Mr J J Russell

CSIRO
ANNUAL REPORT 1965-66

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION | AUSTRALIA

CSIRO

Eighteenth Annual Report

1965-66

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

AUSTRALIA

THIS REPORT of the work of the Commonwealth Scientific and Industrial Research Organization for the year ending June 30, 1966, has been prepared for presentation to Parliament as required by Section 30 of the Science and Industry Research Act 1949–1959. It summarizes the investigations in progress and provides short accounts of some of the advances that have been made. Detailed technical accounts of the Organization's work are provided in the annual reports of individual Divisions and Sections.

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, private individuals, and overseas institutions.

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

Cover

The opening of the new Pastoral Research Laboratory at Townsville, Queensland, by the Minister-in-Charge, Senator J. G. Gorton
(*see page 20*).

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General Review

IT IS VERY NEARLY 50 YEARS since the Commonwealth Government established the first Advisory Council of Science and Industry. This jubilee will be celebrated in the forthcoming year and will then provide an opportunity to review 50 years of progress in which CSIRO and its precursors have served agriculture and industry in Australia.

In the last few years there have been conscious moves by various nations throughout the world to bring science more comprehensively into their affairs. This year has also seen the beginnings of significant changes in Australia, representing the community's growing maturity of understanding of the importance of scientific research and its application to national welfare.

When the Council for Scientific and Industrial Research, the predecessor of CSIRO, began work in 1926, attention was devoted almost exclusively to the important primary industries of the Commonwealth. In 1937, shortly before the outbreak of the war, the Government authorized ventures into science of importance to secondary industry. From 1945 onwards these activities have grown in magnitude so that the CSIRO effort is now devoted about equally to the physical and industrial sciences and to the agricultural and biological sciences.

From the outset, the Organization's efforts to help the development of Australian agriculture through science have been assisted by the complementary efforts of the State Departments of Agriculture to ensure that new ideas and practices were brought to the attention of the man on the land. Over the years close ties of friendly cooperation have grown between CSIRO's scientists and those of the State organizations. The full effectiveness of agricultural research in the Australian economy cannot be attained until the results of new discoveries are applied in practice. The announcement made by the Commonwealth Government that it now intends to provide substantially increased funds to expand the regional research and extension activities of the States is thus particularly welcome.

During the past few years there has been a growing output from CSIRO laboratories of physical and chemical discoveries that are being used by Australian manufacturing industry. In particular, there are now many new processes and products available that can be placed in industry and provide an opportunity for novelty and innovation in the products that Australia manufactures. With the emphasis being

placed on the desirability of improving Australia's world trade through the export of manufactured commodities, it is vitally important that our competitive position be improved. A paramount consideration will be the novelty and originality of the products that Australia offers for sale abroad.

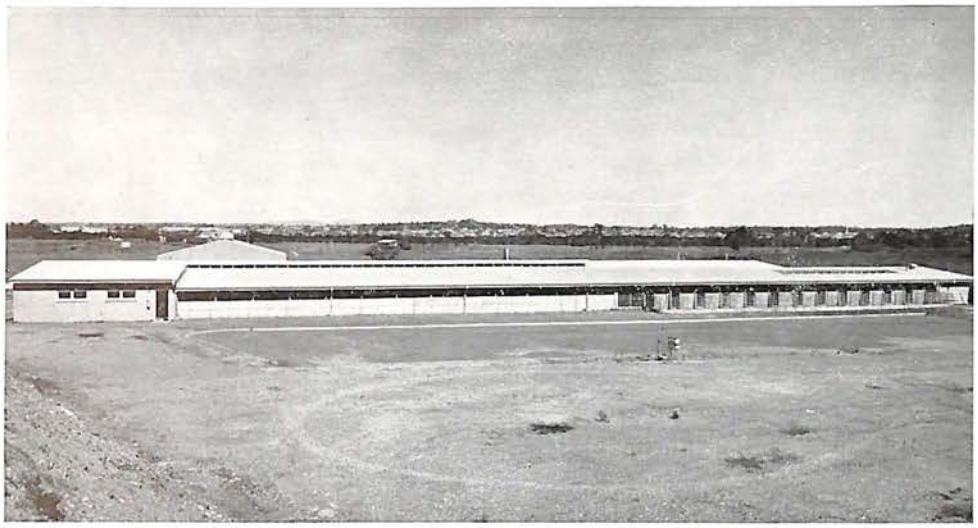
CSIRO can do much to help the development of Australian industry, both by the discovery of new products and processes in its laboratories and by providing the wide background of scientific knowledge necessary to exploit advances in technology. However, industry itself must share in these activities, and to this end the Executive attaches great importance to the growing volume of research and development being undertaken in industrial laboratories. This trend must not only be maintained but also needs further encouragement by the Government, as an important complement to the work of CSIRO. It is of considerable interest that during the year several bodies representative of industry have stressed the need for some form of Government stimulus to research and development by industrial firms. This is very much in line with practices that have already been adopted in Britain, in Canada, and in Europe.

In noting the growing maturity of thinking in Australia on the many facets of science and technology that are important to our future, the recent growth of university teaching and research must not be overlooked. Of particular interest was the action of the Government to set up the Australian Research Grants Committee and to provide funds in support of original research. This constitutes an important addition to the finances available to the universities.

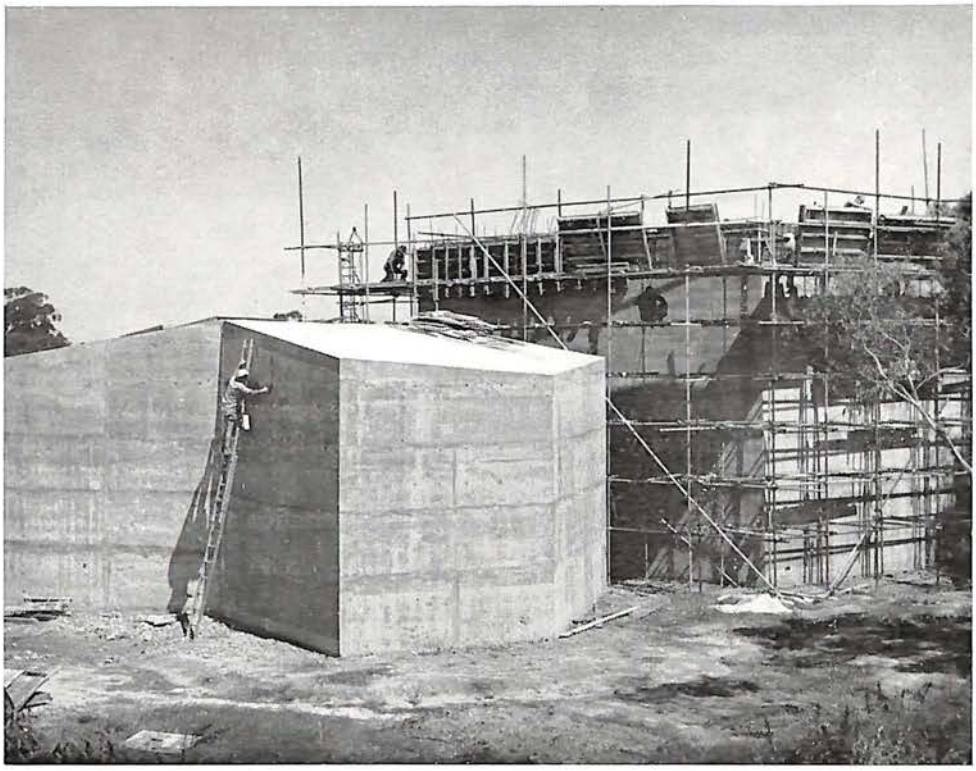
For many years CSIRO has had close working arrangements with Australian universities. This situation can be of benefit in two ways. Firstly, there are scientists in the universities whose contributions to science are of direct interest in CSIRO's own programme. Secondly, there is the possibility that the special facilities of CSIRO laboratories may be used to assist in the education of post-graduate university students.

There is widespread discussion, both here and overseas, about the part that an institution such as CSIRO should play in the education of students. There are difficulties that are not easily resolved. While it may be held that post-graduate students working with CSIRO would acquire an interest in research problems of national importance, the contention of the universities that they are best able to train young men and women in research cannot readily be refuted. There is much to be said for both viewpoints, but while CSIRO is not equipped to undertake research training to any great extent it would be of great benefit to both institutions if closer collaboration in post-graduate teaching could be fostered. This may now be more readily achieved with the strengthening of the universities, and particularly through the growing support that will be available for post-graduate research and teaching.

There is now a noticeable move within Australia towards the fashioning of a policy for science. The situation today is both interesting and encouraging, and thoughts about the support of science in all its aspects must form an important element of Government policy considerations for the future.



Facilities for cattle tick research at Indooroopilly, Qld.



Acoustic chambers in the course of erection at the Division of Building Research, Highett, Vic.

Buildings and Accommodation

Two new laboratories, for the Division of Tropical Pastures at Townsville, Qld., and for the Division of Chemical Physics at Clayton, Vic., were officially opened during the year (see page 20). Although no major building was completed, smaller buildings costing $104,000 were built to provide acoustic chambers for the Division of Building Research at Highett, Vic. A group of buildings that had been purchased at Port Melbourne in 1963/64 were modified at a cost of $122,000 for the Division of Mineral Chemistry, so as to relieve further the accommodation difficulties at the Fishermen's Bend site of the Chemical Research Laboratories. In addition, the mill building of the Division of Textile Physics at Ryde, N.S.W., has been extended ($64,000) and pens for cattle tick fever studies have been constructed at Indooroopilly, Qld., for the Division of Animal Health ($53,000).

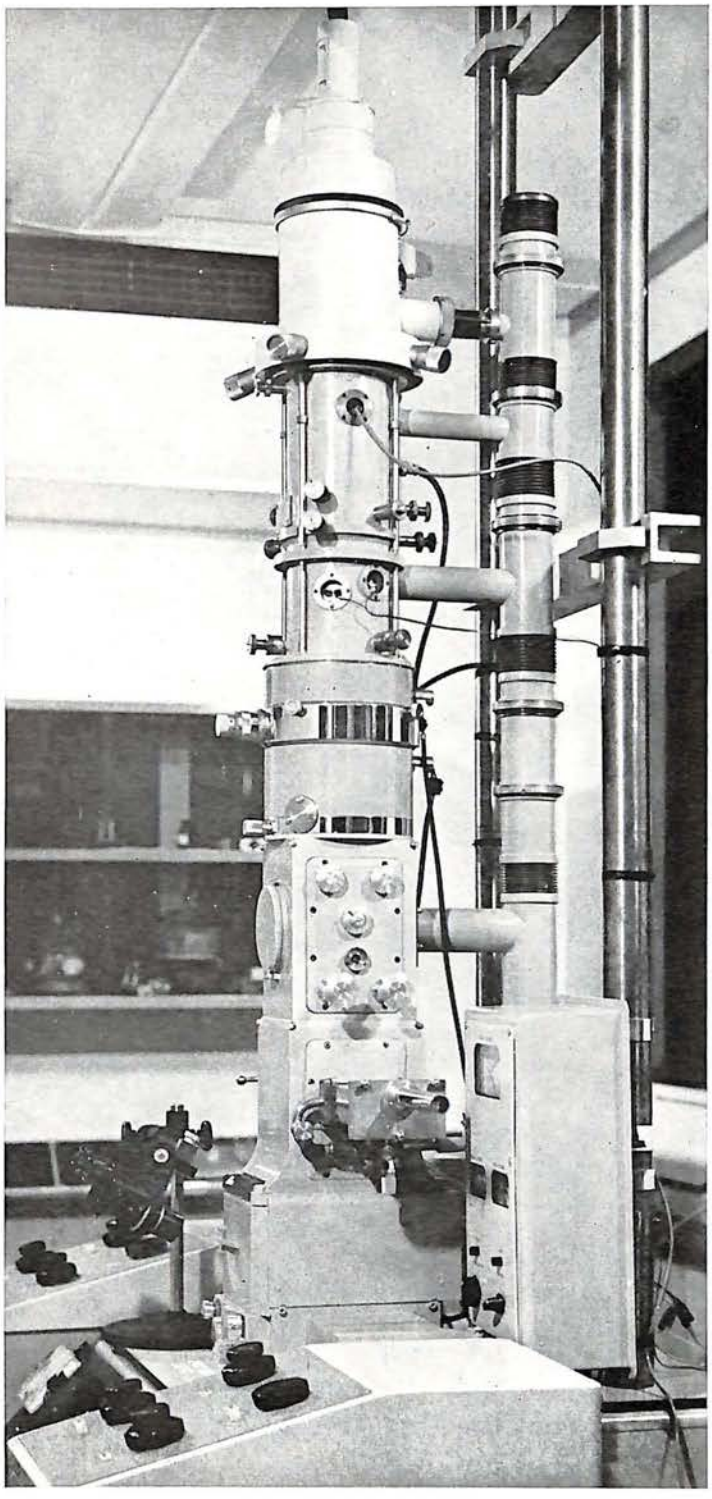
Expenditure on new works for 1965/66 amounted to $2,170,336. Although this is a little less than was spent in 1964/65 ($2,520,536), the programme for the year has enabled a contract to be let for an important major project, the new laboratory for the Division of Radiophysics at Epping, N.S.W. In addition, a new Meat Research Laboratory is being constructed at Cannon Hill, Qld., for the Division of Food Preservation, largely with funds provided from the Australian Meat Research Trust Account. Other important projects now under way include living quarters at the CSIRO Solar Observatory at Culgoora, N.S.W., a field laboratory at Armidale, N.S.W., for the Division of Animal Physiology, and a new laboratory at Katherine, N.T., and glasshouse facilities at Canberra for the Division of Land Research.

Despite these advances, progress with the building programme continues to be unsatisfactory, and this situation must persist unless substantially increased sums of money can be made available to the Organization. A large part of the moneys allocated at present is absorbed in re-housing the staff that is still occupying the emergency, temporary, and often quite inadequate laboratory accommodation that was all that could be provided nearly 25 years ago under wartime conditions. At the present rate of progress many such groups will have no relief for up to 10 years. Furthermore, as advances in science are made, new and different facilities become necessary. This often means new buildings, so that without any extension in the programme some $700,000, or nearly one-third of the present annual expenditure, must be allocated in this way. As a result too little is left each year for the major laboratory accommodation that must be provided for new developments.

Outstanding amongst the current needs of the Organization are:

A new laboratory for the Divisions of Animal Health and Entomology in Queensland. These Divisions have been restricted by unsuitable accommodation for many years. A site has been acquired at Indooroopilly. The Parliamentary Standing Committee on Public Works has reported favourably on the proposal, and the project has been included in the 1966/67 programme;

The transfer of the Division of Chemical Engineering, which is planned as the next stage of the progressive re-housing of the Chemical Research Laboratories. The Executive hopes shortly to have a proposal for a new laboratory placed



Electron diffraction camera designed and built by the Division of Chemical Physics. It incorporates many new features, including provision for convergent-beam diffraction and a number of ingenious micro-manipulation devices.

before the Parliamentary Standing Committee on Public Works to enable it to be included in the new works programme for 1967/68;

A major new building for the Division of Coal Research at Ryde, N.S.W. This Division occupies much temporary accommodation, and it had been hoped that the construction of a major new building could have been commenced in 1967/68. This has not proved possible. It is planned to proceed with this project in 1968/69, following the construction of the Chemical Engineering Laboratory;

New laboratories for the Divisions of Physics and Applied Physics of the National Standards Laboratory. Much of the accommodation these Divisions now occupy is unsuitable for their work, particularly work of the high accuracy and complexity involved in the maintenance of standards. It does not appear that a start can be made with the development of the new site for these Divisions at Bradfield Park, a suburb of Sydney, for at least 5 years.

Finance

In 1965/66 CSIRO expenditure on investigations (including Head Office administration) rose to $32,832,918 compared with $30,829,582 in 1964/65, an increase of $2,003,336 or 6½%.

One of the most difficult factors that must be taken into account in allocating resources is the continual rise in the cost of research. This is due in part to increases in salaries, both sectional and general, and to increases in costs of services. It arises also in part as a consequence of the advances made in science, as the techniques and equipment required for scientific research become increasingly complex and increasingly expensive. Yet these new developments must be adopted as soon as available if the Organization is to remain effective in research, for they may save years of effort and at times may provide the only practicable means of tackling a problem. New techniques and new equipment also mean more skilled staff to operate and service them and reference has been made in previous reports to the difficulties in keeping pace with these needs. The overall effect is that the cost of maintaining a research scientist is rising at the rate of about 7% per annum. In 1961/62 the annual cost per research scientist averaged $23,700; the current figure is about $34,200. A high proportion of the additional funds granted by the Government each year is absorbed by this type of inescapable increase in expenditure.

CSIRO receives considerable financial support from primary industry research funds administered by the following committees on which the Organization is represented: Wool Production Research Advisory Committee, Wool Textile Research Advisory Committee, Wheat Industry Research Council, Dairy Produce Research Committee, Australian Meat Research Committee, and Central Tobacco Advisory Committee.

The proportion of support for the research programme derived from these industry research funds increased further during 1965/66, and contributions now

amount to 22% of the total expenditure on investigations. The Executive welcomes this as it provides an opportunity to make a greater research contribution to the interests of these industries. However, there are aspects of the administration of the funds which are causing the Executive some concern.

Experience over many years has shown that in planning the research programme a broad approach to a problem leads to much greater efficiency in the use of resources, and undoubtedly enhances the quality of the results. The responsibility for the detailed scientific planning of the programme should rest with the Chief of a Division and his senior research staff, who ensure that the needs of the industry are kept constantly under review through consultation with industrial leaders.

The industry fund Committees, on most of which there is a majority of producer representatives, tend to place considerable emphasis on individual projects and to use these to try to build up a programme. This is not the best approach to the planning and execution of a research programme dealing with the complex problems of an industry, nor is it likely to lead to the outstanding new ideas that can be the basis of industrial progress. While it is proper that these committees should be given the fullest opportunity to examine and discuss the programmes with which they are concerned, the present tendency is to seek a large amount of detailed information. Further, the accounting requirements of these committees have made necessary extensive financial controls, which have the effect of placing an undesirable limitation on the freedom of manoeuvre in the conduct of the scientific work of the laboratories. As a result the research worker is left both with less time for his research and with less flexibility in his activities. This is beginning to have an adverse effect on morale.

CSIRO's anxiety is to ensure the most profitable return to these industries for the investment that they and the Government are making in research.

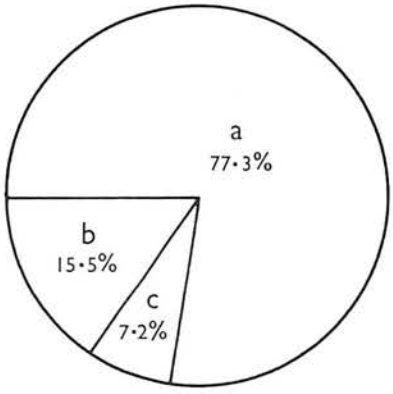
In addition to $32,832,918 spent on investigations in 1965/66, CSIRO expended $973,670 on grants for Studentships and to outside bodies such as the Standards Association of Australia and the various Research Associations, and $2,158,474 on capital works and services under its own control, making a total of $35,965,062. Details of receipts and expenditure are shown in Chapter 5. The Department of Works and the Department of the Interior spent a further $2,259,840 on the construction of buildings, other works, and acquisition of properties for CSIRO.

The table summarizes sources of CSIRO funds and categories of expenditure:

SOURCE OF FUNDS	*Investigations*	*Grants*	*Capital Works and Services*	*Total*
Treasury Appropriation	$24,778,039	$973,670	$1,319,230	$27,070,939
CSIRO Revenue	612,582	—	—	612,582
Total Treasury Funds	25,390,621	973,670	1,319,230	27,683,521
Wool Research Trust Fund	5,087,250	—	365,656	5,452,906
Contributions (other than Wool)	2,355,047	—	473,588	2,828,635
	$32,832,918	$973,670	$2,158,474	$35,965,062

Investigations

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



(a) Commonwealth Treasury		$25,390,621
(b) Wool Research Trust Fund		5,087,250
(c) Contributions—		
Cattle and beef investigations (Meat Research Trust Account)	$597,393	
Dairy research (Dairy Produce Research Trust Account)	209,897	
Wheat investigations (Wheat Research Trust Account)	153,717	
Tobacco investigations (Tobacco Industry Trust Account)	152,245	
New Guinea resources investigations (Department of Territories)	145,150	
Sirex wasp investigations (Department of Health)	85,362	
Leather investigations (Leather Industry Research Fund)	59,937	
Other contributions	951,346	
		2,355,047
		$32,832,918

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

The following diagram gives an indication of how the gross funds ($32,832,918) available to the Organization for investigations in 1965/66 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 and Applied Physics. The main fields in 'general physical research' are Radiophysics, Meteorological Physics, and Upper Atmosphere, and in 'general industrial research' such Divisions as Building Research, Mechanical Engineering, Tribophysics, and the Soil Mechanics Section. 'Research services' covers such items as Library, Publishing, Film Unit, Mathematical Statistics, and the Computing Research Section.

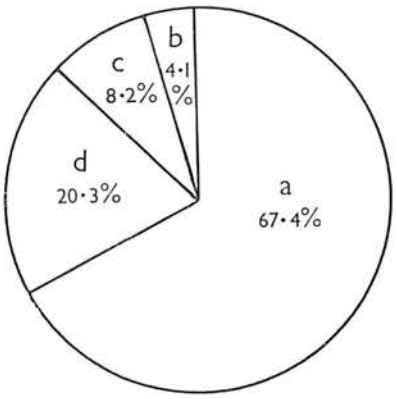
GROSS EXPENDITURE ON INVESTIGATIONS WAS

$32,832,918

WHICH WAS SPENT

12·9%	on animal health and production	$4,215,041
9·1%	on plant industry	2,999,449
6·2%	on entomology and wildlife	2,036,418
3·5%	on soils	1,158,235
2·1%	on horticulture and irrigation	700,465
2·9%	on tropical pastures	943,908
3·4%	on land research	1,122,568
9·7%	on processing of agricultural products	3,179,505
9·6%	on chemical research of industrial interest	3,164,359
2·1%	on fisheries and oceanography	681,565
5·6%	on processing and use of mineral products	1,833,403
6·2%	on physical research of industrial interest	2,041,328
5·9%	on general physical research	1,937,765
5·0%	on general industrial research	1,650,062
3·5%	on processing of forest products	1,135,793
6·0%	on research services	1,982,166
6·3%	on administration	2,050,888
		$32,832,918

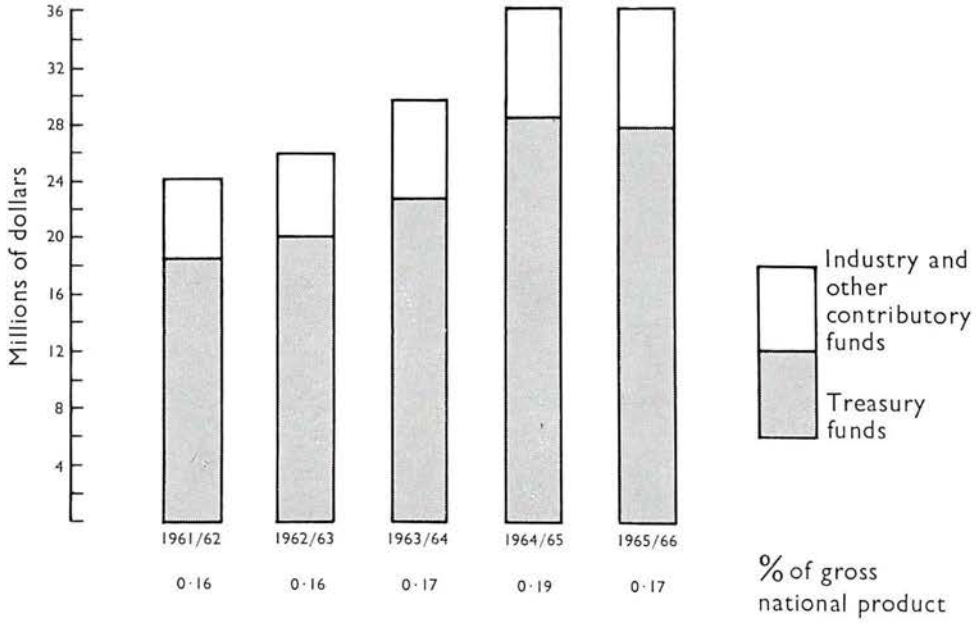
Approximately two-thirds of CSIRO's research expenditure relates to salaries and payments in the nature of salary. Maintenance, i.e. general running expenses, is the next most important item, as shown below.



(a) Salaries	$22,125,933
(b) Travelling	1,352,924
(c) Equipment	2,686,686
(d) Maintenance	6,667,375
	$32,832,918

Total Expenditure

Total expenditure for the year was $35,965,062, a little less than was expended in 1964/65 ($36,492,218). The amounts expended in each of the past five years are shown below.



Staff

The 1964/65 Annual Report drew attention to the need for improvement in the ratio of supporting staff to professional staff in the laboratories of the Organization. This is a continuing problem and for some years the Executive has attempted to overcome it by allotting most of the available increase in staff numbers to the recruitment of additional supporting staff. Although there has been considerable improvement, it will be necessary to continue this policy in the next financial year.

The problem of recruitment and retention of trades staff is at times critical. In any research organization craftsmen with high trade skills are essential for the construction, repair, and maintenance of the intricate and delicate apparatus on which much scientific research depends. In a situation where there is an under-supplied market for such craftsmen, a government organization like CSIRO is at a disadvantage compared with industry because of the less flexible salary policy it must follow. The Organization's inability to recruit and retain craftsmen of the required calibre is causing the Executive increasing concern.

The Organization is continuing to achieve reasonable success in the recruitment of research staff of high calibre. It is difficult to foresee the ultimate effect of the rapid changes that are now occurring in the Australian universities, both in the training of research workers and in their own demands for staff. Meanwhile CSIRO continues to recruit a high proportion (usually well over 70%) of its research scientists from overseas. About one-quarter of these are Australians returning from a period of training or employment in another country but the remainder are overseas nationals. Overseas recruitment has been greatly assisted by the use of a short-term fellowship type of appointment for a fixed term, usually of 3 years, but this normally is effective only at an early stage of a scientist's career. The Executive is finding it difficult to attract and retain senior scientists, particularly those with the ability and eminence to take charge of the Organization's laboratories.

Australia has reached the stage of industrialization where it needs to encourage more freedom of movement of labour to meet the needs of an economy geared to technological progress. For example, both the rapid development of new universities and the greater emphasis on agricultural research and extension services in the States will require significant movement of research and academic staff. The impediment to this movement arising from the lack of transferability of superannuation rights has long been recognized as a serious problem, for which no satisfactory answer has been found. The effects it has had on staff movement to and from CSIRO have recently been analysed in detail, and solutions have been suggested for the problems that were found. These solutions might be extended to other areas of employment, and may provide a satisfactory basis for greater staff mobility on a national scale. The Executive has submitted a comprehensive report to the Minister.

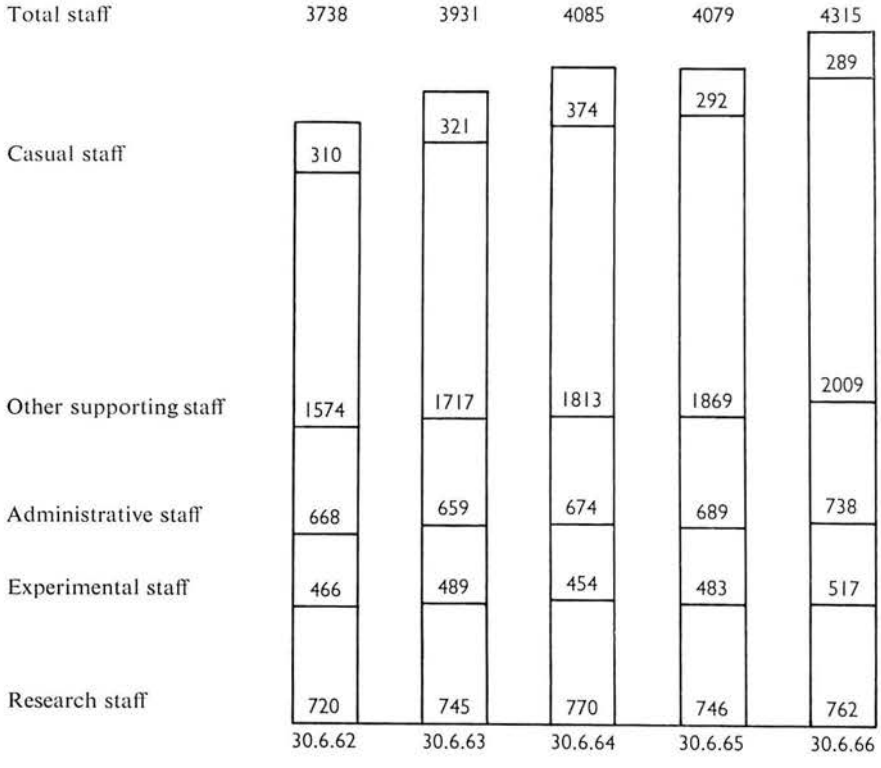
The qualifications, functions, and salaries of several further groups of staff have been reviewed during the year. The new classification structure that has been determined for library staff provides for two groups qualified in librarianship. A university degree or technical college diploma is required for entry to the senior

group, for which the salaries are now comparable with those for most other professional groups in the Organization.

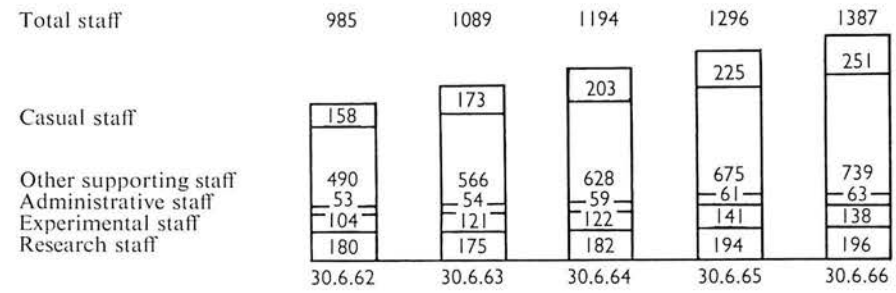
Close and cordial contact has been maintained with the two major staff associations, the Officers' Association and the Technical Association. Items of general interest that have been discussed at various meetings with representatives of these Associations include employment of married women, superannuation transferability, and vehicle safety. The Executive has welcomed the formation of another staff association, the CSIRO Laboratory Craftsmen Association, during the year. This Association intends shortly to lodge an application for formal registration with the Registrar, Commonwealth Conciliation and Arbitration Commission.

The number of staff employed in all categories, including casual employees, increased from 5375 to 5702 during 1965/66. Staff financed by Treasury funds increased by 236 while staff financed by contributory funds increased by 91. Changes in staff numbers in these two categories over the last five years are shown below.

Staff Financed by Treasury Funds



Staff Financed by Contributory Funds



Collaboration with Industry

In countries such as Britain and the United States of America a considerable proportion of government-sponsored research is carried out in industrial research laboratories. The facilities that would be required for such an arrangement are available in few, if any, industries in Australia. Nevertheless, much useful collaboration between industry and CSIRO is possible through use of the facilities available to the Organization. This practice is encouraged by the Executive. In some cases a number of firms join in collaborating with CSIRO; in others, work is undertaken with individual firms or a public authority. In much of this joint activity the firms concerned contribute substantially towards meeting the cost of the research. During the year under review the following new cooperative projects have been begun:

Project	*Division*	*Supported by*
Recrystallization project	Applied Mineralogy	Mount Isa Mines Limited
Investigations into the production of furfural from bagasse	Chemical Engineering	James Cumming & Sons
Hydrometallurgical project	Mineral Chemistry	Mount Isa Mines Limited
McArthur River ore project	Ore Dressing	McArthur Development Company
Investigations into the level of potash in Australian soils	Soils	Australian Potash Research Institute
Development of resonance detectors	Chemical Physics	Perkin Elmer Corporation
Grazing trials	Tropical Pastures	A.C.F. & Shirleys Fertilizers Ltd.

Research Associations

The Science and Industry Research Act 1949–1959 provides for grants to be made by CSIRO to recognized industry research associations. At present four such cooperative associations have been recognized and are receiving grants amounting to $141,500 a year. The total annual expenditure by the associations on research and related activities is currently about $935,000.

The Bread Research Institute of Australia has been receiving a grant since 1950. It has laboratories at Ryde, N.S.W., and provides research and extension services to the industry throughout Australia. During the year extensive improvements and additions were made to the laboratories. The scope of the Institute's activities has been enlarged by the establishment of a Nutrition and Consumer Services Section, financed by the flour-milling industry. The CSIRO Wheat Research Unit is accommodated in the same premises and collaborates closely with the Institute.

The Australian Wine Research Institute, Adelaide, has received a grant since 1955 and is engaged, on a relatively small scale, in long-term research on wine-growing and wine-making. A limited amount of non-routine service work is also provided for the industry.

The Leather Industry Research Association was formed in 1964 to provide financial support for the establishment of a Leather Research Section in the CSIRO Division of Protein Chemistry. Preliminary investigations on a number of projects will be followed by a concentration of effort on those that show the greatest promise.

The Australian Coal Association (Research) Ltd., supported by colliery proprietors, has received a grant since 1956. It was reconstructed in October 1965 as the Australian Coal Industry Research Laboratories Ltd. (ACIRL). This change provided for the admission of coal users to membership, in addition to colliery proprietors. The Commonwealth and the six State Governments are represented on the Board of Management. Following the formation of ACIRL, the research programme is being greatly expanded to include problems in both coal production and coal utilization. Research is carried out in a central laboratory at Ryde, N.S.W., and there are regional service laboratories at Maitland, Newcastle, Bellambi, and Ipswich.

Overseas Research Grants

The Organization has received further 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.

The only major new grant awarded this year was $71,730 from the Ford Foundation for completion of the radio heliograph being built by the Division of Radiophysics. This supplements grants of $490,000 made during the period 1962–65 to cover the main part of the construction of the radio heliograph. Other grants have been made to permit the continuation of several projects commenced in previous years.

Details of all grants received are set out in Chapter 5.

Collaboration with Universities

While CSIRO and the universities have quite distinct functions, many of their activities overlap and there is wide scope for collaboration between them, both in teaching and in research. There is already collaboration in many areas but it would be greatly to the benefit of Australia if it could be extended and better use made of our limited financial and man-power resources. The question of greater cooperation is therefore being studied closely by a committee appointed by the CSIRO Advisory Council; the committee's report should be available to the Council towards the end of 1966.

Practical collaboration between CSIRO and university staff members on a range of research projects has been facilitated by the CSIRO policy of siting its laboratories, where possible, on or near university campuses. 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.

Officers of the Organization assist in university lecturing and demonstrating, particularly in their specialized fields of knowledge. CSIRO and the universities cooperate in an annual marine biology school with a subsidy from the Science and Industry Endowment Fund, and similar activities have been undertaken from time to time in radiophysics. CSIRO feels it could profit considerably from the temporary presence of more young scientists in its laboratories, and would welcome opportunities to play a part in the training of post-graduate students in appropriate fields of study.

In the year under review, grants have been made to support a number of University research programmes of particular interest to CSIRO, including grants for the following purposes:

University of Melbourne:

Pollen research
International Biological Programme
Assist with installation costs of Universal Testing Machine
Spring School on Electron Diffraction

University of Queensland:

Research Fellowship in Parasitology
Research Fellowship in Veterinary Anatomy

University College of Townsville:

Observer for second half of the International Quiet Sun Year

University of Sydney:

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

University of New South Wales:
Investigations into failure of concrete
Research at 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
Biophysical research
Representation at Symposium on Herbivores

University of Western Australia:
Establishment of an Institute of Arid Zone Biology
Post-graduate research in solar energy

University of Tasmania:
Biophysical research

CSIRO has continued its support of 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, Newcastle, and Western Australia, and Monash University.

Advisory Council and State Committees

The Advisory Council is established under the Science and Industry Research Act. Its membership, which consists of the Executive, the Chairmen of the State Committees, and coopted members, covers a wide range of interests and disciplines from the universities, rural and manufacturing industries, and government.

The Council met twice during the year. It reviewed the Organization's estimates and building programme and was particularly concerned at the continuing deficiencies in laboratory accommodation. Other topics discussed included the current approach of the Division of Entomology to insect control (see page 58), water resources research, public relations, and recent developments in cloud-seeding. A report was received from the Council's Committee on Industrial Research Associations. Visits were made to the Divisions of Mechanical Engineering, Animal Health, Animal Physiology, and Textile Physics.

The State Committees, set up under the provisions of the Science and Industry Research Act to advise the Executive or the Advisory Council on matters of general or of particular interest, have been active during the year.

David Rivett Memorial Lecture

The second David Rivett Memorial Lecture was delivered in Canberra on October 21, 1965, by Lord Adrian of Cambridge. The Lecture was entitled "Progress with the Human Nervous System".

The David Rivett Memorial Lectures commemorate the name of the former Chief Executive Officer and subsequently Chairman of the Council for Scientific and Industrial Research. They are given every second year by men who have reached the highest ranks of achievement in scientific research. Lord Adrian, who recently retired from the post of Master of Trinity College, Cambridge, is also a former Professor of Physiology and Vice-Chancellor of Cambridge University. His outstanding services to science have been recognized in many ways. He has been Royal Medallist, Copley Medallist, and President of the Royal Society. The Order of Merit was conferred on him in 1942 and a barony in 1955. He shared the Nobel Prize for physiology and medicine with Sir Charles Sherrington in 1932.

Lord Adrian spent more than three weeks in Australia and visited many of our research laboratories.

Lord Adrian with Mr. H. M. Radford, of the Division of Animal Physiology, discussing an experiment on the role of the central nervous system in controlling reproduction in sheep.

The British science writers at the Division of Radiophysics 210-ft radio telescope at Parkes, N.S.W. From the left, Dr. A. R. Michaelis (Daily Telegraph), *Mr. C. L. Boltz* (Financial Times), *and Dr. E. G. Bowen* (*Chief, Division of Radiophysics*).

Visit of Science Writers

During the year CSIRO and five other Commonwealth Government agencies sponsored a visit to Australia by a group of leading British science writers. The objective of the visit, which took place from March 6 to March 24, 1966, was to allow those participating to become better informed of the extent and achievements of Australian science. It was also hoped that the visit would stimulate Australian interest in the special problems of science journalism. To this end, a well-attended symposium on "Science and the Press" was held in the Australian Academy of Science building in Canberra on March 23.

School for Rain-makers

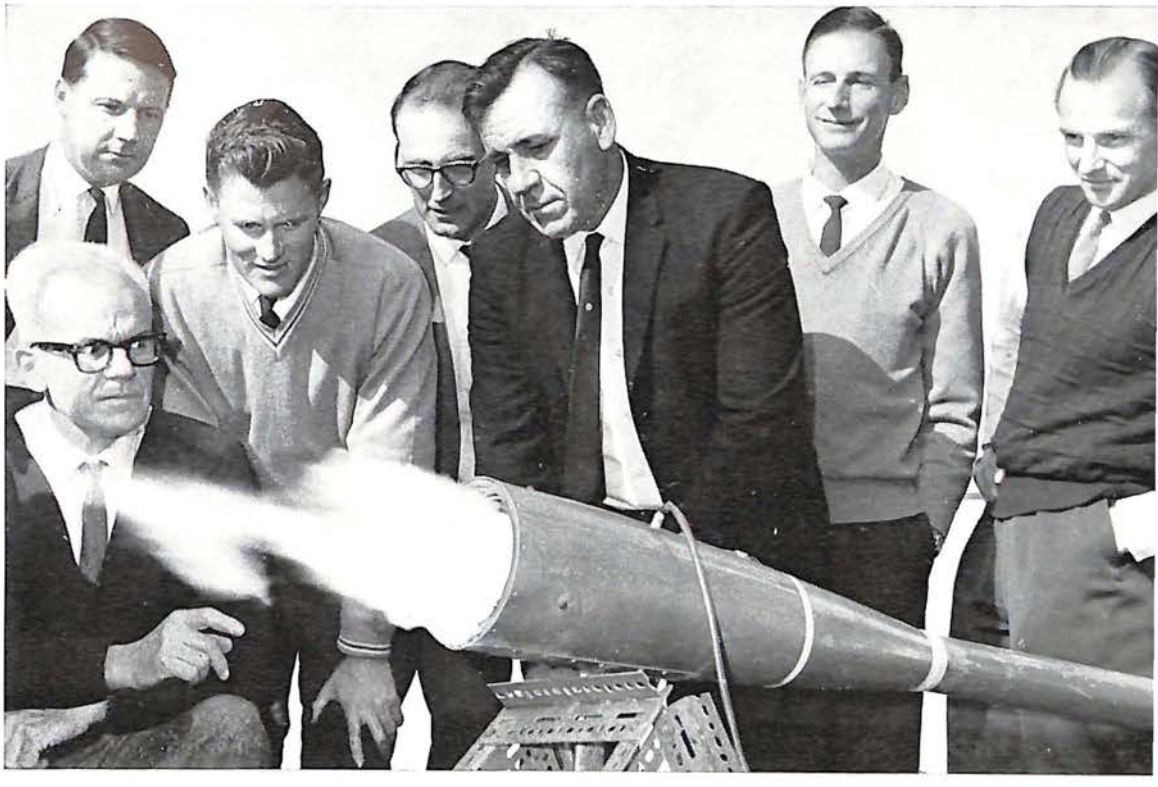
During 1965 CSIRO had several urgent requests from various State authorities for cloud-seeding aircraft to attempt to make rain over regions affected by bush fires and drought. Extensive seeding operations by the Division of Radiophysics in areas of Victoria, New South Wales, and Queensland were followed by good falls of rain when

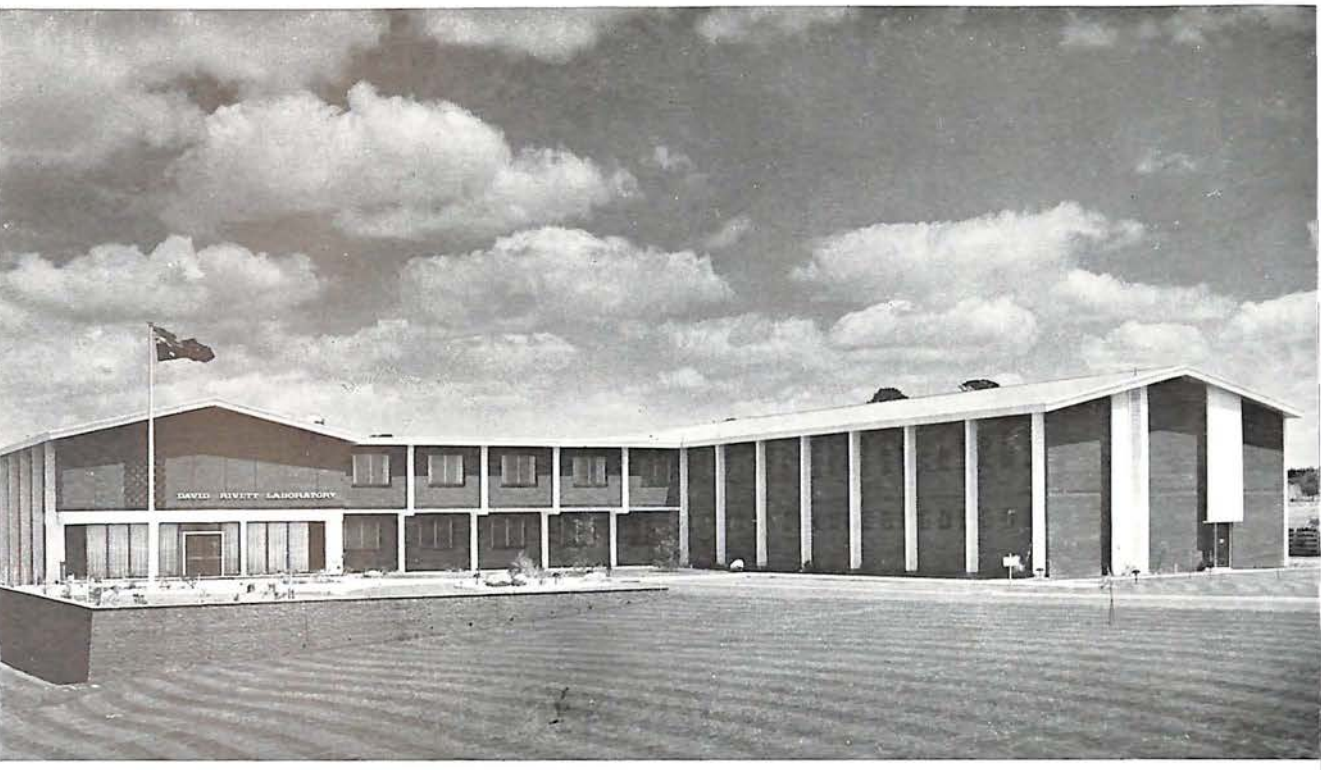
cloud conditions were right. Although the absence of controls makes it impossible to say in these instances whether the rain was due to the seeding, it does appear that there is good justification for carrying out cloud-seeding in emergencies such as droughts or bush fires whenever cloud conditions are suitable.

