CSIRO

Annual Report

1963-64

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION
AUSTRALIA

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Sixteenth Annual Report

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THIS REPORT on the work of the Commonwealth Scientific and Industrial Research Organization for the year ending June 30, 1964, has been prepared for presentation to Parliament as required by Section 30 of the Science and Industry Act 1959.

Important administrative matters, a number of policy aspects of the Organization's work, and items of general interest are recorded in Chapter 1. Some of the significant research developments in the programs of a number of Divisions and Sections are given in Chapter 2. The remainder of the report lists scientific papers published by CSIRO officers; committees; professional and senior administrative staff; and financial details.

Detailed information about the research program is contained in the annual reports issued individually by the Divisions and Sections of the Organization. A complete list of the Organization's laboratories and field stations together with their addresses is published separately each year under the title "CSIRO Divisions and Sections".

General enquiries and requests for information on the Organization as a whole should be directed to the Secretary.

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

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

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General Review

THE PRINCIPAL RESPONSIBILITY of CSIRO is to undertake scientific research in connection with or for the promotion of primary and secondary industry in Australia.

To fulfil this obligation CSIRO must be able to recruit and retain the services of scientific men of outstanding originality and versatility. The discoveries of these scientists must be directed towards making the maximum contribution to the welfare and progress of Australian agriculture and industry.

The activities of CSIRO are divided between some 31 Divisions and a number of Sections which are research groups smaller in size or in an earlier stage of development. At the head of each laboratory is a Chief or Officer-in-Charge, who is responsible to the Executive for the scientific policy and conduct of the research work of his staff. The Chiefs and senior scientists are closely in touch with those areas of Australian agriculture or industry to which their particular scientific activities are most appropriate. In this way they acquire considerable insight into practical problems and are able to assess the opportunities for progress through research. They are also familiar with scientific work relevant to their own program in research laboratories throughout the world, and are thus well placed to judge the appropriate program of research which is likely to make the best contribution to Australia's advancement.

The Executive of CSIRO bears the final responsibility to the Minister for the policy and work of the Organization. In discharging this responsibility in an institution of the size of CSIRO the Executive delegates considerable responsibility for science to the Divisions and Sections and seeks mature and comprehensive advice from its scientists.

Even when a problem of great practical significance is known to exist it is clearly unwise to embark on extensive research activities unless the scientists can see the possibility of an original discovery from which a solution might follow. Conversely, it is frequently true that scientific discovery itself may provide unsuspected and novel opportunities for economic development. Discoveries emerge from imaginative scientific thinking; the role of the individual scientist is vital.

It has been proved by experience that the most effective organization of the staff of a research laboratory is one based on advancement of the individual according to his personal merit and achievement. The principle of merit promotion has always been practised by CSIRO. It has brought great benefits. Recruitment from outside the Organization is practised freely at all levels and new staff immediately take up positions appropriate to their scientific standing. The structure of a laboratory at any time is a reflection of the calibre, experience, and achievements of all its members. Under this system outstanding men emerge as leaders by natural processes.

CSIRO's Act provides for an Advisory Council, and the Executive places great value on its work, particularly that of committees which the Council has set up in recent years to advise the Executive on programs and general policy. The State Committees serve a valuable purpose of bringing opportunities for scientific research by CSIRO to the notice of the Executive.

The Executive avails itself freely of the advice and help of large numbers of agricultural producers, industrialists, and academics. There is a growing awareness among leaders of industry and agriculture of the part which must be played by science in Australian development, not only by CSIRO but by expansion of research in industry itself.

Obituary

Stewart Henry Bastow, D.S.O., B.Sc., Ph.D., a Member of the Executive, died in Melbourne on January 23, 1964, at the age of 55.

After graduating in science from the University of Tasmania in 1926, he became a Demonstrator in Physics at that university. In 1928 he worked with Professor A. L. McAulay on a research program for C.S.I.R. on the electrical behaviour of surfaces of corroding iron.

He spent from 1929 to 1934 at King's College, Cambridge, where he obtained his Ph.D. He worked firstly with Professor E. K. Rideal on catalysis at low temperatures and in high vacua, and then with Dr. F. P. Bowden on the physical properties of surfaces. In 1932 he was awarded a Senior 1851 Exhibition for physical chemistry.

From 1934 to 1937 Dr. Bastow worked for National Enamels Limited and the South Metropolitan Gas Company, England. This was followed by three years with the Anglo-Iranian Oil Company in Persia. In 1940 he was commissioned in the Royal Engineers, where he became an instructor in special tunnelling and demolitions at the School of Military Engineering. He became a major, with special responsibilities for the technical efficiency and layout of anti-aircraft smoke screens. He took part in the Allied invasion of Europe and was awarded the D.S.O.

Dr. Bastow joined CSIRO in 1945 as Officer-in-Charge of the Lubricants and Bearings Section (now the Division of Tribophysics) and in 1949 he became a Member of the Executive.

From then until his death he made a valuable contribution to the administration and development of CSIRO. He had an encyclopaedic knowledge of its work and knew personally a very large number of its officers, including especially the younger ones. He was a frequent visitor to the Organization's laboratories and field stations in all parts of Australia, and is very widely missed.

Outside CSIRO, he had a remarkably wide interest in the problems of Australian industry as a whole and was keenly concerned that the results of scientific research should be made known to industry and applied to the benefit of the community. He also played a leading part in the affairs of the Royal Australian Chemical Institute, of which he was Vice-President in 1962–63.

Executive Appointment

Professor G. M. Badger, Ph.D., D.Sc., F.A.A., Professor of Organic Chemistry at the University of Adelaide, has been appointed to the Executive of CSIRO. Professor Badger, who fills the vacancy caused by the death of Dr. S. H. Bastow, will commence his duties with the Organization next September.

After obtaining his M.Sc. from the University of Melbourne in 1938, Professor Badger went to England where he obtained his Ph.D. from the University of London. In 1941 he commenced war work with Imperial Chemical Industries in Manchester, mainly on the development of anti-malarial drugs, and in 1943 he joined the Royal Navy as Instructor Lieutenant. At the end of the war he went to the University of Glasgow where he received his D.Sc. He returned to Australia in 1949 to take up a position as Senior Lecturer in Organic Chemistry at the University of Adelaide and in 1955 he became the University's first Professor of Organic Chemistry.

Throughout his scientific career, Professor Badger's continuing interest has been in the chemical structure of carcinogenic compounds.

Advisory Council

The following members retired from the Council:

- J. W. Foots, B.M.E.
- B. Meecham, C.M.G., O.B.E.
- Professor J. W. Roderick

The following members resigned from the Council:

- Professor H. N. Barber, M.A., Ph.D., F.R.S., F.A.A. (Chairman, Tasmania State Committee)
- W. A. T. Summerville, D.Sc.
- R. S. Wilson (Chairman, Queensland State Committee)

The following new members were appointed to the Council:

- R. A. Irish, O.B.E., F.C.A.
- P. J. Lawler
- J. P. Norton, O.B.E.
- Professor S. A. Prentice, M.E.E., B.Sc.
- Professor R. T. Prider, B.Sc., Ph.D.
- F. M. Read, M.Agr.Sc.
- W. J. D. Shaw (Chairman, Queensland State Committee)
- G. Sheil, B.Sc., B.C.E., B.M.E.

The Council met twice during the year—in November 1963 at Melbourne and in May 1964 at Canberra. The second day of the Canberra meeting was held in conjunction with a meeting of the Executive and the Chiefs and Officers-in-Charge.

At the November meeting the Advisory Council appointed two subcommittees—one to examine the building situation in CSIRO, the other to examine the need for research for the Australian mining industry. Both subcommittees made a number of important recommendations which are now under consideration by the Executive.

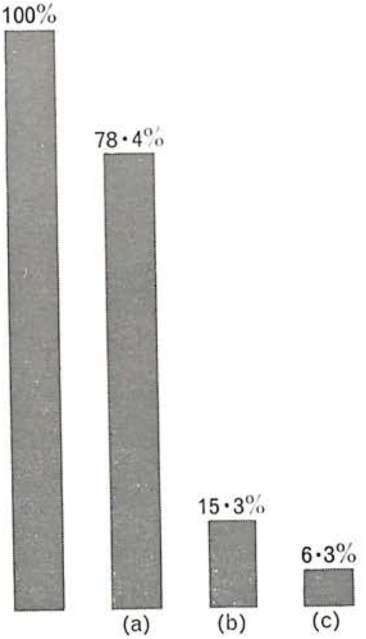
Finance

In the year 1963–64 CSIRO expenditure was £14,869,779. Details are shown in Chapter 5. Of this sum £13,817,051 was spent on actual research work and associated services (administration, library, etc.), including £221,933 for grants which were made available to outside bodies such as the Commonwealth Agricultural Bureaux and the Standards Association of Australia. The sum of £1,052,728 was spent on capital works under the control of CSIRO. (It should be noted that in addition the Department of Works and the Department of the Interior spent £1,314,941 on construction of buildings, other works, and acquisition of properties for CSIRO.)

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

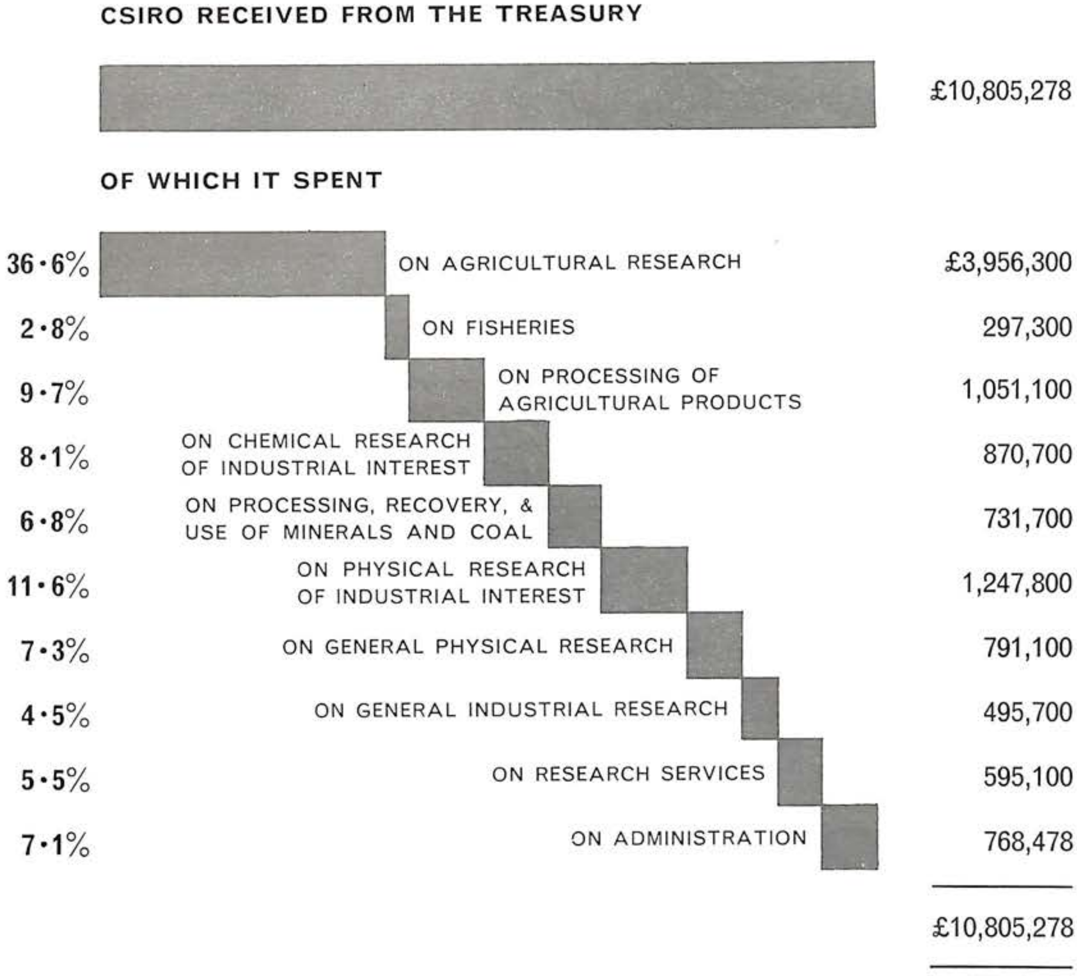
SOURCE OF FUNDS	*Investigations*	*Capital Works*	*Total*
Treasury Appropriation	£10,703,649	£583,910	£11,287,559
CSIRO Revenue	101,629		101,629
Total Treasury Funds	10,805,278	583,910	11,389,188
Wool Research Trust Fund	2,140,855	261,631	2,402,486
Contributions (other than Wool)	870,918	207,187	1,078,105
	£13,817,051	£1,052,728	**£14,869,779**

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



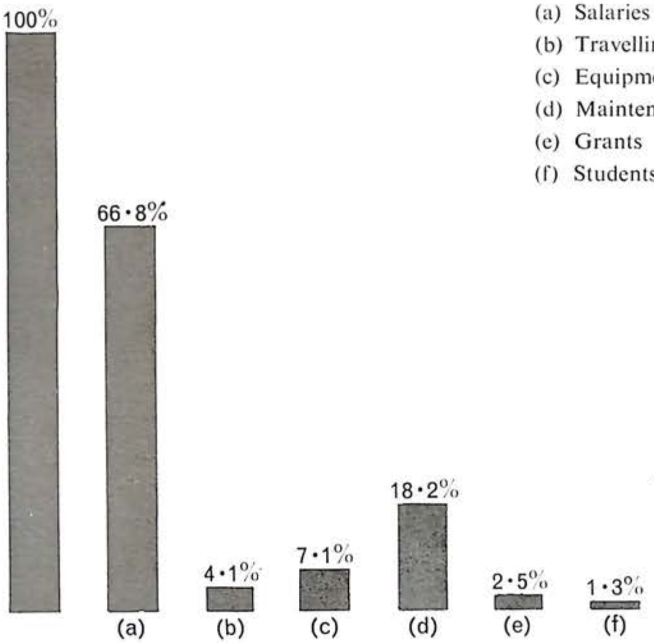
(a) Commonwealth Treasury		£10,805,278
(b) Wool Research Trust Fund		2,140,855
(c) Contributions—		
Cattle and beef investigations (Cattle and Beef Research Trust Fund)	£107,842	
Dairy research (Dairy Produce Research Trust Fund)	79,552	
Tobacco investigations (Tobacco Industry Trust Account)	77,785	
Wheat investigations (Wheat Research Trust Fund Trust Account)	62,736	
New Guinea resources investigations (Department of Territories)	60,732	
Rice investigations (Department of Territories)	49,577	
Individual industrial and private contributions	432,694	
		870,918
		£13,817,051

The diagram below gives an indication of how the Treasury funds (£10,805,278) available for investigations in 1963–64 were used. Chemical Research of Industrial Interest includes the Divisions of Chemical Engineering, Organic Chemistry, Physical Chemistry, Chemical Physics, and Protein Chemistry, while Physical Research of Industrial Interest covers the Divisions of Physics, Applied Physics, and Tribophysics. The main fields in General Physical Research are Radiophysics, Meteorological Physics, and Upper Atmosphere, and in General Industrial Research such Divisions as Building Research, Soil Mechanics, and Mechanical Engineering. Research Services covers such items as Library, Publishing, Film Unit, Mathematical Statistics, and the Computer Section.



Approximately two-thirds of CSIRO's expenditure from Treasury funds 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	£7,215,544
(b) Travelling	443,442
(c) Equipment	771,835
(d) Maintenance	1,958,297
(e) Grants	272,533
(f) Studentships	143,626
	£10,805,277



Buildings and Accommodation

The reasons for the grave shortage of laboratory accommodation facing CSIRO were outlined in the last Annual Report. During the year under review the Advisory Council appointed a committee to examine the problem. In its report it stressed the urgency of the need for accelerating the building program so as to provide adequate accommodation for scientists throughout CSIRO.

Although some progress has been made during the year the problem continues to be one of the most serious facing the Executive, and strenuous efforts are being made to overcome it. As far as CSIRO is concerned this involves the acceleration of the definition of requirements and the preparation of sketch plans and briefs for the various projects under consideration. The problem is made the more difficult by the fact that CSIRO activities are scattered over more than 80 sites throughout Australia. The actual construction of laboratories and buildings is usually undertaken by the Department of Works, or occasionally through private consultants, and efforts have been made to improve further the liaison and working arrangements between the Department and CSIRO. Ultimately, of course, the execution of the program depends on the funds made available by the Government.

Within CSIRO the forward planning of the building program and the preparation of briefs and sketch plans are the responsibility of the Buildings Branch at Head Office. The Advisory Council report stressed the need for strengthening the Branch, particularly on the construction and liaison side, and extra staff are being recruited to carry out this recommendation.

During the year under review a number of significant projects were completed. These are shown in the following list with their costs.

New South Wales

North Ryde: New laboratory, Division of Animal Genetics	£110,000
North Ryde: Technical scale laboratory B, Division of Coal Research	£72,990
Glebe: Animal house, Division of Animal Health	£45,000

South Australia

Urrbrae: Physiology laboratory, Horticultural Research Section	£30,000
Glenthorne: Field laboratory and administration block, Division of Biochemistry and General Nutrition	£20,000

Australian Capital Territory

Black Mountain: Laboratories, Division of Land Research and Regional Survey	£159,000
Canberra: Computing laboratory, Computing Research Section	£150,000

The following list shows the more important new projects commenced during the year with their estimated total costs:

New South Wales

North Ryde: Poultry research building, Division of Animal Genetics	£130,516
Culgoora: Radioheliograph and optical telescope buildings and facilities, Divisions of Radiophysics and Physics	£97,000

Victoria

Parkville: Small animals building, Division of Animal Health	£44,358
Highett: Acoustic reverberation chambers, Division of Building Research	£32,000

Queensland

Townsville: Laboratory, Division of Tropical Pastures	£171,000

Australian Capital Territory

Black Mountain: Workshop, Division of Plant Industry	£63,000

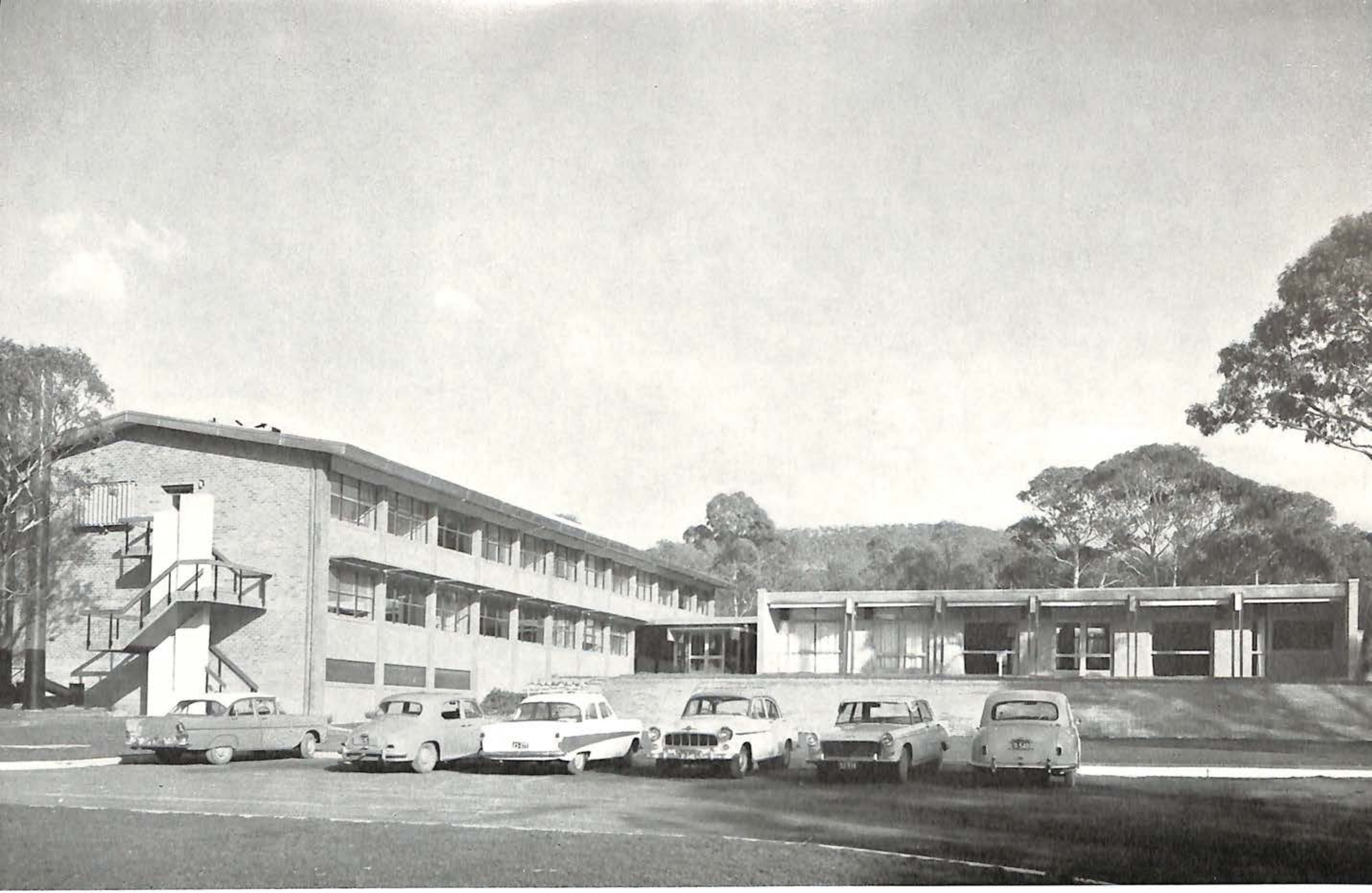
During the year the Buildings Branch has been concerned in the planning of a number of projects. Plans for the Western Australian Regional Laboratory to be built at Perth were approved by the Parliamentary Public Works Committee and the project is now on the 1964–65 works program. The second stage of the laboratories for the Division of Land Research and Regional Survey at Canberra was also approved by the Parliamentary Public Works Committee; it is hoped that this project will go on the design list and be documented during the year 1964–65. Forward planning is being undertaken on several projects. These include the Coal Research Laboratory at North Ryde, N.S.W., the laboratory for the Divisions of Animal Health and Entomology at Indooroopilly, Qld., and a new laboratory for the Division of Chemical Engineering at Clayton, Vic. In addition to these the program planning has been completed for a new laboratory for the Division of Radiophysics at Epping, N.S.W., and it is hoped to obtain approval to place this before the Parliamentary Public Works Committee in the near future. Preliminary planning is also under way on two major projects for which considerable sums will be needed. These are the rehousing of the National Standards Laboratory, at present on the campus of the University of Sydney, at Bradfield Park, and the rehousing of the Chemical Research Laboratories, at present at Fishermen's Bend, Vic., at a site at Clayton adjacent to Monash University. Some relief to the difficult conditions at Fishermen's Bend is being achieved by the transfer of the Division of Mineral Chemistry to a group of buildings at South Melbourne purchased from Balm Paints Pty. Ltd. These buildings are at present being renovated and converted to laboratories. Sketch plans of a new Meat Research Laboratory for the Division of Food Preservation at Cannon Hill, Qld., are well advanced. This laboratory will be largely financed from the Australian Cattle and Beef Research Trust Account, and it is expected that it will be handed to consultants for documentation early in 1964–65.

