studies of Wheat and Flour*	30,921	30,373
Wheat Research Trust Account—*Effects of Lipids on Wheat Quality*	4,423	3,951
	4,304,418	**3,902,914**

Wool Research Trust Fund

Details of transactions during 1964–65 are as follows:

Receipts

	£	£	£
Balance brought forward from 1963–64		31,770 Dr.	
Received from Department of Primary Industry during 1964–65		2,671,274	**2,639,504**

Expenditure

INVESTIGATIONS

Wool Production Research

	£	£	£
Animal Research Laboratories—			
Division of Animal Physiology:			
Ian Clunies Ross Animal Research Laboratory ..	345,798		
Regional Laboratory and "Chiswick" Field Station, Armidale, N.S.W.	184,511	530,309	
Division of Animal Health:			
McMaster Laboratory	69,028		
Animal Health Laboratory	20,076	89,104	

		£	£	£
Division of Animal Genetics:				
Sheep Breeding, Cunnamulla, Qld.	.. ..	47,768		
Animal Genetics Investigations, Sydney	..	115,854	163,622	
Suspense (Overseas Transactions)	.. ..		972	784,007
Plant Industry—				
Headquarters, Canberra	.. .. ..	164,768		
Regional Pastoral Laboratory, Falkiner Memorial Field Station, Deniliquin, N.S.W.	.. ..	70,669		
Field Investigations, Armidale, N.S.W.	..	15,780		
Western Australian Investigations	.. ..	85,117	336,334	336,334
Entomology—				
Field Investigations, Armidale, N.S.W.	..		19,445	19,445
Soils—				
Cobalt Work in Tasmania	.. .. ..		5,051	5,051
Research Services—				
Agricultural Liaison Unit	.. .. ..		21,477	21,477
Chemical Research Laboratories—				
Physical Chemistry	.. .. ..	6,403		
Organic Chemistry	.. .. ..	9,980	16,383	16,383
Biochemistry and General Nutrition—				
Nutrition Laboratory, Adelaide	.. ..	52,334		
Field Studies at Glenthorne, S. Aust.	.. ..	29,957	82,291	82,291
Wildlife Research—				
Wildlife Investigations	.. .. ..		78,139	78,139
				1,343,127
Wool Textile Research				
Wool Research Laboratories—				
Protein Chemistry, Melbourne	.. ..	331,123		
Textile Physics, Sydney	.. .. ..	411,430		
Textile Industry, Geelong, Vic.	.. ..	335,205		
Suspense (Overseas transactions)	.. ..	3,898	1,081,656	
Chemical Research Laboratories—				
Organic Chemistry	.. .. ..		5,764	1,087,420
TOTAL EXPENDITURE—INVESTIGATIONS	..			**2,430,547**

	£	£	£
CAPITAL WORKS			
CSIRO EXPENDITURE			
Wool Production Research			
Animal Research Laboratories—			
Laboratory Equipment	7,042		
Plant Industry—			
Laboratory Equipment	3,100	10,142	
Wool Textile Research			
Laboratory Equipment and Textile Machinery ..		17,073	27,215
EXPENDITURE ON CSIRO BUILDINGS BY DEPARTMENT OF WORKS			
Wool Production Research		52,143	
Wool Textile Research		27,032	79,175
PLANT AND DEVELOPMENTAL EXPENDITURE			
Wool Production Research		27,258	
Wool Textile Research		20,022	47,280
TOTAL EXPENDITURE—CAPITAL WORKS ..			**153,670**
TOTAL EXPENDITURE—WOOL RESEARCH TRUST FUND			**2,584,217**

During the year £81,078 was received from sales of sheep, wool, and other produce from CSIRO Field Stations and Laboratories financed from wool funds. This amount was paid to the Department of Primary Industry for credit to the Wool Research Fund Trust Account.

Miscellaneous Receipts

During 1964–65 miscellaneous receipts amounted to £178,300. Details of the receipts are as follows:

	£	£
Sale of publications	11,212	
Sale of equipment purchased in former years, and other receipts	57,409	
Sale of produce by field stations and laboratories	24,619	
Royalties from patents	19,895	
Testing fees	32,042	
Sale of animals	14,836	
Computing charges	12,276	
Miscellaneous	6,011	**178,300**

The receipts from the sale of produce represent revenue earned by Divisions and Sections apart from the Special Revenue listed under Contributions on pages 204–12.

The amount of £178,300 was credited to the Treasury appropriation, and consequently reduced the requirements from the Treasury by that amount (*see* page 203).

Works Projects (under Control of CSIRO)

Treasury expenditure on works projects financed from funds made available directly to CSIRO is as follows:

	£	£	£
Animal Research Laboratories—			
Animal Genetics—			
North Ryde, N.S.W.		19,332	
Animal Health—			
Restoration of Parkville site	4,189		
Development of Maribyrnong site	1,276	5,465	
Animal Physiology—			
Pasture Research Station, Samford, Qld. ..		2,999	
Plant Research—			
Plant Industry—			
Canberra laboratories	20,065		
Development of phytotron	391	20,456	
Tropical Pastures—			
Cunningham Laboratory, St. Lucia, Qld. ..	2,665		
Pastoral Research Laboratory, Townsville, Qld. ..	7,696		
Kangaroo Hills, Central Tablelands, Qld. ..	1,442		
Pasture Experiments, Abergowrie, Qld. ..	781		
Pasture Research Station, Samford, Qld. ..	3,438		
Cooper Laboratory, Lawes, Qld.	1,708		
Major Animal Production Experiments, Beerwah, Qld.	1,648		
Pasture Experiments, Rodd's Bay, Qld. ..	2,738		
Pasture Experiments, Eskdale West, Qld. ..	105	22,221	
Entomology—			
Canberra laboratories	13,472		
Fruit Fly Investigations, Wilton, N.S.W. ..	3,800	17,272	
Soils and Irrigation—			
Soils—			
Adelaide	9,774		
Cunningham Laboratory, St. Lucia, Qld. ..	41	9,815	
Soil Mechanics—			
Syndal laboratory		4,000	
Horticultural Research Section—			
Merbein, Vic.	2,000		
Adelaide	8,455	10,455	
Irrigation Research Laboratories—			
Griffith, N.S.W.		1,796	

	£	£	£
Food Preservation—			
North Ryde, N.S.W.	4,247		
Cannon Hill, Qld.	847	5,094	
Forest Products		20,214	
Mechanical Engineering		3,000	
Publishing		368	
Chemical Research Laboratories—			
Fishermen's Bend, Vic.	155,957		
Clayton, Vic.	33,658	189,615	
Fisheries and Oceanography—			
Cronulla Laboratory		8,390	
Mathematical Statistics		3,320	
Physics		8,369	
Applied Physics		21,780	
Building Research		13,474	
Radiophysics—			
Chippendale, N.S.W.	7,020		
Narrabri, N.S.W.	45,562		
Radio Telescope, Parkes, N.S.W.	27,813	80,395	
Computing Research Section		1,429,645	
Meteorological Physics		100	
Dairy Research		1,497	
Wool Research Laboratories—			
Leather Research		5,600	
Fuel Research—			
Coal Research Laboratory		1,740	
Wildlife Research		2,798	
Wheat Research Unit—			
North Ryde Laboratory		9,600	
Regional Administrative Office, Sydney		10,221	
Regional Administrative Office, Canberra		32,841	
Regional Laboratory, Western Australia		612	
TOTAL TREASURY EXPENDITURE			**1,962,484**

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