The Division of Radiophysics does not have adequate resources for emergency action of this kind and there is a need for the respective State authorities to take this responsibility within their own States, particularly as they are best able to judge the seriousness of the situation and to assess the priorities of claims from different parts of the State. To this end the Division organized a "School for Rain-makers", which was held from August 2 to August 10, 1965. Eight men from various State government departments in eastern Australia were given lectures and laboratory demonstrations on cloud-seeding techniques.

The programme at the school included instruction in basic meteorological physics, weather systems and cloud development, cloud physics and rain processes, nucleation, seeding techniques, aircraft problems, applications of cloud-seeding to drought and bush-fire relief, and general administrative problems. Those participating in the school were later given one month's practical experience in the field on one of the Division's cloud-seeding experiments.

The silver-iodide smoke generator used in cloud-seeding operations is demonstrated to "students" of the "School for Rain-makers".





The David Rivett Laboratory at Clayton, Vic.

New Laboratories

Pastoral Research Laboratory, Townsville

A new Pastoral Research Laboratory at Townsville, Queensland, was opened on July 27, 1965, by the Minister-in-Charge, Commonwealth Activities in Education and Research, Senator J. G. Gorton.

The new Laboratory is built on a 50-acre site, donated by the Townsville City Council, next to the University. The main building is air-conditioned and has a floor area of 16,500 sq ft, including 1800 sq ft each of glasshouse space and ancillary buildings. The Laboratory is staffed mainly by members of the Division of Tropical Pastures with smaller representation from five other Divisions.

Work at the Laboratory is aimed at increasing cattle turn-off in tropical Queensland. About half of Queensland's six million beef cattle are raised north of the Tropic, mainly on poor native pastures. Low reproduction rates hinder animal production, and several factors, including malnutrition, disease, and tick infestation, cause heavy losses in some seasons. Townsville lies about 800 miles north-west of Brisbane. The higher temperatures and monsoonal-type climate present a different plant environment

and, although much of the work done in Brisbane has application in northern Queensland, it must be interpreted and modified for these conditions.

Associated with the Laboratory is "Lansdown", a 7000-acre cattle station located 30 miles to the south. It is in typical spear grass country and serves as the main northern centre for field research for that region.

David Rivett Laboratory

The David Rivett Laboratory, a new building for the Division of Chemical Physics, was opened on April 1, 1966, by Senator Gorton.

The Laboratory is named after Sir David Rivett, the first Chief Executive Officer of the Council for Scientific and Industrial Research. It is situated on a 38-acre site in Bayview Road, Clayton, adjacent to Monash University. It is the first unit of the CSIRO Chemical Research Laboratories to move from Fishermen's Bend to Clayton. It is planned that the other Divisions will follow later.

The new building incorporates a number of special features dictated by the requirements of the scientific research conducted in it. The Laboratory is totally air-conditioned and dust-free with a zoned system allowing maximum adaptability to the specific requirements of its various sections.

Organizational Changes

Baas Becking Laboratory

A new biogeological unit has been established under the joint sponsorship of CSIRO, the Bureau of Mineral Resources, and the Australian Mineral Industries Research Association. It has been named after the late Dr. L. G. M. Baas Becking, of the Division of Fisheries and Oceanography, who pioneered research work in biogeology in Australia. The Laboratory is housed in the new Bureau of Mineral Resources building in Canberra. The broad objective of its research work is to study the biological and chemical processes associated with the formation of mineral deposits and other geological phenomena.

Division of Animal Genetics "Gilruth Plains" Field Station

The Division of Animal Genetics is to transfer its sheep selection experiment at "Gilruth Plains", Cunnamulla, Qld., to its experiment station "Longford", near Armidale, N.S.W. The move, which will take place next year, is being made in order to speed up the experimental programme and to enable the research staff to maintain closer contact with their colleagues both in CSIRO and in universities and State government departments. At "Gilruth Plains", where sheep are run in large paddocks at one sheep to seven acres, mustering has been a major undertaking. At "Longford", on the other hand, it will be possible for the sheep to be much more closely stocked so that they are closer to hand for experimental treatment and observation. It is hoped also that drought, which has prevented experimental mating at Cunnamulla in three years out of the last eight, will be a less frequent cause of interruption in the higher-rainfall area.

Mineragraphic Investigations

The independent unit previously known as Mineragraphic Investigations has now been incorporated in the Division of Applied Mineralogy. For the present it will continue to be housed in the Geology School of the University of Melbourne.

Changes of Name

The Division of Biochemistry and General Nutrition has been renamed the Division of Nutritional Biochemistry.

The name of the Division of Land Research and Regional Survey has been abbreviated to Division of Land Research.

Overseas Liaison Offices

During the year changes occurred in the staffing of the two Overseas Liaison Offices in London and Washington. Mr. C. Sibley Elliot retired from office as Scientific Attaché, Australian Embassy, Washington. He has been succeeded by Mr. W. Hartley, formerly Chief Scientific Liaison Officer, London. Mr. Hartley, who has previously served in Washington, brings to the Office a considerable knowledge of institutional arrangements for science in the United States. Mr. Hartley will be succeeded as Chief Scientific Liaison Officer, London, by Mr. R. F. Turnbull, who is at present a Senior Principal Research Scientist in the Division of Forest Products. Mr. Turnbull will arrive in London during August 1966.

The Executive has recently been considering the need to establish effective means of liaison with countries other than those served by the two existing overseas offices. In particular it is aware of the need for Australia to maintain the closest contact with the rapid developments occurring in science and technology in Japan. To this end it is proposed to arrange for an Australian Scientific Mission to visit Japan during 1967.

Technical Assistance Programmes

CSIRO and its officers have continued to collaborate with Australian Government agencies and the international organizations responsible for the conduct of technical assistance programmes. Visiting scientists from a wide range of Asian and African countries are working in CSIRO laboratories on problems that demonstrate research techniques or approaches that will be relevant to their work when they return to their home countries.

The intergovernmental bodies such as UNESCO, F.A.O., W.H.O., U.N.T.A.B., and I.O.C. are seeking more frequently to use CSIRO personnel on expert and specialist panels and on short-term assignments in the developing countries, or to recruit our scientists and technologists for longer-term appointments. Whilst the Executive tries to meet these requests, inevitably they cause a diversion of resources away from CSIRO research programmes, mainly in the form of the time of good research scientists. The Executive is examining ways by which an effective contribution can be made without undue disruption of work within CSIRO. One such way is the "twinning" arrangement

whereby a laboratory in Australia establishes an informal institutional affiliation with a similar laboratory in another country. Our experience of such arrangements with institutions in India and Thailand has been very encouraging.

Among the important problems inhibiting the growth of science and technology in the developing countries is a lack of experienced leaders of scientific research organizations and of an understanding of the constitutional and administrative needs of such bodies, especially when located within the framework of a public service. CSIRO is continually being asked for advice on the organization and administration of research, and leading men in science from most Asian countries have visited Australia to study our research management procedures. It appears that these procedures can provide a suitable model for many of the developing countries and UNESCO recently invited CSIRO to conduct on its behalf a Seminar on Science Policy and Research Organization for Developing Countries. This Seminar was held

Sir Frederick White, Chairman of the Executive, talks with three delegates to the UNESCO Seminar on Science Policy and Research Organization for Developing Countries. From the left, Mr. P. P. Sham, Hong Kong, Mr. T. Mizuno, Japan, and Professor S. S. Singh, Nepal.

in Sydney in August and September 1965 and was attended by 20 scientists, mainly directors of laboratories within national research organizations, from 16 Asian countries. Although broad questions of national science policy and relationships between science and economic growth were discussed, the main emphasis of the Seminar was on day-to-day research administration. The proceedings of the Seminar are to be published by UNESCO at a later date.

International Contact

In the history of scientific research there are many examples of the critical importance of international contacts between scientists. In a geographically remote country the need for international exchanges is great and it is the policy of the Executive to encourage CSIRO research scientists to travel abroad either for specific study purposes or to attend international scientific conferences, which are the most effective and economical means of achieving close contact with other leading research workers in a field of science.

It is also the policy of the Executive to encourage the research staff of the Organization to accept office in the international scientific societies, and CSIRO scientists have been elected to office in the International Council of Scientific Unions and in some of the Unions affiliated with that Council. Such elections not only confer honour and distinction on the individuals concerned but bring considerable benefit to Australian science.

The standing of Australian research in world science is high and, as noted in last year's report, increasing numbers of overseas scientists wish to spend periods of study leave in Australian laboratories. This trend continues and a list of overseas guest workers who have spent six months or more in CSIRO laboratories during 1965/66 is given on page 175.

A further reflection of the standing of Australian science is the number of specialist international scientific conferences held in this country. For example, the Australian Academy of Science, the International Union of Crystallography, and the International Union of Pure and Applied Physics joined in sponsoring the International Conference on Electron Diffraction and the Nature of Defects in Crystals in Melbourne in August 1965. The International Symposium on the Hydrodynamics of Plankton Samplers was held at the Division of Fisheries and Oceanography in February 1966 under the auspices of UNESCO, S.C.O.R., and the International Council for the Exploration of the Sea.

With the approval of the Australian Government, invitations have been issued and accepted for further major international gatherings to be held in Australia over the next 3–4 years. These include the International Biometrics Conference (1967), the International Congress of Soil Science (1968), and the International Grasslands Congress (1970). CSIRO will be responsible for the organization of these conferences; others are being arranged under the auspices of the Australian Academy of Science.

Studentships

Each year the Organization awards a number of post-graduate studentships to graduates of Australian universities, as part of the Executive's policy of providing opportunities for research training.

The 1851 Exhibition Scholarships are also supplemented from CSIRO Studentship funds. Several of these scholarships 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, rural science, veterinary science, engineering, or in arts with mathematics as major subject. There were 170 applications; 33 were awarded (4 were subsequently declined). The candidates finally awarded studentships are listed below with the universities from which they graduated.

D. R. Biggins (Western Australia)
R. P. Chaplin (Adelaide)
B. Chauncy (Wollongong University College)
G. R. Dangerfield (Melbourne)
J. M. Fitzgerald (Queensland)
P. S. Gee (Monash)
R. J. D. Gee (Tasmania)
A. R. Grivell (Adelaide)
Miss R. M. Hall (Sydney)
W. S. Hancock (Adelaide)
M. J. Hynes (Adelaide)
B. W. James (Sydney)
R. J. F. Jenkins (Adelaide)
B. R. Lewis (Adelaide)
Miss J. Lions (Sydney)
A. J. McCartney (New England)
P. R. Milne (Adelaide)
J. Norbury (Queensland)
C. M. Perrott (New England)
Miss H. C. Pietsch (Melbourne)
G. P. Rothman (Sydney)
D. K. Sinclair (Adelaide)
J. Staples (Melbourne)
I. L. Thomas (Melbourne)
B. L. Vickery (Queensland)
Miss E. M. Walker (Melbourne)
Miss H. J. Watson (New England)
R. D. Watson (Queensland)
J. D. Wells (Adelaide)

In addition, Mr. R. A. Spence 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 264 applications; 50 awards were made (11 were subsequently declined). The candidates finally awarded studentships are listed below with the universities from which they graduated.

R. J. Atkinson (Western Australia)
M. L. Banner (Sydney)
M. J. S. Bowden (Queensland)
A. J. Bracken (Adelaide)
P. Brooker (Adelaide)
R. A. Brown (Monash)
B. W. Clare (Western Australia)
Miss M. J. Clark (Adelaide)
S. C. Clarke (Western Australia)
J. C. Coll (Sydney)
L. J. Doctors (Sydney)
Mrs. P. S. Elmes (New Zealand)
M. C. Frazer (Monash)
J. P. M. Friend (Sydney)

P. D. Godfrey (Monash)
G. F. Harvey (Queensland)
R. F. Haynes (Tasmania)
R. P. Henzell (Western Australia)
L. G. Hill (Sydney)
A. B. Holmes (Melbourne)
C. J. Howard (Melbourne)
M. B. Jackson (Adelaide)
I. D. Jenkins (New South Wales)
B. W. Keck (Melbourne)
D. K. Kidby (Western Australia)
E. Lindgren (Western Australia)
R. B. McFeat (Adelaide)
W. D. McKee (Adelaide)
R. A. Marty (Queensland)
R. K. Norris (Sydney)
G. M. Polya (Tasmania)
R. F. Pratt (Melbourne)
A. J. R. Prentice (Melbourne)
L. Radom (Sydney)
D. D. Ridley (Sydney)
R. J. J. Stewart (Melbourne)
R. H. Street (Sydney)
L. J. Warren (Queensland)
P. J. Williams (New South Wales)

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. There were 59 applications; 12 awards were made (1 was subsequently declined). The candidates finally awarded studentships are listed below with the universities from which they graduated.

B. Acott (Adelaide)
K. D. Barrow (Adelaide)
S. D. Bradshaw (Western Australia)
I. Dainis (Adelaide)
Miss N. F. Gersch (Adelaide)
G. I. Gaudry (Queensland)
D. G. Hewitt (Western Australia)
C. B. Osmond (New England)
J. D. Saxby (Sydney)
R. F. Tuddenham (New South Wales)
R. T. Worley (Adelaide)

The following officer of CSIRO also was judged of overseas studentship standard: F. J. Roberts (Division of Plant Industry, Perth).

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. The Executive, as Trustees of the Fund, have always retained considerable flexibility in its administration and, for example, have used it to provide support for:

Research by retired professional scientists in areas in which they have established their competence and standing;

Work by gifted amateurs recognized by professional scientists as competent within their field;

Activities encouraging greater interest in scientific research among young people;

Activities providing special opportunities for training of science students; and

In exceptional circumstances, travel grants for attendance at scientific meetings.

Grants are rarely made when, in the opinion of the Trustees, assistance should be available from another institution or for such purposes as the publication of scientific papers or books.

During 1965/66 the Trustees made grants to assist the following:

Dr. J. W. Evans towards the completion of a monograph on leafhoppers that occur in Australia;

Dr. K. G. McKenzie to undertake a study of Australian ostracod fauna;

Mr. K. M. Moore in connection with a programme of entomological research of the genus *Glycaspis*;

Mr. D. J. G. Griffin to conduct studies on decapod crustacea;

Dr. Mary Carver to continue her studies of Australian aphids;

Mrs. S. G. M. Carr to support work on the taxonomy and developmental morphology of *Eucalyptus* species and the ecology of the Bogong High Plains;

Dr. J. R. Ford for an investigation of the breeding cycle of the silver gull and the taxonomy of the genus *Cinclosoma*;

Mr. N. A. Wakefield to continue his studies on the fossil mammalian fauna of south-eastern Australia;

Miss Barbara G. Briggs for a botanical collecting trip in Western Australia;

Mr. J. Goode to support work on the ecology of Australian tortoises;

Mr. E. D. Gill for assistance in preparation of a number of scientific papers;

Mr. J. M. Thomson to support the initiation of a handbook series primarily for the use of undergraduate and post-graduate students; and

Mrs. G. K. Crowcroft in connection with her studies on the marsupial mouse *Sminthopsis crassicaudata*.

Grants were made towards the travelling expenses of:

Mr. A. Dunbavin Butcher to attend a meeting of the International Union for the Conservation of Nature and Natural Resources whilst visiting research establishments in Britain and Canada;

Mr. F. Parker for a collecting trip in the Bismarck Archipelago in connection with his studies of reptiles and amphibians;

Professor D. H. Trollope towards his participation in the International Research and Engineering Conference on Expansive Soils, held in Texas, U.S.A.;

Mr. H. J. deS. Disney to visit England and the U.S.A. for the purpose of studying the methods and problems of field taxonomy; and

Mr. R. O. Chalmers for a visit to the U.S.A., Britain, and Europe in connection with his research into meteorites and tektites.

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, Flinders University, and the Australian National University, to enable them to attend the annual School of Marine Biology at the CSIRO Division of Fisheries and Oceanography, Cronulla, N.S.W.

2

Research Activities

THE RESEARCH ACTIVITIES of CSIRO are spread throughout the Commonwealth. Laboratories are generally located where the facilities for research can best be made available and are not necessarily situated in the area where the problems under investigation arise. For example, CERES, the controlled-environment research laboratory in Canberra, is used for the investigation of plant problems over the whole range of climatic conditions found in Australia. Associated with the main research centres are branch laboratories and field stations that have been established in various parts of Australia. Some investigations also involve extensive field and survey work.

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

Laboratories and Divisions

Animal Research Laboratories, consisting of the following four 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.,

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

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

Applied Mineralogy, with a branch laboratory in Perth, a small laboratory in Sydney, and the *Mineragraphic Section* at the University of Melbourne,

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, with a Solar Physics Observatory at Culgoora, N.S.W.

Wool Research Laboratories, consisting of the following three Divisions:

Protein Chemistry, Melbourne,

Textile Industry, Geelong, Vic.,

Textile Physics, Sydney.

Other Divisions are:

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., as well as Kealakekua, Hawaii, and Ascot, England.

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

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

Forest Products, Melbourne.

Land Research, 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 Brisbane, Melbourne, Perth, and Hobart and in Deniliquin, N.S.W., field stations and experimental farms at Canberra and Deniliquin and at Carnamah, 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 laboratories in Canberra, Perth, Hobart, Brisbane, Townsville, Qld., and Griffith, N.S.W.

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, with a laboratory at Helena Valley, W.A.

Independent Sections

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

Editorial and Publications, Melbourne.

Horticultural Research, Adelaide, and Merbein, Vic.

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

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

Much of the work of CSIRO has relevance not only to more than one problem but also to problems affecting more than one industry. For example, pasture investigations have significance for the production of crops, sheep and wool, and cattle, while soils investigations have a bearing not only on these subjects but also on others as diverse as land development, oil prospecting, and the design of buildings and other structures. Conversely, the resources of several Divisions may 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 28 at the beginning of this chapter, with brief reports on selected items of current interest.

Cattle

Both beef and dairy cattle form the basis of industries that are extremely important to Australia's economy. Beef production particularly may well become even more important in the near future with the development of improved pastures for tropical areas and of promising new export outlets.

CSIRO has been conducting research on problems affecting cattle for many years and the results of this work have had a considerable impact on the industries. The *Divisions of Animal Genetics*, *Animal Health*, and *Animal Physiology* each contribute to work on cattle at centres in Melbourne, Sydney, Brisbane, and Rockhampton. The *Division of Entomology* has a laboratory in Brisbane largely concerned with work on the cattle tick, and much of the work of the *Division of Tropical Pastures* in Brisbane and Townsville is directed towards the development of new pastures for the cattle-growing areas of the north. Similar work is being carried out by the *Division of Land Research* at Katherine in the Northern Territory and in the Kimberleys in Western Australia. Associated work on the handling and quality of beef is being done by the *Division of Food Preservation* in Brisbane (see Food Processing).

The annual expenditure of Commonwealth funds by CSIRO on cattle research is now about $1,850,000 and this is supplemented by some $800,000 from the Australian Meat Research Committee Trust Fund, the Dairy Produce Research Trust Account, and other contributors.

Several important diseases of cattle are being investigated by the *Division of Animal Health*. Because of the risk that diseases from other countries may ultimately be introduced into Australia, several virus diseases and protozoan tick-borne diseases, as yet unknown in this country, are being studied. Work on infectious diseases caused by bacteria and viruses is centred mainly at the Melbourne laboratory and that on cattle parasites and protozoan diseases at Brisbane. The *Division of Entomology* at its Brisbane laboratory has also been concerned with the major problem of the cattle industry in northern Australia, the cattle tick. Its work on the tick is to be extended to cover a range of animal parasites in the new laboratory at Indooroopilly that will be shared with the *Division of Animal Health*. Brisbane is also the centre for the *Division of Food Preservation's* research on beef for which a new meat laboratory is being built at Cannon Hill.

The work of the *Division of Tropical Pastures* on the selection of pasture plants for the northern areas of Australia is directly related to beef production. The Division has recently extended its work to the Townsville area and the main aim of a further new research station, which it is hoped will be established shortly near Mundubbera on land provided by the Queensland Government, is to study the pastures developed by the Division on a large scale and under typical cattle station grazing conditions. The Division is also extending its work on dairy production in the tropics and is establishing additional centres for research on tropical pastures for dairy purposes. Further work on Townsville lucerne by the *Divisions of Tropical Pastures* and *Land Research* has clearly shown that it could be highly significant in the development of more intensive cattle production over a wide area of northern Australia.

One of the major factors retarding the development of dairy and beef production in tropical regions has been the lack of breeds that combine adaptability to the

environment with efficiency of production. The *Division of Animal Genetics* is continuing with studies of the physiology of heat tolerance in both beef and dairy breeds of cattle. Associated with this are the investigations of the *Division of Animal Physiology* on the nutrition and reproduction of beef cattle in hot climates.

Breeding Dairy Cattle for Hot Climates

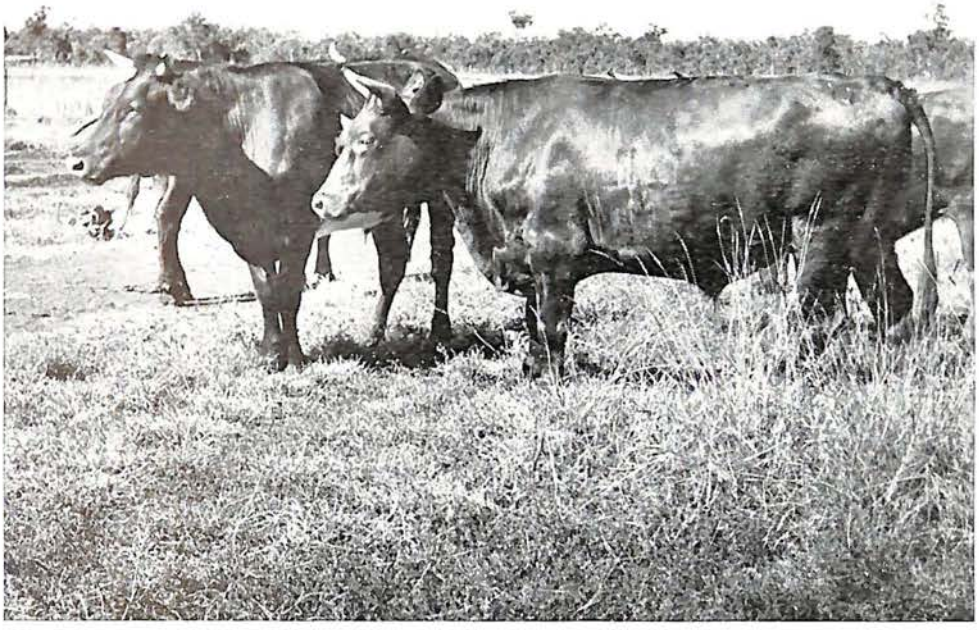
European breeds of dairy cattle suffer some stress in the hotter parts of Australia and their milk production is lower than it is in the cooler dairying districts of the southern parts of the continent. Selection from crosses between British and Zebu cattle for ability to milk well under hot conditions has met with some success overseas, notably in the Jamaica Hope breed. Following this lead, a selection programme was started in 1962 with the cooperation of the N.S.W. Department of Agriculture and eight farmers at Wollongbar, near Lismore, using crosses between the Sahiwal and Sindhi Indian breeds and Jerseys. The bulls are kept at the CSIRO Field Station at Badgery's Creek, and artificial insemination is used to ensure that the progeny of each bull are well represented in each herd. The bulls finally selected were tested in a hot room at Badgery's Creek, and criteria for ability to regulate body temperature by sweating and to maintain appetite under heat stress were developed.

Many of the first-cross cows were culled and the second-generation bulls with the best production background were selected for progeny testing at Wollongbar. The milk production of the quarter-bred Zebu calves born in 1963, in their first year in 1966, seems likely to be satisfactory. Production differences between the female progeny of each bull are showing up sufficiently to allow selection of the best sire for breeding young bulls for further testing. The selected bulls will be used in 1968 but their progeny will not complete their first lactation until 1972.—*Division of Animal Genetics.*

Tropical Grass Pastures for Beef Production

With the combination of good summer rainfall and a high level of solar radiation there is considerable potential for pasture growth in north-eastern Australia. In the search for suitable species for pastures for beef production Nandi setaria and Samford Rhodes grass have emerged as highly promising. Despite very low rainfall in both the second and third years, annual liveweight gains have averaged 435 lb to the acre in an experiment with these grasses over the period 1963 to 1965 at Samford in south-eastern Queensland. Stocking rates varied between one and two beasts to the acre and all the pastures received annual dressings of nitrogen, phosphorus, and potassium. On one setaria pasture where surplus summer growth was fed back to the cattle in winter, the average liveweight gain was 500 lb annually at a stocking rate of two beasts to the acre.

The results of these and other experiments suggest that still higher liveweight gains could be obtained in this environment with its 40-inch rainfall in an average season. Proportionately greater production might be expected in areas with higher rainfall. Pasture yields in excess of 30,000 lb of dry matter to the acre have been obtained under these conditions. The conversion of grass to beef is thus inefficient compared with the conversion obtainable from pastures in temperate regions and this requires further investigation.—*Division of Tropical Pastures.*



Townsville lucerne pastures have been found to improve greatly the rate of growth of young cattle at Katherine in the Northern Territory. These 2½-year-old Shorthorn steers were raised from weaning on Townsville lucerne.

Townsville Lucerne for Beef Production

Early work on the development of intensive production of beef cattle at Katherine Research Station in the Northern Territory was concerned with the evaluation of forage species and of management systems for those species, in terms of the liveweight gain of store steers. This and associated work at Rodd's Bay, Queensland, by the Division of Tropical Pastures established the potential value of Townsville lucerne (*Stylosanthes humilis* H.B.K.) in the summer-rainfall regions of tropical Australia receiving 30 inches of rain or more.

At Katherine the work is now in its second stage and Townsville lucerne pastures are being fitted into year-round fattening regimes for young cattle. In an experiment nearing completion, groups of weaners have been maintained on different combinations of Townsville lucerne and native pasture for the summer and winter months and are being carried to slaughter weight. The most significant result so far obtained is that local Shorthorn cattle, which on native pasture in this region do not normally reach slaughter weight until they are 5 to 6 years old, can be fattened on year-round Townsville lucerne pasture within 2 years of weaning. A group maintained on Townsville lucerne at 3 acres per beast-equivalent per year from August 1963 gained weight at an average of 1 lb per head per day and were ready for slaughter at 2½ years with an average liveweight of 967 lb.—*Division of Land Research.*

Resistance of Cattle to Tick Infection

Resistance to tick infection occurs in many Asian cattle breeds and in some individuals of European breeds. The feeding mechanism of the tick is being examined as a part of a broad study of the factors involved in resistance.

Blood cannot be obtained by the tick through mechanical damage of the host's blood vessels because they barely penetrate the skin. The blood is therefore obtained by haemorrhage into a large necrotic lesion formed in the skin below the tick's mouth-parts, which become embedded in a hardened secretion of saliva.

Glass capillaries fitted over the mouth-parts stimulate ticks to produce a clear watery solution. Only a few microlitres are secreted, but if ticks are first given a subcuticular injection of pilocarpine, which stimulates saliva flow, larger amounts of a more dilute solution can be obtained. Apart from a variety of enzymes, amino acids, salts, and urea (that would not be likely to cause the feeding lesion), the secretion contains a number of pharmacologically active components. Three fractions of these components have been isolated by thin-layer chromatography.

When five microlitres of the secretion are injected intradermally into cattle, simulating the action of the tick, an increase in capillary permeability occurs with consequent exudation of plasma into an area about 1 cm in diameter. A comparison with similar injections of histamine showed that five microlitres of the secretion are equivalent to at least half a microgram of histamine. The secretion is thus highly potent and must have a marked significance in the feeding mechanism of the tick, because it results in an immediate release of nutrients from the blood vessels before they are damaged in any other way. It may also account for the development of the necrotic lesion as an inflammatory response by the host to the escape of plasma proteins.—*Division of Entomology.*

Bovine Vibriosis

Bovine vibriosis is a major cause of sterility and abortion in cattle and the objectives of current work are the improvement of diagnostic tests, and the development of a vaccine that would produce effective immunity under Australian conditions.

An indirect haemagglutination test, using vaginal mucus antibody, has been developed as a diagnostic test. It seems to be about twice as accurate as the better-known vaginal mucus agglutination test, but neither test is particularly satisfactory in a large herd with a number of bulls, where breeding records of individual cows are not available. The emphasis of the research programme has therefore been directed to improving methods of isolation of *Vibrio fetus*, the causative organism, in culture from both cows and bulls in suspect herds. The results have proved satisfactory with bulls in an experimental herd and the technique will now be evaluated in the field.

Investigations leading to the development of a vaccine have been largely successful. In two successive seasons, subcutaneous vaccination with an experimental vaccine has produced a useful degree of immunity in treated cattle. A high proportion of the vaccinated animals did not succumb to subsequent challenge with *Vibrio fetus* and proved to be fertile. This investigation may now be extended into the field, although it will be difficult to obtain a clear evaluation under field conditions.—*Division of Animal Health.*

Distribution of IBR-IPV Virus Disease of Cattle

The infectious bovine rhinotracheitis (IBR)–infectious pustular vulvovaginitis (IPV) virus was first isolated in 1961, from calves in Queensland infected with encephalitis and from Victorian dairy herds infected with IBR–IPV. Later studies of the virus and of the pathogenesis of the disease have greatly extended our knowledge of the distribution of virus in the infected animal.

Following recovery from the acute phase of infection, both cows and bulls experimentally infected with IBR–IPV virus may excrete the virus at irregular intervals. The virus is excreted from the nose and vagina of cows and from the preputial cavity of bulls, and is not associated in most instances with any clinical signs of disease. Other evidence has been obtained of the variable nature of the clinical signs of infection by these viruses. The latest example of its hitherto unknown role in animal disease is the isolation of the virus from an outbreak of bovine pink-eye or infectious keratoconjunctivitis. Thus it appears that this virus may also be responsible for at least some cases of pink-eye.

The distribution of the infection in Australian dairy and beef cattle herds has been investigated and some 3500 serum samples from cattle from all States of Australia, the Northern Territory, and the Territory of Papua–New Guinea have been tested for the presence of antibody to the IBR–IPV virus. Some 28% of the serum samples have contained antibody. It is clear that the disease is present in every State and Territory, but previously has been unrecognized.—*Division of Animal Health.*

Chemistry and Physics

Because of the basic importance of chemistry and physics in most branches of applied science, research on chemical and physical problems forms a considerable part of the work of many of the Divisions of CSIRO. In Divisions that are concerned with particular industries, such as Forest Products, Textile Physics, and Coal Research, the programme includes work on the chemical and physical aspects of the materials and processes used in these industries. Other work may not be directly related to specific industrial problems, but is essential for extending knowledge of the physical and chemical properties of materials and for developing techniques to provide adequate basic information for the solution of practical problems and the development of new industrial processes.

In the group of Divisions that form the *Chemical Research Laboratories* in Melbourne, most attention is directed to problems that are of particular importance to Australia and are unlikely to be investigated elsewhere. The *Division of Organic Chemistry* is concerned largely with chemical substances that have potential uses because of their physiological activity. One of its continuing investigations is a survey of drugs contained in native plants in Australia and New Guinea and the screening of these in collaboration with the U.S. National Institutes of Health and an American firm. Recently this work has been extended to the isolation and identification of substances of animal origin that show promise as selective pest control materials. Other work includes the synthesis of organic substances containing phosphorus, of anthelmintics, and of alkaloids with anti-tumour activity, and a search for organic compounds containing metals that are of potential importance in the

development of new methods for separating and purifying metals occurring in ores found in abundance in Australia.

The *Division of Chemical Physics* is making advances of considerable importance to the whole of chemical science and technology through studies of the application of the techniques of physics to chemical problems. Much of its work is on materials in the crystalline state, and theoretical and experimental studies in X-ray diffraction and neutron diffraction have recently yielded new and significant information on structural details of solids. The work of the Division has also led to the development of several novel scientific instruments which have provided the basis for the growth of a substantial manufacturing activity in Australia, with considerable export potential; these instruments are also manufactured overseas under licence. During the year, the Division moved to Clayton, where it is now housed in the David Rivett Laboratory, close to Monash University (see also page 21).

The *Division of Chemical Engineering* is studying some of the basic operations used in chemical processing and the properties of materials of interest in chemical manufacturing. Other work includes investigations on the desalting of water and the processing of minerals. A different approach to the problem of desalting water is being taken by the *Division of Physical Chemistry*, where a process using ion-exchange resins in a novel way is being developed. The Division is also studying combustion phenomena in relation to the control of bush fires, methods for the control of evaporation of water from storages, and the initiation of ice formation in clouds. Investigations of the properties of matter under very high pressures, of the behaviour of materials in the fluid and solid states, and of the mechanism of crystal growth are continuing.

In the *Divisions of Mineral Chemistry* and *Applied Mineralogy* many of the investigations, although primarily directed at problems of mineral utilization, are of interest to the chemical industry. In the *Division of Mineral Chemistry*, for example, a variety of methods of chemical treatment of ores are being investigated.

Research in various branches of physics is included in the work of the *National Standards Laboratory*, which was established in Sydney in 1938, of the *Division of Radiophysics*, also in Sydney, and of the *Division of Tribophysics*, which developed from the Lubricants and Bearings Section set up in Melbourne to investigate wartime problems in this field. The *Division of Meteorological Physics* was established more recently to undertake research on the basic phenomena occurring in the atmosphere and contributing to the development of weather patterns.

The *Divisions of Physics* and *Applied Physics*, which together comprise the *National Standards Laboratory*, share the responsibility for establishing and maintaining the Australian standards for the measurement of physical quantities, such as temperature, light, length, mass, time interval, electric current, and quantities derived from these. In both Divisions there is active research in areas of physics related to standards and to the development of improved methods of measurement, in order to meet modern demands for greater accuracy in industrial measurements. The research programme also includes work in fields of physics in which the techniques and equipment available in the Laboratory can be used to good advantage. Under the Weights and Measures (National Standards) Act 1960–1964 the Laboratory must also undertake a wide range of precision calibrations and test work.

The *Division of Tribophysics* is investigating the properties of solids, especially metals, and, in particular, the properties of surfaces with the object of improving our understanding of the relations between the structures and properties of engineering materials. Investigations on the behaviour of metals, especially when deformed during manufacture or in use, are being made in the *Physical Metallurgy Section*, in conjunction with the Metallurgy Department of the University of Melbourne.

The special concern of the *Division of Meteorological Physics* is the differences between weather patterns in the Northern and Southern Hemispheres. Much of its work has required the development of new techniques and instruments, several of which are now manufactured commercially, both for local use and for export. The *Upper Atmosphere Section* at Camden, N.S.W., is investigating phenomena in the upper atmosphere, particularly in the ionosphere, which is of importance in long-distance radio communication.

The work of the *Division of Radiophysics* in radio astronomy and in rain and cloud physics research has established it amongst the world's leading research centres in both fields. With the support of grants from the National Aeronautics and Space Administration, U.S.A., the Division is studying radio sources within the Sun's galaxy as well as in distant galaxies and radio emission from the Sun itself. It operates the *Australian National Radio Astronomy Observatory* at Parkes and is collaborating with the *Division of Physics* in the establishment of the CSIRO Solar Observatory at Culgoora, in north-west New South Wales (see page 41). Experiments in cloud seeding and the exacting and difficult laboratory studies of the nature of the processes that lead to the formation of raindrops have progressed to the point where it is now possible to encourage the practical application of the results (see also page 18).

Production of Diffraction Gratings

The availability of precision diffraction gratings produced on the ruling engine developed and made in the Division of Chemical Physics has led to the production of Australian-made spectroscopic instruments which are used throughout the world. The demand for gratings is many times greater than can be supplied directly by the ruling engine, and a technique has been developed for making replica gratings in epoxy resin.

Because of damage from mechanical abrasion and other factors, a grating can be copied only a limited number of times. It is now possible to make "second-generation" copies from these epoxy replicas, so that the original master ruling can be duplicated some hundreds of times. This process of copying from copies greatly extends the usefulness of the original ruling. The replicas are indistinguishable in optical performance from the ruling from which they were copied.

The same replication technique can be used to produce copies of other optical components, and is expected to make an important contribution to the rapidly increasing production of Australian spectroscopic instruments.

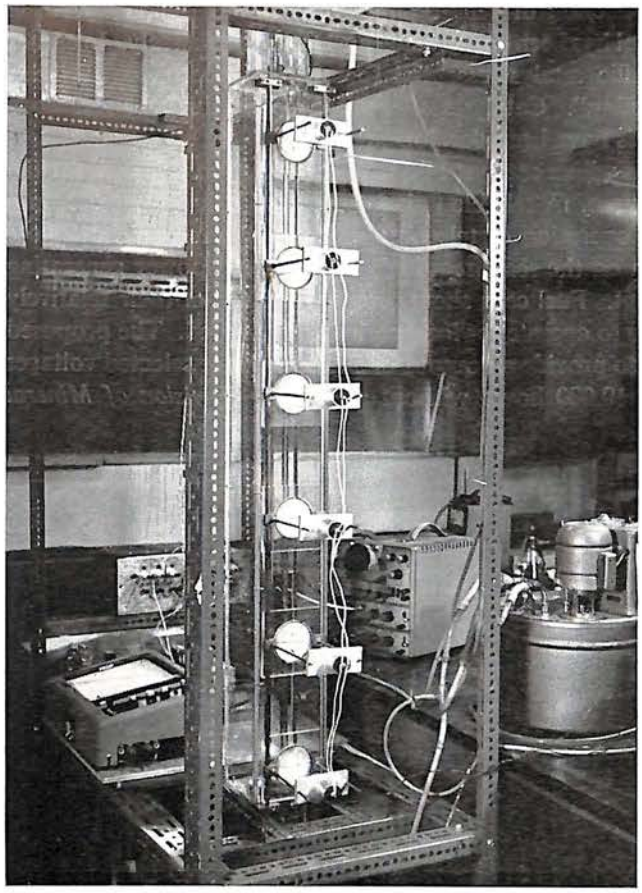
In the ruling of a diffraction grating, accurately parallel, closely spaced grooves are made with a diamond tool which presses each individual groove in a film of pure aluminium deposited on a glass surface. Diamonds used on the ruling engine are specially shaped and polished to produce grooves of the requisite shape, orientation, and surface finish. Some of the 6-inch gratings produced have 32,000 lines per inch,

so that the diamond tool must show no detectable deterioration during the ruling of over 200,000 grooves.—*Division of Chemical Physics.*

Mixing of Viscous Fluids

The mixing of highly viscous materials is a common industrial operation about which little information is available for economic design purposes. Using standard mixers, a study is being made of the effect of mixer speed, mixer size, and process material properties on the progress of mixing in a two-component system. For experimental convenience, aqueous methyl cellulose solutions are being mixed, and the concentration changes in the mixer are followed by a specially developed conductometric method.

It has been found that relative rates of mixing are significantly affected by the total volume of materials charged to the mixer, by the blade speed, and by the rheological properties of the process material. Further experiments are being done to explain these effects in terms of material properties and to provide generalized conclusions for both small- and large-scale mixing equipment.—*Division of Chemical Engineering.*



Apparatus developed in the Division of Chemical Engineering for studying the fundamental physical and chemical processes involved in mass transfer from bubbles of gas or drops of liquid to another phase. As the bubble or drop rises up the glass column its position and volume change are recorded simultaneously.

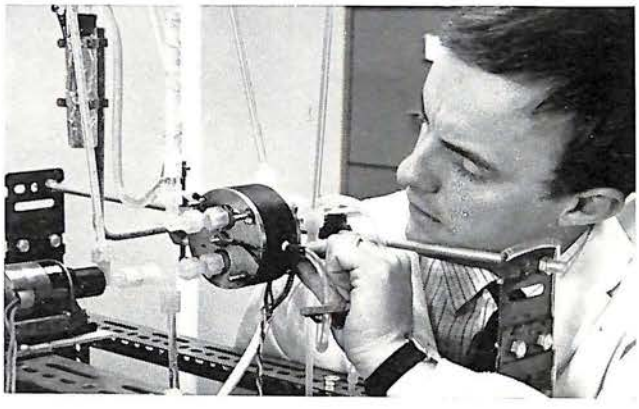
Atomic Absorption Spectroscopy

Continuous advances made by the Division of Chemical Physics in the techniques of atomic absorption spectroscopy have resulted in an even wider acceptance of the atomic absorption methods of analysis that were first developed within the Division as a result of theoretical studies begun in 1953. Atomic absorption spectrophotometers are now made under licence by firms in the United States of America (4), Britain (4), West Germany (1), Italy (1), and Australia. The instruments have been used for making rapid chemical analyses of high sensitivity in such diverse fields as mining, metallurgy, agriculture, physiology, medicine, chemistry, and geology. There has been a remarkable increase in the production of these instruments during the past year. About 2000 have been produced commercially since 1953, but the annual rate of production now exceeds 1000 instruments per year. The value of the Australian production of atomic absorption spectrophotometers exceeds $1,000,000 per annum and more than 60% of the output is exported.—*Division of Chemical Physics.*

Fuel Cell Battery for Small-scale Power Production

CSIRO research on the theory and design of fuel cells has been concerned particularly with the possible production of cells operating on liquid fuels, and a cell designed to use methanol as fuel has been constructed and tested extensively. In earlier methanol fuel cells, the metallic catalyst essential for effective operation has been short-lived because of "poisoning". Catalysts of a new type capable of continuous operation for very long periods have been developed.

A prototype battery of cells with a catalyst of this type is being constructed for the Postmaster-General's Department. A reliable unit for the production of power on a small scale is needed for the operation of telecommunication equipment in remote areas. For power production on the scale required, conventional power generating systems are relatively inefficient. Fuel cells show promise because of their relatively high efficiency and their ability to operate for long periods unattended. The proposed applications require a battery to provide an output of 50 to 100 W at selected voltages from 12 to 52 V for at least 10,000 hours without attention.—*Division of Mineral Chemistry.*



The fuel cell in course of development.