Although these achievements and plans are considerable, when viewed in relation to CSIRO's overall requirements the progress being made in alleviating the general critical building situation is small. After allowing for minor works and other calls on capital funds the amount available for laboratories proper has been about £800,000 per annum for the last few years. To provide sufficient additional accommodation to relieve overcrowding for the existing CSIRO staff would cost about £3,000,000. The two large projects referred to above—moving the National Standards Laboratory and the Chemical Research Laboratories—would cost about £6,000,000.

New Laboratory for Wool Research

A new five-storey laboratory block for the Division of Protein Chemistry in the Melbourne suburb of Parkville was opened by the Minister-in-Charge of CSIRO, Senator Gorton, on October 26, 1963.

The laboratory was designed by the architectural firm of Romberg and Boyd and was built at a cost of approximately £291,000, of which £226,000 was provided from the Wool Research Trust Fund. For the last 11 years the Division has been accommodated at the present site in two converted houses and a two-storey building. The new block will provide more than 29,000 sq ft of floor space. The ground floor will house physical chemistry equipment and there will be a library, staff room, and lecture room on the first floor. There are biochemical laboratories on the second floor and organic chemistry laboratories on the third floor. The fourth floor will be used for research on the proteins collagen and myosin and on other protein investigations not financed from the Wool Research Trust Fund.



The new building of the Division of Land Research and Regional Survey at Black Mountain, Canberra. The laboratory wing is on the left.

New Laboratory for Western Australia

Construction of a new primary industries laboratory for CSIRO in the Perth suburb of Floreat Park has been recommended by the Parliamentary Standing Committee on Public Works. The building will replace the present headquarters of the Western Australian Regional Laboratory which has been located on the campus of the University of Western Australia for some years.

The 28-acre site for the new laboratory is opposite the Empire Games Stadium and adjoins University land. This land was made available to CSIRO by the Western Australian Government. The laboratory will be constructed of reinforced concrete and will have four floors and a total floor area of 43,000 sq ft. Provision has been made in the design for future installation of air-conditioning.

The Divisions of Plant Industry and Soils are the two major groups represented in the Western Australian Regional Laboratory. The new building will also house workers from the Divisions of Entomology, Fisheries and Oceanography, and Mathematical Statistics.

It is expected that the new building will eventually become part of a larger complex containing a secondary industries laboratory.

Computing Research

The past year has seen rapid progress with plans for the use of the computer network. The equipment for the Centre in Canberra was installed in June 1964. Progress has also been made in recruiting staff. The Officer-in-Charge, Dr. G. N. Lance, carried out an overseas recruiting drive during January and as a result about nine offers of appointment are being made to people from the United States of America and the United Kingdom.

The new building at Black Mountain, Canberra, will be opened in September 1964. The satellite machine for Adelaide will be installed by then. Conversion of some office space in the National Standards Laboratory, Sydney, will make it possible to install a satellite there within a few months. The Melbourne computer cannot be installed until the new building at Clayton is finished towards the end of 1964.

Radio Heliograph and Optical Observatory

During the year work started on the construction of a radio heliograph by the Division of Radiophysics. Construction of the instrument has been made possible by a grant of $500,000 by the Ford Foundation. The instrument, which has been developed by an officer of the Division, Mr. J. P. Wild, will give a continuous and complete radio picture of the Sun. The radio heliograph is being constructed on a site at Culgoora near Narrabri, N.S.W.

On the same site an optical observatory will be constructed to the design of the Division of Physics, for observations of changes which occur in the Sun. Such changes have a profound influence on terrestrial phenomena. This observatory will be financed in part from a grant from the U.S. National Aeronautics and Space Administration of $192,000.

Research for the Meat Industry

Funds made available from the Australian Cattle and Beef Research Fund will enable the Division of Food Preservation to build a new meat research laboratory and to expand its present meat research staff from 10 to 30 over the next few years. The laboratory will be built on a 13-acre site at Cannon Hill, Brisbane, close to the Division's present meat research laboratory which was established more than 30 years ago.

The new facilities and the increased research staff will permit a more vigorous attack on the large array of problems awaiting study. Most of these involve chemical, physical, and microbiological studies of changes occurring after slaughter, but some will go back to the living animal to find out how the properties of meat are influenced by the diverse conditions to which the animal is exposed during growth and during handling before slaughter.

Dr. W. J. Scott, Assistant Chief of the Division of Food Preservation, has been appointed Officer-in-Charge of the Laboratory.

Leather Research Fund

The Commonwealth Government has established a Leather Research Fund to finance investigations in CSIRO into problems concerning the Australian tanning industry.

The Commonwealth Government and the tanning industry have each agreed to contribute £22,000 a year to the Leather Research Fund for a period of not less than 5 years. The fund will be used to finance a new program of leather investigations by the CSIRO Division of Protein Chemistry in its new laboratory in the Melbourne suburb of Parkville.

The Division's work on protein chemistry will provide a valuable background for the leather investigations. In turn, it is expected that the Division's work on wool will benefit from a close association with the leather research.

Ord River Diversion Dam Opened

The official opening of the Ord River diversion dam by the Prime Minister on July 20, 1963 marked the completion of the first stage of a scheme to irrigate some 200,000 acres of land in the far north of Western Australia.

The Kimberley Research Station, which was established in 1946 as a joint venture between the Western Australian Department of Agriculture and CSIRO, has played an important role in the foundation of the scheme. Research results have indicated that the main crops suited for production in the area include sugar cane, rice, linseed, safflower, and cotton.

In 1960 the Western Australian Government felt confident enough of the potential of the area to warrant further trials by pilot farms. An agreement was therefore made with Northern Development (Ord River) Pty. Ltd. to conduct a pilot farm scheme in the area to relate the research findings of the Kimberley Research Station to actual farm practice and to assist in determining the economics of production. Eight farms are now in production and five in preparation.

At the opening, the Prime Minister paid tribute to the work carried out by CSIRO and particularly the part played by Mr. C. S. Christian, Member of the Executive, as Chief of the Division of Land Research and Regional Survey from 1950 to 1959 and as the Chairman of the Kimberley Research Station Policy Committee.

David Rivett Memorial Lecture

The first David Rivett Memorial Lecture was delivered in Wilson Hall, University of Melbourne, on September 5, 1963, by Sir Howard Florey, President of the Royal Society. Sir Howard spoke on "The Development of Modern Science".

The aim of the David Rivett Memorial Lecture is to commemorate the name of the late Sir David Rivett, formerly Chief Executive Officer and subsequently Chairman of the Council for Scientific and Industrial Research, and to preserve the vigorous stimulus of his leadership. Sir David was more than any other person responsible for establishing the pattern of CSIRO as it is known today. The Memorial Lecture will be delivered once every two years in one or other of the capital cities of Australia by men who have reached the highest ranks of achievement in scientific research.

Aid to Developing Countries

During the year under review CSIRO has continued to provide facilities for the training of scientists from other countries under the auspices of one or other of the international aid schemes. Officers of the Organization have again visited overseas countries on expert assignments and developmental projects. Collaboration between CSIRO and particular institutions in Asian countries has also continued.

In February 1964 CSIRO was host institution to the Third Meeting of Representatives of National Scientific Research Organizations in the Asia and South-East Asia Regions, sponsored by UNESCO. The Meeting was opened by Senator the Honourable J. G. Gorton, Minister-in-Charge of CSIRO, and M. René Maheu, Director-General of UNESCO, addressed the participants.

The heads of national scientific research organizations, or senior scientists, of some 17 Asian countries attended the meeting. Observers from United Nations agencies and other international associations were also present, as well as five specialist consultants from the U.S.A., the U.S.S.R., Japan, Indonesia, and Australia. The meeting, which was a regional follow-up of the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas (UNCSAT, Geneva, 1963), discussed questions relating to the development of national science policy machinery, the role of science and technology in economic development, research organization and administration, the role of UNESCO in the region, and regional collaboration in scientific research.

A further development arising out of the Geneva UNCSAT Conference has been the establishment of a United Nations Advisory Committee on the Application of Science and Technology for the Benefit of Less Developed Countries. Australia is represented on the Committee by Sir Ronald Walker, Ambassador to France. At meetings of the Committee, Mr. G. B. Gresford, Secretary, CSIRO, has acted as scientific adviser to Sir Ronald Walker.

Commonwealth Collaboration

Following a decision taken at the British Commonwealth Scientific Committee Meeting at New Delhi in November 1962, arrangements have been made for the appointment of a full-time Executive Secretary of the British Commonwealth Scientific Committee. The principal duties of the Executive Secretary are to become acquainted with the special needs of those Commonwealth countries whose scientific effort is in the early stages of development and to suggest how other Commonwealth countries might best contribute to those needs.

CSIRO has contributed substantially to the initial establishment of this new post by seconding Mr. A. J. Vasey as its first occupant. Mr. Vasey, formerly of the Division of Animal Health, commenced his new duties in January 1964 and has already travelled extensively in the Commonwealth countries in Africa.

Contacts with Overseas Science

Because of their geographical isolation it is particularly important that Australian scientists should keep in close touch with the trends of thought and the latest developments in their subject in the leading laboratories throughout the world. CSIRO is active in encouraging and assisting scientists from overseas countries to visit Australia. These range from very senior scientists who come for short periods to discuss research problems, to give lectures and seminars, or to exchange views on research administration, to research workers who stay for longer periods and spend their time actively working at the bench or in the field. Such visits are not only of great benefit to the CSIRO officers with whom the visitors work but also are a means of spreading information about the organization and its work when the visitors return to their homes.

As well as encouraging visits to Australia by overseas scientists it is essential to ensure that Australian scientists have adequate opportunities to travel abroad to study new scientific developments, to obtain information on special research techniques, to undertake advanced studies at the invitation of overseas research organizations, and to attend international meetings. The Executive believes that such visits are of the utmost importance to CSIRO and to ensure the vigorous development of Australian science; during the year under review the Executive has provided means for its officers to make such visits and it believes that the number of these must be maintained at a high level. The Executive is also gratified by the increasing number of invitations received by its officers to take part in international conferences.

Collaboration with Industry

It is the general policy of CSIRO to work with an industry or public authority in seeking solutions to problems which are of concern to a number of companies or interests and from time to time to undertake work for individual companies if other help is not available. During the year under review a number of new cooperative projects have been started including:

An investigation of silting in the Cotter River catchment area by the Division of Plant Industry, with financial support from the National Capital Development Commission; investigations by the Division of Soils into the phosphorus requirements of soils, with financial support from Australian Fertilizers Ltd. and the Sulphide Corporation Pty. Ltd.; grape crop forecasting by the Horticultural Research Section, with financial support from the Australian Wine Board and the Department of Primary Industry; experimental shipments of apples and pears to the United Kingdom by the Division of Food Preservation, with financial support from the Australian Apple and Pear Board; survey of prawns in the Gulf of Carpentaria by the Division of Fisheries and Oceanography, in collaboration with the Queensland Department of Harbours and Marine; survey of tuna in New South Wales and South Australian waters by the Division of Fisheries and Oceanography, with financial support from the Fisheries Development Fund; investigations of the Australian plague locust by the Division of Entomology, with financial support from the Locust Control Fund.

The Organization has continued to be associated with the National Association of Testing Authorities and the Standards Association of Australia.

Collaboration with the Universities

Many CSIRO Divisions and Sections continue to work in close collaboration with Australian universities on particular research programs. Officers of the Organization have continued to assist in university lecturing, demonstrating, and supervising in specialized fields.

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

University of Melbourne:

- Mathematical computing
- Equipment for X-ray diffraction
- Pollen research
- Research on the genetics of regulatory mutants and the nature of enzymatic control

Monash University:

- Installation of superconducting magnet

University of Queensland:

- Research Fellowship in Parasitology
- Research Fellowship in Veterinary Anatomy
- Development of solvent-in-pulp extraction process

University of Sydney:

- Colloid science research
- Research on dairy beef production
- Research on heat and mass transference
- Running expenses at "Fleurs" field station

University of New South Wales:

Research into the failure of concrete

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 the evolution of marsupials

University of Western Australia:

Establishment of an Institute of Arid Zone Biology

Part cost of a cold room for hail research

University of Tasmania:

Research on biophysics

The CSIRO radio astronomy station at "Fleurs", 30 miles west of Sydney, was transferred to the University of Sydney to help the University cope with the increasing number of post-graduate students and teaching staff wishing to undertake research in electrical engineering. The gift followed the completion by the Division of Radiophysics of the program of radio astronomy observations for which the station was established.

CSIRO has continued its support to the Electrical Research Board, which made grants this year to the Universities of Sydney, Melbourne, Queensland, Western Australia, and New England, and provided post-graduate scholarships in the Universities of Sydney and Adelaide.

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

Overseas Research Grants

For a number of years CSIRO has received grants from overseas organizations for specific research projects 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. Major grants awarded during the year include:

£A46,000 from the U.S. Department of Agriculture for an investigation of the chemistry and biological effects of cyclopropenoid compounds by the Division of Food Preservation.

£A8200 from the U.S. Department of Agriculture for structural studies on two forms of ovalbumin by the Division of Food Preservation.

$9850 from the U.S. Department of Health, Education and Welfare for the collection, preparation, and fractionation of extracts of certain plants by the Division of Organic Chemistry.

$97,000 from the National Aeronautics and Space Administration for cinematographic study of solar magnetic fields by the Division of Physics.

$36,400 from the U.S. Department of Health, Education and Welfare for chemical, physical, and genetic studies on myxoma virus by the Division of Animal Genetics.

Science and Industry Endowment Fund

The Executive, as Trustees of the Science and Industry Endowment Fund, made grants to assist the following: Mr. H. O. Webster to purchase equipment for field studies of the noisy scrub bird (*Atrichornis clamosus*); Mr. R. Burn to purchase equipment to continue his project on the Opisthobranchia of New South Wales; Mr. N. A. Wakefield to continue his studies on the fossil mammalian fauna of south-eastern Australia; Mr. R. H. Green to investigate the distribution and general ecology of the small mammals of Tasmania; Dr. W. D. L. Ride to undertake a project concerned with the taxonomy of Australian mammals; Dr. B. Johnson to complete his work on neurosecretion in insects. A calculating machine was made available on loan to Dr. E. A. Magnussen for use in quantum mechanical calculations on transition metal compounds.

Grants were made towards the travelling expenses of Mr. D. K. McAlpine to visit New Guinea on an insect collecting trip and Dr. T. C. Chambers to visit New Caledonia to extend his field knowledge of the fern genus *Blechnum*.

The Trustees also made grants to the A.C.T. Science Teachers Association and the Victorian Science Teachers Association for annual school science awards; students and demonstrators of the Universities of Tasmania, Western Australia, Queensland, Adelaide, Melbourne, Monash, New England, and Townsville to enable them to attend the annual School of Marine Biology at the Division of Fisheries and Oceanography, Cronulla, N.S.W.; science students of U.K. universities to visit Australia to gain further experience in this country.

CSIRO Post-Graduate Studentships

As part of its policy of encouraging post-graduate research training in Australia, CSIRO awards a number of post-graduate studentships each year.

Support is also provided from the CSIRO Studentship Fund to supplement the 1851 scholarships awarded each year to Australian science graduates for post-graduate training in the United Kingdom.

Junior Post-Graduate Studentships

These are awarded, for one year only, to persons holding a pass degree in Science, Agricultural Science, Veterinary Science, Engineering, or Arts with Mathematics as a main subject. There were 138 applications; 35 studentships were awarded (8 were subsequently declined). The candidates who accepted them are listed below with their universities:

J. Baldas (Melbourne)
A. J. Blackman (Tasmania)
R. J. Blagrove (Adelaide)
A. J. Bull (Adelaide)
B. A. Casey (Adelaide)
Miss J. A. Chessell (Western Australia)
Miss E. M. Craddock (Sydney)
Miss J. E. Crawford (Sydney)
M. Craig (Sydney)
R. H. Crozier (Melbourne)
P. W. Donovan (Sydney)
P. C. Drewer (Adelaide)
L. Dubicki (Melbourne)
R. A. Fox (Western Australia)
Miss W. J. Greenhalgh (Queensland)
S. Haris (Sydney)
J. A. Lipa (Western Australia)
V. J. McSweeney (Queensland)
G. L. Paul (Sydney)
G. J. Pearce (Western Australia)
Miss B. J. Pickford (Western Australia)
A. Rainis (New South Wales)
J. W. Redmond (Adelaide)
G. D. Reynolds (Adelaide)
R. G. Senior (Sydney)
B. M. Smith (Adelaide)
J. F. Wrigley (Melbourne)

Senior Post-Graduate Studentships

These are awarded for two years initially to persons holding at least an Honours degree in the fields listed, or equivalent qualifications. The period of the studentship may be extended for an additional year under special circumstances. During the year 250 applications were received; 44 awards were made (11 were subsequently declined). The candidates who accepted them are listed below:

K. D. Barrow (Adelaide)
R. R. Bishop (Adelaide)
R. F. Barrett (Western Australia)
G. D. Campbell (Melbourne)
D. N. Cooper (Adelaide)
B. G. Cox (Melbourne)
I. Dainis (Adelaide)
B. J. Dalton (Monash)
P. L. Dyson (Melbourne)
T. M. Gagen (Queensland)
B. J. Green (New Zealand)
Miss N. F. Gersch (Adelaide)
J. B. Grutzner (Melbourne)
M. R. Hale (Adelaide)
R. J. Hill (Sydney)
B. J. Kabriel (Sydney)
L. A. P. Kane-Maguire (Queensland)
N. A. P. Kane-Maguire (Queensland)
L. P. Jones (Sydney)
J. R. de Laeter (Western Australia)
J. G. Lodge (Sydney)
Miss J. A. Marshall (Adelaide)
R. S. McCredie (Sydney)
Miss D. L. Millard (Adelaide)
A. McKenzie (Melbourne)
I. F. Morrison (Sydney)
B. J. Orr (Sydney)
R. W. Retallack (Western Australia)
P. G. Slade (Adelaide)
J. N. Ward (Sydney)
K. S. White (Queensland)
R. T. Worley (Adelaide)
Miss J. A. Waltho (Melbourne)

Overseas Studentships

These are awarded to research workers in science and allied fields who have obtained, or who are about to obtain, the degree of Ph.D., to enable them to proceed overseas, usually for one year, to work with leaders of research in their special field of interest. During the year 59 applications were received, and 16 candidates were selected, 2 of whom declined in favour of other awards:

C. J. Asher (Western Australia)
P. M. Attiwill (Melbourne)
Miss I. Auzins (Adelaide)
F. J. Ballard (Western Australia)
N. G. Brink (Tasmania)
R. W. Cattrall (Adelaide)
T. S. Chandler (Adelaide)
D. G. Edwards (Adelaide)
Dr. G. P. Findlay (CSIRO)
L. C. Gruen (Melbourne)
Miss K. Korboot (Queensland)
K. J. Mills (Adelaide)
Dr. S. M. Richards (New England)
L. R. Williams (Adelaide)

Awards by Outside Bodies

The Organization was again asked to select candidates for Australian Dairy Produce Board post-graduate studentships, Australian Cattle and Beef Research Committee post-graduate studentships, and Wheat Research Council post-graduate studentships. The Organization was also asked to advise on applications for the Masson Memorial Scholarship of the Royal Australian Chemical Institute.