Bush-fire Prevention and Control

The danger of bush fires can be reduced considerably if fuel on the forest floor in selected areas is burnt under conditions that ensure that the forest is not damaged. The cost of producing an adequate grid of spot fires by orthodox methods would be very high if large areas were to be covered.

Controlled burning can now be done rapidly through the use of an air-dropped incendiary capsule. This has been developed in conjunction with the Western Australian Forests Department and tested in forests under the control of the Department. It has been possible with one aircraft to treat areas of 10,000 acres a day compared with about 1000 acres a day for a ground team. With this method, areas difficult of access on the ground can be treated readily and the speed of the operation allows maximum use to be made of restricted periods suitable for burning.

To assist with controlled burning and with operations in fighting bush fires, a portable infrared detector for use from an aircraft has been designed. It is capable of locating fire fronts precisely in the presence of dense smoke.

Bush fires are rarely intense if the forest fuel is moist, and it has been thought that the principal reason is that heat is absorbed in the evaporation of moisture. The real situation has been found to be more complicated. The presence of water leads to chemical reactions that evolve less heat and produce more smoke than does complete combustion, and the rate of combustion is decreased, so that the flame produced is less intense than that from dry fuel. There is also evidence that water vapour alters the character of a flame in a way that reduces the amount of radiant heat emitted from it, so that there is less rapid drying of fuel ahead of the fire. These effects reinforce each other and account for the very pronounced influence of moisture on the severity of bush fires.—*Division of Physical Chemistry.*

New Large Solar Telescope

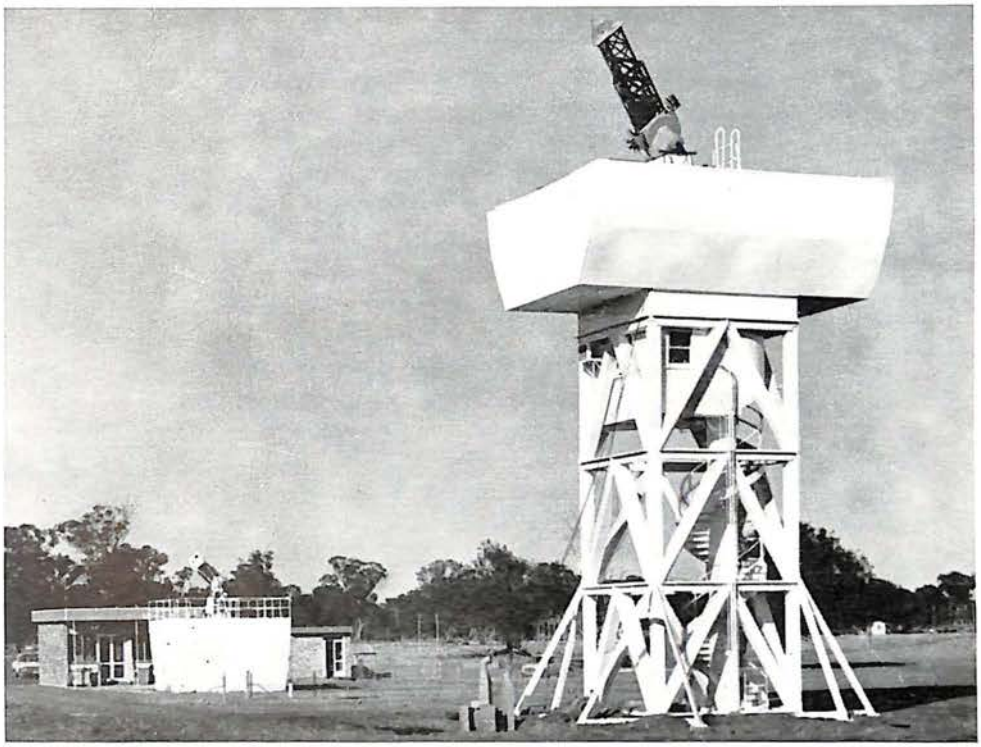
A new large solar telescope, designed by CSIRO scientists and engineers, has been installed at the CSIRO Solar Observatory, located at Culgoora (near Narrabri) in north-west New South Wales. This telescope is designed to photograph the fine structure of flares and various other solar features. If its performance comes up to expectations, it will be capable of resolving details as small as 250 miles in diameter on the surface of the Sun, which is distant some 93 million miles from the Earth.

The chief difficulty in observing fine detail on the Sun arises from turbulent currents of heated air in the Earth's atmosphere. As these image-spoiling currents are worst near the ground, the CSIRO telescope is mounted on a sturdy tower some 50 feet high. The conventional dome can be a source of damaging thermal currents, and the new telescope is therefore provided with a canopy which can be fully retracted into the supporting structure when the telescope is in use. The telescope itself is of open lattice-work construction, so that it remains in full thermal equilibrium with the surrounding air. As a final aid to thermal control, all parts of the telescope directly exposed to the Sun's rays are cooled by an elaborate air system.

The tower is unusual in that it consists of two independent towers, one inside the other. The inner tower carries the telescope, while the outer tower carries all parts of the main structure that might be subject to vibration due to wind or human movement. In this way the telescope itself is protected from vibrations that could

cause blurring of the solar image. The inner and outer towers are mounted on independent concrete foundations.

In operation, the telescope is completely automatic. Even the decision to take an exposure at a particular instant is made by an electronic device that continuously monitors the image quality.—*Division of Physics.*



The new solar telescope at Culgoora, N.S.W.

Obtuse-angled Wedges

During the development of a new type of balance for the measurement of very high fluid pressures, some interesting and valuable properties of an obtuse-angled solid wedge in forceful contact with a solid plane have been predicted, and subsequently confirmed both mathematically and experimentally. If a wedge and a plane are pushed together, no permanent deformation occurs in either component, no matter how large the applied force, provided the angle between the plane and each face of the wedge is small enough. The limiting value of this angle depends on the properties of the materials. As the force is increased, the two components simply touch over an ever-increasing area, and recover completely to their original shape when the force is removed. The edge of the wedge may be as sharp as desired. For high-strength materials, the angle between the plane and each face of the wedge may be of the order of one degree.

A balance or lever with fulcrum bearings of this form is entirely proof against overloading, as far as the bearings are concerned. Other applications, which are being exploited in high-pressure apparatus, are to sealing rings and the bearing edges of various types of valves.—*Division of Physics.*

Photoelectric Pyrometry

The use of materials at very high temperatures, for example in jet engines, rockets, and ceramic fabrications has led to increased research into the physical and metallurgical properties of materials at high temperatures. This has created a demand for an increase in accuracy of temperature measurement above 1000°C. It has been met by the development of a new instrument capable of a tenfold increase in accuracy over existing equipment.

The brightness of glowing bodies, above 1000°C, is used to measure their temperatures with an instrument known as an optical pyrometer. Measurements on the present temperature scale above the freezing point of gold, 1063°C, are made using a visual optical pyrometer. This requires an observer to match the brightness of the body with that of a standard source. In the new instrument this match is carried out photoelectrically, and its calibration at 1063°C has been completed with an accuracy of $\pm 0 \cdot 15$ degC, compared with that of the visual pyrometer, $\pm 1 \cdot 5$ degC. Work is proceeding to extend the calibration of this new photoelectric instrument to higher temperatures.—*Division of Physics.*

Opals

Australia is the world's major source of precious opals and a large proportion of our production is exported. The origin of the beautiful colours of the gems was a mystery until it was resolved recently during the course of work directed to another problem. Opal is a particular form of silica. Because of its importance as a ceramic material, the crystalline structure and origin of opaline silicas are being studied in cooperation with the Geology Department of the University of Adelaide. The first clue to the origin of the play of colours in precious opals came from electron microscope photographs. These showed that the gem is composed of minute spherical particles of silica, remarkably regular in shape and size, packed together in precise arrays. The optical discontinuities between the spheres form a three-dimensional diffraction grating which splits white light into the colours of the spectrum. If the particles are small, the opals display only short wavelengths—violet, blue, and green—and it is necessary for their size to be about 3000 Å to give red and the rest of the spectral colours. We can now understand how the quality of opal is related to its structure and is controlled by the regularity of size, shape, and packing of the spherical particles. Most potch or common opal shows no play of colours, although it, too, is made up from silica particles. Diffraction does not occur because the discontinuities are filled in, or because the particles are too small or too irregular in shape or size.

The spheres of which opal is made up have been shown to be secondary colloidal particles formed by the aggregation of primary silica-sol particles. These have been produced in underground solutions concentrated by subsurface evaporation over many thousands of years. In the laboratory, the growth of the spheres can be acceler-

ated by using pure solutions and high temperature and a synthetic opal is produced within a period of a few weeks. The synthetic lacks many of the characteristic features of the natural stone but shows a similar play of colours. Although an exact duplicate of the natural gem would be very difficult or impossible to prepare, an application has been made to secure patent rights over the process.—*Divisions of Building Research, Tribophysics, and Applied Mineralogy.*

Radiation in Meteorology

Radiation received from the Sun is important in relation to human activity and many other things, such as plant growth, weather and climate, evaporation from crops and reservoirs, and the design of buildings and air-conditioning plants. In its passage through the atmosphere, the energy from the Sun is modified and absorbed to varying degrees, sometimes in a surprising manner. The transmitted radiation that reaches the Earth's surface in the form of direct sunlight and diffuse sky radiation is being recorded continuously and the recorded information is part of the basic material of the research programme of the Division of Meteorological Physics. In conjunction with other observations it has many applications, a recent and rather unusual one being to the study of high-level winds. This arose from observations in 1963 when it was noted that on cloudless days there was a large increase in diffuse sky radiation. It was found that this could be attributed to the presence of large quantities of fine dust in the atmosphere following the eruption of Mt. Agung in Bali. The effect was observable for two years and provided considerable information on high-level wind patterns.

Detailed studies of the distribution of energy in the solar spectrum are now being commenced, particular attention being paid to those wavelengths in the visible and near infrared so important to the photosynthesis process in plants. Similar measurements in the ultraviolet are planned to obtain better understanding of the modifying influences of dust, smoke, haze, and other particles held in suspension in the atmosphere.—*Division of Meteorological Physics.*

Radio Sources and Quasi-stellar Objects

One of the most important of the early projects undertaken with the 210-ft radio telescope at Parkes has been the preparation of the Parkes Catalogue of Radio Sources, a careful listing of the positions and intensity at three frequencies of some 2000 radio sources visible in the southern skies. Special attention has been given to the 700 brightest sources in this list. Over 300 of these have been identified, about two-thirds with familiar radio galaxies and roughly 100 with previously unrecognized quasi-stellar objects or "quasars". These are objects with one hundred times the energy output of the brightest galaxies already known, yet, because their images on photographic plates appear stellar, most are believed to have volumes one-millionth of that of a single galaxy. Their very high intrinsic luminosity makes them visible at distances up to ten times as far as those of the brightest galaxies and so provides an opportunity to study the Universe at greater distances or, the equivalent of this, further back in its history.

The 210-ft telescope has played an important role in research on these objects. Their extraordinary nature was realized three years ago when the position of the

radio source 3C273 was determined. The precision was sufficient to provide certain identification with an object that appeared stellar and that was found by optical astronomers to have a red shift corresponding to a distance of some 2000 million light years. This shift is due to the Doppler effect caused by the recession of this object as it takes part in the general expansion of the Universe.

More recently one of the sources listed in the Parkes Catalogue as "0106+01" has been found to be the most distant object at present known. Examination of the Palomar Sky Survey plates showed that its position coincides with a "blue star", one of the characteristics of quasars being that their radiation contains more ultraviolet than light radiated by normal stars. Photoelectric observations with the 200-inch telescope at Palomar in February 1966 confirmed the ultraviolet excess. A spectrogram obtained since then at Lick Observatory established a record red shift for this object, which indicated it was receding at a velocity of 80% of that of light at a distance from the Earth of the order of 12,000 million light years. The light and radio waves now reaching us from this object have been travelling for almost double the lifetime of the Earth, the Sun, and most of the stars within our own Galaxy.—*Division of Radiophysics.*

Highway Traffic Noise

The noise of city vehicular traffic is sufficiently widespread and annoying to lead to frequent complaints and some precise knowledge of noise characteristics is required if problems relevant to the design of new roads and freeways are to be solved.

Vehicles pass a given point at random, at various speeds, and with various individual noise levels. Many observations of actual traffic flows have been made and a computer programme has been prepared for calculating noise levels at various distances from roads for particular traffic flow patterns. This has allowed a study of the effects of traffic density, variability in speed and noise level of individual vehicles, and varying numbers of traffic lanes. A technique has been developed for taking all these factors into account in assessing the annoyance resulting from any traffic flow.

This study has shown that roadside planting or slightly depressed highway levels may be very desirable. The reduction in noise level by these means might appear insufficient to be of value but they may permit a doubling of the traffic density and could therefore be of considerable importance.—*Division of Building Research.*

Studying highway traffic noise.

Crop Production

Early work on crop production undertaken by CSIRO was developed in the laboratories and field stations of the *Division of Plant Industry* and in smaller independent laboratories dealing with irrigation problems of the Murrumbidgee Irrigation Area at Griffith and with sultana and other horticultural crops at Merbein. Currently work on crops is undertaken by the *Division of Plant Industry* in centres at Canberra, Hobart, and Mareeba, the *Horticultural Research Section* (Adelaide and Merbein), the *Irrigation Research Laboratory* (Griffith), the *Division of Land Research* (Canberra, Katherine, Kununurra, and Darwin), the *Division of Soils* (Adelaide), the *Division of Entomology* (Canberra and Sydney), and the *Wheat Research Unit* (Sydney).

Considering the importance and diversity of crops grown in Australia, overall the expenditure by CSIRO on research in this area is not large, amounting to some $1,300,000 annually. A considerable proportion of this amount is derived from primary industry research funds; for example, the whole of the cost of the work of the Tobacco Research Institute at Mareeba ($190,000) is a charge on the Tobacco Industry Trust Account.

The broad aim of CSIRO's work on crops is to increase their productivity and to extend the areas in which they may be grown. With crops that are already well established, work has been directed at the basic principles of plant production, of soil fertility, and of crop quality. In addition the Departments of Agriculture carry out extensive research on the crops grown within the various States.

Much other work has been done by CSIRO on crop production in new areas and on crops, such as tobacco, that are relatively new in Australia and still present a variety of problems. Cotton is now being grown commercially at Kununurra on the Ord River as a result of pioneering work by the *Division of Land Research*, in collaboration with the Department of Agriculture of Western Australia. Other crops that have been shown to be well adapted to that area include grain sorghum, safflower, linseed, rape, and sugar-cane, while winter cereals such as oats and wheat have shown some promise. The Division is also investigating crops such as cotton and peanuts at Katherine and rice at Humpty Doo in the Northern Territory.

In horticulture several laboratories are working to build up a detailed knowledge of the response of crops to environmental conditions. Irrigated horticultural crops, particularly grapes and citrus, are receiving attention in the *Horticultural Research Section* and in the *Irrigation Research Laboratory*, where the programme also includes work on cotton and rice. In Tasmania the *Division of Plant Industry* is studying the physiology of apple fruits in relation to wastage in storage and in transport. Work that could lead to improved methods of control of orchard pests is being done in several centres by the *Division of Entomology*.

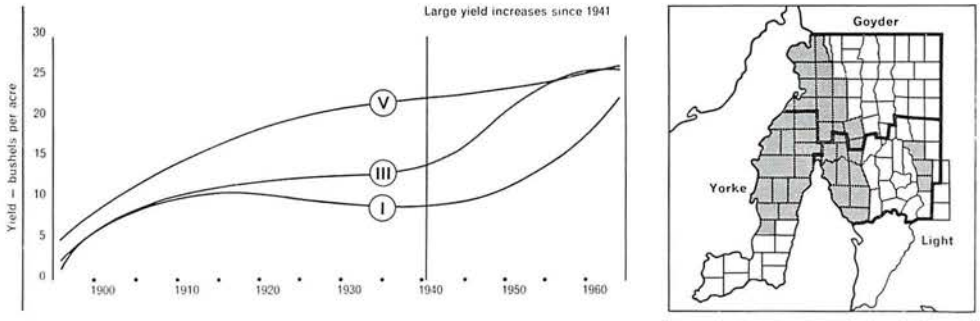
Research in the *Division of Plant Industry* on field crops is directed largely at soil-fertility and weed problems in wheat-growing. Closely related work on wheat is in progress in the *Division of Soils* while problems on the quality of wheat and of flour products are being investigated by the *Wheat Research Unit*.

Specific disease and quality problems in growing tobacco are being investigated by the *Division of Plant Industry* in Canberra and at the *Tobacco Research Institute* at Mareeba.

In addition much of the general research in CSIRO on plant problems and on soils and water has potential application to many of the problems of crop production.

Wheat Yield Trends reflect Benefits of Medic Leys

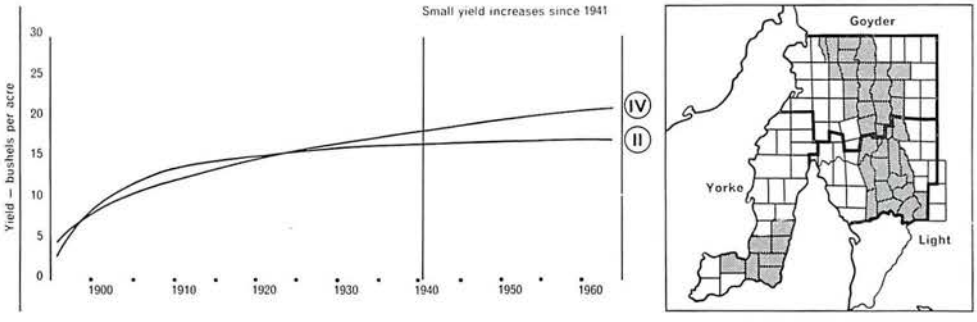
Some years ago examination of crop statistics in the South Australian wheat belt showed that there was a steady increase in average wheat yields in the period 1896 to 1941. The increases were attributed to better varieties, better cultural practice, wider use of superphosphate, and better pest and disease control. Further studies of the regions of Goyder, Yorke, and Light now show that during the years 1941 to 1965 there have been dramatic yield increases in the portion of the wheat belt in which medics have become established. There is clearly defined subdivision of the hundreds into five types each with a characteristic yield trend. The significant features of these types and their distribution and yield trends are illustrated graphically.



Soils—*Sandy with no profile development ranging to loamy mallee types with free lime at or near the surface. Well structured.*

Pasture—*Medics easily established. Self-seeding and have spread throughout the area in 20 to 30 years.*

Management—*Satisfactory rotations of legumes with wheat.*



Soils—*Red-brown earths to transitional solodic soils. No free lime at surface. Poorly structured.*

Pasture—*Medics unsuitable. Subterranean clover must be used but can be difficult to establish.*

Management—*Rotation of legumes with wheat difficult.*

Over the period 1941 to 1965 the increases in yield for types I, III, and V are quite large, ranging from 50% to nearly 100% for types I and III in particular. On the other hand, the trends in types II and IV are the same as they were 20 years ago and involve only small increases.—*Division of Mathematical Statistics.*

Quality Assessment of Wheat on Single-grain Samples

Every few years good Australian varieties of wheat become susceptible to disease, particularly new races of rust, and must be replaced by resistant new varieties. Quality must be maintained too and the more precisely the quality for particular end uses can be specified for the plant breeder, the more readily will it be possible to produce new varieties suited to these needs. Currently work on this problem is directed to a study of the proteins of wheat.

A new method has now been developed for the identification of the proteins in wheat, using only a single grain as a sample. It has the added advantage that the embryo need not be damaged, so that it can be used for further breeding work. The variation in quality between individual ears and grains of a given variety grown under particular conditions has been found to be very small, so the reliability of the method is high.

Related work includes a study of the effects of fatty substances present in the flour or added to it, and of the components of the flour and their baking behaviour. —*Wheat Research Unit.*

Grain varieties of sorghum are highly productive under irrigation at the Kimberley Research Station on the Ord River. In two harvests in 1965, yields of up to 12,000 lb of grain to the acre were recorded.

Cotton–Sorghum Rotations for the Ord River Area

Cotton is the principal commercial crop of the Ord River irrigation area. In the search for possible alternatives, recent investigations at the Kimberley Research Station have demonstrated the potential of both the grain and forage types of sorghum. Under the climatic conditions of the north of Western Australia, with hot summers and relatively warm winters, irrigated sorghum grows all the year round, though more slowly in the winter months than in the summer. It should thus be possible to take several harvests each year.

In 1965 an experiment was carried out with grain and forage varieties under a range of nitrogen fertilizer levels. The crops were sown in January, and by the end of September two harvests had been taken from the grain varieties and three from the forage varieties, which yielded up to 27,000 lb of dry matter to the acre. From the grain varieties, the highest yield was 12,000 lb of grain to the acre, of which two-thirds came from the first harvest in April–May and one-third from the second harvest in September. Further experiments on varieties, time of sowing, nitrogen fertilizer requirements, and spacing are in progress, particularly with grain sorghum. Should the crop prove economic, and if promising outlets can be developed, the timing of cultural operations would fit in with those of cotton, and rotations of cotton and sorghum would then be possible.—*Division of Land Research.*

Ord River Cotton responds to Nitrogen Fertilizers

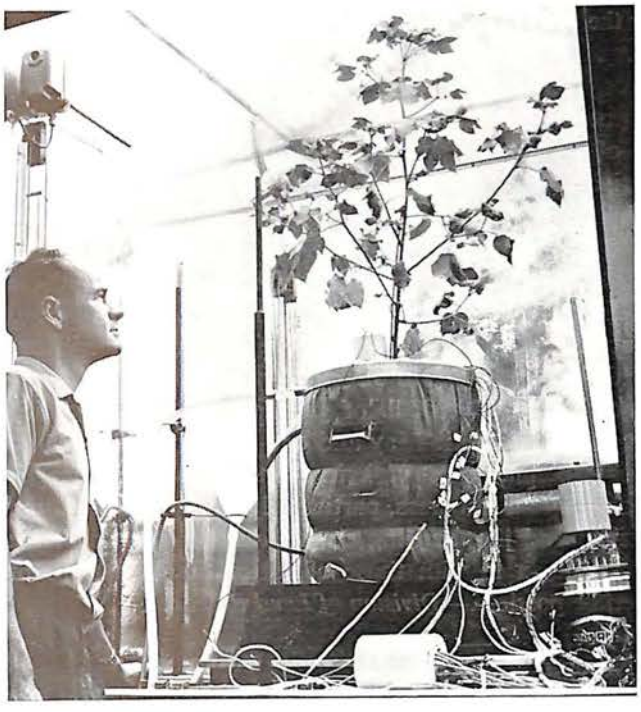
The response of cotton to fertilizers has been studied for many years at the Kimberley Research Station on the Ord River, but potential yields from added nitrogen could not be fully explored because satisfactory insect control was not feasible. Now that more efficient insect control is possible it has been found during the 1964/65 season that cotton lint yields on three-year-old land increased with the amount of nitrogen applied up to the highest rate, which was equivalent to 400 lb of nitrogen or 17 cwt of sulphate of ammonia per acre. In spite of an estimated 20% loss due to boll rot, yields of the order of 1100 lb of lint to the acre were obtained.

Detailed studies of soil and plant have shown that the increase in yield per unit amount of nitrogen applied decreased with increase in nitrogen application but the losses of the fertilizer in the soil–plant system were low and the decreased response was mainly due to smaller rates of uptake at higher applications. These results indicate that an unexpectedly high ceiling yield of lint may be attainable.—*Division of Land Research.*

Cotton-growing in South-eastern Australia

Cotton-growing has now spread from central Queensland to irrigated areas throughout the Commonwealth and every endeavour is being made to establish the crop on the Murray–Murrumbidgee river system, where there is a large irrigated area to develop. The yield of cotton in the region is limited by climate, particularly by the length of growing season and the mean summer temperature. Even more important are limitations on the entry of sufficient water into the soil during the summer growing period.

Much technical knowledge is now available to aid the development of a cotton-growing industry in the area. Using suitable cultural methods, satisfactory yields



Apparatus used in the Irrigation Research Laboratory, Griffith, to make simultaneous measurements of water potentials in plant and soil, and transpiration rate, in experiments on the loss of water from cotton plants.

have been obtained with existing varieties but there are indications that it will prove possible to breed new varieties better adapted to the short growing season. A breeding programme with this end in view has been started. Early sowing and close spacing have been found to be important factors in the production of high yields of fibre with desirable characteristics. Even the most stubborn of the Riverina soil types have been improved for cotton-growing by heavy application of gypsum combined with suitable fertilizer dressings.—*Irrigation Research Laboratory.*

Toxins produced by Rotting Plant Residues

Where wheat stubble is left either lying on the surface or partially incorporated into the top few inches of soil, subsequent yields of cereals are decreased. These decreases in yield are not always due to tie-up of nitrogen; substances toxic to plant growth produced by the rotting residues may often be the cause.

Straw rotted for short periods of 2–6 days by moistening with water containing soil microflora and extracted with cold water has been found to produce the most toxic substances. This was determined by bioassay using wheat and oat plants grown under sterile conditions. The most noticeable effect was on the roots, which were markedly stunted, usually growing to no more than 1 or 2 cm in length during a 21-day growing period. Straw that had been subject to climatic conditions favourable to rotting prior to testing did not produce any toxic effects. However, the effect found under these conditions may not be as apparent or even significant in soil because of the possibility of absorption and rapid breakdown of the toxins. Work is therefore proceeding to evaluate the effect in soil.—*Division of Soils.*

Salt Tolerance of Crop Plants assessed at Seedling Stage

Leaching and improvement of drainage will lower the concentration of salt in a salt-affected soil but complete removal of the salt may not always be possible. The land could still be used, however, if sufficient salt-tolerant varieties of crop plants were available. In studies of the physiology of salt tolerance in plants the comparative tolerance of different varieties of the same species has been determined by the accepted method of growing seedlings under conditions of high salt concentration and recording survival over a six-day period. It has now been found that it may be possible to accelerate these tests by a new method. The uptake of chloride and sodium ions in a seedling when grown under conditions of high salt concentration is an index of its salt tolerance, low ion uptake indicating high salt tolerance. The uptake can be measured over very short periods with the help of radioactive tracers and this leads to an appreciable saving in time even when allowance is made for the preparation and standardization of radioactive solutions.

The importance of salt tolerance has been further emphasized by studies of salt redistribution during the dry conditions experienced in the Murrumbidgee Irrigation Area last year. It was found that whilst there was no accumulation of salt on frequently irrigated plots, salt concentration increased in the root zone of pasture plots subject to periods of water stress such as shortage of irrigation water.—*Irrigation Research Laboratory.*

Nematode (Eelworm) Control

Surveys in Australia of crops such as cereals, citrus, vines, vegetables, bananas, and tobacco have revealed clear evidence of major nematode (eelworm) attacks that have a serious effect on yields. Just as important, too, are chronic insidious losses of 10–20% in almost all growing crops. Experimental studies have shown that the control of plant nematodes by chemical treatment of the soil and by breeding, selecting, and introducing resistant strains of crop plants has led to increased yields.

Long-term trials have been begun to determine the most satisfactory root-stocks for sultana and peach production in Australian soils that are infested with the root knot nematode (*Meloidogyne javanica*). Particular attention is being paid to the factors that influence the ability of nematodes to invade the host plant root, to the mechanism of orientation and penetration, and to the structure of organs in the nematode that are associated with the secretion of active substances. There is evidence that the root knot nematode secretes growth-regulating substances and that the plant root exudes substances which stimulate the secretion of specific enzymes from the nematode larvae. These studies on the complex relationship that exists between the nematode and host plant tissues, causing the formation of giant cells and galls, should lead to better understanding and control of nematode infections.—*Horticultural Research Section.*

Pruning Level regulates Sultana Yields

The percentage of fruitful buds on sultana canes can readily be estimated prior to pruning. As a result of recent work at Merbein it is now possible to define the limits within which yield can be regulated by adjusting the number of fruitful buds left by different levels of pruning.

In a 14-year experiment yield increased evenly with the retention of more canes in the range of three to eight canes and in a 4-year experiment in the range of six to twelve canes. The least heavily pruned vines maintained their superior yield throughout the course of both experiments, indicating the absence of a cumulative effect. Yield was not directly proportional to number of canes per vine; three-cane vines yielded nearly two-thirds as much as eight-cane vines; and six-cane vines more than three-quarters as much as twelve-cane vines.

For most years of the experiment the average bunch weight did not change greatly from season to season and differences in yield were mainly due to differences in bunch number. But in some seasons bunch weight, which cannot be allowed for in pruning, varied considerably and this had a large effect on yield.

In these experiments there was no evidence of overcropping with yields up to $14\frac{3}{4}$ tons of fresh fruit per acre. There appears to be no reason why appropriate pruning should not make yields of this order (or possibly higher) the objective every year. Maximum yields will, of course, be obtained only in years when both bunch number and bunch weight are at their best.—*Horticultural Research Section.*

Water Stress and Fruit Set in Sultanas

Poor fruit set of sultana vines in the Murray Valley has often been attributed to excessively high temperatures around flowering time, but it now appears from experiments with small fruiting vines grown in pots that water stress is a more important factor than high temperatures on their own.

No significant differences in fruit set have been found when potted vines are grown in controlled environments combining day temperatures between 21°C and 30°C with night temperatures between 19°C and 25°C. Periods as long as 3 days with maximum temperatures above 35°C at flowering or 1 week after flowering did not reduce fruit set if ample water was available. On the other hand, 3-day periods of water stress imposed at flowering, or 1, 2, or 4 weeks after flowering, significantly reduced fruit set. There was no effect on fruit set of a similar period of water stress imposed 6 weeks after flowering.—*Horticultural Research Section.*

Protein as well as Starch Synthesized in Chloroplasts

Chloroplasts, the chlorophyll-bearing bodies of leaf cells, have now been shown to perform important functions vital to plant growth besides the long-recognized function of photosynthesis. It has now been recognized that a major portion of leaf protein is synthesized in the chloroplasts. The detailed biochemical reactions involved in this process have been studied with preparations of chloroplasts isolated from leaves. Furthermore, nucleic acids, the chemical regulators of many aspects of plant metabolism, have also been found to be synthesized in the chloroplasts. The chemical energy needed for both these processes is derived directly from photosynthesis.—*Division of Plant Industry.*

Causes of Storage Disorders in Export Fruit

Handling, transport, and storage make up 80% of the total production cost of export fruit up to the time it is loaded on the ship. The cost of actually growing the

fruit is only 20% of the total. Fruit losses in the post-harvest period not only reduce the grower's return but also depress the value of sound fruit on the market. Some of the factors that determine post-harvest behaviour of fruit are therefore being studied.

Small cell size and high phosphorus level in the fruit have been found to be important factors checking breakdown in storage, but high nitrogen levels may be harmful. Susceptibility to bitter pit in apples, which can cause serious losses in the post-harvest period, has been shown to be related to calcium nutrition. The effectiveness of calcium treatments can be increased by the addition of small amounts of organic compounds which themselves do not control bitter pit.—*Division of Plant Industry.*

Blue Mould Resistance in Tobacco Plants

Blue mould disease causes serious losses to the tobacco industry. Breeding for resistance to infection by the disease has been handicapped in the past by the fact that plants of new selections must be subjected directly to general infection and may not then be available for further breeding even if they are only slightly susceptible to blue mould. Potentially useful material might then be lost.

Rapid production of necrotic lesions (a local zone of dead cells) is an important reaction to infection and it has now been found that the incidence of necrosis is highest in the plants that are most susceptible to blue mould. This may well form the basis of a new technique for determining the resistance rating of new types, with the advantage that if it is satisfactory they will still be available for further breeding. In this technique small disks about 1 cm in diameter are punched from a leaf and used for the necrotic lesion test, without significant damage to the plant itself.

It has been found that the necrotic cells are not usually penetrated by the mould, which suggests that a substance poisonous to the fungus may be present. This observation is being followed up because it might have future practical applications.—*Division of Plant Industry.*

Engineering

In the establishment of its engineering and other manufacturing industries Australia has drawn extensively on overseas experience. Such imported technology will no doubt continue to play a significant part in our industrial development but it is important that our dependence upon it should not become too great. There are many problems that are unique to Australia or that are of special importance to local industries. Further, if Australia is to become a substantial exporter of manufactured goods it must exploit its potential to develop new products and to devise new, improved, or cheaper methods of manufacture. There is therefore a pressing need for more research in the various fields of engineering to be undertaken by both government and industry.

A large part of the engineering research in CSIRO is concerned with problems directly related to the industries with which various Divisions are associated, such as

the *Divisions of Forest Products* and *Building Research* in Melbourne (see Timber and Building), the *Divisions of Dairy Research* (Melbourne) and *Food Preservation* (Sydney) (see Food Processing), the *Division of Coal Research* in Sydney (see Minerals and Mineral Processing), and the *Division of Chemical Engineering* in Melbourne (see Chemistry and Physics). The Divisions of the *Wool Research Laboratories* in Sydney, Melbourne, and Geelong are similarly engaged in engineering research for the wool textile industries (see Wool Textiles).

The research activities of the *Divisions of Physics* and *Applied Physics*, which together make up the *National Standards Laboratory* in Sydney, have wider application and are of concern to most of the manufacturing industries. Other laboratories engaged in specialized fields of engineering research are the *Divisions of Tribophysics* and *Mechanical Engineering* and the *Physical Metallurgy Section* and *Soil Mechanics Section*, all of which are in Melbourne.

The requirements of industry for greater precision in measurement are continually extending. It is the function of the *National Standards Laboratory* to maintain the Australian standards for the measurement of length, mass, time interval, temperature, electric current, light, and quantities derived from these. To meet the needs for greater accuracy the two Divisions in the Laboratory undertake research on improved methods and equipment for precise measurement. Much of the calibration work that the Laboratory undertakes under the Weights and Measures (National Standards) Act 1960–1964 is concerned with the examination of standards of high precision that are used in other laboratories as working standards for the calibration of industrial measuring equipment. Most of these laboratories are registered with the National Association of Testing Authorities. The work of the Laboratory also includes investigations on the machining of metals and on methods for assessing machinability. Another substantial programme of research is associated with the geometric analysis of engineering designs and with studies on the dimension variability associated with production processes. A comprehensive account of developments in geometric analysis has been published recently in book form.

The *Division of Mechanical Engineering* is engaged on research in a number of fields that are of special importance in Australia, such as refrigeration and air-conditioning, automatic control equipment, the use of energy from the Sun, and the development of improved agricultural machinery. The work of the *Division of Tribophysics* on the relation between structure and properties of materials is helping to provide a more rational basis for the specification and production of engineering materials. Research in the *Physical Metallurgy Section* is concentrated on certain aspects of the behaviour of metals, especially during the deformation that occurs in fabrication or in use.

Problems of importance in civil engineering are being investigated in the *Soil Mechanics Section*. It is concerned particularly with the load-bearing properties of soils and the changes that occur with movement of water within soils. The behaviour of soils beneath paved areas such as roads and airfields is of particular importance in Australia and the Section has recently collaborated with research institutions overseas in preparing and publishing a comprehensive review of existing knowledge on this subject.

Vibration Measurement by Interferometry

It is often possible to prevent vibration from interfering with the operation of equipment by isolating it on a suitable mounting, or the vibration source can itself be mounted so that vibration is not transmitted to surrounding equipment. To design for effective isolation it is necessary to obtain precise information on the vibration. This can be done by attaching vibration transducers to the vibrating objects so that the motion produces electrical signals having the same characteristics as the vibration.

The relation between the electrical signals and the vibration causing the signals is found by calibrating the transducer on a vibrating table which can be adjusted to give vibrations with known characteristics. This method is not satisfactory when the range of movement in a vibration is very small, and a new method that makes use of optical interferometry has been developed. If one of the surfaces in an interferometer is made to oscillate, the interference fringes will oscillate in the field of view, and the number of fringes passing a reference point can be used to measure the displacement of the moving surface, one fringe corresponding to about 10-millionths of an inch. These fringes can be detected with a photocell and counted electronically as the surface travels from one end of its motion to the other.

This method is being applied to the calibration of vibration transducers. A further study of the theory has shown how the oscillatory displacement can be measured without counting the individual fringes. Instead, a harmonic component of the electrical signal from the photocell is observed, and amplitude fluctuations in this component are used as an alternative measure of the vibratory displacement.—*Division of Applied Physics.*

Quick-stop Metal Cutting Tool

The development of a technique to obtain the information required is often the most difficult part of a research problem. In metal cutting research, "quick-stop" tools are used to "freeze" the high-speed cutting action to allow the area at the chip root, called the shear zone, to be studied. This zone is a small deformed region that extends from the tool point to the work surface. Knowledge of what occurs in this zone is necessary for better understanding of the mechanism of metal cutting and better control of production machining.

The cutting action is "frozen" by accelerating the tool rapidly to a velocity greater than the cutting velocity and ejecting it from the cutting region. Since the deformation producing the chip continues as long as the tool and workpiece are in contact, the ejection time must be as short as possible if the "frozen" chip is to be representative of steady-state cutting at high speed.

A new quick-stop tool has now been developed. It has a tool block that is driven from its holder by a small explosive charge, detonated at will by an electrical fuse. While cutting, the tool block is held firmly in position by a hardened shear pin, which is broken when the charge is detonated. Ejection times of only a few microseconds have been achieved. The use of this equipment has already given information on conditions in the shear zone that could not be obtained with conventional quick-stop devices.—*Division of Applied Physics.*

Switched-bed Regenerative Cooling

Living conditions in the north of Australia can be greatly improved by comfort-cooling of houses. Although simple evaporative cooling systems can be used in regions of low summer humidity, they fail to bring relief in the more humid areas. The available alternative, refrigerated cooling, is usually too expensive to operate because of high local electricity costs.

A form of indirect evaporative cooling that offers a possible solution to the problem is being developed. It uses a precooled bed of crushed rock as a heat exchanger to cool the incoming air supply to a house. Simultaneously, the temperature of a second identical rock bed is reduced by passing through it evaporatively cooled exhaust air from the house. At predetermined intervals the functions of the two beds are automatically interchanged, so that a continuous supply of cool fresh air is provided. The electricity consumption is comparable with that of direct evaporative cooling, but the humidity of the air supplied is very much lower. Compared with a refrigerated cooling system, the running costs are reduced by 80–90%, while the proportion of fresh air in the supply is greatly increased.

A full-scale prototype system has been undergoing laboratory tests, with encouraging results. The system will be operated under more arduous field conditions in trial installations to be made in selected tropical areas.—*Division of Mechanical Engineering.*

Fouling of Water-cooled Condensers

The water-cooled condenser is an essential component of most refrigeration and air-conditioning systems of any size. In use, suspended solids from the circulating water tend to be deposited in the condenser and scale accumulates on the heat transfer surfaces. Both forms of fouling cause serious deterioration in condenser performance.

In deciding on the size of condenser to use in a system, it is customary to use an arbitrary "fouling factor" to ensure that adequate performance is maintained over an extended period. Little or no information has been available on appropriate values for this factor in different localities, and it has now been investigated in several capital cities.

The results have emphasized the importance of correct system design and maintenance. Without regular cleaning, condensers tend to silt up at a rate that depends on the design of the water passages and the cleanliness of the water supply. An appreciable proportion of water that is recirculated through a cooling tower must be continuously run to waste, as otherwise the increasing salt concentration that occurs even with a comparatively pure water supply will rapidly lead to scale formation. The fouling factor normally used is then quite inadequate. These findings will allow a sounder approach to condenser design and use, leading to improved performance, higher operating efficiency, and reduced power consumption in air-conditioning systems.—*Division of Mechanical Engineering.*

Microwave Reflectometer

In radar installations and microwave links, the microwave energy is usually transmitted along waveguides, which are smooth rectangular metal tubes of uniform size. Any sudden change in shape or cross-section reflects some of the energy back

towards its starting-point. The need to remove reflections is even more important in the precise microwave standard measuring equipment being developed in the National Standards Laboratory.

Recently a new method for locating and measuring the characteristics of reflections in waveguide and transmission line apparatus has been developed. The measurements are recorded automatically on punched paper tape and processed by one of the computers in the CSIRO network. One of the advantages of the method is that unavoidable reflections in the measuring equipment itself are cancelled out so that very minute reflections in the waveguide can be observed. Discontinuities that reflect as little as one hundred-millionth of the transmitted energy can now be located and measured.—*Division of Applied Physics.*

Engineering Evaluation of Terrain

Research on the description, classification, and evaluation of terrain for engineering purposes was begun in 1962 and methodological studies have been carried out in the Mt. Isa–Dajarra area of north-western Queensland, the Tipperary area of Northern Territory, and the Leichhardt–Gilbert area of northern Queensland. Considerable progress has been made in the development of a method to obtain quantitative data concerning the physiography, geology, and soils of large areas of country. This can be used to assess such information as a preferred line of route for road construction, the location and nature of earthen materials for use in road and earth dam construction, and the nature of terrain for movement of vehicles.

Considerable interest has been expressed by Army authorities in the ABCA countries (the United States of America, Britain, Canada, and Australia) in the CSIRO approach to engineering terrain evaluation as a means of assessing problems of military communication and the movement of vehicles. A meeting of the ABCA Armies' Quadripartite Standing Working Group on Ground Mobility in Kingston, Canada, in August 1965 recommended that a joint exercise be held in northern Queensland in 1968 to integrate and test the terrain description and classification systems of the four member countries. The exercise would provide a unique opportunity to test all available concepts and procedures for the engineering evaluation of terrain, for civil as well as military purposes.—*Soil Mechanics Section.*

Moisture Conditions beneath Road Pavements

The design of road pavements is often based on the use of a value for the load-bearing capacity of the soil in its weakest condition, that is, when it is fully saturated with water. Many of the new road systems in Australia are being built in semi-arid areas where the clay soils rarely, if ever, become fully saturated. In these areas it would seem to be justified to adopt a design approach based on the higher strength properties of an unsaturated clay. This would result in considerable savings in road costs, as it would be possible to reduce the thickness of pavement required. Empirical design methods based on this concept have been in use in Australia for some time, but little quantitative information has been available on seasonal changes in moisture conditions in the soil or on the moisture movement that may take place in the soil as a result of sealing the road surface.

Another important factor in the design of foundations for engineering structures

such as roads and buildings is the expansive properties of many Australian clay soils. These soils expand considerably when wet and contract on drying. Foundation movement occurs because of seasonal influences or after the surface has been covered by roads or buildings. If this movement is excessive the structure may be damaged.