Organization

CSIRO is organized in four major group laboratories and a number of Divisions and Sections. The four group laboratories are the Animal Research Laboratories grouping three Divisions, the Chemical Research Laboratories grouping six Divisions, the National Standards Laboratory grouping two Divisions, and the Wool Research Laboratories grouping three Divisions. There are also 18 independent Divisions in other research fields and an additional 12 independent Sections.

The Head Office is in Melbourne and associated with it are the central Library, the Film Unit, and the Translation Unit. Regional Administrative Offices are located at Melbourne, Sydney, and Canberra. The Organization also maintains the Australian Scientific Liaison Office in London and the Office of the Scientific Attaché in Washington.

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

LABORATORIES AND DIVISIONS

Animal Research Laboratories, consisting of the following three Divisions:

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

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

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

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

Applied Mineralogy, with a branch laboratory in Perth

Chemical Engineering

Chemical Physics

Mineral Chemistry

Organic Chemistry

Physical Chemistry

and

Microanalytical Laboratory

Sugar Research Laboratory

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

Applied Physics

Physics

Wool Research Laboratories, consisting of the following three Divisions:

Protein Chemistry, Melbourne

Textile Industry, Geelong, Vic.

Textile Physics, Ryde, N.S.W.

Other Divisions are:

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

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

Coal Research, Sydney

Dairy Research, Melbourne

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

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

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

Forest Products, Melbourne

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

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

Mechanical Engineering, Melbourne

Meteorological Physics, Melbourne

Plant Industry, with headquarters and main laboratories in Canberra, laboratories in Perth and Hobart and in Deniliquin, N.S.W., field stations and experimental farms at Canberra and Deniliquin, and at Kojonup and Baker's Hill, W.A., and a 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 a solar radio astronomy observatory at Dapto, N.S.W.

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

Tribophysics, Melbourne

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

Wildlife Research, Canberra

INDEPENDENT SECTIONS

Computing Research, Canberra
Editorial and Publications, Melbourne
Fodder Conservation, Melbourne
Horticultural Research, Merbein, Vic.
Industrial Research Liaison, Melbourne
Irrigation Research Laboratory, Griffith, N.S.W.
Mineragraphic Investigations, Melbourne
Ore Dressing Laboratory, Melbourne
Physical Metallurgy, Melbourne
Soil Mechanics, headquarters in Melbourne with a laboratory in Adelaide
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

Overseas Liaison Offices

One way in which CSIRO maintains close contact with overseas scientific developments is through the Australian Scientific Liaison Office, London, and the Office of the Scientific Attaché to the Australian Embassy, Washington. These Offices also serve as centres for visitors, research students, and visiting scientists and for the recruitment of scientific staff. The Chief Scientific Liaison Officer in London and the Australian Scientific Attaché in Washington have represented Australia at scientific conferences in the United Kingdom, Europe, and North America.

During the year Mr. W. Hartley, formerly Scientific Attaché to the Australian Embassy, Washington, transferred to London as Chief Scientific Liaison Officer. Mr. Hartley was succeeded in Washington by Mr. C. S. Elliot, formerly Assistant Chief of the Division of Forest Products.

Liaison Activities

Agricultural Liaison

Publications are an important part of this activity and their preparation involves establishing and maintaining close liaison between research workers and extension officers.

In addition to the quarterly *Rural Research in CSIRO*, other major publications produced during the year include:

"SOIL AND PASTURE RESEARCH ON THE NORTHERN TABLELANDS, N.S.W."
Written primarily for extension workers, this 80-page book was prepared in collaboration with the New South Wales Department of Agriculture. Like the earlier publication, "Soil and Pasture Research in South-Western Australia", it develops a regional, as distinct from a subject matter, approach to agricultural research.

"WHEN A FARMER SOWS"
Produced on behalf of the Wheat Industry Research Council, this booklet describes some of the work of Australian scientists whose efforts have enabled new and better methods of production and land use to be introduced on Australian wheat farms. The Council has circulated some 90,000 copies to wheat farmers throughout Australia.

Another important liaison activity has been the convening of technical conferences held under the aegis of the Australian Agricultural Council. Major conferences held during 1963–64 were the Australian Fruit Research Conference, the Conference on Carcass Composition and Meat Appraisal, the Australian Grasslands Conference, the Sheep and Wool Conference, and the Vegetable Research Conference.

Industrial Liaison

The Industrial Research Liaison Section has continued to issue the bimonthly publication *CSIRO Industrial Research News*, giving information about developments from CSIRO research programs of interest to Australian manufacturers. The Section has also prepared other publications which broadly survey fields of CSIRO research of interest to industry and the general public.

Many aspects of the relationships between CSIRO and manufacturing industry are included in the work of the Section. An important part of this work is the use that is made of patents, trade marks, and licences, to promote the use in industry of CSIRO inventions. It is one of the major aims of CSIRO to bring about the widest possible use of innovations arising from its research. Past experience has shown that, in many cases, the industrial application of a CSIRO invention is assisted by patenting the invention.

Several other aspects of the public interest are also served by patenting CSIRO inventions. A patent protects an invention from patenting by others; it permits supervision to be exercised over industrial users to ensure that new products and processes do not become discredited owing to the inventions being incompetently applied; and it provides a means whereby a firm that is prepared to invest a substantial amount in developing an invention from laboratory operation to factory production may be granted a measure of priority in use of the invention, and thus be given a reasonable opportunity to recoup its development costs. In the case of inventions relating to wool textiles, patenting provides a basis for technical promotion of new products and finishes, and permits these to be used overseas under the promotional control of the International Wool Secretariat and its affiliated bodies. Finally, while earning revenue is not one of the main aims of CSIRO, patents have made possible the collection of substantial royalties through licensing of overseas manufacturers.

The Section has continued to provide assistance to the Divisions and Sections with patenting and licensing of inventions and with all aspects of the use of patents to promote the industrial application of CSIRO research.

Thirty-one new patent licence agreements were entered into during the year. A collaborative research program was commenced, under the terms of a patent licence agreement covering new organophosphorus insecticides developed in the Division of Organic Chemistry. Collaboration, based on patent rights, between CSIRO and chemical manufacturers has also led to substantial payments by industry for additional research in the Division of Physical Chemistry and in the Division of Plant Industry.

At the conclusion of the period CSIRO had current licensing agreements with 197 licensees. These agreements involved 54 Australian and 243 overseas patents covering 65 inventions.

Research Services

Films

The film "Insect Tissue Culture" won first prize in the Biological Science Section of the VIII International Review of Scientific and Educational Films at Padua and was awarded a silver bucranium. Another film "A Matter of Survival—Toxic Solvents" won a silver award in the Teaching Section of the 1964 annual competition of the Australian Film Institute.

During the year, the Film Unit collaborated with the Australian Broadcasting Commission in producing five half-hour programs—"Science and the Rainmakers", "Science and the Stars", "Science and the Bushfire", "Science and Solar Energy", and "Science and Building Research". These programs will be released later in 1964 under the general title "Outlook".

Television stations made further use of excerpts from CSIRO films in rural and educational programs, and 10 films were transmitted in their entirety through Queensland country channels. Black-and-white copies of a number of the Unit's recent productions have been made to help meet the demand from country television stations for films on the work of CSIRO.

The Film Unit collaborated with A.N.Z.A.A.S. and the Victorian State Film Centre in presenting an exhibition in Melbourne of the best of the films screened at the Second A.N.Z.A.A.S. International Scientific Film Exhibition. Selected overseas scientific films were also screened at high schools in Melbourne, Geelong, Ballarat, and Sale.

The Unit has continued to work in conjunction with the Division of Entomology on time-lapse cinemicrographic studies of insect tissue cultures.

The following films were produced during the year by the Film Unit:

"STABILISING SOFT SITES"

16 mm, Colour, Sound, Screening Time 9 min

The construction of a new laboratory for the Soil Mechanics Section was the occasion of a practical demonstration of soil stabilization. A cheap and effective method of stabilizing the wet, clayey building site by the addition of hydrated lime is shown.

"RESEARCH ON SURVIVAL IN BUSHFIRES"

16 mm, Colour, Sound, Screening Time 17 min

Produced in collaboration with the Division of Physical Chemistry, this film demonstrates the use of a special survival tent developed by the Division's bushfire research team.

"CURRENT RESEARCH IN ENTOMOLOGY"

16 mm, Colour, Sound, Screening Time 28 min

This film reviews some of the research activities of the Division of Entomology—the successful culture of insect tissue cells, the biological control of the Queensland fruit fly and the green vegetable bug, the more efficient use of chemical sprays in the control of cattle tick, and aspects of termite research.

"SOLAR WATER-HEATING"

16 mm, Colour, Sound, Screening Time 12 min

Equipment developed by the Division of Mechanical Engineering for using energy from the Sun to heat water is described. The film is intended primarily for manufacturers of solar water heaters and for installation engineers.

"BIRD BANDING IN AUSTRALIA"

16 mm, Colour, Sound, Screening Time 26 min

This film shows how the banding of birds helps biologists collect information essential for the study and conservation of rare species and for the control of pests. It is intended for general screening and television to encourage the public, particularly school children, to report findings of banded birds.

"SALMON TAGGING"

16 mm, Colour, Sound, Screening Time 11 min

Tagging the Australian salmon, *Arripis trutta*, is helping scientists of the Division of Fisheries and Oceanography to learn more about the movements and distribution of the species. This film is aimed at encouraging commercial and amateur fishermen, canners, and processors to return tags recovered from salmon catches.

"THE INSTALLATION OF A MONOLITH LYSIMETER"

16 mm, Black and White, Silent, Screening Time 17 min

A technique developed by the Division of Meteorological Physics for installing large lysimeters is shown. The lysimeters were developed by the Division to measure evaporation from natural surfaces.

LIBRARIES

CSIRO libraries, in common with other scientific libraries, continually face the problem of adequately housing the great quantities of information required by research workers. It is estimated that the volume of publication of scientific periodicals throughout the world is increasing at an exponential rate of 6% per annum. An even more urgent problem is to ensure that the material already acquired by libraries is readily available to the scientific worker. In a number of overseas countries this problem is at present being tackled by using automated systems of documentation. There are at present between 50 and 60 different systems in use but sufficient experience with them has not yet been obtained to demonstrate conclusively their real effectiveness. Work on these systems has largely concentrated on storage and retrieval problems but research has already shown that, in addition, the mechanization of reading, of abstracting, and of coding may also be achieved.

In 1963, the Chief Librarian visited the United States, England, Israel, and the two larger documentation centres, PANSDOC and INSDOC, to study the mechanized systems in use and the problems involved in the change-over from manual to mechanized systems. Following this visit, CSIRO established a special committee of senior librarians to examine mechanization in libraries. The senior librarian at the Weapons Research Establishment of the Department of Supply, who is already making use of computers, was coopted to the Committee.

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

The revision of the Organization's extensive mailing list has led to the compilation of a list of the material received by gift and exchange from institutions inside and outside Australia. It is hoped to use this list, together with a list of periodicals and serials to which the Organization subscribes, to reveal weaknesses in CSIRO collections by making a computer-based comparison with larger overseas catalogues and union lists.

For some years an index to the work of the Organization's research staff has been held on cards in the Head Office library. The author section of the index has now been revised and prepared for publication.

PUBLICATIONS

The Australian Academy of Science has continued to cooperate with CSIRO in producing the scientific journals published by the Organization and in maintaining a high standard in the papers appearing in them. These journals are: *Australian Journal of Agricultural Research*, *Australian Journal of Applied Science*, *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*.

Editorial policy is decided by a Board of Standards appointed jointly by the Academy and by CSIRO. During the year Professor Sir Macfarlane Burnet retired from the Board and Dr. M. F. Day and Professor R. Street were appointed to it. The present members of the Board of Standards are: Professor W. P. Rogers (Chairman), Mr. A. E. Scott (Editor-in-Chief), Professor N. S. Bayliss, Dr. M. F. Day, Professor R. Street, and Professor J. S. Turner. Advisory Committees are appointed by the Board for each individual journal, and members of the Board serve on appropriate journal committees.

Contributions are published from research workers, irrespective of country or of the establishment to which they are attached. Many papers from workers in Australian universities and a limited number from overseas have been published.

The number of acceptable papers for the *Australian Journal of Chemistry* increased during the past year and since January 1964 this journal has been published monthly.

CSIRO also publishes research results in technical papers of the Divisions and Sections and in special publications such as *CSIRO Wildlife Research*, the "Land Research" series, and the "Soil Publication" series. Many research papers are also contributed by CSIRO officers to other scientific journals both in Australia and overseas.

TRANSLATION

Written and oral translations were produced by the Translation Section, which has officers in Melbourne and Sydney, and by translators attached to Divisions in Adelaide and Canberra. The languages translated include German, Dutch, Swedish, Norwegian, Danish, French, Italian, Spanish, Portuguese, and Russian.

The Translation Section has operated as Australian agent for the Index of Translations of the British Commonwealth Scientific Office, supplying copies of its own translations on request.

State Committees

The following members were appointed as Chairmen of the State Committees:

Queensland:	W. J. D. Shaw
Tasmania:	V. G. Burley, B.E.

The following new members were appointed:

New South Wales:	G. Edgar, D.V.Sc.
	R. A. Irish, O.B.E., F.C.A.
	E. O. Rayner, M.Sc., Ph.D.
Queensland:	G. Sheil, B.Sc., B.C.E., B.M.E.
Tasmania:	Professor G. C. Wade, M.Agr.Sc., D.Sc.
Western Australia:	J. P. Norton, O.B.E.

Organizational Changes

Agricultural Liaison Unit

The Agricultural Research Liaison Section has been transferred to the Secretariat and is now the responsibility of an Assistant Secretary. It has been renamed the Agricultural Liaison Unit and Mr. R. D. Croll, B.Agr.Sc., has been appointed Acting Assistant Secretary (Agricultural Liaison). The Unit will continue to produce *Rural Research in CSIRO* and various leaflets and publications. The other liaison work of the Unit will revolve very largely around the technical conferences which are held each year under the auspices of the Australian Agricultural Council.

Division of Mechanical Engineering

The Engineering Section has been designated the Division of Mechanical Engineering, and Mr. R. N. Morse, B.Sc., B.E., former Officer-in-Charge of the Section, has been appointed Chief of the Division.

Ore Dressing Investigations

The Ore Dressing Laboratory, Melbourne, has been renamed Ore Dressing Investigations.

Retirements and Resignations

Mr. J. K. Taylor, B.A., M.Sc., B.Sc.Agr., retired from CSIRO, after being Chief of the Division of Sojls for 16 years. Mr. Taylor joined the Division in 1927 and became closely associated with his Chief, Professor J. A. Prescott, in building up the Division and expanding its soil survey activities. He was appointed Deputy Chief of the Division in 1944 and Chief in 1947. Under his leadership the scope of the Division's research has been greatly increased and there are now strong research groups concerned with the chemistry, physics, and microbiology of soils, and with clay mineralogy, pedology, and soil survey.

Mr. Taylor played a leading role in the formation of the Australian Soil Society and was its President during 1958–60. He also played an important part in the establishment of the *Australian Journal of Soil Research*.

Dr. M. E. Hargreaves, Ph.D., B.Met.E., of the Division of Tribophysics, has been appointed Professor of Physical Metallurgy at the University of Melbourne.

Dr. R. L. Reid, B.Sc.Agr., Ph.D., of the Division of Animal Physiology, has been appointed Director of the Hill Farming Research Organization in the United Kingdom.

Dr. E. J. Williams, B.Com., D.Sc., Division of Mathematical Statistics, has been appointed Professor of Statistics, University of Melbourne.

New Chief for Division of Soils

Professor E. G. Hallsworth, B.Sc., Ph.D., has been appointed Chief of the Division of Soils following the retirement of Mr. J. K. Taylor. Professor Hallsworth has been Professor of Agricultural Chemistry and Dean of the Faculty of Agricultural Chemistry at the University of Nottingham since 1950. He was Visiting Professor of Soil Science at the University of Western Australia in 1960–61.

Meeting of Executive with Chiefs and Officers-in-Charge

During May 1964, a two-day residential conference of the Executive, Chiefs, and Officers-in-Charge was held at the Australian Academy of Science building, Canberra, the first half of the conference being held jointly with a meeting of the Advisory Council.

The conference provided a forum for discussions on research policy and research administration. Among the items discussed were the evaluation and management of research staff, the balance and development of the Organization's research program, public relations, and the provision of adequate laboratory accommodation.

Honours and Awards

Mr. E. C. B. Langfield, Division of Land Research and Regional Survey: Officer of the Most Excellent Order of the British Empire.

Mr. C. S. Christian, Member of the Executive: Member of the World Academy of Art and Sciences.

Dr. W. Boas, Chief, Division of Tribophysics: Member of the Solid State Commission of the International Union of Pure and Applied Physics.

Dr. H. J. Frith, Chief, Division of Wildlife Research: Doctor of Science in Agriculture, University of Sydney.

Dr. R. G. Giovanelli, Chief, Division of Physics: Fellow of the Australian Academy of Science.

Dr. D. F. Martyn, Officer-in-Charge, Upper Atmosphere Section: Reappointed Chairman of the United Nations Scientific and Technical Committee on the Peaceful Uses of Outer Space. Member of the Executive Committee of the International Council of Scientific Unions.

Mr. R. N. Morse, Chief, Division of Mechanical Engineering: Director of the International Solar Energy Society.

Dr. J. R. Price, Chief, Division of Organic Chemistry: President of the Royal Australian Chemical Institute.

Dr. C. H. B. Priestley, Chief, Division of Meteorological Physics: Member, Advisory Committee of the World Meteorological Organization.

Dr. A. L. G. Rees, Chief, Division of Chemical Physics: Member of the Executive Committee and Bureau of the International Union of Pure and Applied Chemistry. Secretary (Physical Sciences), Australian Academy of Science.

Dr. D. B. Williams, formerly Officer-in-Charge, Agricultural Research Liaison Section: Fellow of the Australian Institute of Agricultural Science.

Dr. G. Alexander, Division of Animal Physiology: Doctor of Agricultural Science, University of Melbourne.

Dr. R. Brewer, Division of Soils: Doctor of Science, University of Sydney.

Dr. J. David, Division of Plant Industry: Doctor of Science, University of Western Australia.

Dr. A. T. Dick, Division of Animal Health: Fellow of the Australian Academy of Science.

Dr. W. C. T. Dowell, Division of Chemical Physics: Doktor der Naturwissenschaften, Free University of Berlin.

Dr. R. C. Gifkins, Physical Metallurgy Section: Federal President, Australian Institute of Metals.

Dr. J. M. Gillespie, Division of Protein Chemistry: Doctor of Science, University of Melbourne.

Dr. J. J. Kowalczewski, Division of Mechanical Engineering: Doctor of Technical Science, Swiss Federal Institute of Technology, Zürich.

Dr. A. McL. Mathieson, Division of Chemical Physics: H. G. Smith Memorial Medal of the Royal Australian Chemical Institute. Chairman of the Commission on Crystallographic Apparatus of the International Union of Crystallography.

Dr. R. J. Meakins, Division of Applied Physics: Doctor of Science, University of London.

Dr. J. D. Morrison, Division of Chemical Physics: Fellow of the Australian Academy of Science.

Dr. A. C. Oertel, Division of Soils: Doctor of Science, University of Queensland.

Mr. B. J. Rigby, Division of Textile Physics: Swedish Jeton.

Dr. J. P. Wild, Division of Radiophysics: Fellow of the Australian Academy of Science.

Mr. F. Wilson, Division of Entomology: Fellow of the Institute of Biology.

2

Progress in Research

THIS CHAPTER consists of a brief survey of some of the more important and interesting developments in the research being carried out by CSIRO. Details of many of the individual projects may be found in the scientific papers and in the letters patent that are listed in Chapter 3.

Detailed information about the Organization's research program is available from annual reports issued by each Division and Section. These may be obtained from the Chief or Officer-in-Charge of the Division or Section concerned. The addresses of the headquarters of each establishment are given in Chapter 4.

Environment of Field Growth

The construction of CERES, the Division of Plant Industry's Controlled Environment Research Laboratory, has provided an excellent facility for studying various aspects of plant performance under precisely controlled climatic conditions. Complementary studies of the environment of growth of plant communities in the field are also being conducted. The aims are to provide a physical description of the environment of various aspects of growth, and to examine the way in which plant communities, through their growth habits, modify their own environment.

Studies are proceeding in two contrasting plant communities, a wheat field and a pine forest. The project is equipped with a mobile laboratory and associated sampling and recording equipment, which permit continuous and automatic recording of such environmental factors as temperature, humidity, solar radiation, wind velocity, and carbon dioxide content.

The work to date has provided a very interesting picture of the distributions of temperature, humidity, and solar radiation in the canopy and of the corresponding distribution of evaporation sources and the movement of sensible heat. Whereas most of the incoming solar radiation, the primary source of energy for evaporation, is absorbed in a shallow layer of foliage at the top of the canopy, the evaporation sources tend to be more evenly distributed over the depth of the canopy. The transpiration rate of foliage near the top of the canopy is less than the available radiant energy, while that of foliage at the bottom of the canopy exceeds it. The higher relative transpiration rate of the bottom foliage is maintained by the movement of heat down through the canopy from the hotter, absorbing region at the top.—*Division of Plant Industry*.

Bulrush Millet in the North

The beef cattle industry of northern Australia is based on native pastures, which, during the dry season, are of very low quality. Cattle at Katherine, N.T., lose up to a quarter of their liveweight between May and November. Recent experiments have demonstrated the value of bulrush millet (*Pennisetum typhoides*), a tall annual grass, as a standing fodder for beef cattle during the dry season.

Bulrush millet has a high productive potential. In a region with an annual average of 35 in. of rain falling in 4–5 months, yields of up to 8 tons of dry matter per acre and ½ ton crude protein per acre have been reached within 16 weeks of sowing. Peak growth rates have approached 400 lb dry matter per acre per day. The deep roots of the crop enable it to withstand intermittent dry spells in the wet season and to take up available soil nitrogen which has been leached beyond the roots of other crops. Over the last two dry seasons, standing millet has carried an average of 2 beasts per acre for 5 months, with an average liveweight gain per acre of 264 lb.—*Division of Land Research and Regional Survey.*

Agricultural Advantages of Monsoonal Northern Australia

Monsoonal northern Australia has had a long history of agricultural failure since the first attempts at European settlement were made 120 years ago. While the environment poses a number of problems for mechanized European agriculture, research has shown that it has a number of advantages.

(*a*) Although almost all of the rainfall of 30–60 in. falls in a short summer period of 4–5 months, the wet season is of relatively high reliability. For example, at Katherine Research Station the 10-year average yield of peanuts is 1400 lb per acre and of grain sorghum 2000 lb per acre, but yield in the worst year for peanuts was still 1100 lb per acre and in the worst year for sorghum 1200 lb per acre.

(*b*) The dry season is extremely dry and equally reliable. In the four winter months, the mean total rainfall is less than 0·5 in., there are no frosts, and dews occur only near the coast. At Katherine, dry standing crops of Townsville lucerne and bulrush millet give better cattle weight gains per acre than when grazed green. They maintain their feeding value until the first rain falls in October or November. At Kimberley Research Station, cotton maturing in April–May can be left on the plant until August–September without loss of yield or quality. Harvesting is spread out and is therefore less costly than in areas liable to autumn and winter rain, dew, or frost.

(*c*) The dry season is warm and, with irrigation, a wide range of temperate crops—linseed, safflower, wheat, oats, rape, and *japonica* rice—can be grown, and the growth of several tropical crops extended.

Two crops of cotton have been experimentally harvested from one sowing in less than a year at Kimberley. A normal November-planted crop, harvested in April, re-irrigated, and given more fertilizer, will give a second crop of similar yield in August–September. Sorghum planted in December was harvested three times, twice at the silage stage and once for grain, within 9 months.

The winters are so warm that crops of tropical *indica* rice have been matured from autumn to midwinter at the Coastal Plains Research Station near Darwin. This increases the efficiency of expensive harvesting machinery. It should also be possible, with appropriate varieties, to follow the ratoon rice-cropping practices now being widely applied in Texas, U.S.A.

Many of these findings are still only at the research level, and means of exploiting these advantages in commercial agriculture are still being investigated. However, the problem is no longer one of adapting agricultural systems developed in temperate regions for the more rigorous conditions of the tropics, but one of exploiting the positive advantages offered by the tropical environment.—*Division of Land Research and Regional Survey.*

New Plants for Tropical Pastures

The improvement of cattle pastures in the northern tropical areas of Australia requires the introduction and utilization of more productive pasture species. In particular, suitable legumes which provide higher protein feed and raise the level of soil fertility are necessary. The search for such species has recently been greatly intensified and a plant exploration and seed collecting expedition made to various countries of Central America and the Caribbean. Collections of seed, especially of legumes, have been secured from Colombia, Venezuela, the Guianas, Guadeloupe, Trinidad, Puerto Rico, Costa Rica, Honduras, El Salvador, Guatemala, and southern Mexico.

The majority of seed collections are of species of the genera *Calopogonium*, *Canavalia*, *Centrosema*, *Desmodium*, *Galactia*, *Leucaena*, *Phaseolus*, *Rhynchosia*, *Stylosanthes*, and *Zornia*. For many of these, nodules containing effective rhizobia were also collected.

This material collected from countries where no detailed collections for Australia have previously been made will have commercial application either through direct use or through plant breeding programs which the widely varying genetic characteristics of the collections will permit.—*Division of Plant Industry.*

Townsville Lucerne Pastures for the North

In previous pasture research at Katherine aimed at improving the nutritive level of beef cattle in the region, an all-purpose pasture mixture of birdwood grass and Townsville lucerne was developed. Although this pasture gave satisfactory weight gains during the summer wet season, it was of only moderate value during the long dry season, though still a great improvement over native pasture.

Recent work at Katherine has shown that Townsville lucerne pastures without the perennial sown grass are of greater feeding value in the dry season than grass/Townsville lucerne pastures. Cattle grazing dry-season pasture with 23% Townsville lucerne gained only 20 lb/head, those grazing pasture with 45% Townsville lucerne gained 99 lb/head, and those grazing pasture with 63% Townsville lucerne (the remainder being volunteer annual grasses) gained 196 lb/head.

Those results, in combination with those obtained from grazing standing bulrush millet, point towards more productive grazing systems for beef cattle in the far north. For wet-season grazing, the alternatives are native pasture, birdwood/Townsville lucerne pasture, or bulrush millet, and, for the dry season, Townsville lucerne pasture or bulrush millet.—*Division of Land Research and Regional Survey.*

New Information on Tropical Pasture Legume Nutrition

Soil nitrogen deficiency, as a factor limiting pasture growth, is of great importance in most parts of the world. In temperate regions it is standard practice to use nitrogen-fixing legumes to supply protein to the grazing animal and to build up the fertility of soils.

Until recently there were virtually no pasture legumes for use in sown pastures in the tropics and subtropics. However, as a result of intensive research in plant introduction, plant breeding, and agrostology during the last 15 years, a range of promising legumes for these regions has been developed, and their requirements and responses to fertilizer application have been investigated.

Research on the nutrition of tropical legumes has produced information which will be invaluable in establishing and managing them in pastures, and has also shown that their fertilizer responses are often quite different from those of temperate legumes. Examples of these findings are:

(1) *Response to acid soil conditions.*—Tropical legumes are more tolerant of acid soil conditions than temperate species, although there is some variability in tolerance. Thus, while the species *Centrosema pubescens*, *Stylosanthes humilis*, and *Lotononis bainesii* are most tolerant to manganese excess and *Phaseolus lathyroides*, *Leucaena glauca*, and *Desmodium* are less tolerant, *Glycine javanica* and *Phaseolus atropurpureus* are grouped with the temperate legume, lucerne, as relatively sensitive species. Similarly, *C. pubescens*, *S. humilis*, *L. bainesii*, *P. lathyroides*, and *P. atropurpureus* (siratro) are relatively tolerant to excess aluminium, whereas *G. javanica* and *D. uncinatum* are sensitive; the tolerant species are also capable of nodulating at pH values as low as 4·5, whereas lucerne will not nodulate below pH 6.

    These findings indicate that most of these new legumes can be grown in acid tropical soils with little or no added lime. It has also been found that some tropical species, e.g. *S. humilis*, are very efficient at extracting calcium, even from soils of low pH.

(2) *Phosphate.*—The legumes *S. humilis* and *L. bainesii* were found to be more efficient in utilizing soil phosphate and to require smaller quantities of added phosphate to promote maximum plant growth than the legumes *D. uncinatum*, *P. lathyroides*, and white clover. In the case of *S. humilis* (Townsville lucerne) this finding is supported by experiments using radioactive phosphorus. These showed that this species is extremely efficient in extracting phosphate from solution and that this efficiency is relatively greater at very low phosphate concentrations. This information provides an explanation of the ability of this legume to thrive

A tall stand of bulrush millet fodder crop at Katherine, N.T., is shown above. Best cattle weight gains are achieved by grazing the dry standing bulrush millet (below) during the winter months.

on a wide range of soils of very low phosphate status over a vast tract of northern Australia, and a further criterion for evaluating new pasture plants for use in that area.

In addition to providing basic nutritional data on pasture legumes, these studies have enabled techniques to be developed for the diagnosis of the nutrient status of pasture legumes growing under field conditions. These diagnoses are based on foliar systems of deficiency or excess which a trained observer may detect by eye, and on the chemical analysis of plant material, from which the content and ratio of the different nutrient elements can be compared with established deficiency or toxicity criteria.—*Division of Tropical Pastures.*

Non-shattering Strain of *Phalaris*

Shattering of seed from the ripening inflorescence is characteristic of many grasses and causes substantial pre-harvest loss of seed from crops of *Phalaris tuberosa.* A study of the structure of the *Phalaris* inflorescence has shown that more seed is retained by the shorter and more compact heads. High retention is also associated with a high silica content of the glumes and with particular shapes of glumes and seeds. Considerable variation exists for this character within the species and, in view of the continuous nature of the variation and the high heritability, it appears that the character is under polygenic control.

Selection to improve seed retention in a strain of commercial *Phalaris* has been highly successful and in field-scale trials the non-shattering variety has produced more than double the yield of the standard commercial variety.—*Division of Plant Industry.*

The Distribution of Nutrient Deficiencies

In planning land use, certain relationships between the native fertility of soils and some feature of the environment are commonly assumed. For instance, the soils found at the bottom of a slope are generally accepted as more productive than those on the hill sides. Alternatively, the soils carrying a certain type of tree may be favoured or rejected for development.

Studies on the Northern Tablelands have dissected chemical fertility into its constituents and have shown that although there are very broad relationships between the appearance of the soil and its general fertility status, not all elements vary in the pattern of their status in the same way.

Whereas sulphur status was independent of topographic situation, molybdenum status was very much influenced by it. Parent material appeared to be the major influence in determining phosphorus status but intensity of weathering modified the relation. Nitrogen status was probably largely a function of land use, which in turn depended on the native vegetation. The results therefore show that the criteria for assessing fertilizer needs differ, depending upon the particular element concerned.—*Division of Plant Industry.*

Injection of a tobacco stem with a spore suspension of the blue mould fungus, Peronospora tabacina, *to induce stem infection. This technique is used to ascertain the degree of susceptibility of breeding lines to stem infection.*

Resistance to Poisons

An important means whereby man controls his environment is by killing off, with antibiotics, pesticides, and weedicides, forms of life which are destructive or dangerous. However, sooner or later, forms resistant to the poison usually appear, as in DDT-resistant house flies, penicillin-resistant staphylococci, and so on. These resistant forms arise by mutation and occur almost inevitably because an effective poison must usually be similar, but not identical, to a necessary natural chemical in the pest. Therefore, only a small genetic change may be required on the part of the organism to render the poison harmless. It is important to know what these changes are and how they come about, so that highly toxic antibiotics and pesticides may be made that are immune to the usual genetic sorts of inactivation.

These problems are being examined genetically and chemically in the enteric bacillus, *Escherichia coli*. There appear to be at least five ways by which a bacterium, and probably any other organism, can become resistant to a poison. (1) Where the poison is taken into the cell by an energy-requiring system, as it frequently is, this system may mutate so that the poison is excluded. (2) The particular chemical reaction in the bacterium that is inhibited by the poison may be lost by mutation. Although such a reaction may be advantageous in normal circumstances, the bacterium is better off without it than having the poison built into more complex processes. (3) The poison may be destroyed: (*a*) by an increase in the production of an enzyme which attacks it, this increase being brought about by duplicating the gene controlling the enzyme; (*b*) by a mutation increasing the efficiency of the inactivating enzyme; (*c*) by a genetic change in the binding properties of an enzyme allowing it to attack a new substance, in this case, the poison.—*Division of Plant Industry*.

Biosynthesis of Haem Pigments

Iron porphyrin (haem) pigments are essential components of respiratory systems in nearly all bacteria and fungi as well as in the higher plants and animals; as such they control the availability of energy to the various organisms. The iron-incorporating reaction, whereby iron is inserted into a porphyrin molecule to yield a haem, is a key step in the haem biosynthetic pathway. By understanding the mechanism involved it might be possible to specifically inhibit the rate of formation of such pigments. This could lead to the development of an inhibitor selectively active against the rapidly dividing parasitic cells which have a higher energy requirement than the resting host cells.

A soluble enzyme system ("ferrochelatase") prepared from both bacterial and animal cells was found to catalyse the incorporation of iron into porphyrins. The same system also catalysed the incorporation of cobalt, zinc, and to a lesser extent copper but was without effect on magnesium, manganese, nickel, and cadmium. Although the present evidence suggests that the same enzyme acts on the different metals, nevertheless the mechanism of iron insertion is unique. Iron incorporation, unlike that of cobalt and zinc, is completely inhibited by the presence of oxygen or by inhibitors which react with thiol groups. Current work is directed towards the purification of the system involved with a view to elucidating the active site of ferrochelatase.—*Division of Plant Industry.*

Nutrition of Lucerne in Acid Soils

Infertility in acid soils may be due to many factors. For example, soil acidity can lead to excessive availability of manganese and aluminium or insufficient availability of molybdenum to the plant, and it can be associated with inadequate levels of calcium. On many acid soils lucerne fails although subterranean clover grows normally. This remains true when effects of manganese toxicity and of deficiencies of molybdenum and calcium are excluded. Studies of this difference in sensitivity have yielded information on two further aspects of acid soil infertility.

In moderately acid soils of pH 5·5–6·0, lucerne, unlike subterranean clover, responded to lime. Most of the lime response was due to improved nodulation. Under these conditions strains of medic *Rhizobium* differed greatly in ability to nodulate lucerne plants. Selection of strains adapted in this respect could have practical advantages.

On more acid soils, of pH 5·0–5·5, subterranean clover still grew normally but lucerne responded to lime even when it was not nitrogen deficient. Here the lime response was reduced or eliminated by large applications of phosphate. Conversely, the apparent phosphate requirement was reduced by liming. In solution culture, lucerne was shown more sensitive than subterranean clover to aluminium toxicity. The effects of lime and phosphate in the soil experiments can largely be explained by their common effects in counteracting aluminium toxicity.—*Division of Plant Industry.*

Ten Years of Land Resources Surveys in New Guinea

The tenth land resources survey in Papua and New Guinea was completed in 1963. About one-sixth of the area of these territories has been surveyed in 10 years' work.

Generally speaking, the surveys have revealed the existence of larger areas with potential for development than was expected. Surprisingly, it is not unusual to find concentrations of indigenous population in poor areas, and large areas with a potential for major development that are virtually empty. The major difficulties in development appear to be: access, drainage, and flooding. With proper land use, erosion will rarely be a severe hazard, whilst soil fertility problems are normally not serious, although they weigh heavily in the present agronomic systems which have virtually no place for artificial fertilizers.

The survey reports and maps can be used as a basis for development planning. They provide information for policy makers to determine future land use, land tenure, agricultural extension, resettlement of population, and road and harbour locations.—*Division of Land Research and Regional Survey.*

Catchment Reclamation at High Altitudes

On depleted nitrogen-deficient areas at high altitudes the climax herbs have been found to be poor colonizers. It is therefore necessary to develop special reclamation techniques, in addition to protecting damaged areas from further disturbance.

The main problem is to obtain an early cover of plant material which will encourage secondary succession to a self-maintaining, hydrologically acceptable plant community. This has been achieved experimentally by using native herbaceous mulches which include seed of both aggressive naturalized species (mainly sorrel, *Rumex acetosella*) and slower-growing climax and sub-climax herbs. The method is now being adopted by State authorities for field-scale use.—*Division of Plant Industry.*

Catchment Studies in Central Australia

Management of the sparse water resources for increased production in central Australia requires knowledge of the quantities and rates of surface run-off from different types of landscape. In a long-term experiment in the Alice Springs area automatic recording instruments have been installed on streams in 18 catchments ranging in size from 1·2 to 66 square miles. Each catchment has been carefully selected to be representative of a particular type of country, and the study covers a range from rugged mountain country to gentle undulating mulga plains.

Owing to the inaccessibility of many of the catchments in wet weather, and the infrequent occurrence of surface run-off, the study is based on the use of long-term recording instruments designed specially for work in remote locations. Rainfall and stream level at the outlet of each catchment are recorded in this way and simple indicating equipment is used to record the slope of the stream water surface at the peak of a flood. Automatic camera equipment, triggered by the rising stream level, is being developed as a means of measuring stream velocities.—*Division of Land Research and Regional Survey.*

Typical arrangement of wax platelets shown by an electron micrograph of a carbon replica of the surface of a sultana grape, magnified 18,000 times.

Drying of Grapes

Most of Australia's grape crop is used for the production of sultanas or raisins. To avoid losses that are often caused by unfavourable weather conditions during drying, the drying rate of the fruit has to be increased. It has been shown that the main barrier for water loss of grapes is the outer layer, the cuticle. Its morphological structure has been revealed by light and electron microscopy and the amount and chemical composition of the surface waxes (bloom) have been determined. The main constituents are oleanolic acid, long-chain alcohols, and fatty acids. It was demonstrated that the actual wax constituents control the water loss of the fruit and thus determine the drying rate.

The increase of the drying rate is achieved by the "cold dip" process, which consists of immersing the grapes in an emulsion of oil and potassium carbonate for a brief period before drying. Contrary to the common belief, this treatment does not remove the surface wax but adds large, but polar, lipophilic molecules, which increase the permeability to water. The dipping effect is reversible, after removal of the oil by washing, the drying rate is reduced to normal, the original ultrastructure can again be observed under the electron microscope, and the electrical potential of the membrane is not changed.—*Horticultural Research Section.*

Control of Timber Regrowth on Grazing Lands

Native tree and shrub species of the original forests and woodlands are regenerating over extensive areas of sheep, beef, and dairying lands in the summer-rainfall zone. In south-western New South Wales and southern Queensland alone, some 80 million acres of cleared country are being re-invaded and stock-carrying capacities reduced.

Regeneration takes place from seed as well as from root and stem suckers, and a wide range of tree and shrub species is involved. Eucalypt species of open forests and woodlands are particularly troublesome and in some areas paddocks have to be cleared every 15 or 16 years.

Poisoning experiments on two of the important species in southern Queensland suggest that it may be possible to reduce the heavy costs of labour and materials. Penetration of the intact bark of sandalwood (*Eremophila mitchelli*) is effected by phenoxyacetic acid compounds in an oil carrier; hence spraying the base of the stem may be an effective control method. Species with thicker bark, such as poplar box (*Eucalyptus populnea*), require mechanical penetration of the bark, but once this is effected water is as efficient a carrier as oil.—*Division of Plant Industry.*

Low-moisture Silage

Considerable interest is being shown at the present time in low-moisture silage or "haylage" as it has been called. With such material loss of nutrients between harvesting and feeding is reported to be lower than with wet silages, while practical experience shows that the drier silages are more suited to mechanical handling and feeding systems. Low-moisture silage is made from heavily wilted and chopped pasture material which is stored in air-tight containers. The exclusion of air prevents mould growth and the relatively low moisture content restricts bacterial activity. However, precise information is lacking as to the most suitable range of moisture contents for storage in this way and the biochemical changes which occur. These factors are being carefully studied to assess the practical value of the technique.—*Fodder Conservation Section.*

Ensiling Tropical Pastures

The recent introduction of new and improved pasture plants in the summer-rainfall areas of Australia has greatly increased the yields of fodder from these areas and their stock-carrying potential. However, there is a relatively short wet season during which growth takes place and, to exploit fully the high yields, conservation is necessary.