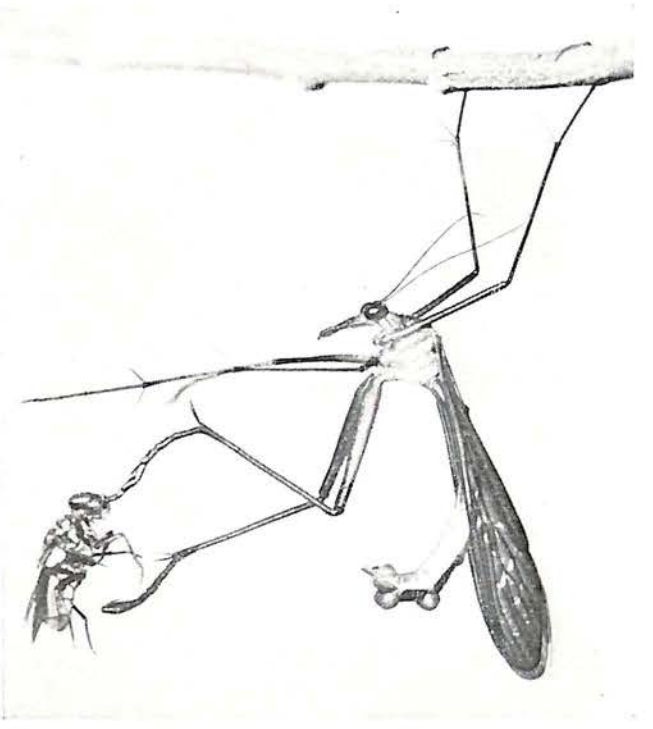
The mechanisms of soil moisture movement involved in both these aspects of the use of soil as an engineering material have not been fully understood and an Australia-wide study of moisture conditions in pavement subgrades has been in progress over the past five years in collaboration with the State road authorities. The results of this project and those of similar projects overseas were reviewed in a Symposium-in-Print conducted in April 1965. The Symposium has been published as a 265-page book entitled "Moisture Equilibria and Moisture Changes in Soils beneath Covered Areas". It includes a review of the present status of engineering knowledge of the principles of water movement in soils, soil moisture measurement techniques, and the methods of prediction of moisture changes in soils beneath covered areas.—*Soil Mechanics Section.*

Entomology

Dramatic increases in food production followed the introduction of organic chemical insecticides in the early 1940s and today there is scarcely an agricultural commodity that does not benefit from their use at some stage. These new insecticides have also been of immense help in the control of some livestock pests and diseases, and there is little doubt that world food problems could well be approaching disaster point at the present time but for their availability and use.

At first the benefits of the new insecticides seemed overwhelmingly in their favour, but difficulties gradually became apparent. The use of insecticides does not normally result in permanent lowering of pest numbers and recurrent applications are usually necessary, often several during the course of one season. Insect populations have evolved that are not killed by economic doses of some of the new chemicals and a struggle has developed between the chemists synthesizing new compounds and the insect populations that develop tolerance to the compounds. Then again, few of the insect poisons are selective. Most of them kill both pests and their natural enemies indiscriminately, and the balance between these may be so altered that a pest population is increased rather than diminished. Finally, the effects of many of these materials persist and extend far beyond the immediate pest–crop complex treated, and residues find their way into food, clothing, animals, and the human body. Carried from one locality to another by air currents, water run-off, or living organisms, pesticides have often travelled great distances. The potential effect of persistent toxic pesticides on human health and on the balance of biological systems has been causing increasing concern.

It is highly unlikely that it will ever be sensible to eliminate entirely the use of chemical insecticides. The search will continue for new, more highly selective materials that will kill insect pests without being unduly harmful to non-target organisms in the environment.



The Division of Entomology is studying the defensive secretions produced by insects and some work has been started on sex-attractant materials. The male Harpobittacus *after capturing a fly protrudes its abdominal glands which secrete a pheromone attractive to the female. The attracted female is presented with the fly and mating takes place.*

There are other potentially valuable means of insect control that do not involve the use of conventional insecticides. Many of these are not new. For example the strategic timing of planting and harvesting to minimize insect damage, rotations with inhospitable crops, field hygiene such as clean fallowing to remove sources of reinfection, the introduction of parasites and predators of the pest, and the selection and use of resistant varieties of plants and animals are but some of the well-established methods. Newer approaches include the release of sterile insects into a population to reduce effective matings, the use of insect hormones and pathogens, and exploiting the effect of substances such as the sex-attractants and alarm and defence materials that are known as pheromones. Each of these methods is likely to be specially valuable for a specific pest. Often the methods may be combined with each other or with the use of insecticides to achieve better control.

This concept of pest control has been inherent in the research programme of the *Division of Entomology* since its inception and it has recently been given increased emphasis. It may be regarded as "pest management", since it leads to the intelligent manipulation of nature, without harming beneficial species, to reduce the numbers in a population to a level where it can cause little or no economic loss.

Developments in pest management are likely to occur more slowly than in insecticides since detailed knowledge of the biology and physical environment of each pest is required; this knowledge can be gained only through research extending over long periods. There is an urgent need for the research effort in this field to be increased.

Insect Vectors of Livestock Disease

The spread of infectious livestock diseases across Asia during the last 10 years has been of concern to all those associated with disease control because of the increased risk of their introduction into Australia. Some of these exotic diseases are transmitted by insect vectors but little was known about the blood-sucking insects attacking stock in Australia before investigations were commenced at the McMaster Laboratory in 1962.

The initial work has been limited to the small blood-sucking midges of the genus *Culicoides*, a group of insects that is known to include the vectors of blue tongue in sheep in South Africa and the United States of America. Various parts of south-eastern Australia have been surveyed to determine which species of midges are present, where they breed, and which of them bite stock. With this information it should be possible to assess the risk of establishment of a vector-borne disease, to determine the probable manner of its spread, and to devise measures appropriate for the control of midges.

The results of this work found use in the emergency that arose in December 1965 in Queensland, when bull semen was illegally brought into Australia and used to inseminate cows. The McMaster Laboratory research group was consulted and a decision was taken by the appropriate authorities that the risk was such that cattle on the primary and surrounding properties should be slaughtered. The group then took the responsibility for a programme of midge control in the district. With prompt assistance from local entomologists a team was operating within 48 hours in co-operation with an army malarial control unit, and the resting-places of midges around creeks were treated with insecticides. Much that was learnt of the organization of such emergency operations may prove invaluable in the future.—*Division of Animal Health.*

Biological Control of Lantana

Introduced insects have been used with spectacular success for the control of lantana in Hawaii, where it is a serious pest just as it is in New South Wales and Queensland. Before similar insects can be introduced into Australia it will be necessary to investigate in detail the range of plants, particularly those of economic importance, that might be attacked by the insect in its new environment. Arrangements have therefore been made in Hawaii to interplant lantana that is infested with the controlling insects with some 60 species of plants that are of economic importance in Australia. If none of these is attacked, steps will be taken to import the insects into Australia. Meantime much useful information about the host specificity of the insects is being obtained.

In the past, tests such as these have been carried out by confining the insects in the presence of the plants to be tested without any other source of food. Any evidence of feeding on useful plants, native or introduced, was sufficient to eliminate the insect from the list of possible introductions. Tests of this type have generally been considered too artificial and they suffer from the disadvantage that a starved insect often acts abnormally under confined conditions. Furthermore, an insect is often too rare or inconspicuous in its native environment to allow any useful testing to be done there. These tests in Hawaii are much more realistic and represent a useful advance in technique.—*Division of Entomology.*

Stink Bug Secretions

The secretions used by some insects as a defence against predators have remained effective over the very long periods of time involved in their evolution and a study of them may have relevance to the problem of development of resistance to insecticides by an insect. The secretions can act either as odorous repellants or contact irritants and poisons. Many are obnoxious and a few are dangerous to man.

The defensive secretions produced by stink bugs, such as the green vegetable bug, the bronze orange bug, and other plant-sucking insects belonging to the Hemiptera, have been studied. Anatomical details have been obtained of the glands that produce the secretions and of the sacs in which the materials are stored. The apparatus of ejection and distribution has also been studied.

The secretions have often proved to be complicated mixtures of many components. For example there are at least 20 compounds in the defensive secretion of the green vegetable bug. The compounds range from inert paraffin hydrocarbons, which act as carriers to aid penetration, to highly reactive α,β-unsaturated ketones and aldehydes which are the toxic principles. Other bugs produce somewhat simpler secretions which contain aldehydes, esters, acids, and alcohols.—*Division of Entomology.*

Cuticle Moulting of Insects

One of the possible new methods of controlling insect pests is based on interference with the biochemical processes underlying the moulting process in which the outer covering or cuticle is shed. It is a form of pest control that would be specific to insects, because the moulting process, which is necessary if insects are to grow, is unlike the continuous growth processes of the higher animals and is a biological phenomenon not often found in other species.

The enzymes that are involved in the moulting process are now being examined. The work is expected to yield information that will show whether the process can be used for pest control purposes. The active moulting fluid is difficult to obtain in quantity from many insects, and the studies are being directed particularly at the mode of action of chitinase which has been obtained from material collected from the gut contents of cockroaches.—*Division of Entomology.*

Hormones of Insects and Crustaceans

A possible method of control of insects with minimum hazard to higher animals is to use chemical substances to interfere with essential biochemical processes that occur only in insects. Of the many substances that are essential for growth and development, hormones are of particular interest. Many insect hormones are unique and produce their effects at extremely high dilution. Whereas their production and release at appropriate stages of growth are essential for normal development of the insect, exposure to their effects at inappropriate times could seriously interfere with normal growth processes. Further, since these substances are vital for the development of the insect it would be very difficult for it to become resistant to their action. Substances to disturb the production or delay the effects of these hormones should also prove valuable for insect control.

The isolation and determination of the structure and the study of the action of insect hormones are thus an attractive and challenging field of research. At present

little is known of the chemistry of these substances. They are present in insects in only trace amounts and their isolation for identification is particularly difficult.

Insects differ from higher animals in having hard exoskeletons which must be shed as the animal grows, pupates, or changes into the adult form. This process is initiated by the so-called "moulting hormones", which should be of particular interest for insect control. As insects are not readily obtained in large quantities, the chemical structures of the moulting and growth hormones of crustaceans are being studied in collaboration with Union Carbide Australia Ltd. Crustaceans and insects belong to the same animal group and crustaceans are more readily available in the quantities required for chemical investigations. Recently a small amount of a pure hormone (crustecdysone) was isolated from the extract of one ton of crayfish waste. The hormone is highly active in inducing pupation in blowfly larvae. It has been found to be a steroid of novel type, quite different from mammalian steroid hormones.—*Division of Organic Chemistry.*

Codling Moth Control

Codling moth is the key insect pest in Australia's apple and pear orchards. Because of the very serious and widespread damage that it causes, and its great ability to multiply under local conditions, the insect must be kept down to extremely low numbers at all times in commercial orchards. This means that it is impossible to rely on biological methods for its control.

Insects, mites, and spiders form integrated communities in orchards and it has been found that most pests are capable of compensating very rapidly for the loss of numbers inflicted by many insecticides. It has also become clear that it is impossible to effect a drastic reduction in the numbers of any one pest with the insecticides currently in use without disturbing the whole balance of species, sometimes with disastrous results. Potentially effective natural agencies, of which many are known to exist, must therefore be tested methodically and fostered to minimize the injury caused by such pests as light-brown apple moth, plant-eating mites, and scale insects. Selective means to reduce codling moth to commercially acceptable numbers have been successfully tested in the field, and a large-scale experiment in cooperation with State Departments of Agriculture is about to be commenced to evaluate the plant extract "ryania" as a selective toxicant specifically aimed at this pest.

The array of chemical pesticides that the grower now must use to control pests in his orchard is becoming increasingly complex and the situation shows signs of becoming even worse. These experiments are therefore timely and of far-reaching importance.—*Division of Entomology.*

Environment Studies

The Australian environment has much that distinguishes it from those elsewhere. The soils of the continent are complex and most of them are infertile, lacking phosphorus and nitrogen and a variety of the trace elements. Some of them are, geologically, very old, and many of them have no counterparts in other countries, for they reflect the peculiarities of the soil-forming factors of climate, vegetation, and topo-

graphy that fashioned them. Water is the limiting factor to production over almost the whole of the continent and the rainfall is often unreliable; few areas are not subject to recurrent droughts, sometimes of great severity. Further, unlike most countries with a European population, Australia still has a developing agricultural frontier, with large areas of land undeveloped, particularly in the northern parts of the continent.

Such an environment presents many problems. It leaves little scope for small-scale settlement so that effective development can proceed only with the sponsorship of governments or of large-scale private enterprises, and then only after much preparatory work has been done. The role of CSIRO in this work has been largely one of taking stock of natural resources so that they can be put to best use and of undertaking the research required to provide solutions to the intrinsic problems that would otherwise hinder effective development.

The Divisions principally concerned with studies of the environment are the *Division of Soils*, with centres of research in Adelaide, Canberra, Brisbane, Townsville, Hobart, and Perth, the *Division of Land Research*, with centres in Canberra, Katherine, Humpty Doo, and Kununurra, and the *Division of Tropical Pastures* in Brisbane and Townsville. It is difficult to define the extent of the overall effort because so much associated work is carried out in other groups. For example the occurrence of minor element deficiencies and their effect on plant and animal nutrition are being studied in many Divisions, notably the *Division of Nutritional Biochemistry* in Adelaide. Work on problems in which water is a factor also appears in a wide range of research programmes, such as the study of water resources, their salinity and the tolerance of plants and animals to saline waters, methods of desalination, irrigation problems, and the modification of the environment through increased rainfall. Other work is directed towards reducing losses of water stored in dams by evaporation and seepage.

In view of the unique nature of many Australian soils, early work of the *Division of Soils* was necessarily directed at devising a system of soil classification to provide a basis for description and assessment of the distribution of soil types. Information on the formation and occurrence of the major soil types is still being accumulated. The earlier investigations have provided a solid basis of knowledge for the development of the more settled areas of Australia and current work is being directed particularly towards soil fertility problems. Potassium, nitrogen, and phosphorus deficiencies are widespread, and areas of soils deficient in minor elements continue to be discovered. The distribution of these elements and the factors affecting their uptake by plants are being studied.

The *Division of Land Research* was initially concerned more with the undeveloped portions of the continent and an efficient and rapid method of surveying large areas of land and the associated environment was required. The Division developed a technique using aerial photographs and requiring limited field sampling to subdivide the land surface into distinctive "land systems" with different land-use potentials. Reports are available for many areas, especially in northern Australia, and some of these areas are now being studied intensively at field stations at Kununurra on the Ord River and Katherine and Humpty Doo in the Northern Territory. Currently the Division is conducting surveys in Papua–New Guinea and the Adelaide River–Alligator River area of the Northern Territory.

Early studies of the region of eastern Australia lying north of 30° latitude and east of the 20-inch rainfall isohyet by the *Division of Tropical Pastures* showed that there was limited scope for increasing the productivity of native grasses. The Division has concentrated on broadly defining different ecological regions and selecting key experimental sites for pasture improvement research. New legume–grass associations have been developed through introducing new species from overseas, selection and breeding, and attention to the widespread soil-nutrient deficiencies. It is now becoming possible to recommend pastures for each region and to specify general principles for their management (see also Pastures).

Many other Divisions are concerned with related work. The salt content of inland water supplies frequently makes them too brackish for direct use. A novel process of water purification using ion-exchange resins that can be regenerated by temperature change is being investigated by the *Division of Physical Chemistry*. Distillation techniques are being developed by the *Division of Chemical Engineering* and the *Division of Mechanical Engineering* has installed an experimental solar still at Muresk Agricultural College in Western Australia. A wide variety of soil–water–plant relationships are being studied by other Divisions, especially in the *Division of Plant Industry* and the *Irrigation Research Laboratory*.

The *Division of Radiophysics* holds a position of world leadership in studies of the possibility of economically increasing rainfall. These investigations have reached the stage where the results could usefully be applied in some areas of Australia. Experiments in which isolated cloud systems have been seeded with silver iodide have shown that in suitable situations up to a million tons of water (equivalent to an average of half an inch of rain over 30 square miles) can be obtained with 20 grammes of silver iodide. Seeding of such cloud systems should be beneficial in areas where severe drought conditions prevail or danger of bush fires exists. Operations on a larger scale such as over the catchment areas of major river systems could also be undertaken provided means of assessing the results were available.

Automatic Weather and Stream Level Recorder for Remote Areas

Following a request to CSIRO from the Australian Water Resources Council, an instrument has been designed with a number of novel features for collecting and processing field data such as rainfall, stream level, air temperatures, or solar radiation intensity. Since only changes in the variable are recorded, long periods of inactivity, such as weeks without rain, waste no recording space but can be estimated from holes punched in a chart. It records rainfall to an accuracy of 1 point (0·01 in.). Standard five-level punched paper tape is used for recording and it can be fed directly into a computer for storage and analysis. The instrument is quite small—15 in. in diameter by 12 in. high, weight 40 lb. An important design feature is that it can operate for a year without servicing. Its nickel-cadmium batteries are trickle charged by a solar cell assembly. The batteries have sufficient reserve to operate during darkness or overcast weather. The instrument has been tested in a wide range of temperatures and has continued to operate satisfactorily even under 16 ft of water. Its simplicity, reliability, and compatibility with the computer suggest it should have a wide application in environment studies.—*Division of Land Research.*

Effect on Sheep of Saline Drinking Water

Saline drinking water may have a bad effect on the health and productivity of sheep but detailed information on the nature and extent of the effects is lacking. The health and productivity of wethers, ewes, and lambs in pens or at pasture have been assessed over several years in which the sheep were supplied with drinking water simulating two main types of Australian underground water. The experiments have shown that the problem is not simple. One type of water, found in South Australia and Western Australia and containing up to 1·3% total solids (mainly sodium chloride), has had no adverse effect on wethers but has depressed the appetite of ewes and the growth rate of lambs. On the other hand, another type of water with a composition typical of bores in the Great Artesian Basin in Queensland, high in bicarbonate and with up to 0·5% total solids, has appeared to depress wool growth in wethers but has had no deleterious effect on ewes or lambs.

It has also been found that the kidneys of Merino sheep undergo adaptive changes in association with the development of tolerance to prolonged drinking of 1·3% sodium chloride solution. These changes have been shown to occur in Dorset Horns, and it is evident that tolerance is related to the species rather than to the breed of sheep. Animals so adapted are unaffected by the jugular infusion of 10% sodium chloride solution, while others which had previously had rain water to drink were promptly rendered gravely ill by the infusion. They were restored to normal health by an infusion of potassium salts, which suggests that the excess sodium chloride produced an electrolyte imbalance. The mechanisms controlling these responses are being studied.—*Division of Nutritional Biochemistry.*

The event recorder developed by the Division of Land Research.

Recharge of Underground Water Resources

In coastal dunes and marine sediments, such as occur in the southern part of the Murray Artesian Basin, the underground water resources are each year subject to some recharge at the time of the rainy season. The recharge of shallow ground water beneath the Gambier Plain, north of Mount Gambier, South Australia, has been followed each year since 1960. The results are reaching a stage for analysis and correlation with average rainfall for the district.

Already it appears that about 10% of an annual rainfall of 30 inches will infiltrate deeply enough into the soil to recharge the ground water under pasture land. Under forest the recharge is less, because forests tend to evaporate more water than pastures. When the results have been fully analysed they should reveal important principles that may guide the management of water-yielding catchments for optimum use of land and water.—*Division of Soils.*

Drought Resistance of Eucalypts

The influence of water stress on eucalypts was studied during the severe drought that affected so much of eastern Australia in the first half of 1965.

The relative water content of the leaves of a number of species was measured and it was found that severe water stress may be experienced even before the leaves die. Moisture contents as low as 45–50% of normal were found in some living leaves. The information gained will be of value in determining the role of soil and atmospheric drought in the distribution of the various species and in the incursions of such plants as spinifex, and thus could be useful in economic land-use surveys.—*Division of Plant Industry.*

Regulating Water Loss from Plants by Artificial Stomatal Closure

Extended periods of rainless weather, particularly when they occur during critical periods of crop growth and development, frequently lead to marked reductions of yield and sometimes to crop failure. During such periods the rate of desiccation may be reduced by the plants themselves by the closure of the stomatal pores, but in many cases closure is incomplete or occurs too late to prevent some reduction of yield. If closure could be reduced artificially as soon as water stress began to develop, it might be possible to stabilize crop yields. Because of the importance of this problem in Australia, the Division of Land Research has commenced an intensive programme of research into physical and physiological aspects of leaf transpiration with special reference to stomatal control mechanisms.

Instruments have been developed to provide, for the first time, specific estimates of stomatal permeability to water vapour diffusion. Calibration procedures have been devised to enable the results from other types of instruments to be interpreted quantitatively. The morphology and anatomy of stomata are being studied in detail using both optical and electron microscopy, and the role of the internal cell wall surfaces in transpiration has been clarified. The efficiency of various metabolic inhibitors in inducing stomatal closure has been assessed and at the present time effective control of the stomatal opening can be achieved in the laboratory. The process will be tested in the field as soon as effective procedures for applying the inhibitors have been devised.—*Division of Land Research.*

Fungus Roots stimulate Plant Growth

Plant roots frequently carry fungus infections that can stimulate growth; if the correct fungi are not present, growth may be impaired. This association of roots with a fungus is called mycorrhiza, and it is of economic importance, particularly in the growth of forest trees. The differences between fungi in their effects on plant growth and the possibility of field establishment of selected fungi are being investigated.

In a type of root infection restricted to forest trees the fungi envelop the roots (ectotrophic mycorrhiza), and infected roots can be several times more efficient than uninfected roots in uptake of phosphate and other nutrients. Phosphate uptake is mainly via the fungus and in laboratory experiments the mycorrhizas of *Pinus radiata* caused by different fungi show large differences in their efficiency in this respect. Differences in the ability of fungi to stimulate plant growth when phosphate is supplied as rock phosphate have also been demonstrated in the glasshouse. Methods of establishing the fungi in nursery soils are now receiving attention. Water relations of these fungus–root associations are also being studied as it has been found that many of the causal fungi can grow at soil moistures below those suitable for water uptake by plant roots.

The internal (endotrophic) type of mycorrhiza being studied occurs on almost all the economic plants. This type of infection is not superficially obvious and little is known of the function of this association, but it is becoming increasingly clear that it stimulates plant growth under some conditions. Detailed studies have shown the existence of at least nine distinct types of causal fungi in Australian soils. In the laboratory infected roots took up twice as much phosphate from a readily available source as did uninfected roots and much of this extra uptake could be ascribed to uptake by the fungus. As with the external types of mycorrhizas found only on trees, the internal types of fungus–root associations may also function by using sources of nutrient not readily available to plant roots and transferring the nutrient to the plant. Little is known yet of the differences between the fungi in their ability to affect plant growth.

As the response of plants to these two types of fungus associations appears to be greatest in soils with a poor supply of one or more major nutrients, these studies may be significant in plant production in many Australian soils.—*Division of Soils.*

Fisheries and Oceanography

Fishery products represent a relatively small part of Australian food production, but they have been making an increased contribution in recent years, especially to export earnings, which have risen from $8,000,000 in 1959/60 to $21,000,000 in 1964/65. Research in this field in CSIRO 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 resources (fisheries). Current annual expenditure is at the rate of a little over $700,000, all of which is provided from government sources. This includes contributions from the States concerned and from the Fisheries Development Trust Account of the Department of Primary Industry for special fisheries investigations.

The main purpose of the Division's fisheries investigations is to assess the availability of various species as a necessary prelude to catch and prediction studies. These investigations depend to a high degree on the cooperation of commercial fishermen and State Governments. Fishermen are the basic source of catch and effort data, while the States are responsible for collecting these statistics and for many of the market-measuring data. Both types of information are essential for resource assessment and special efforts may be necessary to secure industry participation (see, for example, page 69).

Oceanographic research has been conducted for several years in conjunction with the Royal Australian Navy, which has made the facilities of the frigates *Diamantina* and *Gascoyne* available for this type of work. The main subjects for investigation have been oceanic circulation and productivity, with particular attention to the biology, ecology, and productivity of marine animals and plants along the 110° E. meridian in the Indian Ocean, and the plankton and other organisms on the continental shelf and slope around Australia. The East Australian Current, which affects not only navigation and fisheries but also the weather and waste disposal along the east coast, is the subject of other long-term studies. The findings of these

Oceanographic research on HMAS Gascoyne. *The grab has just been brought to the surface and in the foreground samples are being washed and examined.*

cruises thus find application in such diverse areas as fisheries assessment, submarine defence, the accessibility of minerals, and climate prediction. Unfortunately, only one frigate is now available for this research, and the work is further hindered by lack of suitable smaller vessels for associated investigations.

Conservation of Crayfish Stocks in Western Australia

Recent studies in collaboration with officers of the Western Australian Department of Fisheries and Fauna have shown that stocks of the Western Australian crayfish (*Panulirus cygnus*) have been seriously reduced by fishing. It is believed that the present reduced returns to the fisherman may diminish further, unless fishing intensity is reduced and fishing practices are modified.

The Western Australian Department is using film, radio, and television media as well as a special brochure, "Maintaining the Catch", to draw the attention of fishermen to the situation and to seek their active cooperation both in restricting the size of crayfish taken and in providing accurate returns of catch data. The research team recommended that escape gaps for undersized crayfish be built into crayfish pots. The Western Australian Government accepted this recommendation and escape gaps are now required by regulation to be fitted into all pots. Meanwhile studies of the biology of crayfish are continuing and the Government of Western Australia is building a laboratory to accommodate the joint State–CSIRO team engaged in this research.—*Division of Fisheries and Oceanography.*

New Temperature–Salinity–Depth Recorder

Previous techniques for taking samples of the sea at different places and depths used a method in which sample bottles were sent down a line and opened at the desired depth by a "messenger". Apart from being generally inconvenient, this method was unable to provide sufficient samples to give a reasonably continuous record of the variations in physical and chemical properties. The amount of information that could be obtained was limited by the number of sample bottles that could be sent down the line.

To overcome these problems a telemetering probe has been developed. It is known as the TSD recorder and it makes possible a much more detailed determination of the temperature–salinity structure of the sea to depths of 1500 metres. Temperature, salinity, and depth measurements are transmitted to the surface vessel and recorded on a single chart. If more detailed information is required it is necessary only to decrease the rate of descent of the probe. The information is transmitted to the surface either by an electric cable or by an acoustic link. The latter is a new development and it overcomes many of the problems of space and inconvenience associated with electric cables. It uses the transmission in water of sound waves that are picked up by a hydrophone on the side of a survey vessel.

A smaller version of the TSD recorder is now being developed as an accessory in biological sampling. It will be attached to existing biological sampling devices such as, for example, plankton nets that are towed in the normal fashion and fitted with the acoustic link to transmit information to the surface. In this way information about the temperature and salinity at the depth being sampled will be available immediately on the surface vessel.—*Division of Fisheries and Oceanography.*

Food Processing

Problems in food technology continually increase in complexity and importance as consumer requirements become more sophisticated. A large part of CSIRO research in this field is therefore directed at such matters as the improvement of flavour and quality of fresh and processed foods, the development of new methods for producing manufactured food products, and the improvement of quality control. Other work is concerned with the transport of fresh and processed foods, the development of new methods of processing and of new food forms, and, in general, the improvement of efficiency of manufacturing processes.

Food processing investigations in CSIRO are mainly centred in the *Division of Food Preservation* in Sydney and Brisbane and in the *Division of Dairy Research*, Melbourne. Work in the Sydney laboratories covers the handling, storage, and transport of fresh fruit and vegetables, fish, and eggs, methods of quality control, and preservation techniques such as canning, freezing, and drying. Brisbane is the centre of the Division's meat investigations, which are currently being expanded considerably with support from the Australian Meat Research Committee for work on beef quality and on the changes that occur in meat during cooling, storage, and transport. A new laboratory is being erected for this purpose (see page 4). The activities of the *Division of Dairy Research* are directed mainly towards improvements in the efficiency and working conditions of the industry and the development of new foods from milk and of novel methods of processing milk products. The *Horticultural Research Section*, Merbein, is investigating various aspects of the technology of drying vine fruits. The *Wheat Research Unit* is studying the factors that determine the quality of wheat and flour. The Organization also supports the work of the *Bread Research Institute of Australia Ltd.*, under the provisions of Section 9(1)(d) of the Science and Industry Research Act 1949–1959 (see also page 14).

Current total annual expenditure on food research is approximately $1,700,000. Of this some $330,000 is provided by industry and other sources outside CSIRO, including some $140,000 from the Australian Dairy Produce Board, $80,000 from the Australian Meat Research Committee, and $60,000 from the Wheat Industry Research Council.

Much of CSIRO's research on food processing is directly concerned with commercial processes and the Divisions maintain close contact with the industries (with which they collaborate in some investigations) as well as giving advice and assistance to government departments and agencies concerned with food export and food standards. Much time is devoted to stimulating and assisting the commercial application of processes that have been developed. In addition to direct contact, potential users are informed of the results of research work through technical publications, industry conferences, talks, and demonstrations.

In the *Division of Food Preservation* the causes of changes in colour and flavour and other factors influencing quality and storage life of foods are being studied. Research directed to the solution of manufacturing problems must have an adequate backing of more basic investigations on the foodstuffs themselves, and the work includes studies of the enzyme systems in green-plant tissues and in muscle, the nature and behaviour of microorganisms that can cause spoilage during storage and

processing, and the effect of conditions during growth on fruit quality. The *Division of Dairy Research* is continuing investigations aimed at the mechanization of cheese manufacture, the development of new food forms from milk (such as butter powder), and the use of recombined dairy products. The latter work has the general aim of increasing the use of Australian dairy products in Asia. The programme includes basic studies of the chemistry and microstructure of milk and dairy products.

Beef Quality

A technique has been developed at the University of Missouri for the study of the reactions of consumers to the meat they eat. During the past year Professor Naumann, of Missouri, has worked with the Meat Research Laboratory of the Division of Food Preservation to apply this technique to a study of the reaction of Brisbane householders to beef steaks. The surveys will not solve any technological problems of the meat industry but are expected to indicate where problems exist.

Surveys have already been carried out in five areas of Brisbane and a further six are under way. Several points of interest have already emerged. For instance, some 20% of normal steaks from strip loins are definitely disliked, lack of tenderness being the prime reason. Meat that had frozen and thawed out and "aged" before refreezing for distribution was preferred to fresh frozen meat, but differences in "liking" could not be attributed to breed of cattle, nor to the condition of the meat—fresh or frozen. Although differences were associated with different groups of animals, the differences were not reflected in any of the criteria, other than the age of the beast, normally used in grading.

The surveys not only examine the variation in preferences for beef steaks, but also have been designed to answer various questions relating to the behaviour of consumers in giving their replies, and to provide information on socio-economic factors in the preferences shown for various types of meat.—*Division of Food Preservation.*

Export of Dairy Machinery

The extent to which new dairy machinery developed by the Division of Dairy Research is being exported to other countries has recently been highlighted by orders for Bell–Siro cheese-making plant and for CSIRO-designed casein-manufacturing plant placed with an Australian firm by the Scottish Milk Marketing Board. An officer of the Division visited Scotland at the invitation of the Board to advise it on location and installation of the plant for manufacture of casein and sodium caseinate. Within Australia almost 60% of the Cheddar cheese manufactured now passes through the Bell–Siro machines, and eleven of the units, worth about $500,000, have been exported to the United States of America, England, Scotland, Wales, and New Zealand.—*Division of Dairy Research.*

Milk Proteins

The proteins of milk are of exceptionally high biological value, and the several proteins together are of greater value than any of them alone. Casein, the major protein in milk, is manufactured extensively, Australian production having climbed rapidly over recent years to some 20,000 tons per annum. The main uses of casein are industrial, but its food uses are expanding. In foods, it is desirable on both

nutritional and economic grounds that the casein, which forms about 80% of the milk protein, should be combined with the β-lactoglobulin, lactalbumin, and other minor proteins of milk. Casein is readily precipitated by acid, but the other proteins are more difficult to bring out of solution.

The Division of Dairy Research, basing its work on observations originally reported from Russia, has now developed a relatively simple method of precipitating the other proteins with the casein, forming what is commonly called a co-precipitate. The process makes use of CSIRO-developed casein-manufacturing equipment which is now widely used throughout the Australian industry. It yields about 96% of the milk proteins. The calcium content of the product, which largely determines its technical properties in various food uses, can be controlled readily over a wide range. Trial commercial batches of the proteins have already been sent to Japan where their use in food products is being investigated.—*Division of Dairy Research.*

Froth on Milk

Milk used in espresso coffee and in milk shakes sometimes fails to provide the froth that forms a characteristic and attractive feature of these beverages. The failure is seasonal, and occurs in all States. The problem has proved to be of considerable scientific interest. Lipase, an enzyme always present in milk, increases in concentration in the autumn. It acts on the fat globules to produce free fatty acids and mono- and diglycerides, which strongly depress the formation of foam, but only when it is activated, which occurs when milk is agitated and when its temperature fluctuates.

The rapidly extending practice of bulk milk collection involves more pumping and agitation, and in autumn a second milking may be added to the vat, raising the temperature of milk already there. Thus both the seasonal nature of the defect and its recent increase can be explained. With additional care in handling autumn milk on the farm the problem can be dealt with by homogenizing the milk and pasteurizing it at a higher temperature.—*Division of Dairy Research.*

White Centre in Dried Apricots

Production of dried apricots in Australia averages about 2500 tons annually and returns nearly $2 million to orchardists. Returns have often been reduced by as much as $100 per ton through sporadic outbreaks of a defect known as white centre, which has affected a part of each season's crop. In affected fruit, the surface of the cavity that remains after removal of the stone develops a whitish appearance during drying. As many consumers wrongly assume that white centre is due to mould growth, affected fruit is invariably downgraded.

The incidence of white centre can be reduced to negligible proportions by a simple method discovered as a result of recent investigations. The whitish material around the seed cavity was found to have no microbiological activity nor was there evidence of previous mould growth. The deposit was not an efflorescence arising from locally concentrated juice constituents, but appeared to consist entirely of desiccated tissue and cell debris. The fruits found to be most susceptible to white centre were those that had been exposed to sustained high atmospheric temperature towards harvest time or those grown on relatively shallow soils of low water-holding capacity. From

the appearance of freshly halved apricots it was often possible to predict which were most likely to develop the defect after drying. If the pit cavity filled with juice during the sulphuring operation—a processing step preceding drying—white centre seldom developed. If juice was absent from the pit, and more especially if the cavity initially appeared larger than the stone, white centre was likely to develop.

Heat stress and desiccation of the fruit while it matured on the tree thus emerged as the most likely causes and this was confirmed by a series of laboratory and field experiments, which led to a recommendation that the halved and stoned fruits should be sprayed with water to fill the seed cavities before being placed in the sun to dry. Orchardists who adopted this recommendation during the 1966 drying season reported that white centre was reduced to a negligible level.—*Division of Food Preservation.*

Water Damage to Canned Foods

The investigations of the high incidence of water damage in Australian canned fruits shipped to Britain reported last year (see Annual Report for 1964/65, page 47) have been continued with financial support from the Australian Canned Fruits Board. The damage is caused by condensation of moisture from the atmosphere on cold cans, which causes rusting of cans and damage to labels and cartons. Following the experimental shipments from Melbourne during 1964 further shipments were made in 1965 and the investigation has been completed. It is now possible to specify conditions for prevention of water damage and recommendations for maintaining these conditions are being put into effect.—*Division of Food Preservation.*

Minerals and Mineral Processing

The current rapid expansion of the Australian mineral industry has stimulated increased research by CSIRO on mineral processing. The emphasis is on investigations likely to lead to local processing of minerals that have previously been exported in crude form. The present scale of research activity is indicated by the total expenditure on minerals and mineral processing this year—approximately $2,000,000, of which nearly $300,000 was contributed by industry and other sources outside CSIRO.

Three of the Divisions of the *Chemical Research Laboratories* in Melbourne are concerned with work relating to the utilization of minerals. The *Division of Mineral Chemistry* is investigating novel methods for treatment of a variety of Australian ores, particularly those that are abundant in Australia and may have considerable potential for increased exploitation through the application of new techniques in processing. Electrochemical processes and chemical reactions in the plasma state are being studied because they may have useful applications in the production of metals and metal derivatives.

In the *Division of Applied Mineralogy*, current work is concerned largely with the nature, production, and use of non-metallic mineral products. In addition to work on refractories and engineering ceramics, the Division is continuing its investigations on the production and use of cement. The programme of the *Division of Chemical Engineering* includes investigations on processes such as grinding, mixing, and gas–solid fluidized systems that have application in the production and refining of base metals.

The object of the work of the *Division of Coal Research*, in Sydney, is to promote the effective use of coal through an understanding of the processes of combustion, gasification, and carbonization and of industrially important processes dependent on fuels. Full-scale tests with large power-station plant have led to the solution of problems that arise from the particular characteristics of Australian coals.

Investigations relating to the manufacture of ceramic products used in building in the *Division of Building Research*, Melbourne, have led to the development of several new products using local mineral raw materials. Products made principally from basalt wastes have been developed for use both in buildings and in chemical industry, and other ceramic materials are based on zircon. Problems arising in the initial treatment of various Australian ores are being studied in the *Ore Dressing Investigations* laboratory, in association with the Mining Department of the University of Melbourne. It is collaborating with several companies in investigations of the chemistry of flotation pulps and of ore grindability.

CSIRO is one of the two Commonwealth Government agencies that collaborate with the Government of South Australia and the Australian Mineral Industries Research Association Ltd. in supporting the work of the Australian Mineral Development Laboratories in Adelaide. Work in connection with the research programmes of several CSIRO Divisions is being undertaken in these Laboratories, which have established special facilities for analytical work and for pilot-scale testing of processes.

Acid Pressure-leaching of Lead–Zinc Ores

Normal lead–zinc ores when crushed produce discrete particles of the lead and zinc minerals which can then be separated by flotation. One of the largest lead–zinc ore deposits in the world is in the McArthur River area of the Northern Territory. When this ore is crushed the particles contain both lead and zinc and separation by conventional methods is not possible. The extraction of lead and zinc from the ore by chemical methods is therefore being investigated.

CSIRO has been investigating processes for the treatment of minerals by pressure-leaching under acid conditions for some years in connection with the treatment of uranium ores. It seems likely that similar processes will be applicable to the McArthur River ore and arrangements have been made for research in collaboration with Mount Isa Mines Limited and the Electrolytic Zinc Company of Australasia Ltd. Experimental concentrates are now being processed to determine the best operating conditions and to provide the data necessary for the design and construction of equipment for continuous treatment.—*Division of Mineral Chemistry*.

Australian Bentonites

Bentonite is a special variety of clay consisting largely of the mineral montmorillonite, a finer and more chemically active substance than the kaolin and other components of ordinary clays. It is widely used in industry, particularly as a bonding and gelling agent. In agriculture it makes an effective seal against seepage from dams. In an activated form it is the basis of bleaching earth used to clarify oils and fats. Each year thousands of tons of bentonite are imported to meet the Australian demand and these quantities will rise steeply if the mineral is brought into general use, as planned,

in iron-ore pelletizing plants. The annual value of bentonite imported from the main overseas sources, such as Wyoming, will exceed $1,000,000 within the next few years unless acceptable materials from local deposits can be put on the market.

During the past decade several deposits of bentonitic material have been discovered in Australia and a vigorous search has been made for treatments to improve the properties of these clays. The best products of the treatments that have been developed are comparable with imported bentonites. Most of the local deposits yield material that can be activated by acid treatment to produce bleaching earths.

Although bentonitic deposits for which satisfactory treatments have now been devised occur in almost every State, local materials still supply only a small fraction of the demand. The economics of treatment tend to be marginal, reserves are not yet known to be large enough to support long-term production, and internal freight costs are generally high. Mining law restrictions complicate the marketing of the best-quality local deposit so far discovered. However, if iron-ore pelletizing plants in Australia and overseas consume bentonite at the rate expected, the situation should become more favourable for the exploitation of the Australian deposits as high-grade reserves overseas become depleted.—*Division of Applied Mineralogy.*

Metallurgical Carbons from Coal

The carbonization of coal at high temperatures under suitable conditions produces a granular material with a low content of volatile matter. It is an active reducing agent and a suitable source of carbon for certain metallurgical processes. The factors influencing the yield and properties of the carbonized particles have been studied in work supported by funds from industry and aimed at development of a method suitable for commercial use.

Two techniques of carbonization have been investigated. In entrainment-type systems the particles are carbonized while they are carried in suspension in air through the reaction zone. In fluidized-bed systems, particles within the reaction zone are given a turbulent motion similar to that of a boiling liquid by the air passing through them. Optimum yields of a product with the desired properties were obtained in a two-stage process combining both techniques. After partial carbonization while entrained, the particles are "soaked" at a high temperature in a fluidized bed. The entrainment stage improves the yield of solid product and the fluidized-bed stage reduces the volatile matter and hydrogen content.—*Division of Coal Research.*

Filter Aids from Coal

Filter aids are used in many industries to assist in the removal of suspended solids from liquids. As part of a programme aimed at developing new uses for coal and coal products, experimental batches of filter aid materials have been made from various coals by controlled carbonization. The materials have been tested in the filtration of water and ferric hydroxide slurries and samples have been supplied to firms interested in the manufacture or use of filter aids for testing in many other applications.

Rates of filtration and clarifying power have been found to be comparable with good grades of diatomaceous earth. The coal-based filter aids have the advantage that they can be burnt after use, whereas disposal of used diatomaceous earth sometimes

Equipment at the Division of Coal Research for investigations of the performance of electrostatic precipitators.

involves problems. Patent protection has been sought and a small but valuable industry could develop from this work. Potential uses for the filter aids include water filtration for town supplies and swimming pools and sewage treatment. The materials can be activated by suitable treatments for use as decolourizing agents or absorbents.—*Division of Coal Research.*

Electrostatic Precipitation of Fly-ash

When coal is burnt in a power-station boiler a considerable quantity of ash is carried up with the flue gases, and boilers are usually equipped with electrostatic precipitators to prevent this ash from escaping into the atmosphere. It has been known for several years that the fly-ashes from New South Wales bituminous coals are difficult to collect efficiently in electrostatic precipitators.

In collaboration with the Electricity Commission of New South Wales, a series of tests has been made to compare coals from 14 seams in the Liddell area with the coal from the Great Northern seam which is currently being used for power generation. The information from these tests can now be applied in the design of the precipitators for a new power station that will use Liddell coals.

Many features of the performance of electrostatic precipitators are still not fully understood, so that the reasons for poor or variable performance with some coals are not known. For significant improvements in efficiency, a systematic and fundamental investigation of the process and of the characteristics of the materials present in flue gases is necessary and is now being undertaken.—*Division of Coal Research.*

Tin Smelting

The pattern of development of the world's tin smelting industry has been dependent upon the availability of large quantities of high-grade alluvial tin concentrates and this has resulted in heavy depreciation of the value of low-grade concentrates. Several Australian tin producers have great difficulty in producing high-grade concentrates and can do so only at the cost of a recovery so low that up to half the tin in the ore is lost in the process.

The chemistry of tin smelting has been studied and a process that offers the prospect of economic treatment of quite low-grade materials has been devised. A pilot plant is being constructed to test the technical feasibility of the process and to check economic estimates that have been made. If successful, it should make possible more favourable prices for low-grade tin concentrates, with consequent higher overall recovery, and increased tin production from existing fields.—*Division of Chemical Engineering.*

Pastures

During the last 50 years improved pastures have been established on about 40 million acres of the land used for grazing in the temperate southern regions of Australia. This development, on which the country's pastoral industries now greatly depend, is continuing at an accelerated pace and, for example, it is probable that improved pastures will be established on much of the one million acres of new land that are now being cleared annually in the south-west of Western Australia.

A considerable background of research is required for this progress to be achieved. Not only do new areas bring new problems to be solved but also we still have much to learn about those areas in which pastures have already been improved before full benefit can be derived in terms of animal production. Currently, work on pastures is being undertaken by the *Division of Plant Industry* at its main centres in Canberra, Perth, and Deniliquin, the *Division of Land Research* (Canberra and Katherine), and the *Division of Tropical Pastures* (Brisbane and Townsville). There is so much related work that it is difficult to estimate precisely the expenditure on research on pastures in CSIRO, but it is of the order of $4,000,000 annually, which includes about $1,000,000 from contributory funds such as the Wool Research Trust Fund and the Australian Meat Research Fund.

There is still a very large area, possibly one milliard (1,000,000,000) acres, of grazing land in Australia that is unimproved and is under native pasture or other native plants that have volunteered after the clearing of the scrub land. Although improvement of much of this area must be limited by low and uncertain rainfall, there are large areas in the tropical and subtropical regions that receive good reliable rain each year. These regions offer great potential for increased pasture production, especially of beef and, in some cases, of dairy products. The development of these regions has been hampered in the past by the lack of suitable pasture plants, but spectacular progress has recently been made by the *Division of Tropical Pastures* in the introduction, selection, and breeding of new material. Much of this work is now being done at the Division's Townsville laboratory and its newly established Lans-

down Pasture Research Station, supplemented by studies in plant chemistry, plant physiology, and plant breeding at the Cunningham Laboratory, Brisbane. Just as legumes such as white clover, subterranean clover, and medics have been the basis of improvement of pastures in the temperate regions, the key to the development of northern pastures has been legumes suitable for the tropics and subtropics. With a variety of promising plants now available this work is past the pioneering stage, and it is hoped that a new research station will shortly come into operation so that the new pastures can be tested under large-scale practical conditions (see also Cattle).

The *Division of Land Research* is conducting complementary investigations on the development of pastures at Katherine in the Northern Territory and at the Kimberley Research Station in Western Australia. These two centres cover a broad pattern of research aimed at providing the technical background for more intensive pasture production in northern Australia.

The *Division of Plant Industry* at its headquarters laboratory in Canberra is concerned largely with basic studies and the development of new principles that can have application to pasture problems throughout Australia. This work, particularly that on problems of pastures in the temperate regions, is supported and supplemented in regional laboratories and field stations. The Division's work includes studies of soil fertility and plant nutrition and the many factors that limit increased pasture and animal production. New species and varieties of plants are constantly being introduced and tested and used for the selection and breeding of improved pasture plants. It is characteristic of much of this work that it requires the close collaboration of a number of CSIRO Divisions; for example, a wide range of problems associated with the use of *Phalaris tuberosa* in pastures and particularly its toxicity to animals is being studied by the *Divisions of Animal Health*, *Animal Genetics*, *Nutritional Biochemistry*, *Plant Industry*, and *Organic Chemistry*. There is a similar broad range of attack on problems concerned with oestrogens, the female sex hormones that can occur in some clovers in quantities that cause reproductive disturbances in sheep.

Much of the work in other Divisions is related to pasture research such as nutritional studies in the *Division of Soils* on the uptake of nutrients by plants from the soil and in the *Division of Animal Physiology* on the efficient utilization of pastures by the grazing animal.

Promising New Strains of Phalaris for the Riverina

Crop rotations in the eastern Riverina often include a grass and clover pasture phase of at least four-year duration. None of the grasses at present available is entirely satisfactory for the purpose. Wimmera ryegrass suffers from the disadvantage that it is often crowded out by weeds such as barley grass and silver grass, and it can itself be a serious weed in cereal crops. Perennial grasses such as *Phalaris tuberosa* are slow to establish but may be more productive and stable than annuals.

Two strains of phalaris, selected from material introduced from Morocco, have now been chosen for development as pasture plants for the eastern Riverina. They generally produce rather more herbage than ryegrass and with smaller variation from year to year because they are less affected by dry conditions. The new strains should also be useful in north-eastern Victoria where conditions are similar to those in the Riverina.

These new strains can be established by winter sowing, with or without a cover crop, but vigorous stands can also be established by early spring seeding which is an advantage in areas where heavy weed growth or serious soil erosion is likely in winter. Stands of these strains have persisted for 18 months under the high stocking rate of six sheep to the acre. Body weights and wool yields were higher for sheep grazing phalaris than for those grazing ryegrass.

No difficulty has been experienced in killing stands of Moroccan phalaris at the end of the pasture phase, but it is believed that they would remain productive indefinitely in permanent pasture. Both the original Moroccan strains shed their seed very easily but selection for high seed retention over two generations has so improved them that the seed can now be harvested by standard methods. Foundation seed of the strain that performs best in current grazing trials will be produced in 1966.—*Division of Plant Industry.*

New Strains of Phalaris Selected for Low Toxicity

In recent years the number of sudden deaths of sheep grazing pastures in which *Phalaris tuberosa* is dominant has increased rapidly, especially on the tablelands and western slopes of New South Wales. This is associated with the presence of poisonous tryptamine alkaloids in commercial strains of phalaris. CSIRO's extensive plant collections have therefore been searched for low-alkaloid types of phalaris to provide material for breeding non-toxic strains. The prospects of success are now good.

Alkaloid content was found to vary considerably with conditions of growth but some types were found that had a lower content than commercial phalaris. The low content of one Algerian strain was particularly marked. On the other hand two strains were found to contain three to four times more alkaloid than the usual commercial types. Neither composition nor amount of alkaloid in a strain appears to be related to geographic origin or to any external characters. Crosses have been made to determine the inheritance of alkaloid content and composition, and existing improved strains that contain low alkaloid strains in their pedigrees will also be screened.—*Division of Plant Industry.*

New Pasture Legumes for Western Australia's Low-rainfall Areas

Clearing the land in Western Australia has continued at the rate of about one million acres a year since 1950 and the rate shows no sign of decreasing. Much of this land has light soil and a rainfall of less than 16 inches. Development of pastures has lagged behind clearing, largely because of the lack of suitable pasture plants.

Two eastern Mediterranean plants—rose clover and cupped clover—have been found to have great potential for high productivity and persistence under grazing.

The main advantages of these recently introduced legumes are tolerance to a wide range of soil types, ease of establishment, good productivity, good seed yields, and freedom from oestrogenic activity. Stocking rates of two sheep to the acre have now been maintained for several years on experimental areas of both these clovers in the low-rainfall areas. In 1965, considerable areas of Sirint rose clover and Kondinin rose clover were certified for seed. A further two strains of rose clover and two strains of cupped clover are awaiting certification. These oestrogen-free clovers should be suitable for almost all areas of the region with rainfall between 10 and 16 inches but they also show promise for higher-rainfall areas.—*Division of Plant Industry.*

Control of Subterranean Pasture Pests

Subterranean insect larvae have caused severe though sporadic damage to Australian pastures for many years. With the rapid increase in the acreage of improved pastures it has become urgently necessary to determine how far the changed conditions are likely to aggravate the trouble.

From preliminary observations it is clear that the problem is complex, and work is currently being done to find out the conditions under which the insects cause serious damage and to work out the best methods of controlling them. It is already clear that control by widespread use of insecticides would be uneconomic and otherwise undesirable. Close attention is therefore being paid to the natural regulating factors that are capable of modification by agricultural practice.

There are at least six species of root-feeding larvae of scarab beetles and three species of grass grubs that normally feed at night on top growth but under certain conditions may be subterranean pasture pests.

Important facts determined so far are:

There are marked differences in the abilities of the various species to withstand drought;

Some species of scarabs are selective root feeders; others are general soil ingestors, eating root material incidentally;

Carbon dioxide attracts grubs that are selective root feeders and sugars are important feeding stimulants for them;

Although their larvae are well equipped to utilize root material, root-feeding species may complete their development even when deprived of plants for most of the year;

Feeding on clover roots decreases the growth rate of scarab larvae;

Pasture plants may, under some conditions, lose as much as half of their roots before top growth is affected.—*Divisions of Entomology and Plant Industry.*

Availability of Nitrogen fixed by Pasture Legumes

Many pasture legumes available in Australia fix nitrogen from the air and then release it into the soil in a form that can be used by other plants, but the pattern of fixation and release is not the same for each legume. For example, subterranean clover does not release any nitrogen until it has completed its life cycle in late spring, after which there is a rapid transference to the grasses in the pasture. Lucerne has now been found to release its nitrogen slowly throughout the year, whilst white clover in association with cocksfoot competes with the grass for soil nitrogen until the autumn–winter period. These results suggest that the choice of a pasture legume may eventually be determined by how it is intended to utilize the nitrogen that is fixed. It also seems that artificial nitrogen fertilizers might supplement the nitrogen supplied by legumes, if applied when nitrogen is not being released by the legumes.

Experimental work has been conducted for three years on sheep pastures at Ginninderra to find out if nitrogen fertilizers will stimulate early growth and alleviate the late winter feed shortage brought about by dry autumns and cold winters. Some responses have been obtained. So far they have not been economic on sheep pastures but they might well be of value under some circumstances on intensive dairying pastures.—*Division of Plant Industry.*

Combining Summer- and Winter-growing Legumes in Subtropical Pastures

About one-third of the annual rainfall in southern Queensland falls in winter, when temperatures are too low for active growth by summer-growing legumes such as Siratro. The possibility of growing summer and winter legumes in association to take advantage of the full potential of the environment has therefore been examined.

Lucerne, the most promising legume for winter and spring growth, has invariably failed in the past to nodulate and grow effectively on the slightly acid sandy forest soils that predominate in the spear grass region. Recent research into this problem has shown that healthy vigorous plants can be established when the seed is pelleted in a mixture of *Rhizobium* inoculant, gum arabic, and maltose, and coated with lime. Using this technique a successful pasture mixture of lucerne and the summer-growing species Siratro and Rhodes grass has been developed at the experiment site at Eskdale West.

The combination of Siratro, with maximum yield in April, and lucerne, with a peak in October, provides a high level of protein in the pasture for a much longer period than either legume grown singly. This should lead to substantially higher production of beef per acre than that obtained from pastures based on summer-growing legumes alone. This novel combination of winter and summer legumes growing in a single pasture could be valuable over much of the subtropical areas of eastern Australia that receive a significant winter rainfall.—*Division of Tropical Pastures.*

New Method of Studying Legume Nitrogen Fixation

Pasture legumes play a major part in supplying nitrogen to the soil. There is the possibility that the efficiency of the process could be greatly improved, but little is known about how root nodules function. This lack of knowledge of the nitrogen-fixation process has continued because the available techniques for studying the nodules disrupted them and led to loss of their functions.

Active preparations of soy-bean nodules have now been obtained under laboratory conditions and are being used to elucidate the roles of the plant and bacterial components of this important symbiotic system. In the new technique nodules are crushed in a special press in an atmosphere of inert argon gas. The resultant material contains intact bacteria and very finely divided plant material. The activity of the preparations is measured by a tracer technique, using a heavy isotope of nitrogen and controlled amounts of oxygen. Under the experimental conditions the newly fixed nitrogen in the preparations accumulates as ammonia, although in the intact nodule ammonia is rapidly converted to amino acids.—*Division of Plant Industry.*

Effect of Nitrogen-fixing Bacteria on Soil Reaction

A recent study of the secretions in culture media of over 700 strains of tropical and temperate strains of *Rhizobium* has shown that those associated with primitive legumes inhabiting acid soils are invariably alkali-producing, whereas those associated with legumes adapted to alkaline soils produce acid, thus providing protection against the soil environment. In this way the survival of acid-producing *Rhizobium* is favoured in alkaline soils in the face of strong competition from other soil microorganisms.

This new information on acid and alkali production is important to scientists working on the classification of legumes and *Rhizobium*, on legume breeding, and on the development of tropical pastures. For example, the *Rhizobium* used to inoculate clovers and medics could be selected to permit these legumes to be grown on more acid soils than those to which they are at present adapted, without the addition of lime. Natural populations of *Rhizobium* would need to be screened to identify rare types combining alkali production with high nitrogen-fixing potential. Such a selection programme could lead to a major increase in the use of lucerne in subtropical areas.—*Division of Tropical Pastures.*

Feeding Value of Tropical Pasture Plants

Research on pasture plants for the tropical and subtropical areas of Australia is based on replacing and supplementing the poor native grasses with high-quality legumes and grasses introduced from overseas. A number of new species and varieties have already become available through introduction, breeding, and selection and work is being intensified on those groups of plants showing greatest promise. Because very large numbers of introductions and progeny from plant breeding programmes must be handled it is important to have reliable methods for early assessment of feeding value.

Techniques have been developed at the Cooper Laboratory for the measurement of feeding value and are used for plant assessment. The feeding value of plants depends upon the close relationship between animal production and the intake of digestible food; it is assessed by feeding the plants to sheep in pens, then measuring the amount eaten voluntarily and the percentage of the intake that is digested.

Wide differences have been found between tropical legumes and grasses in the change in feeding value with increasing age. For example, the legumes *Phaseolus atropurpureus* (Siratro) and *Glycine javanica* have high values in autumn and winter when the values for grasses of corresponding age are very low. Distinct differences in feeding value that have been found between varieties of Rhodes grass (*Chloris gayana*) have provided valuable information for determining the release of new cultivars for practical use. The techniques are also being used for early assessment of feeding value in plant breeding programmes.—*Division of Tropical Pastures.*

Sheep and Wool Production

The sheep and its products are of great economic importance to Australia and there is a large programme of research on the problems of the industry. The cost of the current national programme of research represents approximately 1% of the value of the national return from sheep and wool: it may be queried whether this is adequate in view of the significance of the industry to Australia and of the rapidly growing competition from synthetics.

Funds to support the Organization's sheep and wool production research programme come from allocations from the Treasury and from the Wool Research Trust Fund. The Fund is administered by the Australian Wool Board, advised by

its Research Advisory Committees, and the amount allocated from it to CSIRO for wool production research in 1965/66 was $3,058,800. In addition the Commonwealth provided funds for the programme directly to the extent of a further $2,750,000 and some $50,000 was contributed from other sources.

The position of the Wool Research Trust Fund requires special comment. It is used to finance both wool production and wool textile research (see also Wool Textiles). The annual income of the fund is derived in part from the woolgrower through a levy of 20 cents per bale of wool, in part from the Commonwealth Government on the basis of 40 cents per bale of wool, and partly from miscellaneous income such as interest on investments and sales of produce. These together provide about 57% of the current expenditure on wool research; the balance, about 43%, is provided from capital reserves. The Australian Wool Board has indicated that by June 30, 1967, these capital reserves will have been exhausted and funds for research (and promotion) must then be wholly derived from annual income.

Clearly this annual income at its present level is insufficient to sustain the current research programme. It is therefore urgently necessary for the Australian Wool Board to approach the industry and the government through the Australian Wool Industry Conference for an increase in the levy. Such an increase will have to be substantial even to maintain present programmes, particularly when the normal annual cost increment is taken into account; at present it accumulates at compound interest at a rate of rather more than 5% per annum.

CSIRO is constantly reviewing its research programmes to ensure that they are directed to the needs of the nation and its industries. In view of the situation that is now developing in the Wool Research Trust Fund an especially detailed analysis of the sheep and wool production research programme was made during 1965/66. The examination revealed that the programme is generally well balanced in the relative emphasis placed on problems of different degrees of economic importance. It is also balanced in the relative attention paid to research aimed directly at the solution of identified industry problems and to research to provide the basic knowledge and understanding necessary if significant advances are to be made.

The analysis also exposed some areas of research needing greater attention. Examples include the seasonal cycle of reproductive activity in the sheep, the onset of sexual maturity, ewe fertility and embryonic mortality, work in depth on the growth of the Merino, basic physiology of weaner ill-thrift, work directed to understanding the disease problems that may result from increased stocking rates, the causes of diseases of reproduction associated with embryonic loss, the application of findings from physiological research to sheep breeding, work to derive principles underlying the use of conserved fodder, and work on soil moisture. It is not clear where funds for work on these projects are to be found.

Many Divisions contribute to the diverse programme of research currently conducted by CSIRO on problems of sheep and wool production. These include the *Divisions of Animal Genetics* (Sydney), *Animal Health* (Melbourne and Sydney), *Animal Physiology* (Sydney and Armidale), *Nutritional Biochemistry* (Adelaide), *Entomology* (Canberra), *Plant Industry* (Canberra, Perth, and Deniliquin), *Soils* (Adelaide and Canberra), and *Wildlife Research* (Canberra).

A problem with great potential for improvement is that of the low lamb-marking percentages achieved in flocks almost throughout Australia. There are many factors involved. The *Division of Animal Genetics*, which has been studying selection for wool production since 1947, recently extended its work to cover selection for increased lambing percentage and better meat production. A relationship between blood type and reproductive performance is being investigated. Factors being studied in the *Division of Animal Physiology* include infertility in the ram, failure of either the ram or ewe in mating, low incidence of multiple births, failure of fertilization or implantation, abortions, and lamb deaths. Several Divisions are contributing to work on the oestrogenic substances that affect the fertility of the ewe and that are found in some strains of subterranean clover and of other legumes. The effects of nutrition, climate, and time of mating are also being studied. Each of these lines of inquiry could make its contribution towards improvement with ultimately a very pronounced overall effect on the percentage of lambs marked.

Much of the Organization's research relating to pastures has direct relevance to sheep and wool production (see Pastures). For example, the work of the *Division of Plant Industry* on the introduction of new species and strains of grasses and legumes, on plant breeding and selection to improve pasture plants such as *Phalaris tuberosa*, on the availability of phosphorus and other fertilizers in soils, and on the control of weeds will lead to improvements in sheep and wool production. The Division is also undertaking experiments on pasture management, other aspects of which are being studied at the *Pastoral Research Laboratory* at Armidale in a carefully integrated programme to investigate stocking rate and its effects on the productivity of pastures and on animal production. The effects of stock movement and the productiveness of different strains and species of pasture plants are being assessed in terms of animal output. The role of fodder conservation and of fodder crops is also amongst the problems being studied.

The nutritional requirements of sheep are being investigated in several Divisions. The tolerance of sheep to the saline waters that are found in many parts of Australia has been studied for many years in the *Division of Nutritional Biochemistry*. This Division and the *Division of Animal Health* have contributed much to our knowledge of metabolic disorders such as those caused by minor element deficiencies, chronic copper poisoning, pregnancy toxaemia, and the toxicity for sheep of *Phalaris tuberosa* pastures. The main stages in the conversion of pasture into wool are being studied in the *Division of Animal Physiology* with the overall aim of acquiring the knowledge necessary to achieve increased productivity. The work is aimed particularly at providing an understanding of the role of sulphur in the wool follicle in view of its importance as a component of the sulphur-containing amino acids of wool. Particular attention is being paid to the food requirements of sheep under drought conditions and considerable progress has been made towards an economic basis for the drought-feeding of sheep without loss in wool production.

A large amount of work is being done on sheep diseases and parasites, particularly in the *Division of Animal Health*. Internal and external parasites, foot-rot, mycotic dermatitis, posthitis, and urinary calculi are being studied in this and other laboratories. Work on the control of sheep blowfly by the *Division of Entomology* and on predators and competitors of the sheep by the *Division of Wildlife Research* is also related to

improvements in sheep and wool production. In addition, the research programmes of other Divisions, particularly 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.

Fodder Conservation in relation to Wool Production

It is widely held that the practice of fodder conservation will extend the limits of safe stocking and will make possible greater animal production per acre. Actually our knowledge of the effects of this practice is meagre and comparisons are being made between grazing systems with and without conservation, at three levels of stocking. In the systems with conservation, half the area is withdrawn from grazing for 10 weeks in the spring and the hay made therefrom is fed to the flock in autumn and winter.

The drought of 1965 provided an opportunity for examining the value of hay made in the previous good spring of 1964 and fed out during the subsequent period of scarcity. At the lowest stocking rate the increase in wool production per acre was small. At the intermediate level there was a substantial increase in productivity, whilst at the highest stocking rate conservation sharply depressed wool production. Under the high stocking rate the combination of cutting and extreme grazing pressure on the non-cut area led to a severe depression in wool production which carried over into the summer. The lift in productivity obtained from feeding back conserved material compensated for only a small part of this production loss.—*Division of Animal Physiology.*

Cortisone can reduce Post-shearing Losses

The extent, predisposing causes, and prevention of post-shearing losses are being investigated. It has been found that the average loss is low, being of the order of 0·7% of all sheep shorn, but that in exceptional conditions more than 50% of a flock of sheep can be lost at a shearing. Sheep in poor condition are more susceptible but losses of sheep in good condition also frequently occur.

Leaving more wool on sheep after shearing has been found to give considerable protection, but the development of shearing machinery to do this satisfactorily would be costly. Exposure to cold stimulates the secretion of the hormone adrenalin which reduces heat loss by constricting the blood-vessels of the skin. In some sheep the constriction of the blood-vessels to the gut becomes excessive, leading to a breakdown of the barrier against absorption of toxins and to malfunction of the pancreas and the liver. The protective action of another hormone, cortisone, is being investigated and the results so far have been most encouraging. It may prove possible to protect against post-shearing losses in situations where the risk is high by a single injection of a long-acting form of the cortisone. The treatment of sheep suffering from exposure to cold and likely to die may also be economically feasible.

The vulnerable period after shearing is determined not only by the shortness of the fleece, but also by the physiological process of adaptation to the sudden change brought about by shearing. The mechanism of adaptation is being studied to provide leads to other means of preventing post-shearing losses.—*Division of Animal Physiology.*

Foot-rot responds to a Single Injection of Streptomycin and Penicillin

Investigations into foot-rot and similar conditions of the feet of sheep have been expanded recently, particularly in the higher-rainfall areas of Victoria. A number of minor conditions of the feet of sheep, including the non-progressive form of foot-rot known as "scald", have been found to occur and have been described and differentiated from classical foot-rot. The occurrence, natural history, and cause of a foot-rot-like condition in cattle and its possible association with the disease in sheep are also being studied.

The causal organism of foot-rot, *Fusiformis nodosus*, occurs freely on the surface of skin taken from the area between the claws of infected feet and under the microscope it is seen to penetrate into the deeper layers. The response of the sheep's defence mechanisms to this infection is the invasion of the skin by white cells and inflammatory fluid, which suggests that injected anti-bacterial drugs might be effective in treatment of the disease. *Fusiformis nodosus* has been found to be susceptible to a number of antibiotics, and a high percentage of infected sheep injected under laboratory conditions responded to a mixture of streptomycin and penicillin.

The treatment also gave encouraging results when tested under field conditions, but further tests are required to define the most efficient way to use it.—*Division of Animal Health.*

The new injection for foot-rot.

Effect of Early Weaning on Wool Production and Lamb Growth

In experiments at Armidale ewes rearing lambs were found to grow only about four-fifths as much wool during lactation, but ate nearly twice as much food, as similar ewes that had borne a lamb but were not allowed to rear it. When lactating ewes were allowed no more feed than dry ewes, wool growth during lactation was reduced to half. These results suggest that the fleece weights of breeding ewes might be increased if the length of their lactation period was reduced. The effects on Merino ewes and lambs of weaning at earlier ages than are customary are therefore being studied.

Lambs only 3 weeks old have been weaned successfully without supplementary feed onto grass pastures reserved for them and have actually grown better than those born to ewes grazing at high stocking rates and weaned at 12 weeks of age. At high stocking rates there may well be a shortage of grass and the ewes will then compete with their lambs for the feed available but provide them with only small quantities of milk. The early separation of lambs from their mothers was also found to retard the onset of worm infestation. This work is being followed up by a study of the effects of early weaning on life-time performances.—*Division of Animal Physiology.*

Best Age for Selection for Increased Weaning Weight

The aim of experiments on meat production at Cunnamulla is improvement in sheep meat production through selection. An analysis of existing records has revealed that body weight at weaning is less heritable than body weight at 15–16 months old even though one body weight is highly correlated with the other. Thus a breeding programme aimed at increasing body weight at weaning could best be based on selection according to body weight at 15–16 months.

Part of the work which it had been planned to do on body composition in groups selected for high and low body weight had to be abandoned because of reduction in numbers through drought losses.—*Division of Animal Genetics.*

Formation of Urinary Calculi

The cause of stone formation in the urinary tract of sheep is being investigated as a preliminary to development of effective means of preventing the condition. The capacity of the sheep's kidney to produce highly concentrated urine is being studied because stone-forming material is more likely to be precipitated when urine concentration is high. The sheep's special ability to concentrate urine (a factor important in adaptation to dry conditions) has been found to be related to the development of special blood-vessels in the kidney.

Urinary calculi commonly contain calcium and magnesium and the excretion of these minerals has been studied. A very large increase in the rate of calcium excretion was found to occur after feeding, while at the same time urine flow decreased so that the concentration of calcium in the urine was greatly increased. Magnesium excretion was also affected but to a lesser extent. The key to the problem may thus lie in the mechanism of these effects of feeding. Following this line of inquiry it has already been shown that the movement of water into the rumen after the sheep eats dry fodder triggers the release from the pituitary gland of a hormone that inhibits the flow of urine.—*Division of Animal Physiology.*

Combined Streptomycin and Penicillin cure Lumpy Wool

Mycotic dermatitis (lumpy wool) is a chronic infection of skin that makes shearing difficult or impossible. It also predisposes sheep to fly-strike and to secondary bacterial rotting of the fleece.

Externally applied disinfectants do not cure the infection because the filaments of the causal bacterium invade too deeply into the skin, where they are not accessible from outside but should be accessible to internally injected antibiotics. The antibiotic injections first tried failed because they inhibited the organism from growing and multiplying but did not kill it. An effective and practicable treatment requires an antibiotic that kills the organism rapidly at concentrations attainable in the tissues. Streptomycin was found to fulfil these requirements in the laboratory so that a single large injection cured 60 to 70% of infected sheep. For reasons not yet explained streptomycin injected with penicillin gives a 100% cure in the laboratory although penicillin is of little or no value on its own.—*Division of Animal Health.*

Cobalt Pellets for Vitamin B_{12} Deficiency

It is now known that vitamin B_{12} deficiency in sheep is associated with cobalt deficiency in pastures and that the condition can be corrected by dosing the sheep with cobalt, but it has not been known how long the treatment will remain effective.

Mature sheep grazing pastures grossly deficient in cobalt have now been maintained in full thrift over a six-year period by dosing with heavy cobalt pellets. The pellets contained 60% cobaltic oxide, weighed 10 g, and had specific gravity 5. They were administered singly, in pairs, or singly with a grinder. Further experiments are being conducted to test whether treated ewes can provide sufficient vitamin B_{12} by transfer through the placenta and in their milk to maintain their lambs until they have grown sufficiently to be dosed with cobalt pellets.—*Division of Nutritional Biochemistry.*

Testosterone Implantation increases Wool Production only Slightly

Over the past few years testosterone propionate implants have been used extensively in Australia for the control of posthitis. The use of testosterone has been associated with increased wool production, but it was not possible to say whether this increase was due to a reduction in the incidence and severity of posthitis, or whether the hormone had specific and direct effects on wool growth.

Observations over two seasons at Armidale have now shown that in flocks of wethers free from posthitis, testosterone implantation does in fact produce an increase in wool production but the normal dose of 70 mg testosterone propionate given in autumn and spring increases the greasy wool cut by only a quarter of a pound per head. Testosterone implantation is associated with an increase in grease content of the fleece, so that on a clean scoured basis the difference in wool production amounts to only a tenth of a pound per head.—*Division of Animal Physiology.*

New Techniques for Nutrition Studies in Grazing Sheep

A wide range of techniques has been developed for the detailed study of metabolic processes in penned animals, but application to grazing animals is seriously hampered by major practical and technical problems; even basic information on the quantity

Experimental sheep quickly become adapted to carrying the equipment that is necessary to study their metabolic processes. This sheep is carrying (A) a padded cover over a re-entrant tracheal cannula. The air expired from the trachea is piped along the shaft of the cart to the gas metering and sampling device (B). The padded cover (C) is over a micro-pump for the infusion of radioactive substances in solution from a reservoir into either the jugular vein or the rumen. The urine collector (D) drains into a tank on the cart.

and quality of feed consumed by grazing animals can be obtained only with difficulty.

As a result of collaboration between CSIRO and the Departments of Biochemistry and Nutrition and of Animal Physiology at the University of New England, several sophisticated techniques have, for the first time, been applied to grazing animals. Equipment that can be carried by sheep is now being used both for the continuous infusion of various radioactive materials into the bloodstream or rumen and for the measurement of respiratory gaseous exchange. The rates of production of volatile fatty acids in the rumen have also been measured. These are major end-products of digestion in cattle and sheep, and their contribution to energy and nitrogen metabolism is being studied. The use of these new techniques will shortly be extended to other problems.—*Division of Animal Physiology.*

Statistics and Computation

The effective use of the results of scientific experiments usually requires quantitative assessment of numerous individual results. The statistical analysis of results is therefore an integral part of most experimental programmes. Within CSIRO, research workers are assisted by the staff of the *Division of Mathematical Statistics*, which has its headquarters in Adelaide. Officers of the Division are stationed with many other Divisions and Sections, and their services are available to research workers throughout the Organization. In addition to the provision of statistical advice and assistance to other research units, the Division has its own research

programme concerned with the development of statistical methods and, in particular, with their application to the analysis of meteorological records in relation to agricultural production.

In 1962, a *Computing Research Section* was established to provide a service to other research units and to undertake research on computing methods and applications. The Section has its headquarters laboratory in Canberra, the main equipment being a Control Data Corporation 3600 computer, and members of the staff are also stationed in Adelaide, Melbourne, and Sydney, where Control Data Corporation 3200 computers are installed. The demand for computer time has grown rapidly and during the year additional equipment has been installed to increase the capacity of the system.

Extensions to Control Data Corporation 3600 Computer System

The last of the computer equipment ordered under the original contract with Control Data Corporation has now been delivered. This comprises large-capacity drum storage units, six remote display consoles, and a high-precision display device. All this equipment has been attached to the Control Data Corporation 3600 in Canberra.

The Highett end of the microwave link with the Control Data 3200 computer at the David Rivett Laboratory, Clayton.

The original monitor system (SCOPE) has been replaced by one written jointly by the staff of the Computing Research Section and Control Data (Australia). Using the new monitor (DAD) all input/output operations are performed simultaneously with the execution of a base-load calculation. In this way, the computer's arithmetic units can be kept busy all the time, and a series of jobs can be completed in far less time than under the previous system. All eight magnetic tape units are now available to the programmer since libraries and working storage can be placed on the drums. Thus the utility of the 3600 has been considerably increased and its useful life prolonged.

The addition of the remote consoles has greatly speeded up the development of users' programmes. It is now possible to "edit" programmes without the use of punched cards as an intermediate medium, and this is achieved without undue expenditure of computer time. These consoles also allow data to be fed into the computer without prepunching cards or paper tape, which improves efficiency, especially when only small quantities of data are involved.

The large high-precision display device enables research on pattern recognition and man–machine communication to be carried out very expeditiously. This research is helped to a great extent by the light-pen facility that is also available.—*Computing Research Section.*

Remote Operation of Computers

The advantages of a large central computer over an equivalent number of small separate units are very great, but much time can be wasted by users in sending or taking their material to the machine and in waiting for their turn to use it. Moreover, machine speeds are now so high that full employment of the capabilities of computers is becoming increasingly difficult.

The possibility of providing direct access to a central computer by a number of remote individual users has been examined. As a result, a prototype installation has been built, with a direct microwave link between a console at Highett, Vic., and the Control Data Corporation 3200 computer several miles away at the David Rivett Laboratory, Clayton. The link has now been commissioned and the system is in limited operation. Although further work is necessary before the aims of the project are fully realized, the results achieved so far have been most encouraging.—*Division of Mechanical Engineering.*

Timber and Building

Much early building construction in Australia was based on methods, designs, and materials originating in the Northern Hemisphere. Native timbers, in particular, were little used except for rough work until well into the twentieth century. Many difficulties were encountered in attempts to use Australian hardwoods in higher-grade construction and in paper-making, and research into problems associated with using these timbers was therefore commenced in CSIR in 1928.

The broad aim of current research programmes is to provide the background knowledge needed to exploit the special properties of local materials and to provide

answers to problems specific to local industries. Within this framework the *Division of Forest Products* in Melbourne is investigating problems of timber utilization through all stages from milling to a wide range of end uses, such as building construction (including the development of some novel forms of construction), the manufacture of furniture, the preservation of timbers, and the manufacture of paper. These investigations have recently been extended also to a study of the effects of conditions during tree growth on strength and other factors affecting utilization. The need for investigations of building materials other than timber led to the establishment of a new laboratory, now known as the *Division of Building Research*, in Melbourne in 1945. Research on some specialized building materials is undertaken by the *Division of Applied Mineralogy*, Melbourne, and the work of the *Soil Mechanics Section* (also in Melbourne) includes studies of the load-bearing properties of soils and the design of building foundations.

Of the total expenditure of about $1,800,000 on timber and building research in 1965/66, some $110,000 was contributed by firms, industry associations, and public authorities.

Many of the initial problems that faced the *Division of Forest Products* in 1928 have been resolved. In more recent years the programme has been broadened and is now largely aimed at further improvements in the efficiency of utilizing our timber resources, at a better quality of timber in the forests of the future, and at extending the use of Australian timbers in the manufacture of products such as plywood and paper. Making use of the vast amount of information the Division has accumulated on Australian timbers, a new schedule of strength groups has been drawn up. It should lead to greater flexibility in the design of timber structures. From its inception the Division has maintained close contact with all branches of the timber industry. Recently the trend of technical development within the industry has been gaining momentum and efforts are being made to foster and improve the flow of technical material to architects and builders.

Early work in the *Division of Building Research* was concerned mainly with materials such as concrete, clay products, and gypsum. Its programme now includes research on thermal control in buildings, building acoustics, structural design (especially in relation to concrete construction), and the special problems of building in tropical conditions. Recently this range of activities has been extended by the initiation of work on building operations and economics. The group concerned has commenced a series of investigations after discussion with an Advisory Committee on Building Operations and Economics Research, which was established to assist in the planning of the programme.

Investigations on cement and concrete are included in the work of the *Division of Applied Mineralogy*, which is one of the six Divisions of the Chemical Research Laboratories. The *Soil Mechanics Section* has been concerned for some years with investigations on expansive clay soils, which cause problems in building construction because of their tendency to swell when wet. The Section is investigating the phenomena involved in swelling and is experimenting with measures that can be taken to prevent damage to buildings.

Management Planning and Control Techniques in Building

Substantial improvements in the efficiency of many manufacturing operations are possible through the application of newly developed scheduling techniques to control the flow of materials and the use of manpower and equipment. These techniques could lead to similar improvements in efficiency in the building industry.

A technique now being investigated is known as "Network Analysis", or sometimes as the "Critical Path Method" (C.P.M.) or "Project Evaluation and Review Technique" (PERT). It depends on representing the individual tasks which make up a construction undertaking by a network diagram. With information on the time and manpower required for each task this provides an abstract model suitable for mathematical manipulation. Alternative schemes for performing the work can then be compared and an optimum scheme can be selected. With regular up-dating the work can be reviewed as it proceeds and the optimum procedure for its completion selected at any given time. The mathematical processing and preparation of status reports can be done by computer.

A computer programme for network analysis and the presentation of reports has been designed for use with Control Data Corporation 3600 and 3200 computers. It has been designed so that additional features can be introduced without disrupting its logical structure and so that the possibilities of computer processing are used without loss of the value of human experience and judgement. The programme is being used in cooperative studies with several building companies and public authorities. The results obtained so far indicate that tender and contract documents should be prepared so that they include more information for use in network analysis.—*Division of Building Research.*

Code of Practice for Light Timber Framing

In the drafting of a Code of Practice for Light Timber Framing by the Standards Association of Australia, the Division of Forest Products has accepted sole responsibility for the preparation of the extensive series of tables of timber sizes required for domestic and other light timber construction. With the aid of a computer the preparation of the tables is nearing completion. The Code of Practice, when finalized, will supersede the Division's Pamphlet No. 112, which gives sizes of members based on now out-of-date criteria of loading and design.

In the preparatory work for these new tables the strength grouping of the timbers used for structural purposes in Australia was revised. As a result a new strength grouping system has been proposed to replace the one in use for the past 30 years. This new system is based on the more extensive strength data now available for Australian species, and better correlations between strength groups and strength properties. It provides for a more rational series of working stresses involving simultaneously both strength group and timber grade. It also takes into account the evidence now available on the variation of stiffness with grade.

The new grouping system and the Code of Practice should lead to more efficient overall use of timber in housing construction. It will provide wider scope for architects and builders wishing to develop and build houses and other light structures that depart significantly from traditional construction designs.—*Division of Forest Products.*

One of the test sites for preservative-treated wood specimens is at Brown River in Papua. Here there are 660 specimens exposed to a severe decay hazard.

Tests of Preservatives using Small Treated Specimens

One of the largest and most comprehensive tests of wood preservatives so far attempted anywhere in the world has been established, using small treated specimens. With 6060 test stakes, tests are being conducted on more than 18 different creosotes and oil-borne preservatives, 16 different water-soluble preservatives, and a number of "dipping" preservatives. The specimens have been distributed around eight sites chosen as representative of conditions of high hazard ranging from the tropical Territory of Papua and New Guinea, through north Queensland and New South Wales, into the mallee and southern regions of Victoria.

Although this test may run for more than 20 years, observations made during the first few years will provide a reliable basis for specifying minimum loadings of preservatives for various commercial uses. As the test progresses, it will yield more complete information upon which to base recommendations for the use of preservatives in ground contact in any part of Australia.—*Division of Forest Products.*

Fungi Essential for Tree Growth

Unlike herbaceous plants most forest trees, both softwoods and hardwoods, do not obtain their nutrients directly from the soil. Instead, they rely on fungi, whose cells (hyphae) absorb from the earth all the water and salts essential for the life and growth of the tree and pass them on to the tree roots. In return, the fungi obtain food from the tree in the form of sugars. Under certain conditions, however, fungi may

invade the cells of the host to form a root rot which leads to the death of the tree. The nature of the balance between fungus and host in normal and pathological conditions is being investigated in conjunction with the Victorian Forests Commission.

These studies are giving information on the mode of nutrition of forest trees, and indicating how living trees and the timber they produce are able to resist fungal attack. They are showing also how trees produce some compounds that can cause technical difficulties in the pulp and paper and other industries.—*Division of Forest Products.*

Wildlife

Much of the wildlife in Australia is unique and the *Division of Wildlife Research* has been established especially to study our mammals and birds. The species investigated range from the rabbit, which is not indigenous but was introduced and is obviously a pest, to those, such as the lyre-bird, which need to be conserved. On the other hand the mutton bird, for example, is being studied because of its importance to an industry. It is, however, not always possible to classify animal problems into questions of conservation or destruction. An example is the position of the various species of kangaroo, which is particularly complex and difficult; the work of the Division has shown that some of the species are undoubted pests in some places, yet at the same time they may be an economically valuable source of protein. Other species are in urgent need of conservation.

Any animal population is always in a delicate, dynamic equilibrium with its environment, and a knowledge of the relationship of a species to this environment is basic to any successful programme, whether it be for control or conservation. Current work on the kangaroo and on species such as the fox, dingo, ravens, native hens, mutton birds, and waterfowl is directed towards providing a background knowledge of the basic biology of the animals, their ecology, behaviour, and physiology of reproduction.

A large part of the Division's work is directed towards control of the rabbit. Effective long-term control of the rabbit over the wide range of climate, soil, and vegetation in which it lives in Australia requires a background of knowledge of its biology in these environments, and much valuable information has already been obtained. The *Division of Animal Genetics* is continuing its work on the effectiveness of strains of the myxomatosis virus.

Much of the work involved in these investigations is conducted in the field, remote from Divisional headquarters, and would not be possible without the cooperation of individual landholders.

Competition for Feed between Kangaroos and Sheep

For some years several species of kangaroos and wallabies have been studied to obtain the basic ecological and biological information essential for a rational approach to management of fauna resources. The studies cover numbers and movement, food intake, growth, and reproduction.

One of the most important aspects that concerns the pastoral industry is the effect of kangaroos on pasture. This work involves measurements of changes in pasture

caused by kangaroos grazing alone or in combination with sheep, and is being done at Tero Creek Station in north-western New South Wales. Two series of observations have been carried out on sand-hill plant communities, one of which had not been grazed by sheep for 15 years, while the other had been grazed continuously by sheep during this time. Sheep have now been introduced into the former area and the long-term changes in each pasture will be observed.

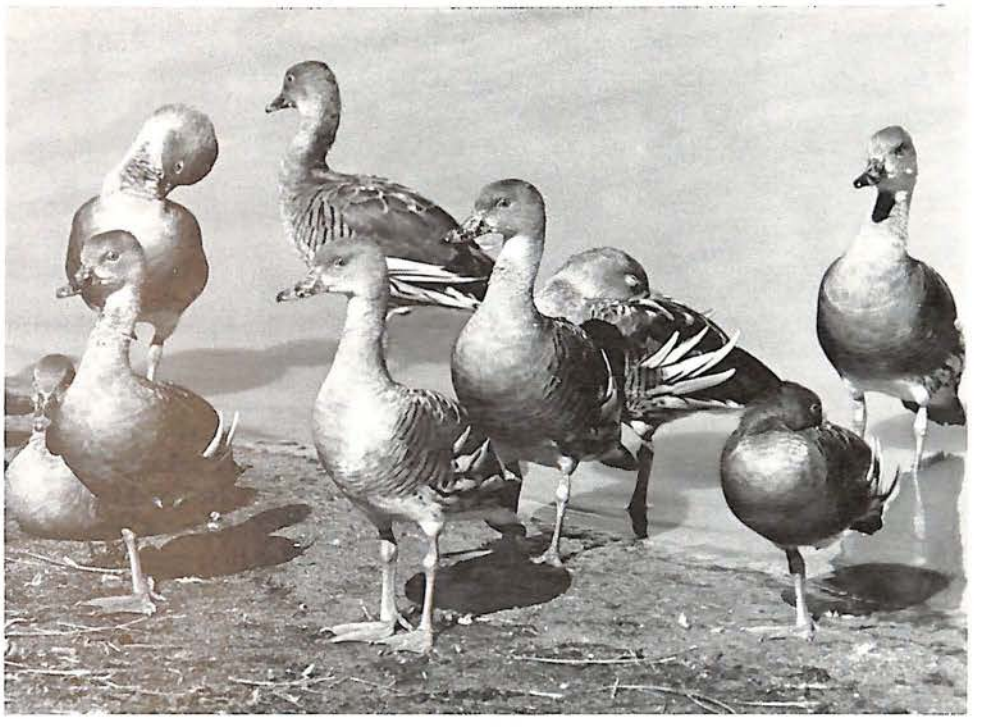
Related work is being done to find what kangaroos actually eat and the plants found in stomachs of sheep, grey kangaroos, and red kangaroos grazing together in south-western Queensland have been analysed botanically. Samples were taken on six occasions in 1963 and in January 1964 from a total of 100 sheep and 114 kangaroos. On no occasion did the two species of kangaroos and the sheep eat the same diet. Even when the kangaroo ate the same plant species at the same time as the sheep, it was usually found that the amounts were different. Red kangaroos and sheep preferred a diet of about 50% herbs plus shrubs and 50% grasses, whereas grey kangaroos ate substantially larger proportions of grasses. Since the herbs and shrubs have a high nitrogen content relative to grasses they must contribute importantly to wool production, and it might be argued that red kangaroos compete with sheep for those plants. In the one or two instances where kangaroos, both red and grey, competed with sheep throughout the year for the same herbs or grass, and where large numbers of kangaroos were present, they must have seriously interfered with wool production. However, the diet of red and grey kangaroos usually contained a large proportion of herbs that were not favoured by sheep.—*Division of Wildlife Research.*

Control and Conservation of Native Fauna

In northern Australia and New Guinea, the distribution of native birds and mammals is not well known. Such surveying and collecting as have been done have mostly been for foreign organizations for diverse purposes and the resulting data and collections are not immediately available to Australian research workers.