A systematic study is now being made of the ensiling characteristics of the more important of these tropical pasture species. From results to date, it is evident that many of these plants differ in certain respects from those commonly grown in temperate regions and present special problems in relation to their conservation as silage. Thus the more rigid structure of some plants prevents easy compaction and exclusion of air, so that fungal attack is common; low contents of fermentable carbohydrates frequently limit the formation of lactic acid, which is essential for good silage. As a result of these investigations it should be possible to develop more suitable techniques for ensiling tropical species, and even to indicate to the plant breeder features which could, with advantage, be introduced into otherwise suitable strains.—*Fodder Conservation Section.*

The Control of Saline Groundwater

The requirements for adequate drainage in irrigated areas must often be based on the prevention of serious salinization of the root zone. The salinity factor is to be taken into account in designing the capacity and in determining the desirable depth of the drainage system. Stabilization of groundwater to a safe level is an important aim of completed or contemplated drainage systems in the irrigation areas of south-east Australia.

The desirable drainage depth under conditions of an unstable saline water-table has, therefore, been studied by considering the dependence of salinization on water-table depth, salinity of groundwater, soil physical properties, and climatic conditions. The concept, critical depth of water-table, was used to characterize the potential salinization of a soil profile. It was concluded that this depth corresponds to the water-table depth at which the flow rate through the soil profile is reduced to values of about $0 \cdot 1$ cm per day. In the main, the critical depth is determined by the moisture conduction properties of the soil. Generally, the water-table should be kept at a deeper level in soils of intermediate texture than in either coarse- or fine-textured soils. The salinity hazard of the fine-textured soils of the Murrumbidgee Irrigation Areas is markedly reduced if the water-table is kept at about 4 ft below the surface or main root zone.—*Irrigation Research Laboratories.*

Atmospheric Changes in the Soil–Plant System

It is well known that nitrogen is removed from the atmosphere by plants and micro-organisms, and it is suspected that nitrogen losses are suffered by soils (and perhaps by plants), particularly after addition of fertilizer nitrogen. These phenomena cause changes in the composition of the atmosphere surrounding the soil and the plants; these changes have not so far been accurately detected.

In order to study these atmospheric changes experimentally it is obviously necessary to grow a plant in a soil in an air-tight container for an extended period, e.g. for several weeks. One difficulty is that a growing plant transpires a large amount of water; this must be either removed and replenished or condensed and returned to the soil. An adequate supply of carbon dioxide must also be provided and arrangements must be made to remove selectively the oxygen produced during photosynthesis. Finally, an accurate and reliable means of gas analysis must be used to measure the small changes in atmospheric composition that occur.

These problems have now been solved. An experimental assembly has been run continuously for nearly 5 weeks, and the labelled nitrogen absorbed by fixation in the legume *Phaseolus atropurpureus* (siratro), and incorporated into the soil and companion grass, was found to equal (within experimental error) the decrease in labelled nitrogen in the atmosphere, measured mass spectrometrically. The amount of elemental nitrogen involved in transfer was about $3 \cdot 5$ mg. It is proposed to construct a number of closed environmental assemblies for studies in fixation and gaseous loss of nitrogen. —*Division of Soils and Division of Tropical Pastures.*

Soil Testing for Fertilizer Applications

The adjustment of fertilizer applications to the needs of individual paddocks on the basis of soil tests is an important aspect of the new, high-efficiency farming of Western Europe and North America. An effective soil test system needs an extensive background of research and a detailed knowledge of specific soil properties and reactions. The findings of one region and of one crop cannot be applied without verification for another region or another crop, and thus a service which is a parallel to the quality control system of industry is a continuing need. Research into the techniques required for a sound soil test system has been carried out for wheat and phosphate fertilizer in the south-western wheat belt of New South Wales by CSIRO officers. The techniques include the calibration of a laboratory test against yield response of wheat in farmers' fields, extending over a range of soils and a range of seasons. Investigation of the reliability of sampling procedures is a very important aspect, since variation in soil test values within a few yards often varied by a factor of ten. The soil test system also relies on a sound factory procedure for analysing the samples and assessing fertilizer requirements.—*Division of Soils.*

Wheatbelt Salinity

Over the past 60 years, as a result of increased salinity, many thousands of acres of valuable farm soils in Western Australia have been rendered unsuitable for cultivated agriculture. Factors involved in increased salinity, which has followed clearing, have been investigated in a typical wheatbelt valley near Bruce Rock. Field and laboratory studies emphasize that salt accumulation is intimately associated with the movement and concentration of water initially precipitated as rain. A three-component hydrologic cycle consisting of surface, seepage, and confined water has been described.

Confined waters occur in a continuous aquifer system extending under most of the landscape and having its intakes in porous soils which receive considerable run-off from adjoining rock outcrops. Low gradients coupled with low permeabilities result in extremely slow transmission of water, leading to ion exchange with the lateritic pallid-zone clays that comprise the aquifer. Waters become increasingly acid, and salinities increase from about 100 p.p.m. near major granite outcrops to over 30,000 p.p.m. where shallow aquifers underlie saline valley floors. Here sub-artesian pressure coupled with capillary forces allows a slow passage of water through the dense confining clays to the surface, where salt is deposited by evaporation. Many areas of the wheatbelt suffered from this type of salinity prior to white settlement, and since clearing, which has resulted in both decreased water usage *in situ* and increased movement of water onto the valley floors, the zone of permanent saturation between aquifer and the surface has increased. This has resulted in a loss, through increased salinity, of large areas of valuable "heavy land" soils.

Both surface and seepage components contribute to the greater volume of water reaching the valley floors, and in addition seepage water from "light land" leads to salinization of discrete areas on valley sides. Such areas have become increasingly evident in recent years and can be expected to become more common as large areas of sand plain are cleared for cultivated agriculture.—*Division of Soils.*

Failure of Earth Dams

Water supplies for country towns and farm properties in eastern Australia often depend on storages provided by earth dams. Recently several town supply dams have failed by a phenomenon known as piping. The failure rate for smaller farm dams ranges from 10 to 20%, with the rate in some areas of Queensland even higher.

Field and laboratory studies associated with over 50 earth dam failures have revealed two main failure patterns, apart from seepage losses through the floor of the dam. In the first, water is lost over a period of weeks or months due to seepage distributed throughout the earth wall. The second type of failure usually occurs when the dam is first filled with water. As in the first case, a localized zone of permeable clay, often arising from poor compaction during construction, allows a small flow of water to appear on the downstream face of the earth wall. However, the soil then begins to disperse rapidly in the leakage water and the small flow channel rapidly enlarges, leading to the formation of a tunnel or pipe straight through the wall through which the stored water escapes rapidly, often in a matter of hours.

Chemical studies on the water and the clay fraction of soils from dams which failed in the second manner have shown that these "susceptible" soils are dominated by monovalent cations, such as sodium, on the exchange complex of the clay. The amount of dissolved salts in the stored water, together with the amount of exchangeable sodium on the clay, determines whether the soil will remain flocculated or become deflocculated and thus be likely to be carried away with the leakage water.

These studies, combined with mechanical and physical tests on the soils used in the dam walls, have shown the necessity of recognizing the susceptible soils before construction commences, so that steps may be taken to control the moisture content and density of the earth fill during placement in order to eliminate the possibility of failure.—*Soil Mechanics Section.*

Engineering Problems in Regional Development

Throughout the world, increasing use is being made of soil and land classification systems as a basis for studying engineering problems encountered during the development of large areas of country, particularly underdeveloped areas. The economic construction and maintenance of roads in such areas demand a systematic knowledge of the occurrence and nature of all the earthen materials used in roadmaking and of the *in situ* soil conditions both before and after the placing of the pavement. In addition, it is desirable to have a classification system which expresses engineering characteristics needed to determine requirements for drainage and for the nature and extent of earthworks and bridgeworks necessary for road construction in a specific area.

Research programs are in progress aimed at evaluating the pedological and the terrain systems of classification as a basis for obtaining and recording such data for engineering purposes. The great soil group category of the pedological soil classification is being used as the basis of an Australia-wide program of soil sampling to define the chemical, physical, mineralogical, and engineering properties of the soil components. Fifteen soil moisture installations have been set up in various parts of Australia to determine the effect of pavement cover on the moisture status of each soil in a particular climatic environment.

The terrain classification system used in Australia by the Division of Land Research and Regional Survey is based upon the geomorphological definition of the components of a landscape, in terms of land systems and land units. To assess the usefulness of these concepts as a means of classifying terrain for engineering, as distinct from agricultural purposes, two areas in northern Queensland, one of 2200 sq miles in the vicinity of Mt. Isa, and another of approximately 110,000 sq miles in the Leichhardt-Gilbert area, are being studied.—*Soil Mechanics Section.*

Virus Diseases of Livestock

In the 1960-61 Annual Report it was noted that a virology section had been established at the Animal Health Laboratory at Parkville, that in early work several infectious diseases of cattle, sheep, and pigs had been investigated, and that viruses had been isolated from some of these. During the subsequent years, the virology section has continued to be the only research group in Australia working on virus diseases of livestock, and has virtually completed the first phase of the program, namely to assess the incidence of some major virus diseases of mammalian livestock in Australia. In the next few years the individual diseases will be studied more intensively. To date, the section has succeeded in isolating from Australian livestock (for the first time) viruses causing the following diseases:

> Sporadic bovine encephalomyelitis, bovine papular stomatitis, infectious bovine rhinotracheitis, infectious pustular vulvovaginitis, and bovine mucosal disease—virus diarrhoea.

These diseases cause economic losses in herds, especially in younger animals, through their effects on the brain and associated nervous tissues, the respiratory tract, the genital tract, and the intestines.

Thus the Parkville Laboratory has made a major and first contribution to knowledge of virus diseases of livestock in Australia; in doing so, the development of skills and techniques, and the training of workers, could prove invaluable to the nation in the event of the introduction of a serious exotic virus disease of livestock.—*Division of Animal Health.*

Cobalt Deficiency and Phalaris Staggers

The dramatic response which supervenes on the provision of minute traces of cobalt to flocks grazing on certain tracts of the southern Australian littoral awakened a world-wide awareness of the nutritional importance of trace elements. This was a little over 30 years ago. Many discoveries of prime scientific importance have followed, and, in turn, application of this new knowledge in the field of agriculture has yielded spectacular economic returns.

Laboratory investigations leave little doubt that cobalt, *per se*, has no physiological function in animal tissues. The essential nutrient is the cobalt-containing complex, vitamin B_{12}, and the metabolically active forms are derivatives of this complex. These latter function as coenzymes in isomeric transformations, particularly in those intramolecular rearrangements involved in the utilization of propionic acid.

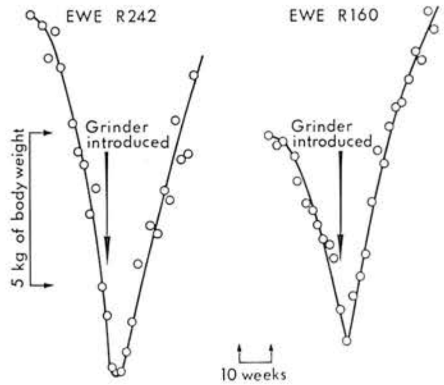
Vitamin B_{12} is produced in nature only by a few classes of microorganisms. Ruminants derive their comparatively large requirements of this vitamin through the activity of particular microorganisms which flourish among the rumen flora only when sufficient cobalt is available. The necessary amount of cobalt, though minute, is not always present in the pastures. In the absence of sufficient cobalt, vitamin B_{12} producers are overgrown by other organisms within the rumen contents. Production of the vitamin then falls below the level necessary to maintain the animal's status, and stores within the tissues are drawn upon and depleted to a stage at which normal metabolic function is impaired. From this point the syndrome of the deficiency disease progresses slowly to a fatal termination. Reinstatement of the required cobalt concentration within the rumen will, at any time, rapidly restore the deficient ruminant to normal health and productivity.

Besides providing enough vitamin B_{12} for the animal, an adequate supply of cobalt in its rumen contents can protect the animal against certain toxic substances ingested in its fodder. Protection against the substances which lead to phalaris staggers, for example, is a particularly striking phenomenon. The perennial grass, *Phalaris tuberosa*, which in association with subterranean clover has been widely exploited for pasture development in southern Australia, produces a substance which is either poisonous or potentially poisonous to sheep—at times up to 90% of the individuals comprising experimental flocks depastured on relatively pure stands of phalaris has succumbed to phalaris staggers. Maintenance of an adequate supply of cobalt to the rumen contents protects against this malady. At this juncture the toxic agent has not been isolated, so it is not known whether phalaris contains a non-poisonous precursor that becomes converted to the neurotoxic agent by microorganisms which flourish in cobalt-deficient rumen contents, or whether the neurotoxic agent itself is produced by the plant and destroyed within the rumen by microbiotic activity favoured by cobalt. Vitamin B_{12} status of the animal itself is not involved; the malady may be prevented by maintaining an adequate concentration of cobalt within the rumen.

To ensure the animal's vitamin B_{12} status a continual supply of cobalt to the rumen contents is desirable; to protect the animal from phalaris staggers a continual supply is *essential*. Cobalt pellets were developed to provide husbandry practice with a feasible means of meeting these demands. Based primarily upon the fact that heavy objects, inadvertently ingested in the fodder, remain in the rumen indefinitely, pellets comprised of cobaltic oxide and iron filings were devised which will remain in the rumen and provide by continuous solution from the surface the modicum of cobalt required. Observation that under certain grazing conditions the surface becomes fouled by deposits of calcium phosphate and other substances led to the development of grinders which by abrasion keep the surface clean and active. Such development depends essentially upon the results of long-term experimental testing under a variety of grazing conditions. Critical tests have been in operation for several years. Some of the results and their bearing upon the type of pellet and grinder now recommended are illustrated on the opposite page.—*Division of Biochemistry and General Nutrition.*

After five years, cobalt pellets introduced into sheep at Robe, S.A., have slowly dissolved and become smaller like the one illustrated at the left above. They still continue to provide a lavish supply of cobalt (0·5 mg per day) to the rumen contents. Pellets introduced into sheep grazing on certain pastures elsewhere tend to accumulate concretionary layers of calcium phosphate which prevent liberation of cobalt. The group of six pellets above at the right shows a range of phosphate deposits after six months in sheep on irrigated pastures at Dry Creek, S.A. A steel grinder administered along with a pellet keeps its surface clean and functional. An engineer's grub-screw serves this purpose admirably.

Besides preventing deposits, grinders may dispose of them. The pellet at right above, recovered after 5 months, was like the pellet at left when the grub-screw (centre) was introduced. Abrasion reinstated sufficient functional surface within 6 weeks. Typically dramatic responses of the animals as soon as the masking layer had been abraded away are indicated in the diagram at right.



Intensive investigations in the laboratory seek to reveal the factors which encourage deposition of foreign matter on the surface of the pellets. Changes within the rumen contents under various conditions are recorded continuously by instruments introduced through a fistula. The experimental sheep remain quite comfortable, and in the course of long-term experiments become affectionate pets.

Translocation of Plant Nutrients by Grazing Sheep

Recent work at Armidale has shown that sheep excreta are very unevenly distributed over a grazing area; previously, the distribution was thought to be fairly even. At stocking rates from 3 to 7 sheep per acre an average of 34% of the total dung output of the flock was concentrated on the sheep camp, which comprised about 6% of the paddock. Hence there is a large drain of nutrients from the bulk of the paddock to a small area. This loss is reflected in very large increases of potassium and phosphorus on the sheep camp soils, causing deficiencies over the rest of the paddock after 6 years' grazing at 6 sheep per acre. There are also large changes in the botanical and chemical composition of the pasture in different parts of the paddock. Although increased stocking rate speeds up the translocation of plant nutrients, the distribution is a little more uniform at high stocking rates. It is probable that management procedures could be devised to reduce the losses and hence fertilizer requirements.

The process of camping behaviour is common on most commercial properties. On the national scale it is estimated that the equivalent of nearly half a million tons of superphosphate alone is being removed annually from grazing areas to sheep camps. Even larger quantities of other nutrients are involved, although soil reserves may buffer fertilizer needs for some time. This translocation of plant nutrients emphasizes the need for long-term grazing experiments to evaluate trends of fertility in pastures.—*Division of Animal Physiology*.

Kidney Function in the Sheep

To allow observation of the normal behaviour of the sheep's kidney, the urinary tract has been surgically diverted to the exterior through the flank; urine may thus be continuously collected directly from the kidney without any distress to the sheep. This has provided a valuable way of studying how the kidney responds to normal events in the life of the undisturbed animal.

Feeding has been found to exert a marked effect on the kidney; urine flow falls and urine concentration rises. It is believed that the effects are caused by the antidiuretic hormone, arginine vasopressin, and that the direct stimulus for the release of the hormone arises from changes in the composition of the blood after feeding. Although the action of the hormone has been widely studied in other species, its exact significance in the sheep has not hitherto been investigated. As a ruminant, the sheep enjoys an ability to eat a lot of food very quickly, but in doing so it may embarrass the body fluids in the gut by rapidly accumulating soluble dietary salts. This raised concentration of solutes creates a demand for water in the rumen, and water is therefore attracted from the blood into the gut. The subsequent change in the composition of the blood is the signal for the release of antidiuretic hormone which promptly acts on the kidney. Under the influence of the hormone the urine becomes concentrated, so that the kidney conserves water at a time when it is needed by the digestive system. In this way the sheep uses a familiar physiological process (hormonal control of water excretion) to suit its mode of episodic eating.—*Division of Animal Physiology*.

Control of Parasites Increases Animal Production

The advent of new highly efficient drugs active against both the immature and mature forms of the common gastro-intestinal worm parasites of sheep has made practicable a more precise measurement of the effects of these parasites on fat lamb and wool production. In one experiment with groups of 50 lambs, those treated once monthly gained, in 4–5 months, an average of 5·8 lb more than the untreated lambs, and 59·5% of them had reached 80 lb body weight in a specified period compared with 47·6% of the controls. In a similar experiment the treated lambs gained an average of 3·8 lb more, and 86% reached 80 lb body weight compared with 78% of the controls.

Merino weaners, while being treated monthly for a year, grew on the average 1 lb more wool than untreated weaners, and only 4·5% of them had tender fleeces compared with 31·8% of the controls. Thus there are appreciable economic advantages to be gained by keeping internal worm infections at low levels.—*Division of Animal Health.*

Successful Selection for High Twinning Rate in Merino Sheep

Since 1954 high and low twinning rates have been selected for in two groups of medium Peppin Merinos, at Deniliquin. Base ewes which had given birth to twins or singles at each of their 5- and 6-year-old lambings were mated respectively to rams born as twins or singles. Ewe progeny at these base matings have completed 7 lambings, and the two groups differ by 0·20 lambs born per ewe per mating. The progeny in the high-twinning group averaged 0·88 lambs born per ewe mated at 2 years, rising to a maximum of 1·56 at 6 years, compared with 0·78, rising to 1·26, for the low-twinning group.

Until 1963 all ewe progeny were mated without selection. From 1956 onwards rams used were 18 months old and were selected according to the high or low twinning performance of their dams. The difference between the groups in numbers of lambs born per ewe mated, averaged over all ages of ewe, had increased to 0·29 at the 1963 lambing. The increase has occurred mainly through increased twinning rate in the 2-year-old ewes; in 1954–55 only 6% of 2-year-old ewes mated in the high-twinning group produced twins, whereas by 1963 the figure was 40%. Maiden ewes in 1963 bore 1·22 lambs per ewe mated in the high-twinning group, compared with 0·96 in the low.

Triplets, even in the high-twinning line, have so far been rare (2·7% of all births). A group of ewes was bought from a commercial breeder who had been selecting for birth rates for about 10 years. Each ewe was born as a triplet or quadruplet. She was mated "initially" to two quintuplet rams born in different sets and bought from the same breeder. The result has been that 57% of all births from matings of these ewes and their progeny have been multiple (ewes aged 2–6 years), 13% being triplets and 4% quadruplets.