Information on the distribution and status of this fauna is urgently needed. It is possible that diseases of domestic birds and mammals, at present unknown in Australia, could be introduced accidentally and spread by the movements of native animals, against which control measures might then be needed. These measures could not be effectively devised without a sound knowledge of the species. Conversely, many of our native fauna need to be conserved, and conservation is similarly hindered through lack of information on their distribution and status. These problems will undoubtedly be aggravated by increasing agricultural development in northern Australia and New Guinea.

The Division of Wildlife Research has made some surveys of fauna in such areas, but only as opportunity offered. Nevertheless, a large amount of valuable material and information has been assembled. The Sepik district of New Guinea has been visited several times in the course of a collaborative survey with the Australian National University. Other surveys have been in the Cobourg Peninsula in the north-west of Arnhem Land, Cape York Peninsula, the Coral Sea islands, and a rather more detailed survey in forest areas in north-eastern New South Wales.—*Division of Wildlife Research.*



Little is known of the fauna of the tropical areas of Australia. The photograph shows one of the waterfowl, the green whistle duck, Dendrocygna eytoni, *which is at present abundant on tropical lagoons in the north.*

Basic Knowledge of Rabbit Distribution

A group of research workers in the Division of Wildlife Research is working to provide the essential biological background knowledge concerning rabbits that is required as a basis for the development of more economical and effective strategic methods of control.

The studies include field ecology, reproduction, behaviour, parasitology, physiological changes, and adjustment of the animals to their environment. An understanding of the rabbit problem in Australia calls for a better knowledge of distribution patterns and the ways in which rabbit numbers fluctuate in different habitats and regions. In order to provide the required answers, field workers in the Division have developed methods of estimating rabbit populations and are measuring changes in numbers in five different populations in widely separated regions of eastern Australia. All the techniques available are being used, including the accurate mark-recapture method, counts of rabbits on the surface during daylight and dark, the density and size of rabbit warrens and their rate of use, and aerial surveys of warren distribution over large areas. Where possible, different types of studies are carried out in the same areas at the same time so that changes in numbers measured in one way may be directly compared with the same changes measured in another way.

The data from the first series of observations show great differences between

rabbit densities in different habitats. Thus in a subalpine habitat over 90% of warrens were confined to open country grazed by stock. Similarly, in a subtropical habitat over 90% of all warrens were confined to alluvial sand-hills bordering a river. Drought conditions in north-western New South Wales reduced the numbers of rabbits counted in one area by more than 75% in 12 months. Aerial surveys of large areas of the arid zone have shown a marked discontinuity in the distribution of rabbit warrens, with peaks of high density limited to certain major physiographic regions. These include sand-dunes near swamps and the margins of stony rises. A gradual accumulation of data through both intensive census-taking and ground and aerial surveys will ultimately permit the measurement and prediction of fluctuations in numbers with some degree of accuracy. The strategy of rabbit control will benefit accordingly.—*Division of Wildlife Research.*

New Strains of Myxomatosis for Rabbit Control

The object of the myxomatosis research of the Division of Animal Genetics is to produce new strains of the virus that will be useful for rabbit control and to find the best methods of using myxomatosis under existing field conditions. Considerable work has been done on the development of new techniques for the research.

A simple method of collecting blood samples in the field for the assay of antibodies has been devised. Results of a survey in New South Wales begun in August 1965, in cooperation with the Pastures Protection Boards, indicate that in many rabbit populations the percentage of rabbits that are immune is small. In these, the introduction of virulent Glenfield virus could be useful. It is probable that the susceptible rabbits which form the majority of the population are relatively young, probably mostly kittens. These would usually be killed by Glenfield virus before field strains can take over. Other areas have nearly 100% immunity and in some areas all rabbits tested have proved immune. This is probably due to the failure of adults to breed during the drought, so that only old rabbits are in the community. These should be poisoned before they can breed.

A new and simple method of infecting rabbits via the eye has been developed. Small quantities of dry powdered material mixed in a small quantity of abrasive are inserted into eyes with the tip of the little finger. No dilution, syringe, or other apparatus is required. Another development has been a new method of growing virus that produces cultures containing much more infective material than before and so is much more likely to infect susceptible rabbits.—*Division of Animal Genetics.*

Control of Problem Birds on Airfields

When a bird is struck by an aircraft the incident is usually fatal for the bird and may severely damage the aircraft. The frequency of bird strikes depends on the density of bird populations and the number of aircraft using the same air space. The number of birds decreases with altitude and consequently almost all bird strikes by regular air transport services occur within the circuit areas of airports.

As a preliminary to finding means of permanently lowering bird numbers near airfields, the environmental requirements of the various bird species frequenting them are being studied at 16 airfields throughout Australia. Practical application of the findings has already been possible, and has resulted in a spectacular decrease in

numbers of some of the species of problem birds. The cessation of tipping of garbage during daylight hours at dumps near airports has resulted in a reduction of more than 80% in the number of silver gulls at the airports of Sydney and Adelaide. Also the drainage of swamps and the stringing of wires over tidal beaches and ponding areas at Sydney Airport have reduced the numbers of gulls roosting there at night from 8000 to less than 10. Treatment of the vegetation on parts of airfields which attract birds either as a source of food or as roosting and nesting habitats has also helped to reduce many bird populations on airfields.

The programme of the Division of Wildlife Research covers a wide variety of birds that have been reported on Australian airports. Many of these are being studied primarily in relation to their importance to agriculture and forestry, but the findings are applicable to the problem caused by the birds at airfields. As their basic biology is revealed, cheaper, simpler, and more practicable control methods can be developed.—*Division of Wildlife Research.*

Wool Textiles

Wool textile research in CSIRO is carried out in the *Divisions of Protein Chemistry* (Melbourne), *Textile Physics* (Sydney), and *Textile Industry* (Geelong), which together comprise the CSIRO *Wool Research Laboratories.* Research in these Laboratories was not commenced until 1949 but many improvements in wool processing and testing have already been introduced. Finance for their work comes from allocations from the Wool Research Trust Fund which is administered by the Australian Wool Board. The Board is advised by the Wool Textile Research Advisory Committee. In 1965/66 the amount allocated to the Wool Research Laboratories was $2,600,200.

The Wool Research Trust Fund is used to finance both wool textile and wool production research (see also Sheep and Wool Production). At present about 15% of the funds expended are derived from the woolgrower by means of a levy of 20 cents per bale of wool; the Commonwealth Government provides about 30% on the basis of 40 cents per bale of wool; approximately 12% is met from miscellaneous income to the Fund, such as interest on investments and sales of produce; the balance, about 43%, is provided from reserves including the capital of the fund which was established with the proceeds from the sale of wool during World War II.

The objective of the research in the Laboratories is to ensure that advances in modern science and technology are fully exploited for the benefit of the wool industry. All operations, from the branding of wool while on the sheep, through the handling and transportation stages, to wool textile processing and testing are subject to scrutiny. Considerable emphasis is placed on new processes leading to the improvement of consumer goods and the development of new uses for wool.

A large proportion of Australia's wool is exported for processing overseas and it is important that the results of the work of the Laboratories should be promoted into industry throughout the world. This is effected largely through the International Wool Secretariat, which, through its Research and Development Committee, is also playing an increasingly important role in coordinating wool research activities in the principal wool-growing and wool-processing countries and in suggesting those

lines of inquiry most likely to meet current consumer needs. Work in the Geelong Division on the new process for shrink-proofing wool, details of which have been announced recently (see below), was given impetus by the emphasis the Committee placed on the need for a simple and effective process for shrink resistance. Current emphasis is placed on such requirements as resistance to yellowing, wrinkle resistance, and faster methods of setting wool fabrics.

The three Laboratories work closely together. Work in the *Division of Protein Chemistry* is concerned with the basic structure and chemistry of wool, to provide a better understanding of its properties and the changes that take place during processing. It also undertakes research on processes that do not use conventional textile processing equipment. The physical properties of wool are studied in the *Division of Textile Physics*, with special attention to the mechanical and water-sorption properties of wool fibres. This work is associated with practical applications to processes and with the development of improved testing methods. Research in the *Division of Textile Industry* is concerned mainly with textile processes and related studies, for which it has installed a full range of wool-processing equipment.

The Third International Wool Research Congress was held in Paris between June 29 and July 9, 1965. It was organized by l'Institut Textile de France and was attended by over 300 scientists from the leading wool-producing and wool-processing countries. Some 30 delegates attended from Australia, mainly from the CSIRO Laboratories and from the Australian Wool Board and universities. Ideas and information were freely exchanged over the whole range of wool research, leading to considerable benefit through re-direction of the world's wool research resources into new lines of inquiry. The next meeting is to be held in San Francisco in 1970.

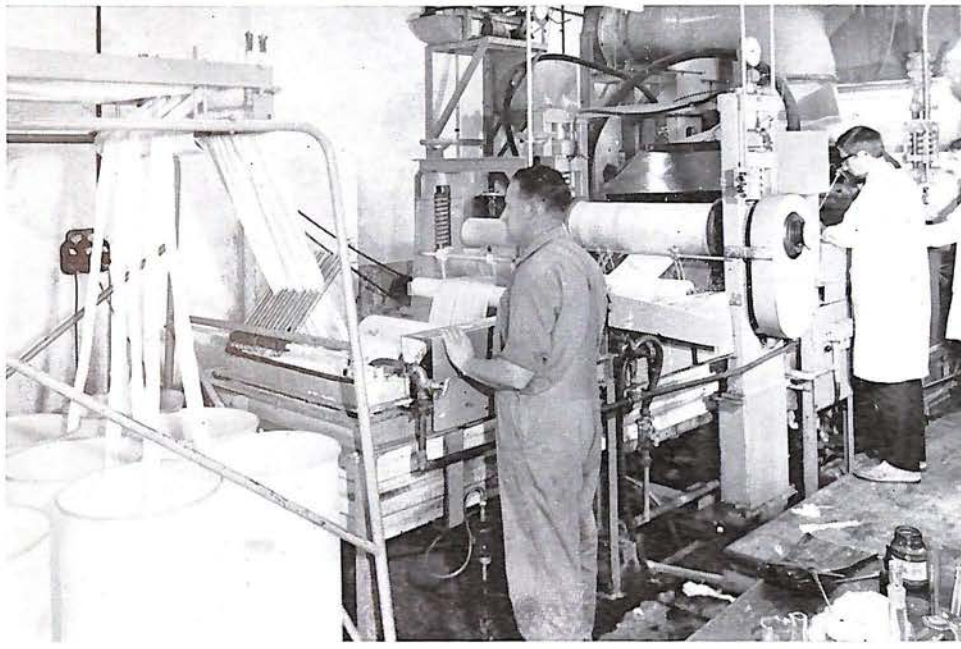
Amino Acid Sequence in Wool

A knowledge of the basic structure of wool is important for the understanding of many of the characteristics of the wool fibre and the changes that occur during processing. In work on the chemical structure of wool the constituent proteins must be isolated for study. These proteins, like proteins from other sources, are built up from amino acids, but because of the unusual characteristics of the wool proteins it is not easy by conventional techniques to be sure that any fraction is a single pure component. Recently the Division of Protein Chemistry has obtained considerable evidence that it has isolated a single protein from wool and, for the first time, established the order of occurrence of a substantial number of amino acids within it.

This protein fraction is made up of about 200 amino acid components. Most of those present recur many times, so that about 80% of the components consist of only six amino acids. Previously little has been known of the order of occurrence of amino acids in any wool protein. A sequence of over 30 amino acids in the central part of the molecule has now been established.—*Division of Protein Chemistry.*

New Processes for Shrink-proofing Wool

The search for a satisfactory process for shrink-proofing wool has extended in CSIRO over the past 18 years. During this time several processes have been developed but each has been too complex or too uneconomical for widespread industrial application. Two new techniques using synthetic resins have now been developed.



The new resin process for shrink-proofing wool tops. The first bath on the left contains a solution of detergent. This is followed by a water rinse and the pretreatment with a very weak solution of chlorine that prepares the fibre surfaces so that they will take up the resin as a uniform deposit. The resin is applied in the last bowl before the wool passes into a drier which is beyond the picture to the right.

The first of these is applicable only to woven woollen fabrics, to which the resin is applied as a padding treatment during the finishing of the cloth. The process has been readily taken up by industry and produces material that resists shrinking on washing, is stronger, and wears better.

The second process is applied as a continuous treatment to tops and is greatly superior to earlier methods. It is simple, the wool in sliver form passing continuously through an extremely weak solution of chlorine which is then neutralized. This prepares the surface of the fibres for the next stage of treatment, in which the wool passes through a solution of synthetic resin in water. In contrast, earlier processes required the use of costly organic solvents. The type of machinery required is already in use in some Australian wool textile mills and should need little modification. Yarn spun from the treated wool will produce fabric that can be machine-washed in all types of machinery now available. In addition the treatment eliminates pilling, in which small balls of fibres are formed on the surface of garments, especially on home-made knitwear.

Large-scale trials of the process have been conducted in Australian and overseas mills during the past year, and applications have been made for patents in the major wool-processing countries. It should greatly extend the usage of wool when mills become equipped with the machinery for commercial production.—*Division of Textile Industry.*

Development Contract for Yield and Fineness Testing Equipment

One of the major problems facing wool-buyers and others connected with the wool industry is that whilst some of the characteristics of wool can be assessed readily by handling and visual appraisal, others present difficulty. Among these is yield, which is the percentage of actual wool in a bale of greasy wool. Along with the percentage of burr and the fineness of the wool, it is usually appraised visually. Although a fair degree of accuracy is attained, there are many occasions when it would be advantageous to be able to measure these characteristics. Such measurements are, in fact, made by Wool Testing Houses, but current methods are laborious and it would not be practicable to test more than a small proportion of the Australian clip.

Considerable progress has been made in investigations on a number of improved methods of testing for yield, burr, and fineness. To speed up the completion of this work, an arrangement has been made with a Sydney firm of wool machinery manufacturers for the development of the equipment for these tests jointly with CSIRO.—*Division of Textile Physics.*

Regain Testing to Certificate Standard

The CSIRO Direct Reading Regain Tester developed earlier is now widely used in industry. To achieve the greater precision required for the issue of certificates in wool commerce under the Regulations of the International Wool Textile Organization, an improved conditioning oven has been developed. It has been designed to make precise regain measurements rapidly, and to be simple and reliable in operation.

In the CSIRO Conditioning Oven, the arrangements for holding wool samples ensure that air heated to 105°C passes through all parts of the sample so that drying is rapid. Precise weighing is achieved by eliminating buoyancy and convection effects. The oven has given very good results during several months' use by the Australian Wool Testing Authority.—*Division of Textile Physics.*

Processing Performance of Wool

The performances of different lines from a Merino clip have been compared in manufacture and in final products, and similar comparisons have now been made with Polwarth and Corriedale clips. The results show differences in processing performance between the various lines but less difference between the fabrics produced. These studies indicate that one of the advantages to be derived from separating a clip into many lines is that it facilitates the evaluation of yield by the buyer. It is much easier to estimate the yield from a homogeneous line of fleece wool than it would be if lots were combined, even though the final fabrics from the different lines may not be significantly different.

Preliminary comparisons of wools from flocks of sheep maintained at different rates of stocking have shown no difference either in processing performance or in properties of the final fabrics. This indicates that no deterioration of wool quality has resulted from higher stocking rates. Such studies are helping to form a valuable link between research in wool production and wool utilization.—*Division of Textile Industry.*

Sock Trials

Over the past three years, a wearer trial has been conducted to assess the performance of Australian-made men's wool socks. The socks were worn under normal conditions by the participants in the trial, and each sock change and wash was recorded. Washing was carried out under supervision. There were about 30 participants in the trial and socks were washed daily. The two major items assessed were shrinkage and the number of wearings before holes appeared.

The results obtained show that it is possible to manufacture correctly shrink-proofed socks that survive about 100 washes before failure, or 200 washes if about 20% of nylon is added. Increasing the percentage of nylon does not appear to improve performance. The trial showed that many commercially available socks had only a fraction of this durability. The implication is that existing shrink-proofing techniques can give satisfactory results but are not being correctly applied.—*Division of Textile Physics.*

Electrostatic Charging of Fabrics in Hospitals

Because of the use of inflammable anaesthetics, current codes of practice relating to safety in operating theatres prohibit the use of textiles prone to develop electrostatic charges. The development of these charges on various fabrics and the use of antistatic agents have been investigated in collaboration with the Royal Melbourne Hospital. It has been found that commercial antistatic agents effectively prevent the development of static charges on earthed textile materials made of fibres normally static-prone, but that antistatic agents are relatively ineffective on blends of static-prone and static-free fibres.

The results show that changes are needed in the definitions and tests in the current codes of practice. For example, the present standard test for electrical conductivity of textiles is unsatisfactory, and it has been found that in any case it is not related simply to the development of static charges on a fabric. Application of the information obtained in the investigation could permit a substantial saving to Australian public hospitals but is not possible without revision of regulations relating to safe practice.—*Divisions of Protein Chemistry and Applied Physics.*

Lanolin Recovery

The recovery of wool wax from wool-scouring liquors is important for several reasons: scouring efficiency can be improved, there are fewer problems in the disposal of effluent, and the product can be sold, after refining, as lanolin. The commonest method of recovery, which uses centrifuges, is, however, not very efficient and the factors affecting the performance of commercial centrifuges have been studied extensively. It has been found that greatly increased yields of wax can be obtained by making simple adjustments to existing equipment and procedure. In trials in three wool-scouring plants the yield of wax has been increased by approximately 40% over a period of 6 months.—*Division of Textile Industry.*

3

Services and Publications

THE PRIMARY FUNCTION of CSIRO is to undertake research that can be used to promote the development of Australia. It is not enough to discover the solution to a scientific problem; the results of research must be communicated to others. Through publication in scientific journals these results become added to the world's store of knowledge and so are available to other scientists. Effective communication to industry is not so readily achieved.

CSIRO is, to a large extent, dependent upon other government agencies and upon industry for the development of its research results for practical application. In the agricultural industries there is usually much work to be done before the regional and local significance of these results can be assessed and advice to the producer formulated. The State Governments have set up Departments for research and advisory services for this purpose but in the secondary industries similar services are not available nor would they be practicable. An industrial enterprise is thus usually dependent upon its own technical staff for the assessment of the significance of new developments in relation to its own activities. In the absence of such technical staff any effort aimed at communicating the results of research to industry must be largely ineffective.

One of the major difficulties in securing the application of CSIRO research results in secondary industry arises from the lack of suitable arrangements in Australia for development work. Development is an activity that is essentially different from the research work that precedes it. It requires a different staff and different facilities and usually costs a great deal more. While there is a need to take development further in CSIRO, this cannot be a complete answer to the problem. The scope within CSIRO for this type of work is limited and in any case it should be conducted within the framework of the industry concerned. The inability of a large section of Australian industry to handle its own development work is a serious obstacle that needs greater attention from both government and industry.

In the circumstances a wide variety of means is adopted by CSIRO to secure the application of its research results and these are largely dictated by the capabilities of the industries concerned. The Organization maintains close contact with the research and extension services set up by the State Governments for the benefit of the primary industries, and a vigorous liaison programme has been adopted to aid the exchange of scientific information between these services and CSIRO Divisions and Sections. It has been necessary to adopt quite different means to secure the application of research results in secondary industry. Novel processes are patented

when this appears likely to aid industrial application. Divisions that are directly associated with particular industries maintain active advisory services and issue publications describing new developments and drawing attention to possible applications. Wherever possible, the Organization collaborates with industry in development work. The extensive holdings and services of the CSIRO libraries are available to both research and industrial users. Instructional films are made to demonstrate new processes and to assist in the training of operators.

Agricultural Liaison Activities

CSIRO is only one of several institutions concerned with research in agriculture. The Departments of Agriculture which provide the research and extension services in each State undertake a wide range of research on problems arising within their regions of interest. In many of the universities the faculties of agriculture have particularly strong research schools. In such a situation effective interchange of research information becomes imperative, and it is essentially for this purpose that CSIRO set up its Agricultural Liaison Unit. Liaison is effected by a variety of means such as technical conferences, specialist committees, publications, and extensive use of personal contact.

An important development in recent years has been the greatly increased collaboration between officers of CSIRO, State Departments, and universities. This situation is extending rapidly and it has been possible to arrange some interchange

The National Standards Laboratory held Open Days on August 10 and 11, 1965. Over 2500 people attended to see the 140 exhibits on display in the main laboratory building and in the branch laboratory at Newtown.
Closed-circuit television was used to demonstrate the plasticity of metals when being machined. A microscope objective fitted to the camera shows a greatly enlarged image of a cutting tool on the screen.

of staff. It will be of great benefit to Australia if a mechanism can be developed for such transfers to be effected without loss to the individuals concerned (see also page 11).

Some of the work of CSIRO is carried to a stage that permits immediate integration and interpretation in a form suitable for use by extension officers. During the year over 100 research papers were handled in this way in the liaison quarterly *Rural Research in CSIRO*.

Much other work cannot be treated so directly; it requires integration with other knowledge, further testing, or adaptation before it can be put to practical use. Technical conferences are then a valuable means of bringing together those concerned. During 1965/66 conferences on weeds, cereal agronomy, soil science, and the arid zone were arranged on behalf of the Australian Agricultural Council, and CSIRO was also involved in the organization of the 1966 Northern Territory Scientific Liaison Conference. Comprehensive reviews have been prepared of the research on phosphate in agriculture in Australia and of research on soils and pastures in south-eastern South Australia and south-western Victoria.

CSIRO does not undertake agricultural extension work of its own accord but has cooperated with State Departments of Agriculture in several special projects. An extension publication, "Drying of Grapes", was produced in collaboration with the Departments of Agriculture in New South Wales, Victoria, and South Australia. CSIRO also joined with the Western Australian Department of Fisheries and Fauna in a joint programme to secure the cooperation of commercial fishermen in work on the biology of crayfish and to maintain the productivity of the crayfish fishery.

Contact with Secondary Industry

All Divisions and Sections of CSIRO maintain close contact with industry, both to establish its specific requirements and to encourage the utilization of the results of research. Some laboratories, such as the Divisions of Forest Products and Building Research, are associated directly with an industry and their activities are naturally integrated with its needs. Other Divisions, such as the Division of Chemical Physics, are working in a branch of science rather than with a single industry and their work spreads over the interests of a range of industries. Much time is spent in stimulating, assisting, and steering the commercial application of processes developed in CSIRO laboratories. Very close collaboration is achieved when it is possible to arrange sponsorship of investigations in CSIRO by firms or industry associations, particularly when the CSIRO effort is augmented by participation by industry technical staff.

Specialized services are available to industry in several CSIRO laboratories. The Division of Chemical Engineering provides a wide range of experimental facilities for the development of pilot plants and for experiments in which the size of equipment required is beyond the usual laboratory range. The National Standards Laboratory, which maintains Australia's standards of measurement, undertakes calibrations of working standards and tests on instruments where a high level of precision is required and the necessary facilities are not available elsewhere. Many Divisions, particularly those associated with a single industry, maintain active advisory and information services that handle some thousands of enquiries each year.

Patents

CSIRO uses patents primarily to encourage the use of its research results by Australian industry, and patents are taken out and licensed in whatever way will lead to the most effective application of its inventions.

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 1965 is given below.

Division of Chemical Engineering

Herbert, L. S., and Sterns, U. J.—Improvements in and relating to the distillation of sea water and the like. Aust. Pat. 258,434.

Kelsall, D. F.—Cyclone elutriator. U.S. Pat. 3,166,496. Philipp. Pat. 2017. Brit. Pat. 988,577. Jap. Pat. 453,833.

Division of Plant Industry

Dudman, W. F.—Sorbic acid derivatives. Israeli Pat. 17,382. Jap. Pat. 437,657. Aust. Pat. 256,925.

Phillips, J. N.—Porphin derivatives, process for preparing same, and compositions, especially fungicides containing same. Aust. Pat. 254,144.

Division of Mechanical Engineering

Kowalczewski, J. J.—Improvements in refrigerant expansion devices. Aust. Pat. 250,887.

Division of Textile Physics

Mackay, B. H.—Improvements in means for heating a stream of air or other gas. Aust. Pat. 259,847.

Stuart, I. M.—Improvements in direct-reading proportional balances. Aust. Pat. 254,244.

Division of Tribophysics

Davis, A. J.—Improved fine control valve for fluids. Aust. Pat. 253,294.

Division of Dairy Research

Czulak, J.—Method and apparatus for manufacturing cheddar, cheshire or like cheese. U.S. Pat. 3,167,862. N.Z. Pat. 134,522.

Czulak, J., and Freeman, N. H.—Improved press. Brit. Pat. 979,168. Can. Pat. 716,830.

Division of Forest Products

Page, M. W., and Gottstein, J. W.—Method of jointing green timber. Aust. Pat. 253,753.

Division of Physics

Ramsay, J. V.—Interferometer. Brit. Pat. 974,378.

Division of Textile Industry

Delmenico, J.—A process for the durable creasing or other permanent setting of textile materials containing wool or other keratin fibres. Belg. Pat. 654,053. Sth. Afr. Pat. 64/4790.

Farnworth, A. J.—A process for the permanent creasing or other permanent setting of woollen or worsted fabrics or other materials containing wool or other keratin fibres. Dan. Pat. 102,028. Jap. Pat. 310,208.

Henshaw, D. E.—Forming yarns and other twisted assemblies. Can. Pat. 703,221. Indian Pat. 84,731. Belg. Pat. 646,976. N.Z. Pat. 133,253. Argent. Pat. 143,434. Israeli Pat. 18,072. Aust. Pat. 260,092. Ital. Pat. 676,507. Pakist. Pat. 113,890. Span. Pat. 302,233 (apparatus). Span. Pat. 302,232 (process). Sth. Afr. Pat. 64/1491.

Knothe, W. E. O.—Apparatus for transferring fibrous material. Ital. Pat. 675,254. Aust. Pat. 258,408.

McPhee, J. R., and Feldtman, H. D.—Wool treating process. Belg. Pat. 651,439.

Morgen, W. V.—Method and apparatus for the removal of burrs and other foreign matter from fibres. Ital. Pat. 674,723. Aust. Pat. 259,442.

Walsh, J., and Sinclair, J. F.—Method and apparatus for forming a substantially uniform layer of textile fibres. Swed. Pat. 194,361.

Division of Mineral Chemistry

Scott, T. R.—Improvements in and relating to the production of alumina. Argent. Pat. 142,012 (patent of addition to Argent. Pat. 136,699). Paraguayan Pat. 1515. U.S. Pat. 3,185,545. Germ. Pat. 1,179,919.

Scott, T. R.—Improvements in and relating to the production of alumina. Aust. Pat. 257,170 (patent of addition to Aust. Pat. 237,278).

Scott, T. R.—Improvements in and relating to the production of aluminium compounds. Aust. Pat. 260,266 (patent of addition to Aust. Pat. 237,278).

Division of Protein Chemistry

Flanagan, G. F., Sutherland, W. J. A., and Bladier, J. W.—New and improved hydraulic prime mover. Aust. Pat. 260,963.

Garrow, C.—Improved method and apparatus for pressing materials having entrained fluids. Aust. Pat. 256,728.

Tugen, R. G.—Moulded felt and the manufacture thereof. N.Z. Pat. 133,043. French Pat. 1,358,377. Ital. Pat. 675,011. Indian Pat. 84,209.

Division of Applied Mineralogy

Walker, G. F.—Method of producing carbon-silicate complexes. U.S. Pat. 3,188,225.

Walker, G. F.—Suspensions, coatings and films of vermiculite and like minerals. Aust. Pat. 257,511.

Division of Chemical Physics

Stiff, G. M.—Variable width slit operating mechanism. French Pat. 1,387,514.

Walsh, A.—Apparatus for spectrochemical analysis. Swed. Pat. 194,181.

Walsh, A., and Sullivan, J. V.—High intensity atomic spectral lamps. French Pat. 1,371,588. Aust. Pat. 260,726.

Division of Coal Research

Brooks, J. D., and Harrison, R. J.—Method and apparatus for dealkylating and hydrogenation of organic compounds. U.S. Pat. 3,202,664.

Division of Food Preservation

Casimir, D. J., Mitchell, R. S., and Lynch, L. J.—Improvements in methods and apparatus for shelling peas. N.Z. Pat. 135,938. Aust. Pat. 259,115.

Publications for Industry

It is important that new knowledge should be passed on as rapidly as possible to those who can use it. To secure the rapid and effective application of the results of research in Australian industry CSIRO Divisions issue a wide range of publications covering developments within the scope of their activities. Some of these publications, such as *CSIRO Forest Products Newsletter* and *CSIRO Food Preservation Quarterly*, are issued regularly. In addition many reports are issued in printed or roneoed form to provide industry with the information required for technical assessment of specific new developments. A list of publications issued in 1965/66 for use by industry follows.

Division of Building Research

Fibrous Plaster Research Notes. No. 11 (1965).

Ready Research References. No. 8 (1965)–No. 11 (1966).

Tropical Building Research Notes. No. 10 (1965)–No. 15 (1966).

Reports

F1–10. Stains on painted fibrous plaster, "lustre stains". M. J. Ridge and G. R. Boell. (1965.)

F1–11. The "water requirement" of calcined gypsum. 5. High-strength cast gypsum by the use of gum arabic and calcium oxide. M. J. Ridge and G. R. Boell. (1965.)

01·1–2. Assessment of joint sealers by outdoor exposure in cyclic movement testers. N. G. Brown. (1966.)

02·2–30. Sizes for roof gutters and downpipes. K. G. Martin. Revised ed. (1965.)

02·5–10. Bitumens for built-up roofs. 3. Some studies on plastic rupture. K. G. Martin. (1965.)

Technical Papers

16. Solar position and radiation tables for Canberra (latitude 35° S.). J. W. Spencer. (1965.)
17. Solar position and radiation tables for Melbourne (latitude 38° S.). J. W. Spencer. (1965.)
18. Solar position and radiation tables for Adelaide (latitude 35° S.). J. W. Spencer. (1965.)
19. Solar position and radiation tables for Darwin (latitude 12½° S.). J. W. Spencer. (1965.)

Division of Chemical Engineering

CRL/CE/R10. Brown coal drying: cost estimate for Fleissner process. K. L. Piggott. (1965.)

CRL/CE/M12. Tin smelting in a short rotary furnace. T. R. A. Davey. (1965.)

Division of Coal Research

Coal Research in CSIRO. No. 27 (1965)–No. 29 (1966).

Location Reports

336. Characteristics of further coals from Lobe D, Leigh Creek Coalfield, South Australia. (1965.)
337. Report on seams from Ipswich Borehole NS 280, Bundamba district, southern Queensland. (1965.)
338. Report on seams from Bowen River Borehole NS 518, Bowen River Coalfield, northern Queensland. (1965.)
339. Report on Cameron seam from Borehole NS 306 in the Haighmoor mine area, North Ipswich district, southern Queensland. (1965.)
341. Characteristics of further coals from Lobe C, Leigh Creek Coalfield, South Australia. (1966.)
342. Report on Cameron and Haighmoor (bottom) seams from Borehole NS 320 (Haighmoor mine area), North Ipswich district, southern Queensland. (1966.)

Miscellaneous Report

272. The manufacture of pipe-coating enamels from carburetted-water-gas tar. D. Osetzky. (1965.)

Technical Communication

48. The association of minerals with macerals and microlithotypes in some Australian coals. Michelle Smyth. (1966.)

Division of Fisheries and Oceanography

Technical Papers

20. Application details and sea-trial results of an antifouling and anticorrosion system. B. Wisely. (1966.)
21. Non-seasonal variations in the hydrological environment off Port Hacking, Sydney. F. F. de Castillejo. (1966.)

Division of Food Preservation

Calculation of freezing times of boneless meat in cartons from 50° to 10°F. (1965.)

Recommendation for prevention of white centres in dried apricots. D. McBean. (Aust. Dried Fruits Association: Melbourne 1965.)

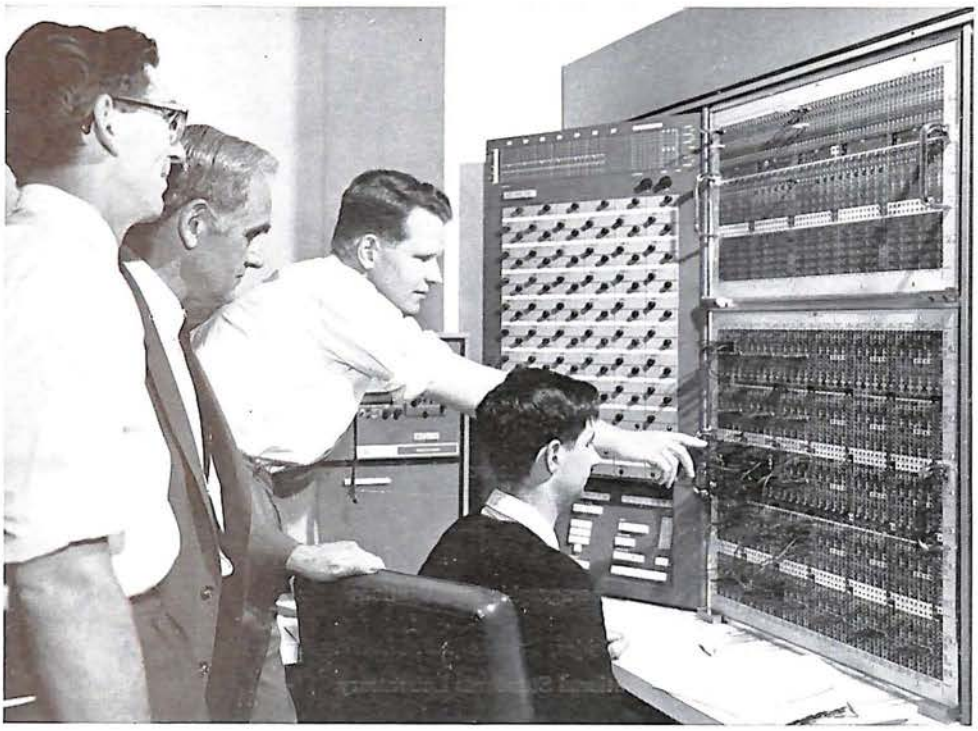
CSIRO Food Preservation Quarterly. Vol. 25 (1965).

Foodpres News. No. 13 (1965)–No. 15 (1966).

Meat Research Newsletter. No. 65/1 (1965).

Circular

7-P. Determination of thermal processes for canned foods. P. W. Board. (1965.)



A new analogue computer, which will be available for use by all Divisions, has been installed in the Division of Chemical Engineering. It was officially commissioned by Sir Frederick White, on November 23, 1965. The EAI 8800 is perhaps better described as a simulator, as it does not compute in the usual way but simulates a physical system by setting up an analogous electrical system.

Division of Forest Products

CSIRO Forest Products Newsletter. No. 320 (1965)–No. 330 (1966).

Technological Papers

36. Pulping studies on New Guinea woods. III. Investigations on various hardwood species. F. H. Phillips. (1965.)
37. Assessment of wood qualities for tree breeding. III. In *Pinus radiata* D. Don. J. W. P. Nicholls and H. E. Dadswell. (1965.)
38. Australian plant gums. I. Classification and identification of gums from arborescent Angiosperms. A. T. Proszynski, A. J. Michell, and C. M. Stewart. (1965.)
39. Tannin formaldehyde adhesives for wood. II. Wattle tannin adhesives. K. F. Plomley. (1966.)
42. Laboratory evaluation of the durability of brigalow (*Acacia harpophylla* F. Muell.) heartwood. E. W. B. Da Costa and F. J. Gay. (1966.)

Division of Land Research

Land Research Series

15. General report on lands of the Wabag–Tari area, Territory of Papua and New Guinea, 1960–61. R. A. Perry, M. J. Bik, E. A. Fitzpatrick, H. A. Haantjens, J. R. McAlpine, R. Pullen, R. G. Robbins, G. K. Rutherford, and J. C. Saunders. (1965.)

Technical Papers

26. Wet-season development pattern of some native grasses at Katherine, N.T. M. Lazarides, M. J. T. Norman, and R. A. Perry. (1965.)
28. Katherine Research Station 1956–64: A review of published work. M. J. T. Norman. (1966.)

Division of Mathematical Statistics

Technical Papers

19. Linear relationships between mean-sea-level pressure fields and point dry-bulb temperatures in the Australian region. L. G. Veitch. (1965.)
20. Recurrent events in sequences of independent binomial trials with alternating probability of success. A. M. W. Verhagen. (1965.)
21. The notion of induced probability in statistical inference. A. M. W. Verhagen. (1966.)

Division of Mechanical Engineering

Engineering Development (E.D.) Reports

9. A solar still for water desalination. W. R. Read. (1965.)
10. Unit phytotrons. K. A. Robeson. (1966.)

Division of Meteorological Physics

Technical Paper

15. The "Evapotron": an instrument for the measurement of eddy fluxes in the lower atmosphere. A. J. Dyer and F. J. Maher. (1965.)

Mineragraphic Investigations

Technical Paper

5. Mineragraphy of fault-zone sulphides, Broken Hill, N.S.W. S. M. Richards. (1966.)

National Standards Laboratory

Test Pamphlet

6. Physical metrology. (1966.)

Division of Plant Industry

Technical Papers

21. The plants of the Australian Capital Territory. Nancy T. Burbidge and M. Gray. (1965.)
22. Experiments with orchard spray treatments for the control of bitter pit in apples in Tasmania. D. Martin, T. L. Lewis, and J. Cerny. (1965.)

Soil Mechanics Section

An engineering assessment of the Tipperary area, Northern Territory, Australia.

I. Terrain classification and surface terrain parameters. K. Grant and G. D. Aitchison. (1965.)
II. Engineering characteristics of earthen materials. G. D. Aitchison, G. Renfrey, and K. Grant. (1966.)

Mobile Field Conference on Terrain Evaluation, Darwin–Mt. Isa–Cairns, August, 1964. Report. (1965.)

Technical Memoranda

4. The modification of soil by lime. (1966.)
5. A review of methods for the determination of moisture flow properties of soils. B. G. Richards. (1966.)
6. A computer program for the solution of the two-dimensional diffusion equation applied to subgrade moisture conditions. B. G. Richards. (1966.)

Technical Paper

1. Terrain features of the Mt. Isa–Dajarra region and an assessment of their significance in relation to potential engineering land use. K. Grant. (1966.)

Technical Reports

5. A thermistor hygrometer for the direct measurement of the free energy of soil moisture. B. G. Richards. (1965.)
6. Equipment to study the performance of soil samplers. J. G. Lang. (1966.)

Division of Soils

Soils and Land Use Series

48. Soils of the East Bald Hill area, Collinsville district, north Queensland. R. F. Isbell. (1966.)

Division of Wildlife Research

CSIRO Wildlife Research. Vol. 10 (1965)–Vol. 11, No. 1 (1966).

Technical Paper

9. Third and fourth annual reports on bat-banding in Australia. K. G. Simpson and E. Hamilton-Smith. (1965.)

Wool Research Laboratories

CSIRO Wool Textile News. No. 9 (1965)–No. 10 (1966).

Division of Textile Industry

Reports

G.13. Pretreatment of pure wool fabric for dry permanent setting. (1965.)
G.14. Setting durable creases and pleats in pretreated pure wool fabric. (1965.)
G.15. Treatment of woollen fabrics with soft polymers. (1965.)

Liaison Publications

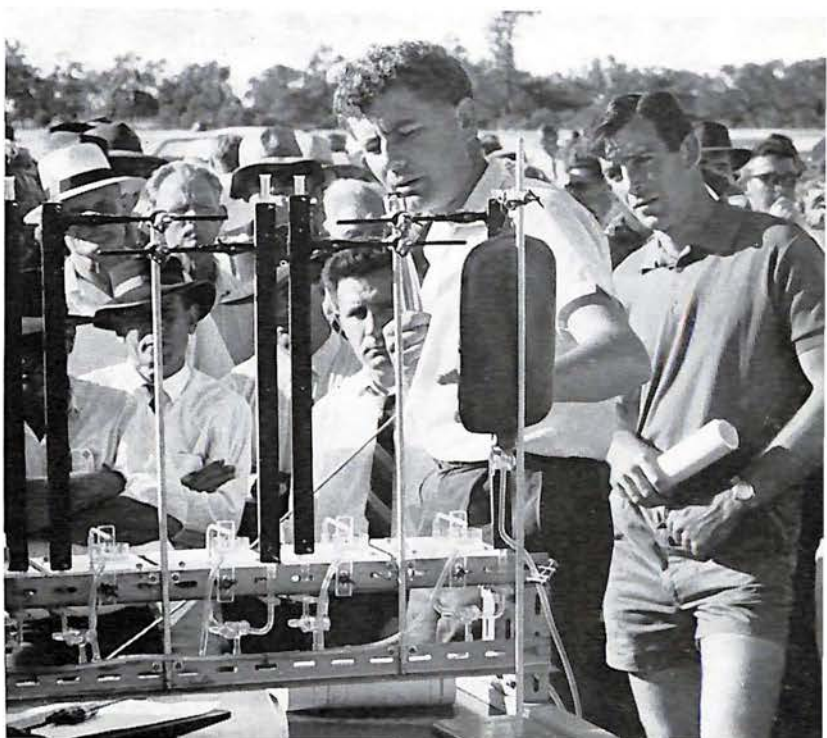
CSIRO Industrial Research News. No. 52 (1965)–No. 57 (1966).
Rural Research in CSIRO. No. 52 (1965)–No. 54 (1966).
Drying of grapes. (1966.)

Bulletin

284. Phosphorus fertilizer research in Australia. E. A. Jackson. (1966.)

Miscellaneous

Scientific Serials in Australian Libraries. (1965, 1966.)
Australian Science Index. Vols. 9–10. (1965, 1966.)
CSIRO Abstracts. Vols. 13–14. (1965, 1966.)
CSIRO Divisions and Sections. (1966.)
List of Publications. (1966.)



Nearly 400 people attended the Open Day of the Fawkner Memorial Field Station at Deniliquin, on October 27, 1965. Visitors saw the results of recent work at the Station, which has shown that gypsum can have a much wider use than was formerly thought possible, particularly on light soils where water penetration is a problem. They also saw research being carried out on weaner growth, lucerne improvement, weed control, and wheat and wool production under irrigation.

Libraries

The research laboratories of CSIRO are located in various centres, each of which is serviced by a working collection of the library material it needs. In addition, the Central Library at Head Office is responsible for acquisitions and exchange and undertakes the variety of centralized activities necessary to make the collections readily accessible to users throughout CSIRO as well as in the universities and industry. These activities include the preparation and publication of abstracts and indexes and of the union catalogue *Scientific Serials in Australian Libraries*. Together these libraries make up the CSIRO Library System, which contains 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 $600,000 annually.

Growth of the CSIRO Library System arises partly from growth of the Organization itself but more importantly from growth in the volume of published information required for scientific research. The urgent need to explore means of conserving library space was mentioned in last year's Annual Report. During the current year most of the larger libraries have energetically culled material from their shelves and are reducing holdings to those basic to the research activities of their centre. The inactive material has been forwarded to the deposit store of the Central Library or, particularly in the case of duplicate material, made available to the newly created university libraries.

Further progress has been made towards mechanization of library procedures. During the year feasibility studies of the mechanization of operations involved in handling serials and periodicals have been completed and CSIRO is about to undertake a detailed systems analysis of the whole range of clerical work in libraries before proceeding to the final step of programming for the computer. The feasibility trials have shown that the computer can handle with efficiency and economy quite a high proportion of the work now performed repetitively in the libraries of the system. In addition a draft thesaurus that gives a profile of the interests of the scientists of the Organization has been prepared as the initial stage in attacking the "information location" problem.

The demands on the library service from both within and outside CSIRO have continued to increase. A translation service is also maintained by staff located in centres in Melbourne, Canberra, Sydney, and Adelaide.

CSIRO is now the Australian National Member of the International Federation of Documentation (F.I.D.). With the increasing need for cooperation and standardization to cope with the volume of published scientific information, it is hoped that F.I.D. will play a leading part in coordinating activities in the major libraries both here and overseas.

Archives

Although on an archival basis the records of CSIR, and even of the earlier Institute for Science and Industry, are quite young, the development of science and technology in Australia is a field of special interest to the historian. The files held by CSIRO

contain much of the history of the nation's early industrial growth and of the people concerned. Biographers and historians who wish to make use of the Organization's records are encouraged to do so and the Executive has recently taken steps to provide facilities to assist them in their work. This service is now being used for several projects. A history of the Advisory Council of Science and Industry and of the Institute of Science and Industry, that were the early precursors of CSIRO, is to be published in September this year.

Scientific Films

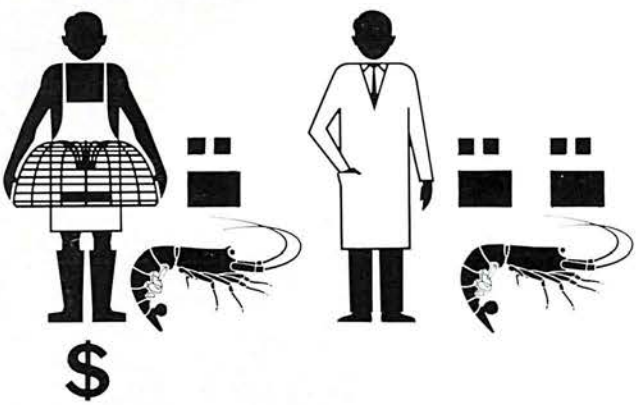
The CSIRO Film Unit has produced further films on a variety of scientific subjects. Although these films are directed at specialist audiences such as schools and universities, research scientists, and industry, many are of wider general interest.

Copies of the films are held in CSIRO Film Libraries in Melbourne, London, and Washington and in the National Film Library in Canberra. Prints are made available at half cost to State Film Centres in Australia and at net cost of printing to other approved users locally and overseas. Some films are also distributed commercially in the United States of America and Britain on a royalty basis. Television stations in Australia make considerable use of CSIRO film material, particularly in educational and rural programmes, and some films are now being produced specifically for these purposes.

The Honorary General Secretary of ANZAAS, Professor J. R. A. McMillan, presents Mr. S. T. Evans, Officer-in-Charge, CSIRO Film Unit, with the 1966 Orbit Award for the films "Birth of the Red Kangaroo" and "Window into Space".

The Film Unit has again won high recognition for the quality of its productions. The Orbit Award for the best scientific film submitted to the ANZAAS International Film Exhibition in 1966 was presented jointly to "Birth of the Red Kangaroo" and "Window into Space". The latter film was also awarded a Bronze Bucrania at the Tenth International Exhibition of Scientific–Didactic Film in Padua in September 1965. Two films, "Approach to Science" and "Bird Banding in Australia", were shown at the Commonwealth Arts Festival in London. "Approach to Science" and other films were also shown at some of the leading international scientific film exhibitions during 1965.

The Unit has continued to collaborate with ANZAAS in arranging screenings of outstanding scientific films in schools and universities in Victoria. These screenings are now arranged in all States and through them CSIRO films are being widely shown to a large audience of growing importance.



"Maintaining the Catch"—A special pamphlet, an article in the CSIRO publication "Fisheries Newsletter", the daily press, and a stylized animated film were used by the Western Australian Department of Fisheries and Fauna in the joint campaign to secure the cooperation of fishermen in limiting the size of crayfish taken.

The following 16-mm films were completed during the year:

"Aerial Attack on Grass Fires"—colour, sound, screening time 5 min.

The performance of a light crop-dusting Cessna dumping loads of 75 to 100 gallons of water on burning wheat stubble during a controlled burn-off at Orange, N.S.W., during autumn 1965.

"Birth of the Red Kangaroo"—colour, sound, screening time 21 min.

This film is a unique record of marsupial reproduction—mating, pre-birth behaviour of the pregnant female, and birth itself. The journey of the new-born young up into the pouch is shown in detail. Animated diagrams explain the significance of the oestrous cycle and gestation period, and the development of the embryo and of a delayed "blastocyst". The film was produced in collaboration with the Division of Wildlife Research.

"Embryonic Development of the Light-brown Apple Moth"—black and white, sound, screening time 18 min.

Some of the most challenging problems in biology today are concerned with "differentiation".

In this film, produced in collaboration with the Division of Entomology, time-lapse cinemicrography enables us to see the entire development of an embryo of the light-brown apple moth to the larval stage. The 6½ days that it takes have been compressed into 12 minutes on the screen.

"*A Fellow in the Film Unit*"—black and white, sound, screening time 26 min.

Mairaj Ali, a Colombo Plan Fellow, came to Australia in 1965 from the Karachi Marine Biological Research Station to study scientific film production. In this film he records his impressions of Melbourne and the CSIRO Film Unit, where he spent most of his time.

"*Maintaining the Catch*"—black and white, sound, screening time 9½ min.

This film was produced as part of a campaign to show fishermen the significance of biological research on the crayfish and the need of the industry to restrict the size of crayfish taken in catches. It contains practical advice on the fitting of escape gaps to crayfish pots. It was produced in collaboration with the Agricultural Liaison Unit, the Division of Fisheries and Oceanography, and the Western Australian Department of Fisheries and Fauna.

"*Geometric Analysis of Engineering Designs—The Theory of Position Tolerancing*"—colour, magnetically striped sound, screening time 16½ min.

Animated diagrams are used to present a new method of engineering drawing and design analysis. The film is intended primarily for trainee engineers and engineering draftsmen.

"*First Ever*"—colour, silent, screening time 8 min.

A film record of the first Victorian Brick-laying Championships, conducted at Ballarat in February 1966, produced for the Victorian Brick Manufacturers' Association.

Scientific Publications

The publication of the results of research in scientific journals provides the means of exchange of information between scientists throughout the world. The Australian Academy of Science has continued to cooperate with CSIRO in producing and in maintaining high standards in the scientific journals published by the Organization. Editorial policy is decided by a Board of Standards appointed jointly by the Academy and CSIRO. Advisory Committees for each individual journal are appointed by the Board and members of the Board serve on 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*.

Contributions to these journals are not limited to the staff of CSIRO and papers are accepted from research workers irrespective of their affiliations. A small number is received from overseas workers. The research staff of CSIRO also contributes many papers to other scientific journals, both in Australia and overseas (see "Published Papers").

Technical papers and other special publications for industry are listed on page 109.

Members of the staff have also contributed from their specialized knowledge of particular branches of science to the publication of books, as listed on page 164.

Published Papers

The following papers were published during the year ended December 31, 1965.

ANIMAL RESEARCH LABORATORIES

DIVISION OF ANIMAL GENETICS

ASHTON, G. C.[1]—Serum amylase (thread protein) polymorphism in cattle. *Genetics, Princeton*, 1965, **51**, 431.

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ASHTON, G. C.,[1] and CARR, W. R.[2]—Serum transferrins in some African antelopes. *Rhod. Zamb. Mal. J. agric. Res.*, 1965, **3**, 109.

ASHTON, G. C.,[1] and LAMPKIN, G. H.[3]—Serum albumin and transferrin polymorphism in East African cattle. *Nature, Lond.*, 1965, **205**, 209.

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BROOKER, M. G., and DOLLING, C. H. S.—Pigmentation of sheep. I. Inheritance of pigmented wool in the Merino. *Aust. J. agric. Res.*, 1965, **16**, 219.

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FINLAY, D. E.—Selection for pattern of an artificially canalised character. *Am. Nat.*, 1965, **99**, 431.

GRIGG, G. W.—Determination of nuclear ratios of microconidial strains. *Neurospora Newsl.*, 1965, **7**, 13.

GRIGG, G. W.—Induction of microconidiation or macroconidiation on the same *Neurospora* stock. *Neurospora Newsl.*, 1965, **7**, 12.

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GRIGG, G. W.—The prevention of competitive suppression in microbial plating experiments. *Nature, Lond.*, 1965, **207**, 105.

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KINDRED, B. M.—Selection for temperature sensitivity in scute *Drosophila*. *Genetics, Princeton*, 1965, **52**, 723.

[1] Present address: Department of Genetics, University of Hawaii, Honolulu.
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[6] Jagiellonian University of Cracow, Poland.
[7] Present address: "Raheen", Wallangarra, Qld.
[8] Department of Physiology, School of Rural Science, University of New England, Armidale, N.S.W.

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O'KELLY, J. C.—A study of bovine blood cholinesterase levels. *Aust. vet. J.*, 1965, **41**, 347.

PENNYCUIK, PAMELA R.—The effects of acute exposure to high temperatures on prenatal development in the mouse with particular reference to secondary vibrissae. *Aust. J. biol. Sci.*, 1965, **18**, 97.

POST, T. B.[10]—Changes in levels of salivary sodium and potassium associated with the mustering of beef cattle. *Aust. J. biol. Sci.*, 1965, **18**, 1235.

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[10] Present address: Neurochemistry Section, New Jersey Neuropsychiatric Institute, Princeton, New Jersey, U.S.A.
[11] Division of Fisheries and Oceanography, CSIRO.

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[3] University of Maryland, College Park, Md., U.S.A.

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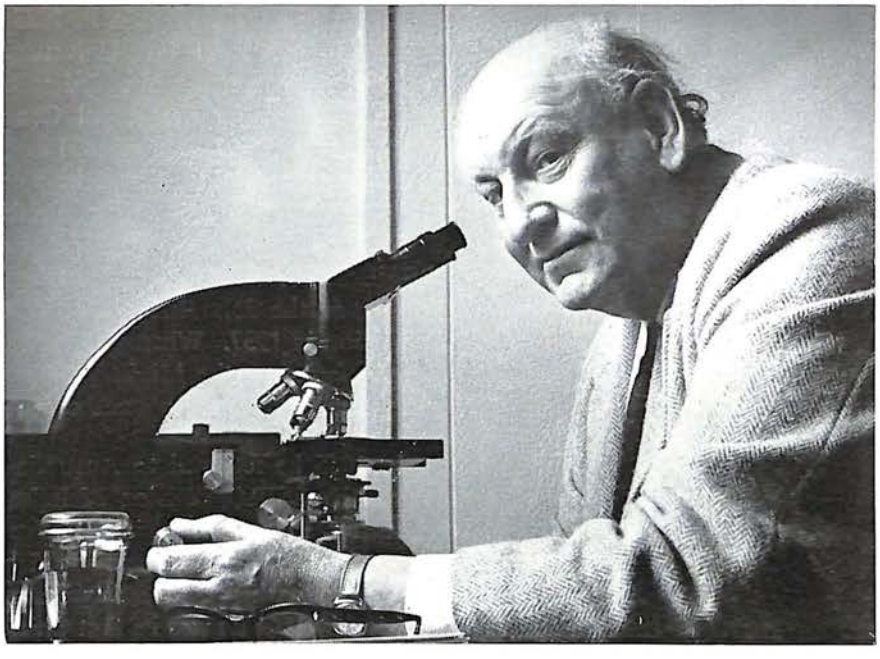
Personnel

Obituary

Dr. Hedley Ralph Marston, Chief of the Division of Biochemistry and General Nutrition, died in Adelaide on August 25, 1965, after a short illness. He was aged 64.

Dr. Marston joined the Division when it was first formed in 1927, and was appointed its Chief in 1944. Under him it developed into an outstanding research institute for the study of the physiology, biochemistry, and nutrition of ruminants, and of the sheep in particular. His own research was mainly in the following fields: energy metabolism and thermodynamics of food utilization by ruminants; nutrition and wool production; the importance of cobalt and copper for ruminant nutrition; and the nutritional physiology and metabolic function of the cobalt-containing vitamin B_{12}.

Dr. Marston was elected a Fellow of the Royal Australian Chemical Institute in 1938 and a Fellow of the Royal Society of London in 1949. He was a Foundation Fellow of the Australian Academy of Science and its first Treasurer (1954–55).



Executive Appointments

During the year four new members of the Executive have been appointed. They are Mr. W. Ives, M.Ec., Dr. J. R. Price, D.Sc., D.Phil., F.A.A., Dr. M. F. Day, B.Sc., Ph.D., F.A.A., and Dr. K. L. Sutherland, D.Sc., Ph.D., F.A.A.

Mr. Ives graduated B.Ec. in 1938 and M.Ec. in 1942 from the University of Sydney. In 1939 he joined the Bank of New South Wales as a research officer in agricultural economics, and he was appointed in 1942 to the Rural Industries Division of the Department of War Organization of Industry. At the end of the War he became a Senior Research Officer in the Bureau of Agricultural Economics, and in 1946 he joined CSIRO as Technical Secretary of the Division of Plant Industry.

Mr. Ives was made an Assistant Secretary at Head Office in 1949 and Secretary (Biological Sciences) in 1952. From 1954 to 1956 he occupied the post of Chief Scientific Liaison Officer in London. He was appointed Executive Officer in 1959 and Associate Member of the Executive in 1962.

Dr. Price graduated B.Sc. in 1933 and M.Sc. in 1935 from the University of Adelaide. He was then awarded an overseas scholarship by the Royal Commissioners for the Exhibition of 1851 and left Australia for England, where he worked at Oxford University under Professor Robert Robinson, F.R.S. After graduating D.Phil. he became Head of the Chemical Section of the John Innes Horticultural Institution in 1937. When war broke out he transferred to the Ministry of Supply and worked on propellants and explosives.

In 1945 he returned to Australia and joined the CSIRO Division of Industrial Chemistry. He was appointed Officer-in-Charge of the Organic Chemistry Section in 1960, and when the Section became a Division in 1961 he was its first Chief.

Dr. Price was awarded the D.Sc. degree by the University of Adelaide in 1954 and the H. G. Smith Memorial Medal of the Royal Australian Chemical Institute in 1956. He was President of the Institute from 1962 to 1964. He was elected a Fellow of the Australian Academy of Science in 1959.

Dr. Day joined the staff of the Division of Entomology in 1938, after graduating with honours from the University of Sydney. A few months later he was granted leave to work at Harvard University where he subsequently obtained his Ph.D. He resigned from CSIRO in 1940 to become Lehman Fellow at Harvard. During 1941–42 he lectured at Washington University, Missouri.

In 1944 he rejoined CSIRO as a member of its Scientific Liaison staff in Washington and two years later he returned to the Division of Entomology; he became an Assistant Chief of that Division in 1963.

Dr. Day was elected a Fellow of the Australian Academy of Science in 1956.

Dr. Sutherland graduated B.Sc. from the University of Melbourne in 1937 and M.Sc. in 1941. He joined the CSIRO Division of Industrial Chemistry in 1940 to continue his work on flotation, and in 1947 was awarded the Davy–Faraday Fellowship of the Royal Institution in London, where he worked for two years. He was subsequently awarded the degrees of D.Sc. by the University of Melbourne and Ph.D. by the University of London, also the Rennie Memorial Medal (1943) and the H. G. Smith Memorial Medal (1957) of the Royal Australian Chemical Institute.

Dr. Sutherland returned to CSIRO in 1950 and in 1958 he was appointed Chief

of the newly formed Division of Physical Chemistry. He was elected a Fellow of the Australian Academy of Science in 1959.

Dr. Sutherland is at present Director of Research for the Colonial Sugar Refining Company, and will serve on the Executive in a part-time capacity.

Retirements and Resignations

Dr. I. W. Wark, C.B.E., D.Sc., Ph.D., F.A.A., retired from the Executive during the year, and Sir Otto Frankel, D.Sc., D.Agr., F.A.A., F.R.S., Emeritus Professor G. M. Badger, D.Sc., Ph.D., F.A.A., and the Rt. Hon. Lord Casey, P.C., G.C.M.G., C.H., D.S.O., M.C., M.A., resigned from the Executive.

Dr. Wark has rendered outstanding service to CSIRO over the past 26 years. After a distinguished research career in universities and in industry, he undertook the formation of CSIR's Division of Industrial Chemistry in 1939. Under his leadership the Division rapidly grew into a flourishing centre for research in pure and applied chemistry.

When Dr. Wark joined the Executive in 1960, he brought a wide knowledge of the physical sciences and a keen appreciation of the problems of Australian industry. He strongly urged the encouragement of research in industry, and the strengthening of industrial sophistication to improve Australia's export position.

In recent years many honours have been conferred upon him. He was President of the Royal Australian Chemical Institute (1957–58) and Treasurer of the Australian Academy of Science (1959–63), and was elected an Honorary Member of the Australasian Institute of Mining and Metallurgy (1960) and a Fellow of University College, London (1965). In 1963 he was created C.B.E. for his outstanding services to science.

On his retirement, Dr. Wark became Chairman of the newly established Commonwealth Advisory Committee on Advanced Education.

Professor Badger joined the Executive in 1964. During his short period with CSIRO he maintained his keen interest in the training of research workers. He was Chairman of the CSIRO Studentship Committee and an advocate of closer relationships between CSIRO and the universities. He found time to fill two public offices during his term with CSIRO, as President of the Royal Australian Chemical Institute and as a member of the Commonwealth Research Grants Committee.

He resigned in order to accept the post of Deputy Vice-Chancellor of the University of Adelaide.

Sir Otto Frankel came to Australia in 1951 to lead CSIRO's largest research division, the Division of Plant Industry. Under his leadership the Division developed into one of the world's foremost centres for plant research. Research workers of the highest calibre were attracted to his laboratory in Canberra, and he built up strong teams of scientists to work in all the important fields related to plant production.

His outstanding contributions to the science of genetics were recognized by his election to a Fellowship of the Royal Society of London in 1953. He is a Fellow

and former Vice-President of the Australian Academy of Science and was a member of the Council of the Australian National University.

Sir Otto was created a Knight Bachelor in the New Year's Honours List "in recognition of his outstanding public service in the fields of plant research and biology".

He resigned to resume his research in genetics and to broaden his activities in international science.

Lord Casey became a part-time member of the Executive in 1960, when he was elevated to the peerage. His association with the Organization began in 1937, when he was appointed Minister-in-Charge of CSIR. He relinquished this post shortly after the outbreak of the war to fill a series of important posts, as Australian Minister to Washington, Member of the British War Cabinet (resident in the Middle East), and Governor of Bengal.

Lord Casey was re-elected to the House of Representatives in 1949 and once again became Minister-in-Charge of CSIRO. As a Member of the Executive he interested himself in many of the facets of work at Head Office, in the radio telescope project, the Freedom from Hunger Campaign, and the Commonwealth Scientific Committee. Lord Casey resigned in order to assume the high office of Governor-General of Australia.

Dr. T. S. Gregory, D.V.Sc., Chief of the Division of Animal Health, retired in April 1966. He joined CSIR in 1926 and spent 40 years with the Organization, except for two breaks of service. During the years 1929–37 he was at the Universities of Melbourne and London, and in 1940–46 he served with the A.I.F. In 1953 Dr. Gregory was awarded the degree of D.V.Sc. by the University of Melbourne for his studies on infectious diseases of sheep and cattle. He became Chief of the Division of Animal Health in 1959.

Dr. F. H. S. Roberts, D.Sc., retired in January 1966, after twenty years' service as Officer-in-Charge of the Veterinary Parasitology Laboratory at Yeerongpilly, Qld. Before joining CSIRO, Dr. Roberts was on the staffs of the Commonwealth Prickly Pear Board and the Queensland Department of Agriculture and Stock. During the war he served in the A.A.M.C. and attained the rank of Major. He contributed much to our knowledge of cattle ticks and the ecology and physiology of internal parasites of cattle under tropical and subtropical conditions. After his retirement, Dr. Roberts accepted a Senior Research Fellowship, under which he will prepare a monograph on Australian ticks.

Dr. C. H. Gallagher, D.V.Sc., Ph.D., of the Division of Animal Health, has resigned to take up appointment as Hughes Professor of Veterinary Pathology and Bacteriology, University of Sydney.

Mr. J. A. Mabbutt, M.A., of the Division of Land Research, has been appointed Professor of Geography in the University of New South Wales.

Dr. P. Mason, M.Sc., Ph.D., of the Division of Protein Chemistry, has been appointed Professor of Physics, Macquarie University.

Dr. G. B. Sharman, D.Sc., of the Division of Wildlife Research, has been appointed Professor of Zoology in the University of New South Wales.

Dr. J. M. Swan, D.Sc., Ph.D., of the Division of Organic Chemistry, has been appointed Professor of Organic Chemistry, Monash University.

Dr. E. O. P. Thompson, M.Sc., Ph.D., of the Division of Protein Chemistry, has been appointed Professor of Biochemistry in the University of New South Wales.

New Chiefs of Divisions

Mr. R. W. R. Muncey, M.E.E., has been appointed Chief of the Division of Forest Products. He succeeds the late Dr. H. E. Dadswell, D.Sc., who died in December 1964.

After graduating B.E.E. from the University of Melbourne in 1943, Mr. Muncey joined the CSIR Lubricants and Bearings Section (now the Division of Tribophysics), where he worked on the development of instruments for measuring the muzzle velocity of projectiles. In 1946 he transferred to the Division of Building Research, where his main interests have been in architectural acoustics, thermal insulation, and concrete slab floors for houses.

Dr. A. E. Pierce, D.Sc., Ph.D., F.R.C.V.S., has been chosen to succeed Dr. T. S. Gregory, D.V.Sc., as Chief of the Division of Animal Health. He will take up his new post in August 1966.

After graduation from the Royal Veterinary College in 1942, Dr. Pierce spent several years working on trichomoniasis of cattle at the British Ministry of Agriculture and at the University of Wisconsin. Since 1952 he has been at the Agricultural Research Council's Institute of Animal Physiology at Babraham, Cambridge. Dr. Pierce has twice spent periods in the Division of Animal Health as a guest worker. He was here in 1954–55 as an Ian McMaster Fellow, and he paid a second visit in 1962–63.

Honours and Awards

Dr. W. Boas, Chief, Division of Tribophysics: Foreign Scientific Member, Max Planck Gesellschaft.

Dr. I. Brown, Division of Physical Chemistry: Doctor of Science, University of Adelaide.

Mr. V. D. Burgmann, Chief, Division of Textile Physics: Fellow of the Textile Institute.

Mr. L. R. Clark, Division of Entomology: Syme Prize, University of Melbourne (shared).

Mr. J. Conochie, Division of Dairy Research: Silver Medal, Australian Institute of Dairy Technology.

Mr. W. T. Cooper, Division of Coal Research: Chairman, Institute of Fuel (Australian Membership).

Mr. S. T. Evans, Head Office: Chairman of the Governors, Australian Film Institute.

Sir Otto Frankel, Member of the Executive: Knight Bachelor.

Dr. J. Giovanelli, Division of Food Preservation: Goldacre Award, Australian Plant Physiology Society.

Dr. T. S. Gregory, Chief, Division of Animal Health: Gilruth Prize, Australian Veterinary Association.

Dr. S. D. Hamann, Chief, Division of Physical Chemistry: Fellow of the Australian Academy of Science.

Dr. W. E. Hillis, Division of Forest Products: Doctor of Science, University of Melbourne.

Dr. E. M. Hutton, Division of Tropical Pastures: President, Australian Institute of Agricultural Science.

Dr. R. M. Moore, Division of Tropical Pastures: Fellow, Australian Institute of Agricultural Science.

Mr. I. E. Newnham, Chief, Division of Mineral Chemistry: 1965 Chemical Society (London) Lecturer in Australia.

Dr. J. R. Philip, Assistant Chief, Division of Plant Industry: David Rivett Medal, CSIRO Officers' Association.

Dr. M. J. Ridge, Division of Building Research: Doctor of Science, University of Melbourne.

Mr. N. H. Shaw, Division of Tropical Pastures: Fellow, Australian Institute of Agricultural Science.

Dr. S. F. Smerd, Division of Radiophysics: Doctor of Science, University of Liverpool.

Sir Henry Somerset, Member of the Executive: Knight Bachelor and President, Australasian Institute of Mining and Metallurgy.

Sir Frederick White

Dr. S. D. Hamann

Mr. H. A. Stephens, Division of Applied Mineralogy: President, Australian Association of Foundry Institutes.

Dr. J. M. Swan, Division of Organic Chemistry: Doctor of Science, University of Melbourne; and Syme Prize, University of Melbourne (shared).

Mr. A. M. Thompson, Division of Applied Physics: Sperry Award, Instrument Society of America (shared).

Dr. A. D. Wadsley, Division of Mineral Chemistry: H. G. Smith Memorial Medal, Royal Australian Chemical Institute.

Sir Frederick White, Chairman of Executive: Fellow of the Royal Society.

Overseas Guest Workers in CSIRO Laboratories

Division of Animal Health	
Professor K. B. McEntee (U.S.A.)	Bovine infertility
Dr. A. A. Shalapour (Iran)	Parasitology
Mr. H. C. Tewari (India)	Parasitology
Divisions of Applied Mineralogy and Mineral Chemistry	
Dr. R. Ruh (U.S.A.)	Crystal structure analysis
Division of Chemical Physics	
Professor H. G. Hecht (U.S.A.)	Theoretical chemistry
Dr. G. Lehmpfuhl (Germany)	Electron scattering
Professor R. C. Williams (U.S.A.)	Electron microscopy
Division of Coal Research	
Dr. R. A. Friedel (U.S.A.)	Infrared spectroscopy
Dr. K. Ouchi (Japan)	Electrical properties of coal
Mr. P. S. Kulkarni (India)	Mass spectroscopy
Division of Entomology	
Dr. J. Rehacek (Czechoslovakia)	Insect tissue culture
Dr. J. A. L. Watson (Britain)	Taxonomy
Dr. A. C. S. Crossley (Britain)	Insect physiology
Division of Food Preservation	
Professor H. D. Naumann (U.S.A.)	Meat research
Professor E. Epstein (U.S.A.)	Food microbiology
Dr. E. Allen (U.S.A.)	Food chemistry
Horticultural Research Section	
Dr. S. D. Van Gundy (U.S.A.)	Nematology
Irrigation Research Section	
Mr. A. G. George (U.S.A.)	Cotton agronomy
Mr. B. B. Fischer (U.S.A.)	Weed control in cotton
Division of Land Research	
Dr. J. V. Lake (Britain)	Plant–soil–water relationships
Division of Physics	
Professor J. A. Cowan (Canada)	Low-temperature crystallography
Division of Plant Industry	
Mr. S. Kawanabe (Japan)	Ecology of pasture grasses
Mr. S. Isobe (Japan)	Crop canopies
Dr. G. Anderson (Britain)	Organic phosphorus in soil
Dr. D. J. C. Friend (Canada)	Growth of cereals
Professor J. A. Businger (U.S.A.)	Micrometeorology
Dr. J. H. Campbell (U.S.A.)	Gene and enzyme evolution
Dr. Lijljan Tosic (Yugoslavia)	Tobacco diseases
Professor R. F. Labbe (U.S.A.)	Porphyrin biosynthesis
Professor H. Highkin (U.S.A.)	Physiological genetics
Division of Radiophysics	
Dr. I. Moiseyev (U.S.S.R.)	Solar radio astronomy
Dr. G. Tovmassian (U.S.S.R.)	Galactic radio astronomy
Dr. J. Hanasz (Poland)	Solar radio astronomy
Division of Soils	
Dr. W. E. Larson (U.S.A.)	Soil strength
Dr. B. Mosse (Britain)	Soil microbiology
Mr. Shim Sang Yung (Korea)	Water relations of forest soils
Mr. M. A. Hammad (U.A.R.)	Soil science
Mr. B. R. Gangwar (India)	Soil microbiology
Division of Wildlife Research	
Professor J. Mary Taylor (Canada)	The genus *Rattus*
Professor B. Elizabeth Horner (U.S.A.)	The genus *Rattus*
Miss P. Berger (U.S.A.)	Breeding of the tammar wallaby
Division of Protein Chemistry	
Dr. R. E. Peterson (U.S.A.)	Enzyme purification
Mr. T. Haylett (South Africa)	Amino acid studies

Advisory Council

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E. P. S. Roberts
Sir Henry Somerset, Kt., C.B.E., M.Sc.
K. L. Sutherland, Ph.D., D.Sc., F.A.A.

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Victoria—L. W. Weickhardt, M.Sc.

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W. J. Russell
L. W. Samuel, B.Sc., Ph.D.
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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, 1966

OFFICE OF THE EXECUTIVE

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

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At Beef Cattle Research Unit, Cunningham Laboratory, Brisbane
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Principal Research Scientist—L. J. Lambourne, M.Sc.(Hons.), Ph.D.
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Architectural Acoustics

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Principal Research Scientist—A. F. B. Nickson, M.Sc.
Experimental Officer—W. A. Davern, A.R.M.T.C.
Experimental Officer—P. Dubout, B.Sc.

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Senior Research Scientist—K. G. Martin, B.Sc. (Hons.)
Research Scientist—K. R. Rao, M.Sc., Ph.D.
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Experimental Officer—L. F. O'Brien, A.R.M.I.T.
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Research Scientist—J. Beretka, B.Ch.Eng., M.Sc.
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Experimental Officer—B. C. Molony, A.F.T.C.

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Principal Research Scientist—E. Hoffmann, Dr. Phil.
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Building Operations and Economics

Principal Research Scientist—F. J. Bromilow, M.Sc., Ph.D.
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See Chemical Research Laboratories

DIVISION OF CHEMICAL PHYSICS

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Research Scientist—I. R. Jorgensen, B.Eng., Ph.D.
Research Scientist—G. M. Lukaszewski, M.Sc., Ph.D.
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Experimental Officer—K. J. A. Perger, Dip. Radio Eng.
Experimental Officer—L. J. Rogers, A.R.M.T.C.
Experimental Officer—P. R. Smith, A.R.M.T.C.
Experimental Officer—D. A. Swift, A.R.M.I.T.
Experimental Officer—J. A. Watts, A.R.M.T.C.
Experimental Officer—B. W. Wilson, B.Sc.
Engineer—G. H. Weeks, B.E.E.

DIVISION OF ORGANIC CHEMISTRY

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Principal Research Scientist—J. A. Lamberton, B.Sc.(Hons.), Ph.D.
Principal Research Scientist—K. W. Zimmerman, Dr.Ing. (*at University of Melbourne*)
Senior Research Scientist—L. K. Dalton, A.S.T.C.
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Chief Research Scientist—D. E. Weiss, D.Sc.
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Principal Research Scientist—I. Brown, D.Sc.
Principal Research Scientist—L. F. Evans, D.S.M.B.
Principal Research Scientist—A. Ewald, B.Sc., Ph.D. (*at University of Sydney*)
Principal Research Scientist—V. A. Garten, D.Sc.
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Senior Principal Research Scientist—W. T. Williams, Ph.D., D.Sc., D.I.C.
Principal Research Scientist—C. E. Wallington, M.Sc.
Senior Research Scientist—M. B. Clowes, B.Sc., Ph.D.
Senior Research Scientist—T. S. Holden, B.Sc.
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Research Scientist—B. J. Austin, M.Sc., Ph.D.
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Experimental Officer—D. J. Langridge, B.Sc.
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Experimental Officer—J. P. Penny, M.Sc., Ph.D.

Adelaide Subsidiary: at University of Adelaide, S.A.

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Experimental Officer—D. R. Ross, B.Sc.
Scientific Services Officer—E. H. Kinney, B.S.

Melbourne Subsidiary: at David Rivett Laboratory, Clayton, Vic.

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Experimental Officer—J. Tindale, B.Sc.(Hons.)
Scientific Services Officer—R. J. Hurle, B.Sc.

Sydney Subsidiary: at National Standards Laboratory, Chippendale, N.S.W.

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Scientific Services Officer—G. S. Masters, B.Sc.
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Principal Research Scientist—D. A. Forss, M.Sc.
Principal Research Scientist—R. D. Hill, B.Sc., B.Com.
Principal Research Scientist—E. G. Pont, M.Sc. Agr.
Senior Research Scientist—R. Beeby, A.R.M.T.C.
Senior Research Scientist—J. Conochie, B.Sc. (Agric.)
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Experimental Officer—J. F. Hayes, B.Sc.
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Experimental Officer—F. G. Kieseker, B.Agr.Sc.
Experimental Officer—A. J. Lawrence, B.Sc.
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See Chemical Research Laboratories

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See Animal Research Laboratories

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See Chemical Research Laboratories

DIVISION OF PHYSICAL CHEMISTRY

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See National Standards Laboratory

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Senior Research Scientist—W. D. Andrew, M.Agr.Sc. (*seconded to F.A.O.*)
Research Scientist—H. Doing, D.Agr.Sc., Ph.D.
Research Scientist—P. W. Michael, B.Ag.Sc. (Hons.), Ph.D.
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At Wagga Agricultural Research Institute (New South Wales Department of Agriculture)

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At Regional Laboratory, Armidale, N.S.W.

Pasture Investigations

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At Waste Point (Kosciusko State Park)

Alpine Ecology

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At Riverina Laboratory, Deniliquin, N.S.W.

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At University of Queensland

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Soil Chemistry

Senior Research Scientist—J. D. Colwell, B.Sc.Agr.(Hons.), Ph.D.
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Senior Research Scientist—D. S. McIntyre, M.Sc., Ph.D.
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SUGAR RESEARCH LABORATORY

See Chemical Research Laboratories

TASMANIAN REGIONAL LABORATORY

Headquarters: Stowell Avenue, Hobart

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DIVISION OF TEXTILE PHYSICS

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UPPER ATMOSPHERE SECTION

Headquarters: Carrington Road, Camden, N.S.W.

Officer-in-Charge—D. F. Martyn, Ph.D., D.Sc., F.A.A., F.R.S.
Principal Research Scientist—E. B. Armstrong, B.Sc., Ph.D.
Senior Research Scientist—R. A. Duncan, D.Sc.
Experimental Officer—D. G. Cartwright, B.Sc. (Hons.)
Experimental Officer—R. A. Challinor, Ph.D.
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.
Senior Research Scientist—D. J. Winzor, B.Sc. (Hons.), Ph.D.
Experimental Officer— Mrs. I. C. Barnes, B.Sc.
Experimental Officer—Mrs. J. P. Loke, B.Sc.
Experimental Officer—J. A. Ronalds, B.Sc.
Experimental Officer—M. Wootton, B.Sc.(Hons.) (*on leave*)
Experimental Officer—C. W. Wrigley, M.Sc. (*on leave*)

DIVISION OF WILDLIFE RESEARCH

Headquarters: Barton Highway, Canberra, A.C.T.

Administration

Chief—H. J. Frith, D.Sc.Agr.
Administrative Officer—P. E. R. Magi, B.A.
Librarian—Mrs. J. F. Bland

Marsupial Biology

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.) (*on study leave*)
Experimental Officer—D. L. McIntosh

Rabbit Biology

Principal Research Scientist—K. Myers, B.Sc. (Hons.)
Senior Research Scientist—J. D. Dunsmore, B.V.Sc., Ph.D.
Senior Research Scientist—R. Mykytowycz, D.V.M.
Research Scientist—P. J. Fullagar, B.Sc.(Hons.), Ph.D.
Research Scientist—R. L. Hughes, B.Sc.(Hons.)
Experimental Officer—K. D. Casperson, B.Sc. (Hons.)
Experimental Officer—I. P. Parer, B.Agr.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—S. J. J. F. Davies, B.A.(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—A. E. Newsome, M.Sc.
Research Scientist—G. F. van Tets, M.A., Ph.D.
Experimental Officer—L. W. Braithwaite, B.Sc.
Experimental Officer—F. N. Robinson, B.A. (*at Perth*)
Experimental Officer—A. K. Shipway, B.Sc. (Hons.) (*at Alice Springs*)

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 Research Laboratories Committee

F. G. Lennox, D.Sc. (*Chairman*)
V. D. Burgmann, B.Sc., B.E.
M. Lipson, B.Sc., Ph.D.

DIVISION OF PROTEIN CHEMISTRY

Headquarters: 343 *Royal Parade, Parkville, Vic.*

Chief—F. G. Lennox, D.Sc.
Assistant Chief—W. G. Crewther, M.Sc.
Administrative Officer—B. G. Bond
Librarian—Mrs. J. M. Dye, B.A.
Senior Principal Research Scientist—R. D. B. Fraser, Ph.D., D.Sc.
Senior Principal Research Scientist—H. Lindley, B.A., Ph.D.
Principal Research Scientist—J. M. Gillespie, D.Sc. (*overseas*)
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., Dip.Ed., Ph.D.
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.(Hons.), Ph.D.
Research Scientist—G. M. Bhatnagar, M.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—E. Suzuki, B.Eng.
Research Scientist—B. J. Sweetman, M.Sc., Ph.D.
Research Scientist—M. A. W. Thomas, B.Sc., D.Phil.
Research Scientist—J. R. Yates, M.A., Ph.D.
Engineer—E. P. Lhuede, B.Mech.E.
Scientific Services Officer—C. Garrow, M.Ag.Sc., B.Com., D.P.A., A.A.S.A.
Scientific Services Officer—J. P. E. Human, M.Sc., Ph.D.
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.
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—Mrs. C. A. Money, M.Sc.
Experimental Officer—D. E. Rivett, F.R.M.I.T.
Experimental Officer—R. J. Rowlands, B.Sc.
Experimental Officer—C. M. Roxburgh, B.Sc., Ph.D.
Experimental Officer—I. W. Stapleton, B.Sc., Dip.App.Chem., Ph.D.
Experimental Officer—K. I. Wood, A.R.M.T.C.
Experimental Officer—Miss A. F. Woodlock, B.Sc.(Hons.)

DIVISION OF TEXTILE INDUSTRY

Headquarters: Princes Highway, Belmont, Geelong, Vic.

Chief—M. Lipson, B.Sc., Ph.D.
Assistant Chief—G. W. Walls, B.Sc.
Administrative Officer—J. H. G. Watson, A.A.S.A.
Librarian—Miss L. A. MacGowan
Principal Research Scientist—J. Delmenico, B.Sc., Ph.D.
Principal Research Scientist—A. J. Farnworth, M.B.E., M.Sc., A.G.Inst.Tech., Ph.D. (*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—P. R. Brady, M.Sc., Ph.D.
Research Scientist—J. H. Brooks, M.Sc., Ph.D.
Research Scientist—J. Lappage, 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—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. 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.
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.
Assistant Chief—J. G. Downes, B.Sc.
Engineer (*Acting Divisional Secretary*)—H. W. M. Lunney, B.Sc., B.E.
Librarian—Mrs. Y. B. Esplin, B.Sc., Dip.Lib.
Senior Principal Research Scientist—M. Feughelman, B.Sc., A.S.T.C.
Principal Research Scientist—E. G. Bendit, B.Sc.(Eng.), M.Sc.
Principal Research Scientist—A. R. Haly, M.Sc.
Principal Research Scientist—Mrs. K. R. Makinson, M.A.
Senior Research Scientist—K. Baird, M.Sc., Ph.D.
Senior Research Scientist—H. G. David, B.Sc., Dip.Ed.
Senior Research Scientist—E. F. Denby, B.Sc., Ph.D., D.I.C.
Senior Research Scientist—H. W. Holdaway, B.Sc., M.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., A.S.T.C., Ph.D.
Senior Research Scientist—B. J. Rigby, M.Sc., 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—B. H. Mackay, B.Sc., Dip. App.Phys.
Research Scientist—R. Postle, B.Sc., Ph.D.
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, M.Sc.
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—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.
Experimental Officer—T. W. Mitchell, A.S.T.C.
Experimental Officer—A. McD. Richardson, B.E.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*)
Experimental Officer—L. Heisler, B.Sc. (*seconded to Electrical Engineering Department, University of Sydney*)
Experimental Officer—T. E. Treffry, B.Sc.Agr. (*on leave*)
Experimental Officer—W. Muller, B.E.E. (*on leave*)

5

Finance

A summary of the Organization's receipts and expenditure from July 1, 1965, to June 30, 1966, has been given on pages 6–10. Details are given below:

Expenditure

	$	$	$
SALARIES AND CONTINGENCIES*			**1,737,663**
INVESTIGATIONS			
ANIMAL RESEARCH LABORATORIES			
Gross Expenditure		4,215,041	
Animal Genetics			
Gross Expenditure		1,074,159	
LESS Contributions from—			
Wool Research Trust Fund	329,075		
Meat Research Trust Account	54,760		
Special Revenue Fund—"Belmont" Field Station ..	30,062		
†U.S. National Institutes of Health	8,686		
Total Contributions		422,583	
Net Treasury Expenditure			651,576
Animal Health			
Gross Expenditure		1,243,564	
LESS Contributions from—			
Wool Research Trust Fund	196,470		
Alexander Fraser Memorial Fund	373		
Dairy Produce Research Trust Account ..	11,835		
Ian McMaster Bequest	7,872		
Meat Research Trust Account	81,906		
Merck, Sharp & Dohme (Aust.) Pty. Ltd. ..	6,644		
Total Contributions		305,100	
Net Treasury Expenditure			938,464

* 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 Physiology			
Gross Expenditure		1,411,571	
LESS Contributions from—			
Wool Research Trust Fund	1,147,700		
Burdekin Bequest (Drought Feeding)	636		
Meat Research Trust Account	92,835		
Total Contributions		1,241,171	
Net Treasury Expenditure			170,400
Nutritional Biochemistry			
Gross Expenditure		485,747	
LESS Contributions from—			
Wool Research Trust Fund	176,568		
Total Contributions		176,568	
Net Treasury Expenditure			309,179
PLANT INDUSTRY			
Gross Expenditure		2,999,449	
LESS Contributions from—			
Wool Research Trust Fund	705,490		
†Christmas Island Phosphate Commission ..	827		
Dairy Produce Research Trust Account ..	13,468		
Department of Primary Industry	17,991		
†Fisons Pest Control and J. R. Geigy	40,782		
†Foundation for International Potash Research ..	727		
Legacy of the late J. O. Holston	283		
Meat Research Trust Account	16,926		
Pipeline Technologists Pty. Ltd.	392		
Tobacco Industry Trust Account	151,655		
Wheat Research Trust Account	20,694		
Wollogorang Pastoral Company	773		
Total Contributions		970,008	
Net Treasury Expenditure			2,029,441

† Overseas organization.

	$	$	$
ENTOMOLOGY AND WILDLIFE			
Gross Expenditure		2,036,418	
Entomology			
Gross Expenditure		1,454,859	
LESS Contributions from—			
Wool Research Trust Fund	47,787		
Department of Health	82,322		
Department of Primary Industry	32,665		
General Donations	247		
Meat Research Trust Account	104,070		
N.S.W. Forestry Commission, N.S.W. Department of Agriculture, and Department of Primary Industry	10,271		
River Murray Commission, Snowy Mountains Hydro-Electric Authority, and Kosciusko State Park Trust	5,059		
Special Revenue Account—Amberley	2,731		
†U.S. National Institutes of Health	4,540		
Wheat Research Trust Account	3,192		
Total Contributions		292,884	
Net Treasury Expenditure			1,161,975
Wildlife Research			
Gross Expenditure		581,559	
LESS Contributions from—			
Wool Research Trust Fund	181,029		
Department of Civil Aviation	21,334		
Meat Research Trust Account	7,816		
Total Contributions		210,179	
Net Treasury Expenditure			371,380
SOILS			
Gross Expenditure		1,158,235	
LESS Contributions from—			
Australian Mining Industries Research Association ..	172		
Bureau of Mineral Resources	297		
Commonwealth Fertilizers & Chemicals Ltd., Australian Fertilizers Ltd., Cuming Smith and Mt. Lyell Farmers Fertilizers Ltd.	4,415		
†Department of Agriculture, British Solomon Islands ..	384		
†International Atomic Energy Agency	464		
†Rockefeller Foundation	3,362		
S.A. Woods and Forests Department, W.A. Forests Department, and Australian Paper Manufacturers Ltd.	7,946		
Wheat Research Trust Account	36,510		
Total Contributions		53,550	
Net Treasury Expenditure			1,104,685

† Overseas organization.