Until recently, only low estimates of heritability for reproductive rate had been published, and it has been widely believed that selection was not likely to raise lambing percentages. Recent estimates from the CSIRO flock at "Gilruth Plains" have shown that the heritability of number of lambs born at ages later than 2 years is sufficiently high for selection to be successful. The groups at Deniliquin have confirmed this, and the rise in twinning rate in maiden ewes gives promise that as selection proceeds, it will be possible to select more ewes on their 2-year-old performance.—*Division of Animal Genetics.*

Protein Metabolism and Wool Growth

Wool growth is considerably influenced by nutrition, but there has been much uncertainty regarding the important nutritional factors limiting wool growth. Various experiments have indicated that either protein or energy is the main nutritional factor limiting wool growth. However, a definitive answer to this problem has not been obtained, mainly because of the fact that the sheep's food is first subjected to fermentation in the rumen. The value of protein added to the diet will depend on the extent of breakdown and resynthesis of protein, associated with microbial growth, in the rumen. To interpret the effect of any nutritional treatment on wool growth it is necessary to know the effect of the treatment on the end-products of digestion available for absorption and metabolism by the sheep.

In order to determine the importance of protein, or more specifically the essential amino acids supplied by the protein, for wool growth, protein and amino acid supplements have been administered directly into the abomasum. These protein supplements are completely digested and the end-products of digestion are absorbed in a form that is useful to the sheep. The sheep were maintained on a basal diet on which their wool growth rate was 4–5 grams clean dry wool per day. Supplements of 60 g casein per day resulted in substantial increases in wool growth rate; the extra wool grown was 6–7 g clean dry wool per day. Sulphur-containing amino acids (L-cysteine or DL-methionine), given at the rate of 2–3 g/day, increased wool growth by 2–3 g/day, whether they were given as a sole supplement or added to the casein. The sheep receiving supplements of casein plus S-amino acids grew about 14–15 g wool per day; this rate of wool growth would be close to their genetic potential.

In contrast to the above effects, supplements of 60 g/day of another protein (gelatin) produced only slight increases in wool growth. Gelatin has a very low content of S-amino acids, is completely lacking in tryptophan, and is deficient in several other essential amino acids. When supplements of S-amino acids were added to gelatin, wool growth was increased by 2–3 g/day, as was observed with casein, but the wool growth rate was still well below that obtained with an equivalent amount of casein.

These experiments indicate that the supply of protein available for digestion and absorption in the small intestine is an important nutritional factor limiting the rate of wool growth. The content of S-amino acids is very important and lack of other essential amino acids can also limit wool growth. Further, it appears that sheep can grow wool at a rate close to their genetic potential provided an adequate amount of good-quality protein reaches the intestines.—*Division of Animal Physiology.*

Digestion of Protein in Sheep

Under some conditions, much of the protein eaten by sheep is destroyed by microorganisms in the sheep's rumen; under other conditions the microorganisms synthesize protein from material that would otherwise be worthless to the sheep. For this reason, the amount of protein available for conversion to meat and wool cannot be predicted from the amount consumed in the feed. Studies have recently been made of the protein available to the sheep after the food has been digested in the rumen. Sheep grazing on improved pastures ate at different times of the year 100–400 g protein per day. On the average about one-third of this was destroyed in the rumen. However, sufficient protein escaped destruction to ensure that the wool growth would not have been limited by a lack of protein. In other experiments sheep eating wheaten chaff consumed about 60 g crude protein per day; as a result of protein synthesis in the rumen, however, about 150 g protein per day became available to the sheep. These studies are being continued to provide a better basis for investigating the nutrition of grazing sheep.—*Division of Animal Physiology.*

Use of Radioisotopes in the Study of Wool Growth

Cystine, labelled with either carbon-14 or sulphur-35, is being used for measurement of the rate of growth in length of wool fibres on experimental sheep. When [^{35}S]-cystine is injected intravenously some of the label is incorporated into each growing fibre and reaches the margin of the fully keratinized portion of the fibre within an hour of the injection. The radioactive zone of the fibre can be revealed by autoradiography, that is, by placing a photographic film in close contact with the fibre for a suitable time and then developing the film. Repeated doses at intervals of a few days produce a series of radioactive zones, the distances between which can be measured with great accuracy with a projection microscope. When staples of the fleece are autoradiographed, the radioactivity from the doses produces a series of black bands which can be used to measure wool growth rates.

Intradermal doses of cystine or other amino acids labelled with ^{14}C or ^{35}S produce labelling of the fibres that are growing at the injection site. By the use of ^{14}C, which has a half-life of about 5,600 years, a "permanent" timing mark can be put on the fibres.

Radioactivity in wool can be measured easily and accurately by liquid-scintillation counting. A wool sample can be cleaned, dried, and assayed within 2 hours of collection. Thus, after administering [^{35}S]-cystine intravenously to a sheep, wool samples can be clipped daily to determine the average emergence time of the newly synthesized wool from the skin. The emergence times after successive doses can be used to determine when the wool from tattooed areas of skin should be clipped. This refinement of the tattooed area method is yielding more precise information on the rate of response of wool growth to nutritional and other experimental treatments.

When clipping periods were based on emergence times, it was found that the measured rate of change of wool growth was much faster (up to three times) than was indicated by regular clipping. Present data, based on emergence times, clipping, and autoradiographic length measurements, have indicated that most of the response of wool growth to changes in food intake occurred within 2 weeks.—*Division of Animal Physiology.*

Wool Growth during Lactation

For about two-thirds of every year many millions of ewes are engaged in bearing and raising a lamb and it is generally accepted that wool growth is less at these times than on dry sheep. Wool growth on a group of lactating fine-wool Merinos grazing sown pasture at Armidale was found to be 18% lower during the 7 weeks following lambing than that on similar ewes that bore a lamb but were not allowed to rear it. In the subsequent 7 weeks up to weaning, wool growth was 14% lower than on the group of dry ewes.

During a 5-week period immediately after the lambs were weaned the two groups of ewes grew similar amounts of wool, indicating a rapid recovery in production and that the appreciable loss of wool due to suckling a lamb is not afterwards made up by extra, compensatory, growth. Work is proceeding to determine how far the suckling period can be shortened without affecting the progress and subsequent performance of the lamb and to find out the extent to which the wool clip from the ewe can, as a result, be increased.—*Division of Animal Physiology.*

High-cost Operations in Sheep Husbandry

It is a common notion that the development of a pasture improvement program on a sheep property needs to be followed by further practices such as intensive subdivision, fodder conservation, and forage cropping for grazing. These are costly operations, which must substantially augment the output of salable products if the cost of production of wool or meat is not to be increased. However, there is little critical evidence on the effect of these practices on output under Australian conditions of sheep husbandry.

Investigation of the impact of these operations on sheep production is being made at Armidale. Results over several years show that growing fodder crops for grazing in winter, the period which imposes limits on both production per head and the number of stock that can be carried, has little effect on animal production. Any advantage from the cropped portion of the property appears to be compensated by an accompanying disadvantage due to the reduction in pasture area prior to, during, and following the cropping period. The compensatory mechanisms in this and other pastoral practices are being investigated.—*Division of Animal Physiology.*

Pleuropneumonia and Pleuropneumonia-like Organisms

In addition to the investigations into contagious bovine pleuropneumonia that have been referred to in previous reports, there is a concurrent program of fundamental research into the biology of the pleuropneumonia organism, *Mycoplasma mycoides*, and a comparative study of a number of related organisms (so-called pleuropneumonia-like organisms, or PPLOs) which have been isolated from diseased animals other than cattle, e.g. goats, sheep, and poultry. The work has included studies of the morphology, nutritional requirements, and antigenic constitution of PPLOs, and of the antigenic relationship between various species of *Mycoplasma*. By these studies further progress has been made towards an understanding of the biology and interrelationships of this important group of microorganisms, and knowledge of certain livestock diseases has been extended. This knowledge was recently applied in quickly differentiating the causal organism of a recently discovered disease in goats in Australia from one which causes serious losses in both sheep and goat populations overseas.—*Division of Animal Health.*

Intestinal Parasites of Cattle in Northern Australia

Significant advances have been made in research relating to the control of helminth parasites of cattle in northern Australia. The conditions governing the spread and intensity of infection have now been fairly well defined.

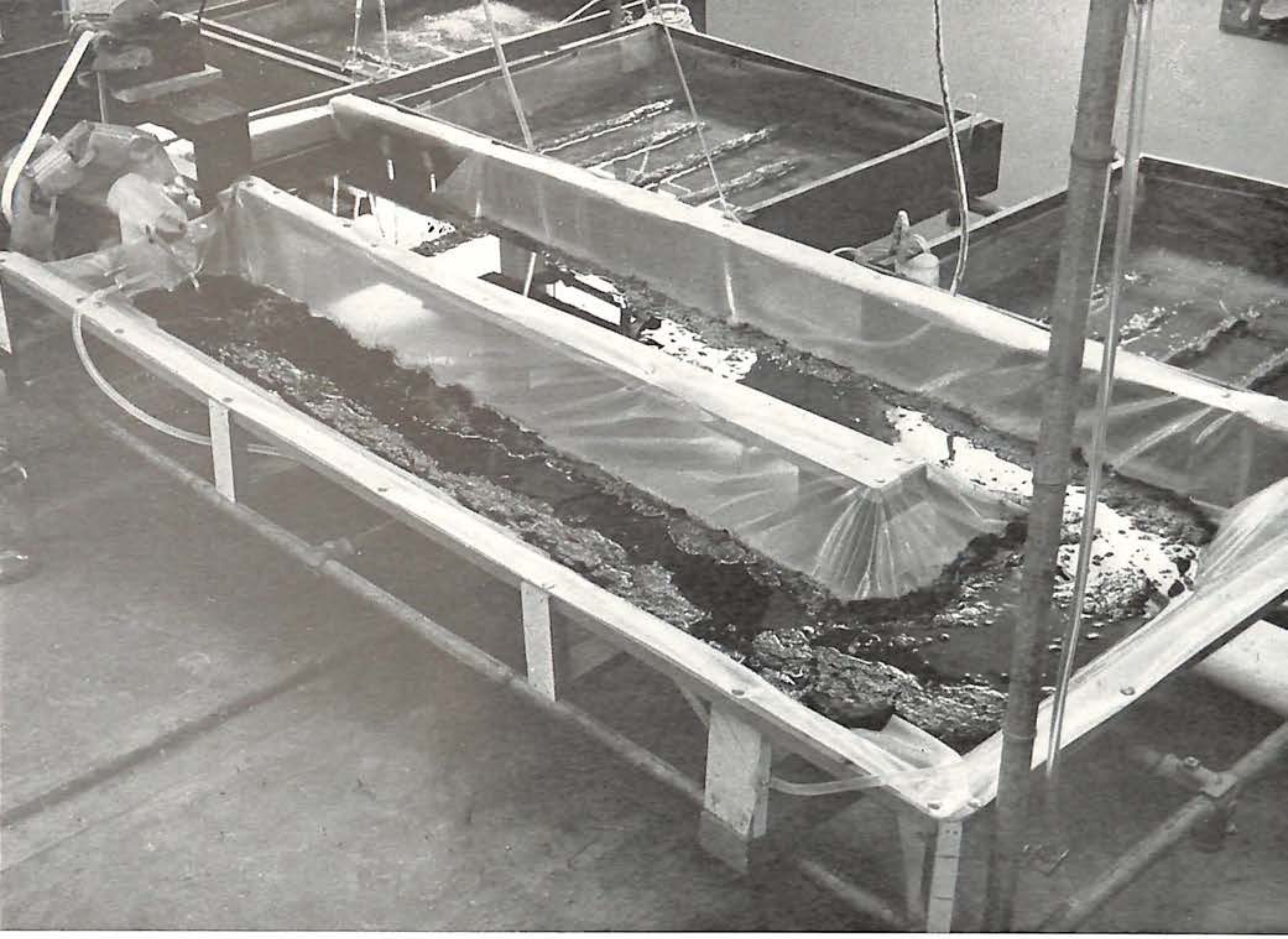
The practical application of this knowledge, in association with findings regarding the strategic use of the two highly efficient anthelmintics, Thiabendazole and Neguvon, has presented opportunities for more effective control than was previously possible. Furthermore, the results of tests have shown that the use of Neguvon by subcutaneous injection offers an easier and speedier method of treatment for young intractable animals, particularly beef cattle.

The immunity normally acquired with age by cattle under natural grazing conditions has been the subject of further study, as it may be possible, once the basic mechanisms of this phenomenon are understood, to stimulate it by artificial means to give good protection to young cattle. Work this year has shown that immunity to the nodular worm may be stimulated by all parasitic stages in the life cycle but that the adult stages are the most potent.—*Division of Animal Health.*

Infectious Infertility of Cattle Herds

A major experimental and epidemiological investigation of bovine vibriosis has been under way for some years. This venereal disease of dairy and beef cattle herds produces temporary infertility and some abortion, principally in heifers. It is widespread in Australia, where, over large areas, it cannot be countered by the use of artificial breeding, as has been the case in closely settled, more intensively farmed countries overseas.

Such research on breeding problems cannot produce spectacular results, for it is slow and expensive. Certain aspects of the pathology of the artificially induced diseases



An artificial freshwater channel for breeding Lymnaea tomentosa, *the freshwater snail which is the intermediate host of the liver-fluke* Fasciola hepatica. *De-ionized water is used, the flow is regulated, and food for the snails is supplied by the growth of algae. The temperature of the room is regulated. The snails are transferred to cultures and infected artificially with the larvae of* F. hepatica *for the production of metacercariae, which are the infective stage. By this means, sheep can be given known doses of* F. hepatica *for experimental purposes and anthelmintics can be tested against liver-fluke of known age.*

have been studied and this has produced important new knowledge. The widely used diagnostic test—the vaginal mucous agglutination test—has been evaluated under Australian conditions of cattle husbandry; another test—an indirect haemagglutination test—has been developed, and in its application in a survey of the disease in Tasmania it shows promise of a high degree of accuracy combined with greater speed and practicability.

Experimental approaches to the development of a vaccine to provide useful immunity under Australian conditions are continuing; in the process, a valuable body of epidemiological data is being accumulated but the very difficult problem of providing protection against the disease has not yet been solved.—*Division of Animal Health.*

Resistance of Cattle to Ticks

Cattle are known to vary widely in their susceptibility to infestation with the cattle tick, *Boophilus microplus*. Animals on which few ticks reach maturity are said to be tick resistant, and though this condition is usually associated with Brahman or Zebu cattle, varying degrees of tick resistance also occur among British breeds. The improved control that results from running resistant cattle together has been demonstrated at Amberley in southern Queensland, where a herd of A.I.S. cows was divided into "resistant" and "susceptible" groups which were then run separately over a period of a year. Whereas the susceptible cattle required 5–6 dips the resistant cattle needed acaricidal treatment on one occasion only. Similar observations have shown that, even under the consistently high tick challenge existing in the wet tropical area of Ingham, Zebu-cross cattle rarely require dipping whereas British breeds require dipping at 4–6 week intervals throughout the year.

With a view to studying the inheritance of tick resistance in cattle the A.I.S. cows at Amberley were mated with a moderately resistant A.I.S. bull in 1961 and 1962. Examination of the cows and their calves at regular intervals has shown that there is a high degree of correlation between the numbers of ticks carried by the cows and by their progeny. Tick resistance thus appears to be highly heritable, and it should be possible to breed for this character. A quick and reliable method for selecting tick-resistant cattle for breeding is not yet available, but efforts are being made to develop techniques which might eventually be applicable to stud cattle. Tick-resistant cattle undoubtedly would provide the most logical solution to the tick control problem in northern Australia, and though breeding for tick resistance would be a slow process, the discovery that tick resistance is heritable suggests that this may be an answer to the cattle tick problem.—*Division of Entomology*.

Insect Pheromones

Recent research has underlined the importance, in insect biology, of chemical modes of communication. It is now clear that odour perception is much more acute than sight in most insects and special scents are known to form the basis for such vital processes as species recognition, food and host detection, direction finding, sex attraction, and caste regulation in social groups. The active substances involved are termed "pheromones" and their investigation has opened up a new field of promise for the development both of our knowledge of the fundamental mechanisms of animal biochemistry and of highly specific methods of insect control.

The chemical identification of insect pheromones poses special problems, owing to the small amounts of active substances involved, but these problems are now being overcome with the aid of modern chromatographic and spectrometric techniques. Already, several important pheromones have been identified overseas and, in some cases, the active compounds are available synthetically. In the Division of Entomology, parallel investigations are concerned largely with termites and good progress has been made towards the identification, in one species, of pheromones involved in trail-laying, alarm reaction, and the regulation of numbers of the soldier caste.

Insect pheromones are mostly relatively simple compounds but they show remarkable specificity in their action and are generally effective in exceedingly small amounts. The prospective value of such properties in the field of specific pest control would appear high but this potential has not yet been tapped to any great extent. However, increasing use is being made of synthetic lures in the control of fruit-fly species in Australia and elsewhere, and parallel developments may confidently be expected in other fields where the use of broad-spectrum insecticides is precluded on grounds of hazard or hygiene.—*Division of Entomology*.

A Modern Approach to Pest Control

Entomologists are becoming increasingly aware of the disadvantages involved in the indiscriminate use of powerful insecticides to control pests. Insects previously unimportant have been elevated to pest status; beneficial insects have been affected adversely; and, in increasing quantities, toxic residues have appeared in foodstuffs and other products used by man.

The Division of Entomology has always regarded pest control as a problem in population ecology and has undertaken long-term studies on the dynamics of insect populations with the object of developing the ecological principles and perspective required for satisfactory control. These investigations have shown that it is desirable to regard the control of noxious insects as *pest management*. This approach, which implies the husbandry of nature by man, includes the judicious use of insecticides.

Pest management aims to deal with noxious species without affecting the population numbers of associated organisms in ways that create further problems. To achieve this aim, a working knowledge is required of the population ecology both of pests and of relevant associated species. This knowledge will make possible the improved use of known methods of control and the effective application of new procedures.

Pest management will require much more scientific effort than was needed for the wholesale destruction of insects by powerful chemicals, but it is the only approach that offers promise of a satisfactory, long-term solution to the problem of pest control.—*Division of Entomology*.

Sirex Research in Tasmania

The woodwasp, *Sirex noctilio*, potentially a serious pest of *Pinus radiata* plantations in Australia, was first discovered in Tasmania in 1952, and in Victoria late in 1961. In association with the National Sirex Committee and interested research bodies, a field station was set up in 1962 near Hobart Airport. More recently another one has been established in England, which will be the centre for the collection of European parasites.

Investigations have shown that two parasites introduced into Tasmania a few years ago by the Tasmanian Department of Agriculture are well established. The egg parasite, *Ibalia leucospoides*, has dispersed to points at least 40 miles from the point of liberation in 1960. Sampling of the forest near Hobart Airport suggests that no dramatic control by these parasites can be expected, though they will help to depress the *Sirex* population. Three other parasite species have been introduced from India and North America during the past year. Two of these have already been liberated in small numbers in the field. *Ibalia leucospoides* has been distributed from Hobart to the north of Tasmania and to Victoria.

Studies on the ecology of *Sirex* and the parasites are also in progress. Preliminary tests have been carried out on the olfactory responses of *Sirex* and one of its parasites, *Rhyssa*, and experiments have been set up to determine why certain trees are killed while others are not. With the help of radiographic techniques, the life-cycle of *Rhyssa* is now much more clearly defined. Many other aspects of *Sirex* biology, such as oviposition patterns and oviposition potential, which were previously obscure, have now been clarified.—*Division of Entomology.*

Oceanographic Cruises in the Indian Ocean

The extensive program of oceanographic field work being carried out on cruises of H.M.A.S. *Diamantina* and *Gascoyne* in Western Australian offshore waters will contribute towards the International Indian Ocean Expedition (1959–65). A series of six seasonal biological cruises along a single section of the south-east Indian Ocean (meridian 110° E., from 9° to 32° S.) was completed during August 1963. This series is unique as it represents the main seasonal work being done during the Expedition.

From preliminary analysis of the data collected it is already clear that the section line has cut through a very complex and interesting area. There is extensive seasonal variation in physical, chemical, and biological properties, particularly towards the north, and this variation is clearly correlated with the seasonal wind and current systems in the region. Areas of high production have been located which were previously only suspected; other areas have been located (e.g. 20°–23° S.) where there are periods of greater plankton abundance, possibly associated with transient eddies; and there are periods and regions of extremely low fertility.—*Division of Fisheries and Oceanography.*

Southern Bluefin Tuna

Within the large mackerel family, the tuna is of greatest industrial importance. This is true throughout the world, although the importance of the individual tuna species depends on the region. In Australia, the tuna industry is based on the catching and processing of the southern bluefin species.

The main features of the distribution of this species in waters around Australia have now been determined. Most of the juveniles (1–4 years old) inhabit the waters adjacent to the Australian and New Zealand coasts, while the majority of adults frequent the deeper oceanic waters. But such segregation is incomplete, particularly for 5-year-old fish undergoing the transition from juvenile to adult.

Results of extensive tagging, length measurements, and fish-scale readings have provided evidence of three broods or stocks among the juvenile population and have indicated the dominant migratory trends of these fish. While in coastal waters the juvenile fish perform seasonal migrations of an oscillatory nature which seem to be regulated to a large extent by temperature and to vary for the particular stock. The majority of the fish appear to originate in Western Australian waters and after a few years to migrate to South Australia and New South Wales. The New South Wales fishery operates on fish between 3 and 4 years of age. These juveniles move up the coast in autumn and spring, penetrating sometimes as far north as Sydney. A return migration occurs in summer and appears to be associated with movement of the 65°F isotherm. Most of the fish in this migration return to South Australian waters. The South Australian fishery operates principally on 3- and 4-year-old fish, some of which are known to have migrated from Western Australian and New South Wales waters. There is evidence that barriers to migration can exist and that these influence the stock composition in the existing fisheries.—*Division of Fisheries and Oceanography*.

Reproduction in the Rabbit

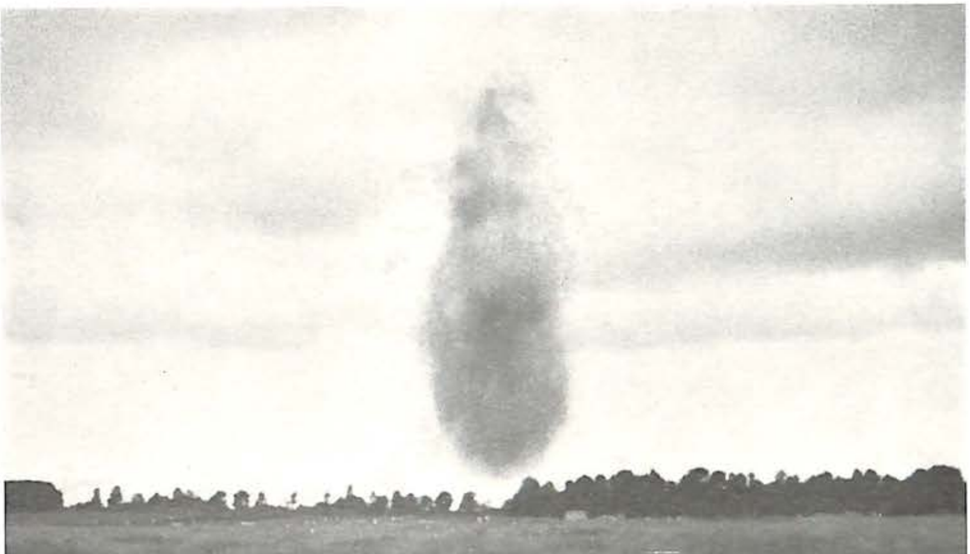
Factors influencing reproductive success in the rabbit are being studied within climatic and pasture conditions ranging from subtropical through semi-arid to subalpine. One detailed study involved the examination of samples of rabbits shot every few days following the breaking of a severe drought in a semi-arid area in the north-west of New South Wales.

The dry season had resulted in a complete cessation of breeding in the rabbit population—sperm production had ceased in males and the females were in complete anoestrus. Rains in autumn produced a response in growth of food plants which was apparent as early as the second day after the rain started. An associated response occurred in the rabbit population, and mating, ovulation, and pregnancy first occurred about 1 week after the rain. Within 6 weeks of the rain 80% or more of the adult females were pregnant or lactating.

Similar investigations have shown that reproduction in the rabbit has a high degree of adaptability to circumstances and the output of offspring may be regulated through a variety of natural controls involving delay in reaching breeding maturity in dry seasons, increase in number of eggs shed, and thus in litter size, as the breeding season develops, and loss of unborn young due to high temperature and other stresses. Moreover, matings following immediately after the birth of young are reduced if pasture conditions are poor, and mating will not occur again until litters are weaned about 1 month after birth; by this mechanism alone the littering rate in individual females may be reduced from one litter each month to one every 2 months.

Laboratory studies of fundamental aspects of male and female fertility have now been started to link the phenomena observed in the field with a basic physiological mechanism. The results should assist in predicting population explosions or the building up in numbers of rabbits, and hence the forecasting of the need for control measures by landholders, and they will also assist in the strategic timing of these measures.—*Division of Wildlife Research*.

The possibility of using aircraft to drop extinguishing agents onto bushfires is being investigated by the Division of Physical Chemistry in collaboration with the Forests Commission of Victoria. The photograph above shows one of the agents, a mixture of bentonite and water, being fed from a Ceres aircraft at a rate of 200 gallons in 4 seconds. The photograph below shows the cloud of bentonite slurry falling towards a field, where containers had been placed to collect the particles and determine their distribution pattern over the ground.



Population Control

Fundamental research on habits and on population regulation in birds has been undertaken by the Division of Wildlife Research to help to understand the biological principles underlying the control of their numbers in nature. Particular emphasis has been given to the role of the very different social systems in the species studied, namely the Australian magpie (*Gymnorhina tibicen*), the royal penguins (*Eudyptes chrysolophus schlegeli*), and the silver gull (*Larus novae-hollandiae*).

The amplitude of annual fluctuation in numbers of these species is greatly reduced by reduction of the potential breeding population size, by deferment of maturity, and by breeding failure due to social causes. The magpie illustrates all three controls. An important finding is that females can breed successfully in their first year when excess food sufficiently minimizes the inhibiting aggression of older females of the same territorial group.

Data on all three species now support the view that an important function of intraspecific hostility—whether it is territorialism or not—is to ensure efficient feeding in relation to the breeding-place. Thus the distribution and size of breeding aggregations are limited primarily by available food and specific competition for it, while the current controversial view that these are determined by competition for nest-sites is considered untenable.—*Division of Wildlife Research.*

Total Movement and Distribution of the Red Kangaroo

There is considerable controversy about the status of the kangaroo as a pest; it is said to be an important competitor for pasture with sheep and cattle, while conservationists are concerned lest large-scale control measures may lead to extinction of the species. An unbiased assessment of its true status requires a detailed knowledge of its biology and this is also necessary as a basis for recommendations about control or conservation.

One aspect of the biology of the kangaroo which has been studied is the extent to which individual animals move about the country; it is important to know to what extent kangaroos from other areas are likely to move in to graze in local pastures, and also how rapidly areas are likely to be restocked with immigrant kangaroos following control operations. It has been widely thought that the red kangaroo will follow the path of rainstorms to feed on the subsequent flushes of green feed and that they will travel many miles in doing so.

To obtain information about their movements, red kangaroos have been caught and marked, and then released. Some of them have been seen again up to 3 years later, but none have been more than 15 miles from the point of original capture. In addition, the movement and distribution of red kangaroos had been studied by counting them from low-flying aircraft at intervals of a few months in areas, each of 1000 sq miles, in inland New South Wales.

Their distribution is closely related to the availability of short, green herbage; long, green grass and dry herbage are avoided. Kangaroos are most numerous on the wallaby grass plains which plant ecologists consider were produced as a result of the introduction of seed to the inland plains. Originally, extensive areas were covered by saltbush and boree scrub—vegetation types which would support very few red kangaroos. Thus, there is little doubt that the major factor in producing relatively high numbers of red kangaroos in New South Wales has been the development of the grazing industry itself and its consequent effects on native pasture.

The studies have shown that red kangaroos are not as mobile as has been thought, and that migratory movement of kangaroos does not explain the fall in numbers which has been observed in the study areas. It is probable that harvesting of kangaroos for meat has been the most important cause.—*Division of Wildlife Research.*

Native Hen Investigation

Intensive fieldwork on the social behaviour and ecology of a population of the Native Hen (*Tribonyx mortierii*) at Hunting Ground has now been concluded. The objects of the investigation were the measurement of damage caused by the birds, and the study of their distribution, food, behaviour, and breeding to develop better methods of damage prevention.

The most important damage occurs to cereals, particularly oats planted near water. Native Hens may eat a quarter of the leaves of the oats on the edges of crops bordering water during the first 6 weeks after sowing, but some recovery occurs.

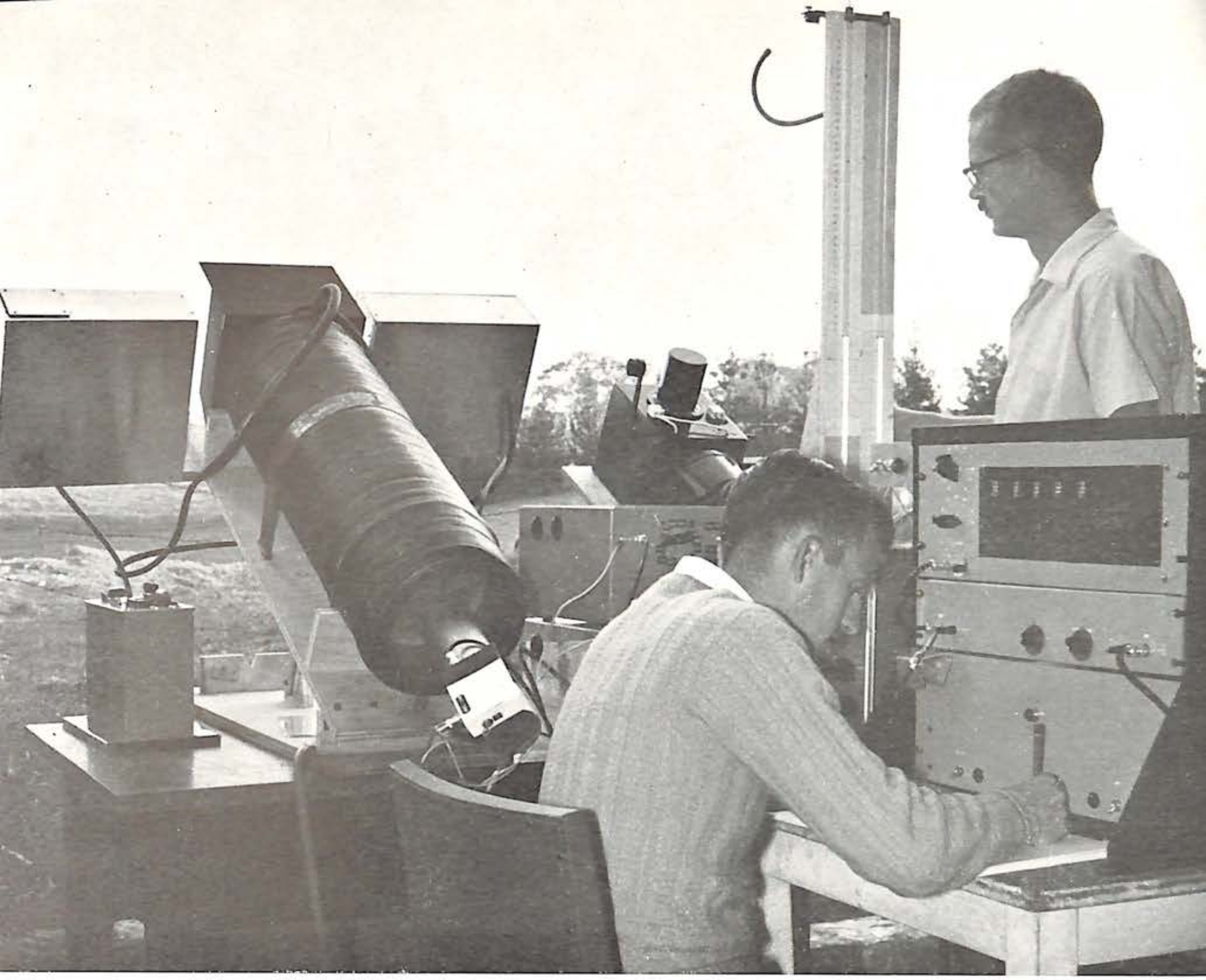
Each bird of a small population was individually marked, and regular observations showed that the species is very sedentary. It normally lives in small groups restricted to 10 acres or less. In spring, however, about half the birds are ejected from their groups and invade or re-invade other areas, travelling up to 12 miles. Natural mortality of eggs and young is slightly over 50%.

Research on the above species forms a useful introduction to the study of the closely related bald coot (*Porphyrio melanotus*), an important pest of rice in Australia. —*Division of Wildlife Research.*

Sources of Atmospheric Energy and Momentum

Most of the atmosphere's energy derives from convection of heat and evaporation of water from the Earth's surface, whilst its external "brake" is the friction at the surface. The laws governing these interactions, in their purest form, must be studied at highly ideal, uniform, flat, obstruction-free sites. Experiments at Kerang, Victoria, have shown conclusively that the upward flow of heat (per unit gradient of temperature) considerably exceeds the corresponding vertical flow of momentum (per unit gradient of wind speed), the factor reaching 3 under extreme conditions. There is now some evidence, awaiting confirmation under a variety of conditions, that the flow of moisture (per unit gradient of humidity) is intermediate between the other two processes.

The laws of transport, when finally understood from such ideal site experiments, would aid world-wide estimation, on an operational basis for weather analysis and forecasting, of the fundamental sources and sinks of the atmosphere's energy and momentum.—*Division of Meteorological Physics.*



Preparing to observe the width of the green line from the night sky with a sensitive Fabry–Pérot interferometer constructed in the Upper Atmosphere Section.

Air Glow

The high atmosphere gives out a very weak glow, nearly invisible to the naked eye; this light is produced by chemical reactions between the various atoms and molecules of air. In particular the oxygen atoms emit a feeble green light in a narrow spectral line. The width of this line tells us the temperature of the atmosphere at a height of about 55 miles, the height from which the light comes. This is the coldest portion of the whole atmosphere, as was discovered by physicists of the Radio Research Board in 1935.

A sensitive optical device (a specially built Fabry–Pérot interferometer) has been built to measure the width of this oxygen green line and its variations from night to night; in this way the seasonal variation of the temperature in the coldest part of the atmosphere is being examined.—*Upper Atmosphere Section.*

Very Long Radio Waves above the Ionosphere

The ionosphere at a height of about 60 miles above the ground acts as a mirror almost impenetrable to long radio waves. There is reason to believe that very long radio waves are generated either very high in the atmosphere or in outer space and that very little of this radiation can be detected at ground level. The only way to study these is to send radio receivers aloft in rockets that can penetrate the ionosphere and radio their findings back to the ground on short waves, which *can* penetrate the ionosphere.

No suitable rockets were available in Australia, but the U.S. National Aeronautics and Space Administration provided several Aerobee rockets to CSIRO scientists. Miniature long wave radio receivers built in the Upper Atmosphere Section, Camden, N.S.W., were flown aloft at Wallops Island, Virginia. These experiments have provided a wealth of information about long radio waves in the high atmosphere, and about the way in which they propagate.—*Upper Atmosphere Section.*

Tertiary Paleotemperatures

In conjunction with the National Museum, Melbourne, a study has been made of the ocean temperatures around the southern coast of Australia during the Tertiary period, which extends back in time for 60 million years. The method used depends on the fact that the ratio of the oxygen isotopes of mass 16 and 18 in the carbonate of a sea-shell is directly related to the temperature of the seawater in which the shell has grown. This isotopic ratio has been determined by mass spectrometry for fossil shells and it has been possible to obtain paleotemperatures to $\pm 1°C$.

The most interesting feature of the results so far obtained has been the relatively sudden drop from a tropical temperature of 25°C to a temperate one of 15°C, which apparently occurred about 25 million years ago. The sharpness of this drop will require an explanation in geological or cosmological theory; if geological theory is not adequate, then the possibility of some extraterrestrial phenomenon being responsible will have to be considered.—*Division of Chemical Physics.*

Smell of Rain

Although the combination of odours associated with rain falling on dry soil has frequently engaged the attention of poets, the phenomenon has been ignored by scientists. It is primarily in arid regions that this characteristic odour is most widely recognized and it is generally related to the first rains after a period of drought; for obvious reasons it is referred to as the "smell of rain".

It has now been shown that most silicate minerals and rocks yield the odour under circumstances which preclude any effect from intrinsic organic or micro-biological contamination, and "petrichor" (essence of stone) has been proposed as a name for this unique odour. An oil which possesses the odour in highly concentrated form can be recovered by steam distillation or solvent extraction of the appropriate minerals, the yield being proportional to the exposed surface area and increasing with the time of exposure. Chromatography and infrared spectrography are being used to identify the constituents of the oil.

It has been found that conditions which promote formation of petrichor also give rise to the synthesis of amines, and a possible relationship between the origin of the odour and the fixation of nitrogen is being studied.—*Division of Mineral Chemistry.*

Organometallic Chemistry

In the rapidly developing field of organometallic chemistry, zirconium remains one of the few metals very little represented. Only two organo-zirconium compounds are known and these have potential use in the gas plating of zirconium metal and as polymerization catalysts. Both are complexes of the unsaturated hydrocarbon cyclopentadiene. New methods have been discovered for the preparation not only of these known compounds but also of several new products of this kind. Thus cyclopentadiene will react directly with reduced forms of zirconium (and titanium) halides at 200–300°C to give cyclopentadienyl-zirconium compounds in high yield.

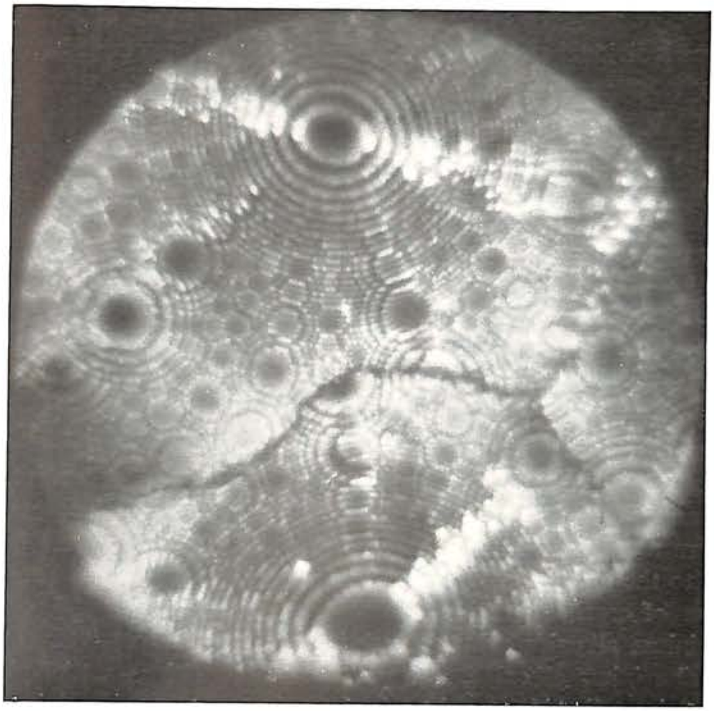
In addition, a new simple reaction process has been developed for the preparation of cyclopentadienyl derivatives of a wide range of metals including iron, thorium, uranium, scandium, and the rare earths. The method is capable of large-scale application and, in collaboration with the Division of Chemical Engineering, is being developed to a point at which commercial operation could become feasible.—*Division of Organic Chemistry and Division of Mineral Chemistry.*

Imperfections in Crystals

The mechanical and other physical properties of solids depend largely on small departures from crystal perfection. Alkali halides, such as sodium chloride or lithium fluoride, which can be grown as large single crystals, are convenient solids in which to study the properties of some of these imperfections because the number of vacant lattice sites can be controlled readily by the incorporation in the lattice of impurity ions of the same size during the growth of the crystals.

Experiments have shown that most of these impurity ions are paired with lattice defects of opposite electric charge to form dipoles. The dielectric measurements have shown that these pairs, or dipoles, aggregate at first into groups of three and then later into larger complexes. The state of aggregation at any time depends on the previous heat treatment of the crystal.

Hardness measurements have been made on the same crystals and, contrary to expectation, it is found that, in general, hardness does not vary with the state of aggregation of the impurity ions. Two exceptions have been found, however, in which the presence of aggregates larger than trimers does increase the hardness.—*Division of Applied Physics.*



Field-ion micrograph of tungsten, showing the arrangement of atoms in three adjoining crystals and the atomic structure of the boundaries between them. The white spots are the atoms, regularly arranged in patterns related to the crystal geometry. The photograph also shows how the regular pattern is disturbed at the boundaries between the crystals. The magnification is approximately 5 million times.

Metals under a Microscope which magnifies 5,000,000 Times

Metals at elevated temperatures stretch slowly under loads that they would easily bear at lower temperatures—that is, they "creep". Creep often leads to fracture at relatively low extensions and so limits the usefulness of metals in critical applications, for instance in turbine blading or in nuclear reactors.

It is known that these failures may develop from small cavities that form when the crystals which make up a lump of metal slide over one another, such sliding being specific to creep conditions. Each crystal is normally about one-thousandth of an inch across and consists of a regular array of the metal atoms, so forming a unit which is bound to neighbouring crystals by strong atomic bonds across the boundary.