	$	$	$
HORTICULTURE AND IRRIGATION			
Gross Expenditure		700,465	
Horticultural Research			
Gross Expenditure		321,959	
LESS Contributions from—			
Australian Dried Fruits Association	1,755		
Australian Wine Board and Department of Primary Industry	5,376		
Dried Fruits Control Board	494		
Dried Vine Fruits Research Committee	1,732		
Packing Companies and Co-operative Dried Fruit Sales Pty. Ltd.	100		
Special Revenue Fund—Coomealla, N.S.W. ..	9,108		
Total Contributions		18,565	
Net Treasury Expenditure			303,394
Irrigation Research			
Gross Expenditure		378,506	
LESS Contributions from—			
N.S.W. Water Conservation and Irrigation Commission	5,341		
Special Revenue Fund—Irrigation Research Laboratory, Griffith, N.S.W.	14,344		
Total Contributions		19,685	
Net Treasury Expenditure			358,821
TROPICAL PASTURES			
Gross Expenditure		943,908	
LESS Contributions from—			
A.C.F. & Shirleys Fertilizers Ltd.	7,923		
Dairy Produce Research Trust Account ..	35,214		
Meat Research Trust Account	136,298		
Special Revenue Fund—Samford Farm	8,144		
Total Contributions		187,579	
Net Treasury Expenditure			756,329

	$	$	$
LAND RESEARCH			
Gross Expenditure		1,122,568	
LESS Contributions from—			
Department of National Development	17,969		
Department of Territories	145,150		
F. C. Pye Research Fund	3,542		
Meat Research Trust Account	21,481		
Northern Territory Administration	26,888		
W.A. Department of Agriculture	14,866		
Total Contributions		229,896	
Net Treasury Expenditure			892,672
PROCESSING OF AGRICULTURAL PRODUCTS			
Gross Expenditure		3,179,505	
Food Preservation			
Gross Expenditure		1,142,650	
LESS Contributions from—			
Australian Apple and Pear Board	2,374		
Australian Canned Fruits Board	1,121		
Australian Dried Fruits Association and Department of Primary Industry	604		
Australian Dried Fruits Board	88		
Australian Egg Board	1,020		
Australian Meat Board	1,021		
Department of Primary Industry	7,371		
Meat Research Trust Account	62,690		
Metropolitan Meat Industry Board of N.S.W.	1,369		
N.S.W. Department of Agriculture	8,291		
Rice Marketing Board	1,089		
†U.S. Department of Agriculture	23,771		
Various Contributors	21,428		
Total Contributions		132,237	
Net Treasury Expenditure			1,010,413
Dairy Research			
Gross Expenditure		429,734	
LESS Contributions from—			
Dairy Produce Research Trust Account	149,379		
Total Contributions		149,379	
Net Treasury Expenditure			280,355

† Overseas organization.

	$	$	$
Wheat Research			
Gross Expenditure		70,910	
LESS Contributions from—			
Wheat Research Trust Account	55,710		
Total Contributions		55,710	
Net Treasury Expenditure			15,200
Wool Research			
Gross Expenditure		1,536,210	
LESS Contributions from—			
Wool Research Trust Fund	1,518,384		
Blanket Freight Equalization Fund	113 Cr.		
Wool Buying and Selling Account	17,939		
Total Contributions		1,536,210	
Net Treasury Expenditure			NIL
CHEMICAL RESEARCH OF INDUSTRIAL INTEREST			
Gross Expenditure		3,164,359	
Chemical Research Laboratories			
Gross Expenditure		2,348,450	
LESS Contributions from—			
Wool Research Trust Fund	35,586		
Australian Mineral Industries Research Association	6,876		
Colonial Sugar Refining Co. Ltd.	787		
Conzinc Riotinto of Australia Ltd.	9,967		
Conzinc Riotinto of Australia Ltd. and Monsanto Chemicals	1,716		
General Donations	5,725		
James Cumming & Sons	432		
Mary Kathleen Uranium Ltd.	196		
Meat Research Trust Account	18,610		
National Coal Research Advisory Committee ..	22,187		
†Perkin Elmer Corporation	951		
Ricegrowers Co-operative Mills Ltd.	341		
†Smith, Kline, and French Laboratories (U.S.A.) ..	5,669		
Techtron Pty. Ltd.	429		
Union Carbide Australia Ltd.	194		
†U.S. National Institutes of Health	18,650		
Total Contributions		128,316	
Net Treasury Expenditure			2,220,134

† Overseas organization.

	$	$	$
Protein Chemistry			
Gross Expenditure		815,909	
LESS Contributions from—			
Wool Research Trust Fund	706,527		
Leather Industry Research Fund	59,937		
Leather Research Fund	1,201		
Wool Buying and Selling Account	1,247		
Total Contributions		768,912	
Net Treasury Expenditure			46,997
FISHERIES AND OCEANOGRAPHY			
Gross Expenditure		681,565	
LESS Contributions from—			
Department of Harbours and Marine	16,656		
Department of the Navy	454		
Department of Primary Industry and Tasmanian Department of Agriculture	31,295		
Total Contributions		48,405	
Net Treasury Expenditure			633,160
PROCESSING AND USE OF MINERAL PRODUCTS			
Gross Expenditure		1,833,403	
Coal Research			
Gross Expenditure		843,385	
LESS Contributions from—			
Electricity Commission of N.S.W.	5,148		
Electricity Trust of South Australia	17,257		
General Donations	6,202		
National Coal Research Advisory Committee ..	28,255		
State Electricity Commission of Victoria ..	6,793		
Total Contributions		63,655	
Net Treasury Expenditure			779,730

	$	$	$
Chemical Research Laboratories			
Gross Expenditure		760,317	
LESS Contributions from—			
Cement and Concrete Association of Australia ..	16,211		
Conzinc Riotinto of Australia Ltd.	17,549		
Conzinc Riotinto of Australia Ltd. and New Broken Hill Consolidated Ltd.	4,716		
Department of National Development	2,237		
Electrolytic Zinc Company	2,322		
General Donations	1,383		
Ian Potter Foundation	1,997		
Mount Isa Mines Ltd.	5,259		
Murphyores Pty. Ltd.	7,055		
Reserve Bank of Australia	19,583		
State Electricity Commission of Victoria, Gas & Fuel Corporation of Victoria, and Australian Paper Manufacturers Ltd.	4		
†W. R. Grace Pty. Ltd. and Georgia Kaolin ..	1,510		
Total Contributions		79,826	
Net Treasury Expenditure			680,491
Mining and Metallurgy			
Gross Expenditure		229,701	
LESS Contributions from—			
Australasian Institute of Mining and Metallurgy ..	7,516		
Bureau of Mineral Resources and Australian Mineral Industries Research Association	2,027 Cr.		
General Donations	14,208		
McArthur Development Company	1,229		
State Electricity Commission of Victoria ..	28		
Total Contributions		20,954	
Net Treasury Expenditure			208,747
PHYSICAL RESEARCH OF INDUSTRIAL INTEREST			
Gross Expenditure		2,041,328	
National Standards Laboratory			
Gross Expenditure		2,041,328	
LESS Contributions from—			
Length Measurement Research Fund	242		
†U.S. Air Force	54 Cr.		
†U.S. National Aeronautics and Space Administration	12,021		
†U.S. National Bureau of Standards	18,478		
Total Contributions		30,687	
Net Treasury Expenditure			2,010,641

† Overseas organization.

	$	$	$
GENERAL PHYSICAL RESEARCH			
Gross Expenditure		1,937,765	
Radiophysics			
Gross Expenditure		1,342,928	
LESS Contributions from—			
N.S.W. and Queensland Governments	22,190		
†U.S. National Aeronautics and Space Administration	25,388		
Total Contributions		47,578	
Net Treasury Expenditure			1,295,350
Meteorological Physics			
Gross Expenditure		400,354	
LESS Contributions from—			
Tobacco Research Trust Account	590		
Total Contributions		590	
Net Treasury Expenditure			399,764
Upper Atmosphere			
Net Treasury Expenditure			109,822
Radio Research Board			
Gross Expenditure		84,661	
LESS Contributions from—			
Postmaster-General's Department, Australian Broadcasting Control Board, and Overseas Telecommunications Commission	44,661		
Total Contributions		44,661	
Net Treasury Expenditure			40,000

† Overseas organization.

	$	$	$
GENERAL INDUSTRIAL RESEARCH			
Gross Expenditure		1,650,062	
Building Research			
Gross Expenditure		634,813	
LESS Contributions from—			
Associated Fibrous Plaster Manufacturers of Australia, Australian Plaster Industries Ltd., and Colonial Sugar Refining Co. Ltd.	6,164		
Cement and Concrete Association of Australia ..	9,503		
Housing Commission of Victoria, State Electricity Commission of Victoria, Victorian Railways Department	1,567		
Whitelaw Monier Pty. Ltd.	567		
Total Contributions		17,801	
Net Treasury Expenditure			617,012
Tribophysics			
Gross Expenditure		344,937	
LESS Contributions from—			
Union Carbide Australia Ltd.	4,579		
Total Contributions		4,579	
Net Treasury Expenditure			340,358
Soil Mechanics			
Gross Expenditure		304,225	
LESS Contributions from—			
Department of the Army	45,537		
S.A. Housing Trust and S.A. Department of Mines ..	2,146		
Water Research Foundation of Australia ..	240		
Total Contributions		47,923	
Net Treasury Expenditure			256,302
Mechanical Engineering			
Gross Expenditure		366,087	
LESS Contributions from—			
General Donations	592		
†University of Wisconsin	1,591		
Wheat Research Trust Account	37,611		
Total Contributions		39,794	
Net Treasury Expenditure			326,293

† Overseas organization.

	$	$	$
PROCESSING OF FOREST PRODUCTS			
Gross Expenditure		1,135,793	
Forest Products			
Gross Expenditure		1,135,793	
LESS Contributions from—			
Australian Paper Manufacturers Ltd. Associated Pulp and Paper Mills Ltd. Australian Newsprint Mills Pty. Ltd. New Zealand Forest Products Ltd. ..	15,053		
Australian Plywood Board	22,901		
†Department of Forestry, British Solomon Islands ..	2,520		
†Department of Forestry, Fiji	3,731		
Department of Territories	8,872		
General Donations	257		
Total Contributions		53,334	
Net Treasury Expenditure			1,082,459
RESEARCH SERVICES			
Gross Expenditure		1,982,166	
Computing Research			
Net Treasury Expenditure			550,042
Mathematical Statistics			
Net Treasury Expenditure			330,458
Extramural Investigations			
Net Treasury Expenditure			147,054
Other Services			
Gross Expenditure		954,612	
LESS Contributions from—			
Wool Research Trust Fund	43,813		
Total Contributions		43,813	
Net Treasury Expenditure			910,799

† Overseas organization.

	$	$	$
MISCELLANEOUS			
Patent Fees		20,173	
Furlough and Compensation		119,441	
Unattached Officers		55,908	
Various		121,613	
Gross Expenditure		317,135	
LESS Contributions from—			
David Rivett Memorial Fund	4,074		
Total Contributions		4,074	
Net Treasury Expenditure			313,061
TOTAL TREASURY EXPENDITURE—INVESTIGATIONS			**23,652,958**
OTHER SERVICES			
Research Associations—Grants			
Bread Research Institute	42,500		
Wine Research Institute	15,000		
Coal Association (Research) Ltd.	40,000		
Australian Leather Research Association ..	42,176	139,676	
Overseas Research Studentships		319,503	
Other Grants			
Commonwealth Agricultural Bureaux	164,600		
Standards Association of Australia	274,000		
National Association of Testing Authorities ..	59,228		
Minor International Associations	16,663	514,491	
TOTAL OTHER SERVICES			**973,670**
TOTAL SALARIES AND CONTINGENCIES, INVESTIGATIONS, AND OTHER SERVICES			**26,364,291**
LESS Receipts from sales of equipment, publications, etc., and revenue earned by Divisions and Sections, details of which are shown on page 230			612,582
TOTAL TREASURY EXPENDITURE			**25,751,709**

Contributions

This section shows receipts and disbursements during the year 1965–66 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 228–30. Of the total expenditure of $8,281,541 recorded in this Fund, $7,442,297 refers to normal research activities and $839,244 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	5,087,250	365,656	5,452,906
Contributions (other than Wool)	2,355,047	473,588	2,828,635
	7,442,297	839,244	8,281,541

The details are as follows:

	Receipts 1965–66 & *Balances brought forward* 1964–65	*Expenditure* 1965–66
	$	$
Wool Research Trust Fund (*details are shown on pages 228–30*)	5,695,257	5,452,905
Animal Research Laboratories		
Alexander Fraser Memorial Fund—*Fluke Investigations* ..	373	373
Beef Cattle Nutrition Account (Animal Physiology) ..	177	NIL
Burdekin Bequest—*Drought Feeding Investigations* ..	908	636
Dairy Produce Research Trust Account—*Endoparasites of Dairy Cattle*	4,034	3,524
Dairy Produce Research Trust Account—*Infertility in Dairy Cattle*	8,959	5,783
Dairy Produce Research Trust Account—*Virus Diseases of Dairy Cattle*	4,000	2,528
Estate of the late Captain Ian McMaster—*Scholarship* ..	12,874	7,871
General Donations (Animal Health)	26	NIL
General Donations—*Myxomatosis Investigations* ..	145	NIL
Meat Research Trust Account—*Genetic Studies*	63,360	54,760
Meat Research Trust Account—*Virological Diseases of Cattle*	49,786	52,160*
Meat Research Trust Account—*Acquisition of Property at Jimboomba for Cattle Tick Investigations*	99,202	68,386
Meat Research Trust Account—*Nutritional Studies* ..	83,426	82,255
Meat Research Trust Account—*Bloat Research*	15,798	10,581
Merck, Sharp & Dohme (Aust.) Pty. Ltd.—*Anthelmintics Research*	15,543	6,644
†Population Council Inc.—*Studies on Induced Infertility* ..	39	NIL
Special Revenue Fund—"*Belmont*" *Field Station, Rockhampton, Qld.*	45,434	30,062
†U.S. National Institutes of Health—*Chemical, Physical, and Genetic Studies of Myxoma Virus*	9,100	8,686
†U.S. National Institutes of Health—*Visit of Dr. Druger* ..	51	NIL

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	Receipts 1965–66 & *Balances brought forward* 1964–65 $	*Expenditure* 1965–66 $
Plant Industry		
Apple and Pear Board—*Contribution to Expenses of Experimental Shipment to Britain*	147	NIL
Australian Fertilizers Ltd. and Sulphide Corporation Pty. Ltd.—*Phosphate Soil Testing*	2,407	NIL
Australian Tobacco Research Trust—*Tobacco Research Institute, Mareeba, Qld.*	130,000	135,399*
Australian Tobacco Research Trust—*Blue Mould Investigations, Canberra*	7,383	12,547*
Australian Tobacco Research Trust—*Tobacco Investigations: Chemical Anti-fungal*	7,500	1,309
Australian Tobacco Research Trust—*Tobacco Investigations, Melbourne*	NIL	2,400*
Colonial Sugar Refining Co.—*Genetics Research*	4	NIL
†Christmas Island Phosphate Commission—"C" *Grade Phosphate*	1,000	827
Dairy Produce Research Trust Account—*Nutrition of Dairy Pastures in W.A.*	14,086	13,468
Department of Primary Industry—*Biochemical Studies of Weed Killers*	12,000	12,410*
Department of Primary Industry—*Ecology of Skeleton Weed*	8,000	5,581
Estate of J. O. Holston—*Alpine Ecology*	420	283
F. C. Pye Research Fund—*Laboratory at Black Mountain*	245,899	245,165
†Fisons Pest Control and J. R. Geigy—*Chemical and Plant Anti-fungal Investigations*	79,304	40,782
Foundation for International Potash Research—*Potassium Status of Clover Pastures*	3,447	727
†International Atomic Energy Agency—*Measurement of Mutation Rates in Plants*	6	NIL
Meat Research Trust Account—*Plant Introduction Testing Station*	7,936	6,187
Meat Research Trust Account—*Pasture Plant Collecting and Testing*	11,000	10,740
National Capital Development Commission—*Cotter River Catchment Investigations*	646	NIL
North Queensland Tobacco Growers' Co-operative Association Ltd.—*Investigations in Burdekin Valley*	158	NIL
Pipeline Technologists Pty. Ltd.—*Thermal Conductivity Investigations*	800	392
Special Revenue Fund—*Baker's Hill*	58,618	24,711
†Sulphur Institute of America—*Plant Nutrient Element Deficiencies*	1,084	NIL
†U.S. National Institutes of Health—*Genetic Studies*	5,537	NIL
Various—*Symposium on the Collection and Processing of Field Data*	6,083	NIL
Western Australian Golf Association—*Research on Grasses*	100	NIL
Wheat Research Trust Account—*Plant Breeding Investigations*	20,846	16,987
Wheat Research Trust Account—*Lucerne Investigations*	2,200	2,431*

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	Receipts 1965–66 & *Balances brought forward* 1964–65 $	*Expenditure* 1965–66 $
Plant Industry (continued)		
Wheat Research Trust Account—*Skeleton Weed Investigations*	1,000	95
Wheat Research Trust Account—*Protein Synthesis in Wheat Grain*	2,200	1,181
Wollogorang Pastoral Company Pty. Ltd.—*Rhizobium Studies*	400	773*
Entomology		
Australian Meat Research Committee—*Acquisition of Land at Amberley, Qld., for Cattle Tick Investigations* ..	4	NIL
Dairy Produce Research Trust Account—*Black Beetle Investigations*	925	NIL
Department of Health—*Sirex Wasp Investigations* ..	98,251	85,362
Department of Primary Industry—*Ecological Studies* ..	10,950	11,039*
Department of Primary Industry—*Locust Outbreak Analysis*	14,471	21,626*
General Donations—*Entomology*	6,628	247
Meat Research Trust Account—*Tick Survival*	139,102	85,808
Meat Research Trust Account—*Acaricide Problems* ..	93,970	61,643
Meat Research Trust Account—*Biological Control of Buffalo Fly*	26,194	21,228
Snowy Mountains Hydro-Electric Authority and River Murray Commission—*Phasmatid Investigations*	6,088	5,059
Special Revenue Fund—*Cattle Tick Investigations, Amberley, Qld.*	6,625	2,731
†U.S. National Institutes of Health—*Multiplication of Insect Polyhedron Virus*	22,475	4,540
†U.S. National Institutes of Health—*Fellowship of Dr. M. S. Lea*	2	NIL
Various—*Biological Control of Lantana*	19,800	10,271
Wheat Research Trust Account—*Skeleton Weed Investigations*	5,000	364
Wheat Research Trust Account—*Experimental Silo* ..	2,716	2,099
Wheat Research Trust Account—*Aeration of Stored Grain* ..	1,282	728
†World Health Organization—*Insecticide Resistance of Houseflies*	1,511	NIL
Wildlife Research		
Department of Civil Aviation—*Investigations into Bird Fouling of Jet Aircraft*	23,558	21,334
Meat Research Trust Account—*Dingo Studies*	9,750	7,816
Petfoods Ltd.—*Food for Budgerigars*	157	NIL
Soils		
Australian Fertilizers Ltd.—*Phosphate Requirements of Soil* ..	500	NIL
Australian Mineral Industries Research Association—*Purchase of X-ray Spectrograph*	172	172
Bureau of Mineral Resources—*Microbiological Prospecting for Oil*	1,414	297
Commonwealth Fertilizers and Chemicals Ltd., Cuming Smith and Mt. Lyell Farmers Fertilizers Ltd., and Australian Fertilizers Ltd.—*Bacterial Fertilizers*	4,012	4,415*

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	Receipts 1965–66 & *Balances brought forward* 1964–65 $	*Expenditure* 1965–66 $
Soils (continued)		
†Department of Agriculture, British Solomon Islands—*Soil Analysis*	1,360	384
†International Atomic Energy Agency—*Tritium Research* ..	4,413	464
Potash Research Institute—*Potash Level in Australian Soils* ..	3,000	NIL
†Rockefeller Foundation—*Interactions of Plant Roots and Micro-organisms*	4,883	3,362
S.A. Woods and Forests Department, Australian Paper Manufacturers Ltd., W.A. Department of Forests—*Problems of Growth*, Pinus Radiata	7,256	7,946*
Wheat Research Trust Account—*Soil Tillage Studies* ..	11,414	11,061
Wheat Research Trust Account—*Fertilizer Requirements of Wheat*	10,250	7,191
Wheat Research Trust Account—*Effect of Decomposition of Wheat Straw on Fertilizer*	9,566	9,314
Wheat Research Trust Account—*Organisms on Wheat Growth*	11,000	8,944
Zinc Corporation Ltd. and Philips Electrical Industries Pty. Ltd.—*Mineralogical Research*	782	NIL
Horticulture and Irrigation		
Australian Dried Fruits Association—*Research in Nematology*	3,522	1,755
Department of Primary Industry and Australian Wine Board—*Wine Grape Crop Forecasting*	11,152	5,376
Dried Fruits Control Board—*Dried Fruits Investigations* ..	3,564	494
Dried Vine Fruits Research Committee—*Biological Processing*	NIL	1,732*
Ground Water Salt and Reclamation Revenue Account ..	1,105	NIL
N.S.W. Water Conservation and Irrigation Commission (Griffith Research Station)	5,359	5,341
Nyah-Woorinen Dried Fruits Inquiry Committee—*Dried Fruits Investigations*	185	NIL
Packing Companies and Co-operative Dried Fruits Sales Ltd.—*Dried Vine Fruit Investigations*	732	100
Special Revenue Fund—*Coomealla, N.S.W.*	12,325	9,108
Special Revenue Fund—*Irrigation Research Laboratory, Griffith, N.S.W.*	20,236	14,344
Tropical Pastures		
A.C.F. & Shirleys Fertilizers Ltd.—*Trial Work at Rodd's Bay*	10,903	8,848
Dairy Produce Research Trust Account—*Tropical and Sub-tropical Pastures*	46,172	38,179
Meat Research Trust Account—*Pasture Plant Physiology* ..	19,176	18,201
Meat Research Trust Account—*Development and Plant Nutrition Investigations*	77,780	76,837
Meat Research Trust Account—*Genetic Breeding Investigations*	23,620	22,368
Meat Research Trust Account—*Pasture Nitrogen Project* ..	20,174	18,084
Meat Research Trust Account—*Carbohydrate Chemistry of Plants*	10,350	6,535
Special Revenue Fund—*Samford Farm*	19,768	8,144

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	Receipts 1965–66 & *Balances brought forward* 1964–65 $	*Expenditure* 1965–66 $
Land Research		
Department of National Development—*Kimberley Research Station*	20,092	17,969
Department of Territories—*Resources Survey in Papua and New Guinea*	136,572	145,150*
F. C. Pye Research Fund—*Installation of Lysimeter, Katherine, N.T.*	6,105	3,542
Meat Research Trust Account—*Investigations in Northern Territory High-rainfall Areas*	17,928	17,261
Meat Research Trust Account—*Beef Cattle Research, Katherine, N.T.*	6,848	5,837
Northern Territory Administration—*Rice Research* ..	14,958	26,888*
W.A. Department of Agriculture—*Cattle and Beef Research Project, Kimberley*	2,822	14,866*
Food Preservation		
Australian Apple and Pear Board—*Experimental Shipment of Apples and Pears*	254	289*
Australian Apple and Pear Board—*Apple and Pear Investigations*	4,499	2,084
Australian Canned Fruits Board—*Damage through Condensation on Cans of Export Fruits*	1,122	1,122
Australian Dried Fruits Association—*Visit to Australia of Professor M. W. Miller*	88	88
Australian Dried Fruits Association and Department of Primary Industry—*Dried Tree Fruits Investigations* ..	2,948	604
Australian Egg Board—*Egg Investigations*	780	779
Australian Egg Board—*Packaging of Egg Pulp*	1,312	241
Australian Meat Board—*Contribution towards Cost of Physical Chemistry Laboratory*	3,283	NIL
Australian Meat Board—*Mechanical Skinning of Sheep* ..	6,000	1,021
Darling Downs Co-operative Bacon Association—*Re-processing Stocks of Canned Meats*	131	NIL
Department of Primary Industry—*Fruit Fly Commodity Treatment of Citrus Fruits*	7,277	7,371*
Meat Research Trust Account—*Problems on Beef Quality* ..	93,830	79,196
Metropolitan Meat Industry Board of N.S.W.—*Meat Investigations*	1,000	1,369*
N.S.W. Department of Agriculture—*Fruit and Vegetable Storage Investigations*	9,964	7,945
N.S.W. Department of Agriculture—*Alstonville Research Station*	346	346
Rice Marketing Board—*Rice Research*	1,001	1,089*
†U.S. Department of Agriculture—*Study of Differences in the Chemical Structure of Albumin and* S-*Ovalbumin* ..	6,481	5,061
†U.S. Department of Agriculture—*Investigations into the Cyclopropenoid Compounds found in Cotton Seed*	24,150	18,710
Various Contributors (Food Preservation)	35,756	21,428

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	Receipts 1965–66 *& Balances brought forward* 1964–65 $	*Expenditure* 1965–66 $
Dairy Research		
Dairy Produce Research Trust Account—*Dairy Research* ..	163,881	149,379
Wool Research Laboratories		
Associated Woollen and Worsted Textile Manufacturers of Australia—*Blanket Freight Equalization Fund* ..	2,112	113 Cr.
Donations for Worsted Processing Research	3,040	NIL
General Donations (Protein Chemistry)	283	NIL
General Donations (Textile Industry)	558	NIL
General Donations (Textile Physics)	4	NIL
Leather Industry Research Fund	41,760	59,937*
Leather Research—*Residual Funds of Australian Leather Research Association*	1,202	1,202
Wool Buying and Selling Account	41,788	19,186
Wheat Research Unit		
Wheat Research Trust Account—*Quality Studies of Wheat and Flour*	60,470	54,581
Wheat Research Trust Account—*Effects of Lipids on Wheat Quality*	7,751	7,129
Chemical Research Laboratories		
Australian Mineral Industries Research Association—*Study of Breakages in Continuous Mills*	10,879	4,749
Australian Mineral Industries Research Association—*Development of Size Sensing Element*	4,185	2,126
Cement and Concrete Association of Australia—*Cement Investigations*	18,729	16,211
Colonial Sugar Refining Co. Ltd.—*Sugar Research* ..	978	51
Colonial Sugar Refining Co. Ltd.—*Sugar Fire Research* ..	772	736
Conzinc Riotinto of Australia Ltd.—*Calcination Project* ..	12,096	6,517
Conzinc Riotinto of Australia Ltd.—*Development of Solar Pond*	538	523
Conzinc Riotinto of Australia Ltd.—*Condensation Project* ..	8,550	2,928
Conzinc Riotinto of Australia Ltd.—*C.R.A.S.O. Project* ..	15,548	17,548*
Conzinc Riotinto of Australia Ltd. and New Broken Hill Consolidated Pty. Ltd.—*Neutron Activation Project* ..	8,296	4,716
Conzinc Riotinto of Australia Ltd. and Southern Portland Cement Ltd.—*Development of Coarse Batch Sizer* ..	24	NIL
Department of National Development—*Yarraman Bentonite Project*	2,237	2,237
Electrolytic Zinc Co. Ltd.—*Electrolytic Studies*	8,200	2,322
†Georgia Kaolin and W. R. Grace Pty. Ltd.—*Mineral Organic Investigations*	11,961	1,510
Ian Potter Foundation—*Visit to Australia of Dr. Ruh* ..	NIL	1,997*
James Cumming & Sons—*Production of Furfural from Bagasse*	800	432

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	Receipts 1965–66 & *Balances brought forward* 1964–65 $	*Expenditure* 1965–66 $
Chemical Research Laboratories (continued)		
Mary Kathleen Uranium Ltd.—*Water Evaporation Control* ..	196	196
Meat Research Trust Account—*Study of Plant Alkaloids* ..	19,000	17,108
Meat Research Trust Account—*New Acaricides and Anthelmintics*	1,502	1,502
Miscellaneous Contributors (Chemical Research Laboratories)	36,879	7,108
Mount Isa Mines Ltd.—*Recrystallization Project* ..	10,000	5,259
Murphyores Pty. Ltd.—*Ilmenite Reduction Project* ..	6,801	7,055*
National Coal Research Advisory Committee—*Coal Carbonizer/Gas Turbine Feasibility Study*	3,000	3,064*
National Coal Research Advisory Committee—*Hydrogasification of Coal*	24,000	19,123
†Perkin Elmer Corporation—*Atomic Absorption Project* ..	NIL	951*
†Population Council Inc.—*Studies on Induced Infertility* ..	1,303	NIL
Reserve Bank of Australia—*Fuel Cell Project*	35,898	19,583
Ricegrowers Co-operative Mills Ltd.—*Vegetable Oil Extraction Investigations*	700	341
†Smith, Kline, and French Laboratories, U.S.A.—*Phytochemical Survey*	23,007	5,669
State Electricity Commission of Victoria and Gas & Fuel Corporation of Victoria—*Clinkering of Brown Coal Ash* ..	NIL	4*
Techtron Pty. Ltd.—*Optical Gratings Development Project* ..	8,265	429
Union Carbide (Aust.) Ltd.—*Semi-polymers*	277	194
†U.S. National Institutes of Health—*Plant Alkaloids* ..	6,560	18,650*
Various—*N.M.R. Services Project*	2,550	1,716
Western Australian Chamber of Mines (Inc.)—*Cyanidation of Gold*	1,297	NIL
Fisheries and Oceanography		
Department of Harbours and Marine—*Gulf Prawn Survey* ..	3,700	8,499*
Department of Harbours and Marine—*Queensland: Tuna Search*	NIL	8,157*
Department of the Navy—*Marine Fouling Investigations* ..	454	454
Department of Primary Industry—*Tuna Search, N.S.W. and S.A.*	32 Dr.	NIL
Department of Primary Industry and Tasmanian Department of Agriculture—*Tuna Survey, Tasmania*	NIL	31,295*
Electricity Commission of N.S.W.—*Fly Ash Programme* ..	746	NIL
Fisheries Development Trust Account—*Sperm Whale Investigations*	1,294	NIL
Coal Research		
Colonial Sugar Refining Co. Ltd.—*Purchase of Special Equipment for Coal Research*	107	NIL
Electricity Commission of N.S.W.—*Electrostatic Precipitation of Fly Ash*	20,000	5,148
Electricity Trust of S.A.—*Investigations into Boiler Gas Path Problems*	34,198	17,257

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	Receipts 1965–66 & *Balances brought forward* 1964–65 $	*Expenditure* 1965–66 $
Coal Research (continued)		
General Donations	11,276	6,202
National Coal Research Advisory Committee—*Fluidized Bed Non-slagging Gasification*	7,000	5,194
National Coal Research Advisory Committee—*High-temperature Chemistry and Physics of Fly Ash*	8,000	6,969
National Coal Research Advisory Committee—*Combustion and Flame Science*	18,000	13,193
National Coal Research Advisory Committee—*Electrostatic Precipitation of Fly Ash*	5,000	2,899
State Electricity Commission of Victoria—*Brown Coal Investigations*	15,477	6,793
Mining and Metallurgy		
Australasian Institute of Mining and Metallurgy—*Mineragraphic Investigations*	10,659	7,516
Broken Hill Mine Managers' Association—*Contribution towards Salary of Dr. S. M. Richards*	755 Dr.	NIL
General Donations (Ore Dressing)	2,889	13,710*
McArthur Development Co.—*McArthur River Ore Project*	3,000	1,229
Miscellaneous Contributors (Mineragraphic Investigations)	1,693	498
State Electricity Commission of Victoria—*Geological Consultations*	1,683	28
Geobiological Group		
Bureau of Mineral Resources and Australian Mineral Industries Research Association—*Baas-Becking Biological Group*	53,802	2,027 Cr.
National Standards Laboratory		
General Donations (Applied Physics)	1,019	NIL
†Machinability Donations Account (Metrology)	228	NIL
†U.S. Air Force—*Thermal Expansion of Solids at Low Temperatures*	54 Dr.	54 Cr.
†U.S. National Aeronautics and Space Administration—*Cinematograph Study of Solar Magnetic Fields*	22,722 Dr.	12,021*
†U.S. National Bureau of Standards—*Solar Flare Patrol*	NIL	18,478*
Various Contributors—*Length Measurement Research Fund*	1,287	241
Radiophysics		
†Ford Foundation—*Construction of Radio Heliograph*	108,249	58,625
General Donations	50	NIL
New South Wales and Queensland Governments—*Cloud Seeding for Drought Relief*	21,007	22,190*
†U.S. National Aeronautics and Space Administration—*Radio Astronomy*	24,519	25,388*
Various Contributors—*Rain and Cloud Physics Research*	16,000	NIL

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	Receipts 1965–66 & *Balances brought forward* 1964–65 $	*Expenditure* 1965–66 $
Meteorological Physics		
Australian Tobacco Research Trust—*Meteorological Observations*	800	590
Radio Research		
Postmaster-General's Department, Australian Broadcasting Control Board, and Overseas Telecommunications Commission—*Radio Research Board Activities*	45,483	44,661
Building Research		
Associated Fibrous Plaster Manufacturers of Australia, Australian Plaster Industries, and Colonial Sugar Refining Co. Ltd.—*Fibrous Plaster Research*	12,217	6,164
Cement and Concrete Association of Australia—*Concrete Research*	26,357	9,503
General Donations (Building Research)	9,585	5,060
Housing Commission of Victoria, Victorian Railways Department, State Electricity Commission of Victoria—*Mould Infestation in Dwellings*	1,417	1,567*
Jaywoth Besser Ltd.—*Efflorescence on Concrete Blocks* ..	1	NIL
Whitelaw Monier Pty. Ltd.—*Research into Cement Tiles* ..	582	567
Tribophysics		
Union Carbide (Aust.) Ltd.—*Catalytic Oxidation of Olefins* ..	29,994	4,579
Soil Mechanics		
Department of the Army—*Soil Stabilization Project* ..	3,523	NIL
Department of the Army—*Terrain Evaluation Survey* ..	46,268	38,411
Department of the Army—*Joint A.B.C.A. Field Exercise* ..	14,000	7,126
S.A. Department of Mines and S.A. Housing Trust—*Land Use in Urban Areas*	10,659	2,146
Tasmanian Department of Health—*Foundation Investigations in Tasmania*	2,121	NIL
Water Research Foundation of Australia—*Water Retention in Earth Dams*	8 Dr.	240*
Mechanical Engineering		
General Donations	1,038	592
Miscellaneous Contributors—*Construction of Forced Circulation Solar Hot Water Service*	530 Dr.	NIL
†University of Wisconsin—*Oversea Visit of D. J. Close* ..	1,591	1,591
Wheat Research Trust Account—*Powered Wheels* ..	16,835	16,231
Wheat Research Trust Account—*Grain Moisture Studies* ..	25,268	21,381

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	Receipts 1965–66 & *Balances brought forward* 1964–65 $	*Expenditure* 1965–66 $
Forest Products		
Australian Plywood Board—*Veneer Gluing and Plywood Research*	22,564	22,901*
†Department of Forestry, British Solomon Islands—*Timber Utilization in Solomon Islands*	8,000	2,520
Department of Territories—*Development of Pulp and Paper Industry in New Guinea*	11,204	8,872
General Donations (Forest Products)	15,356	257
†Government of Fiji—*Timber Research in Fiji*	3,470	3,731*
Paper Companies and New Zealand Forest Products—*Paper Pulp Investigations*	18,910	15,054
Mathematical Statistics		
David Rivett Memorial Fund	48,130	4,074
Miscellaneous Contributors—*Mathematical Statistics* ..	10	NIL
Sundry Contributors (CSIRO)	1,862	NIL
TOTAL CONTRIBUTIONS	**9,322,212**	**8,284,273**

Wool Research Trust Fund

Details of transactions during 1965–66 are as follows:

Receipts

	$	$	$
Balance brought forward from 1964–65		55,287	
Received from Department of Primary Industry during 1965–66		5,639,970	**5,695,257**

Expenditure

INVESTIGATIONS

Wool Production Research

Animal Research Laboratories—			
Division of Animal Genetics:			
Animal Genetics Investigations, Sydney	229,942		
Sheep Breeding, Cunnamulla, Qld.	100,325	330,267	

* Expenditure on this work in excess of receipts will be recovered in 1966–67.
† Overseas organization.

	$	$	$
Division of Animal Health:			
Animal Health Laboratory	47,228		
McMaster Laboratory	153,535	200,763	
Division of Animal Physiology:			
Ian Clunies Ross Animal Research Laboratory ..	769,338		
Regional Laboratory and "Chiswick" Field Station, Armidale, N.S.W.	371,701	1,141,039	
Division of Nutritional Biochemistry:			
Nutrition Laboratory, Adelaide	124,913		
Field Studies at Glenthorne, S. Aust.	51,653	176,566	1,848,635
Plant Industry—			
Headquarters, Canberra	355,959		
Regional Pastoral Laboratory, Falkiner Memorial Field Station, Deniliquin, N.S.W.	135,139		
Field Investigations, Armidale, N.S.W.	37,451		
Western Australian Investigations	170,584		
Cooperative Projects with N.S.W. Department of Agriculture	6,357	705,490	705,490
Entomology and Wildlife—			
Division of Entomology:			
Field Investigations, Armidale, N.S.W.		47,787	
Division of Wildlife:			
Wildlife Investigations		181,029	228,816
Chemical Research Laboratories—			
Organic Chemistry	20,153		
Physical Chemistry	15,171	35,324	35,324
Research Services—			
Agricultural Liaison Unit		43,813	43,813
			2,862,078
Wool Textile Research			
Wool Research Laboratories—			
Protein Chemistry, Melbourne	706,789		
Textile Physics, Sydney	653,126		
Textile Industry, Geelong, Vic.	865,258	2,225,173	2,225,173
TOTAL EXPENDITURE—INVESTIGATIONS ..			**5,087,251**

	$	$	$
CAPITAL WORKS			
CSIRO Expenditure			
Wool Textile Research			
Laboratory Equipment and Textile Machinery ..		113,938	113,938
Expenditure on CSIRO Buildings by Department of Works			
Wool Production Research		71,438	
Wool Textile Research		33,576	105,014
Plant and Development Expenditure			
Wool Production Research		100,384	
Wool Textile Research		36,319	136,703
Wool Buying and Selling Account			10,000
TOTAL EXPENDITURE—CAPITAL WORKS ..			**365,655**
TOTAL EXPENDITURE—WOOL RESEARCH TRUST FUND			**5,452,906**

During the year, $116,176 was received from sales of sheep, wool, and other produce from CSIRO Field Stations and Laboratories financed from wool funds. This amount is payable to the Department of Primary Industry for credit to the Wool Research Fund Trust Account.

Miscellaneous Receipts

During 1965–66, miscellaneous receipts amounted to $612,582. Details of the receipts are as follows:

	$	$
Sale of publications	22,124	
Sale of equipment purchased in former years, and other receipts	67,372	
Sale of produce	53,171	
Royalties from patents	56,347	
Testing fees	59,054	
Sale of animals	10,788	
Computing charges—External users	149,100	
Computing charges—Internal users	179,146	
Miscellaneous	15,480	**612,582**

The receipts from the sale of produce represent revenue earned by Divisions and Sections apart from the Special Revenue listed under Contributions on pages 219–28.

The amount of $612,582 was credited to the Treasury appropriation and consequently reduced the requirements from the Treasury by that amount (*see* page 218).

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.		14,623	
Animal Health—			
Parkville site	12,334		
McMaster Laboratory, Glebe, N.S.W.	600		
Lansdown Pasture Research Station, Qld.	5,548		
Veterinary Parasitology Laboratory, Yeerongpilly, Qld.	764	19,246	
Animal Physiology—			
Pastoral Research Laboratory, Townsville, Qld. ..		3,000	
Nutritional Biochemistry			
Adelaide		11,063	
Plant Research			
Plant Industry—			
Canberra laboratories	46,660		
Riverina laboratory, Deniliquin, N.S.W.	656	47,316	
Entomology			
Canberra laboratories	17,080		
Ginninderra Experimental Station, A.C.T.	1,976	19,056	
Wildlife			
"Gungahlin", A.C.T.		4,950	
Soils and Irrigation			
Soils—			
Adelaide	52,353		
Cunningham Laboratory, St. Lucia, Qld.	48		
Pasture Research Station, Samford, Qld.	5,346	57,747	
Horticultural Research Section—			
Adelaide	33,538		
Merbein, Vic.	7,162	40,700	
Irrigation Research Laboratories—			
Griffith, N.S.W.		1,554	

	$	$	$
Tropical Pastures			
Cunningham Laboratory, St. Lucia, Qld.	46,836		
Pasture Research Station, Lansdown, Qld.	15,230		
Pasture Research Station, Samford, Qld.	6,198		
Cooper Laboratory, Lawes, Qld.	5,422		
Pasture Research Station, Beerwah, Qld.	1,274		
Nunbank, Meandarra, and Banana, Qld.	3,553		
Rodd's Bay, Qld.	270		
Gigoomgan, Qld.	60		
Queensland Cattle Station, Mundubbera, Qld. ..	37,800	116,643	
Food Preservation			
North Ryde, N.S.W.		43,657	
Dairy Research			
Highett, Vic.		2,054	
Editorial and Publishing			
East Melbourne		312	
Chemical Research Laboratories			
Clayton, Vic.	140,937		
Fishermen's Bend, Vic.	124,544		
Garden City, Vic.	33,715	299,196	
Fisheries and Oceanography			
Cronulla laboratory, N.S.W.		1,605	
Coal Research			
North Ryde, N.S.W.		54,800	
Physics			
Culgoora, N.S.W.		77,507	
Radiophysics			
Radio telescope, Parkes, N.S.W.		25,627	
Meteorological Physics			
Aspendale, Vic.		1,710	
Building Research			
Highett, Vic.		16,380	
Tribophysics			
Melbourne		37,457	
Soil Mechanics			
Syndal, Vic.		3,336	
Mechanical Engineering			
Highett, Vic.	12,000		
Griffith, N.S.W.	4,015	16,015	

	$	$	$
Forest Products			
Melbourne		36,950	
Applied Physics			
Chippendale, N.S.W.		61,676	
Site Services			
Canberra		7,373	
Canberra Library			
Black Mountain, A.C.T.		5,317	
Computing Research Section			
Scientific Computing Equipment, Canberra, Adelaide, Melbourne, Sydney		259,381	
Head Office, Melbourne		3,237	
Regional Administrative Office, Sydney		1,560	
Regional Administrative Office, Brisbane		16,500	
Regional Administrative Office, Melbourne		350	
Regional Laboratory, Western Australia		11,332	
TOTAL TREASURY EXPENDITURE			**1,319,230**

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