Studies have been aimed at understanding just how the deformation during creep occurs, particularly how the crystals manage to slide. A good deal of information has been obtained using the ordinary optical microscope and some special adaptations of it, at magnifications up to 1000 times. From this a theory has been developed that invokes the presence of specific irregularities called "ledges" on the grain-boundary surface to account for the characteristics of sliding and the initiation of the cavities.

Now two other kinds of microscope are being used. One is the electron microscope, which is capable of magnifying to 200,000 times and thus resolving structure nearly down to the atomic level. With this the cavities at grain boundaries have been detected at a very early stage of development and some evidence for "ledges" seen.

The other is the "field-ion" microscope, which gives a magnification of several millions and thus resolves individual atoms. Such a microscope has been built in the laboratory at a cost comparable with that of a good optical microscope, whereas an electron microscope costs many times as much.

Such photographs allow testing and further development of the hypothesis put forward from the other work. The understanding of the nature of sliding during creep and of the way the cavities grow will permit suggestions to be made for the improvement of metals for use at high temperatures.—*Physical Metallurgy Section.*

Organoaluminium Compounds

The highlight of the dramatic growth of organometallic chemistry in the last decade has been the emergence of organoaluminium compounds as large-scale industrial chemicals, which are used in the production of high-density polyethylene and long-chain alcohols and offer routes to a wide range of other organometallic compounds. A major factor in determining the synthetic possibilities in organometallic chemistry is the ease with which an organic or other group can be switched from one metal atom to another or from a metal atom to a carbon atom. The problem may be illustrated by reference to the organoaluminium alkoxides, which are intermediates in the industrial oxidation of organoaluminium compounds. It is important to know whether an organoaluminium alkoxide exists as such in solution or as a mixture of trialkylaluminium and aluminium alkoxide, and under what conditions a trialkylaluminium and an aluminium alkoxide may be mixed to give an organoaluminium alkoxide. This kind of question has only been answered occasionally and often uncertainly in the past. Proton magnetic resonance spectrometry has now permitted valuable, unambiguous information to be obtained about the organoaluminium alkoxide problem. By the same means, it has been shown conclusively that dimethylaluminium chloride exists as such in solution in ether. This contrasts with the closely related problem of the structure of Grignard reagents, which has been a subject of controversy for many years.—*Division of Organic Chemistry.*

Chemical Properties of Water at Very High Pressures

Although it has been realized for a long time that the chemical properties of water must be altered by compression, it is only recently that experiments have established the type and magnitude of the changes that occur.

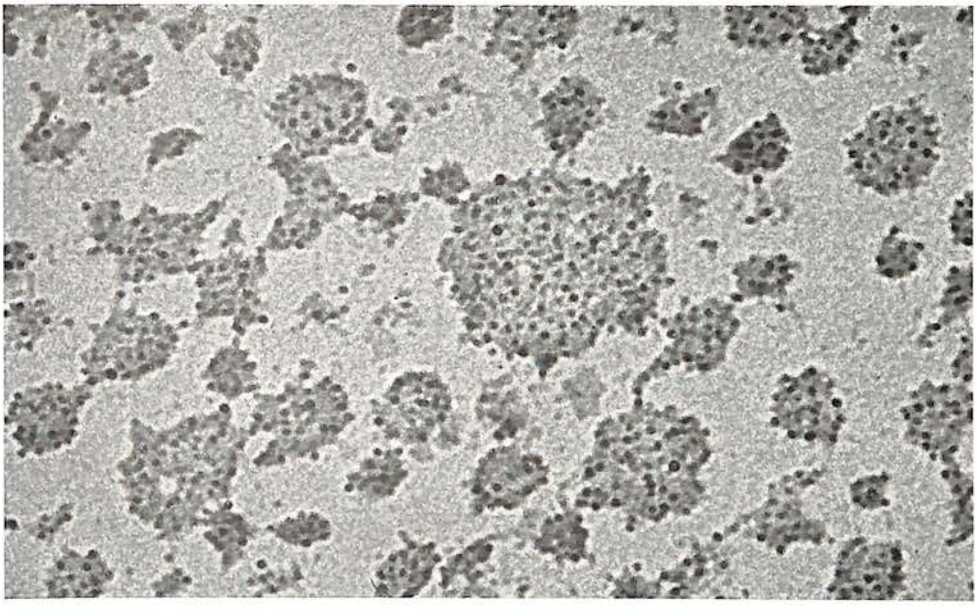
The most striking change is in the degree of ionization of water. Water is normally a weak electrolyte, but under increasing pressure its degree of ionization rises rapidly and its properties begin to resemble those of strong acids and bases. By a novel potentiometric method using a pressure-compensated glass electrode, it has been found that the ionization product of water at 25°C is four times greater at a static pressure of 2000 atmospheres than at 1 atmosphere. Other experiments at much higher pressures, generated by explosions, show that a pressure impulse of 160,000 atmospheres raises the ionization product by a factor of 10^{12}; the water is then as strong an "acid" as concentrated hydrochloric acid. Quite apart from their intrinsic value in the theory of electrolytes, these findings have an important bearing on aspects of geochemistry, marine physics, and marine biology.—*Division of Physical Chemistry.*

Structure of Casein Micelles

The whiteness of milk is due to the fact that the casein present is not in solution but is dispersed in small aggregates which reflect the light. These aggregates, or micelles, are mostly between 400 and 1600 Å in diameter. They consist of from some hundreds to tens of thousands of casein molecules, together with some calcium phosphate. In many aspects of the behaviour of casein in dairy products and dairy processing—the setting of milk in cheesemaking, storage gelation in condensed milks, heat coagulation during sterilization—it is the micelles and not separate casein molecules which are involved. Knowledge of the detailed structure of the micelles is necessary for the understanding of such problems. Such knowledge would also shed light on the chemical and physical make-up of the complex casein molecule, known to consist of several fractions, about which more complete understanding is being vigorously sought by research groups in several countries, including Australia.

The task of examining the internal structure of the micelles is a difficult one because extremely thin sections are needed to obtain satisfactory resolution under the electron microscope. By the use of very hard embedding material it was found possible to cut sections only 100 Å thick. From these were obtained the first electron micrographs of the interior of the casein micelle. They showed a structure with distinct granules each about 100 Å in diameter. This size is consistent with the existence of casein as a spherical complex of one κ-casein molecule with 6–8 molecules of α-casein, together with several more loosely associated β-casein molecules, giving a total "molecular weight" of about 300,000.—*Division of Dairy Research.*

Electron micrograph of the interior of the casein micelle, magnified 100,000 times.



Molecular Changes in Setting Wool

When wool is stretched and steamed it fails to return to its original dimensions even when immersed in hot water. This property of "set" is utilized in producing special finishes in wool fabrics, for example in permanent creasing or flat setting. Setting can be accelerated by steaming wool in the presence of bases or, as in the SI-RO-SET process, of reducing agents. A study of the chemistry of setting, aided by radioactive tracer techniques, is providing a clearer picture of the complex molecular changes which occur during this apparently simple process.

A new chromatographic procedure for lanthionine analysis and a radiochemical procedure for thiol analysis have been used to evaluate the relative roles of these two chemical groupings in the setting process. Thiol-disulphide interchange appears to play a key role and it is possible to improve set considerably by producing extra thiol groups during the setting treatment but ensuring their destruction when setting is complete.

During stretching, polypeptide chains in α-keratin are extended and aligned, and steaming improves the orderliness or crystallinity of the new extended β-structures. These changes can be observed by X-ray diffraction studies. An alternative method of observing changes in the conformation of polypeptide chains is by tritium–hydrogen exchange. In this new technique, the wool is immersed in tritiated water and the number of hydrogen atoms exchanging between the two phases is measured by radioactive methods. After setting, the most inaccessible hydrogen atoms are permitted to exchange more readily owing to the α–β transformation. Exchange data of this kind are providing information about molecular changes which might occur not only in setting but in alkaline scouring and other treatments of technological importance.—*Division of Protein Chemistry.*

Toxic Alkaloids in *Phalaris tuberosa*

As the high-yielding grass, *Phalaris tuberosa*, becomes more widely used in improved pastures in south-eastern Australia, its toxicity to sheep is a matter of increasing concern. Although a high degree of protection against the "staggers" syndrome is afforded by cobalt pellets, this treatment is apparently not effective against the more acute syndrome.

Three tryptamine alkaloids, dimethyltryptamine, 5-methoxydimethyltryptamine, and bufotenine, have recently been isolated from *Phalaris tuberosa*, the first two being present in substantial amounts. These bases are highly toxic and are known to exert powerful effects on the central nervous system in regard to which their close structural relationship to serotonin may be an important factor.

Their possible role in *Phalaris* toxicity is currently under study in the Divisions of Animal Health and of Biochemistry and General Nutrition. If, as seems likely, such a role is substantiated, a new approach will be opened up for the study of other stock diseases involving ataxia due to the consumption of toxic plants.—*Division of Organic Chemistry.*

Composition of Wool Proteins Affected by Nutrition

The proteins from both normal and aberrant wools can be broadly classed into two groups—those with a low sulphur content and those with a high sulphur content relative to that of the whole fibre. While the composition of the former group appears to be unaffected by such factors as copper deficiency, changes of nutritional level, or even infusion of sulphur-containing amino acids directly into the abomasum (fourth stomach of the sheep), the latter group exhibits marked variations in the types of proteins which are synthesized. An increase in nutritional level or in the availability of S-amino acids causes an increase in synthesis of those protein components richest in sulphur, while a decrease in the level of nutrition or a deficiency in copper causes a decrease in the amount of these proteins.

As variations in the relative proportions of these protein components may be expected to be reflected in changes in the physical properties of the fibre, the way may be open to produce, by dietary means, fibres with desired characteristics.—*Division of Protein Chemistry.*

A New Analytical Service for Wool Research

Progress in research in wool chemistry depends largely on the analysis of proteins and peptides for their amino acid composition. Wool itself presents particular difficulties in analysis, due to its bulk, insolubility, high decomposition temperature, and, of course, its facility for absorbing and desorbing moisture as the relative humidity changes. During the course of research on both wool structure and the various wool finishing processes, many components of wool may be changed. The present analytical methods for determining many of these components require either further development or strict control of conditions if accurate, unambiguous results are to be obtained.

To meet the dual functions of developing the essential methods and relieving research officers of routine time-consuming analyses, an analytical group has been formed which now provides the Division of Protein Chemistry with estimations of protein nitrogen, sulphur, acetyl groups, ash, and moisture on micro amounts of material, as well as thiol and disulphide groups, and complete amino acid analyses.

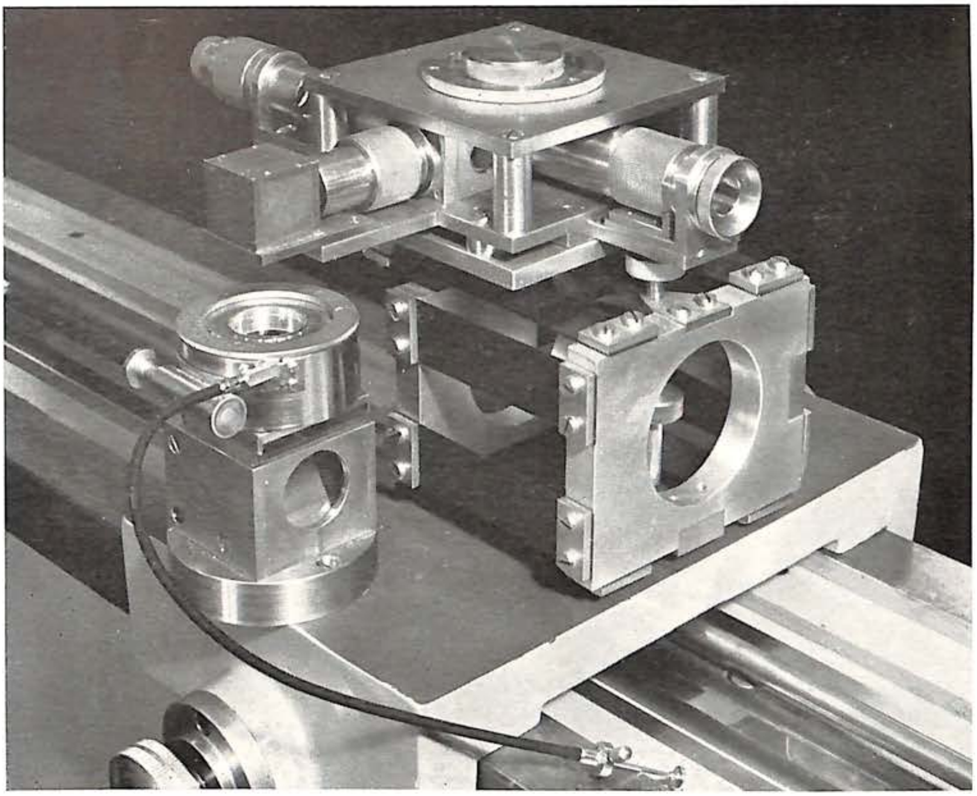
The determination of thiol and disulphide groups, which may be affected by chemical changes during the treatments necessary to bring the material into solution, is carried out on the intact protein wherever possible. Some apparently anomalous thiol groups have been found in wools partially oxidized by shrinkproofing treatments and also in wools yellowed by irradiations. The recent discovery in the Division of a new compound, cystine monoxide, has provided an explanation of these anomalies. This compound also serves as a useful model for the development of a completely specific method.

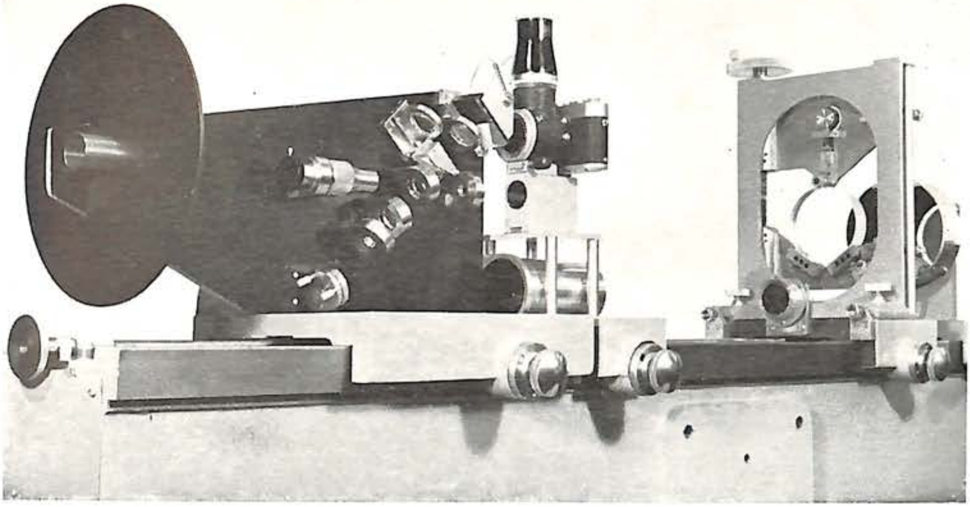
Although changes in the properties of wool after chemical treatments have frequently been attributed to the formation of the amino acid lanthionine, investigations have been restricted by the difficulty of its specific determination. A new analytical method has been developed recently and will be invaluable in elucidating the role of lanthionine in certain reactions of wool.

The amino acid tryptophan, which may be associated with yellowing of the wool fibre, is most unstable and usually requires a separate determination. Present methods enable reproducible analyses of this amino acid to be achieved. However, these methods are not completely specific, and there is a possibility that some tryptophan may be lost during analysis.

A multi-column analyser, originally developed in the Division to meet the large demands for amino acid analyses, has been improved in reliability, operation time, and output. A program has been written so that a computer may do the large number of calculations required, while, in order to minimize the work of data preparation, the analyser has been fitted with an attachment which records the outputs on punched tape suitable for feeding directly into the computer.—*Division of Protein Chemistry.*

Interferometers for testing lenses, such as the Williams interferometer illustrated on the opposite page, where the two beams are separate, are very sensitive to vibration: even very small movements of the equipment affect the two beams differently and the picture obtained is blurred. This trouble can be reduced by new types of interferometers developed overseas. These are "common-path" interferometers, where the two beams follow the same path. The double-focus interferometer shown below is an example of a common-path interferometer, several of which have been made in the Division of Physics. They have proved to be much simpler to use to test lenses than the older systems with separated beams.





Interferometers are optical instruments that have a wide variety of uses and their study is part of the optical program of the Division of Physics. Of the several instruments that have been made, the Williams interferometer is used for testing lenses and in it the light is separated into two beams. One beam goes through the lens to be tested while the other goes through a reference lens of known high quality. The instrument then shows how far the light-wave that has gone through the lens being tested departs from the ideal wave from the reference lens. The Williams interferometer is suitable for testing relatively large lenses against a small reference lens.

Control of Metabolic Processes

If critical metabolic processes occurring in fruits and vegetables could be controlled, great improvements in quality and yield and also storage life could be obtained. Although it is believed that most of the major metabolic pathways occurring in plant tissues have now been established, there is little information available on the factors which control these processes in the living cell.

Studies have shown that from pea seeds a cell-free extract can be obtained which is capable of degrading carbohydrates such as starch or glucose to pyruvic acid or alcohol and carbon dioxide by the process of glycolysis. Oxygen inhibits carbohydrate utilization by this extract and acts as a controlling factor by inhibiting an enzyme (triose phosphate dehydrogenase) which is involved in the glycolysis sequence of reactions. When oxygen is rigorously excluded, carbohydrate breakdown is again increased.

These studies have led to the identification of a new enzyme, protein disulphide reductase, that is involved in the reactivation of triose phosphate dehydrogenase. This may be responsible in part for the so-called Pasteur effect (inhibition by oxygen of carbohydrate utilization) which is well known in intact plant tissues.

Investigations of this kind provide valuable background information that will undoubtedly assist in the studying of the storage of fruit and other products in atmospheres whose levels of carbon dioxide and oxygen are controlled artificially.—*Division of Food Preservation.*

Chemical Components of Eucalypt Wood and Leaves

A survey of the polyphenols in the leaves of the *Eucalyptus* genus is being undertaken, and a major part of the genus has now been examined. Members of the main divisions can be distinguished by the presence of one of a small number of distinctive components. Groups of closely related species in these divisions have closely related chemical compositions. By means of these chemical characteristics the incorrect classification of certain species by earlier botanists has been readily revealed and the data support the conclusions of recent botanical studies. This technique could become a valuable aid in the difficult task of classifying this large and variable genus.

During this survey, physiological variants of a few species have been discovered. These differ from the normal forms in that the leaves contain large amounts of stilbenes. The most common source of stilbenes is the heartwood of a wide range of timbers. These compounds can impart durability or can interfere with the pulping and preparation of high-grade paper. They also damage certain varnishes and surface coatings. As leaves are much more suitable than heartwood for the study of the mechanism of the formation of stilbenes and other polyphenols, the discovery of these variants has greatly facilitated the work on these wood extractives. Their biosynthesis is being studied with the aid of radioactive compounds and the resultant information should indicate whether their formation in the tree can be controlled.—*Division of Forest Products.*

Applications of Atomic Absorption Spectroscopy

Theoretical studies begun in 1953 indicated that, contrary to generally accepted opinion, methods of chemical analysis based on the measurement of absorption of light by atoms would offer important advantages over conventional methods using atomic emission spectra. The method and the apparatus developed have been patented, and Australian and oversea firms have been licensed to manufacture atomic absorption equipment. There are now more than 500 atomic absorption installations in existence and the number is increasing every year.

The atomic absorption method is rapid and accurate, whilst the high sensitivity makes it particularly valuable in the determination of trace metals. Since all work on the function and use of trace metals in soils, plants, and animals depends ultimately on the ability to analyse for these elements with speed and accuracy, it is not surprising that atomic absorption spectroscopy is now used for analytical purposes in agricultural laboratories throughout the world. In Australia the technique is used in the sugar, tobacco, wine, and fertilizer industries, as well as in irrigation and pasture research.

The method is similarly applicable to the analysis of body fluids such as blood serum and urine, and is now used in several Australian hospitals and medical schools. It is also used in the lead-smelting industry to monitor the concentration of lead in the urine of workers exposed to hazard from fumes of the metals.

Mining, metallurgical, and secondary industries have found atomic absorption techniques ideally suited to the determination of a wide range of metals. For example, the Zinc Corporation at Broken Hill makes more than 1000 determinations per week for elements such as lead, zinc, silver, and copper, whilst a prospecting company in Southern Rhodesia has carried out almost half a million copper analyses in 12 months.

An interesting and rather unusual application is to the analysis of the lubricating oil used in the diesel locomotives of the Commonwealth Railways; the concentrations of metals such as iron, chromium, copper, and silver are a guide to the mechanical condition of different parts of the engine and indicate when the unit should be withdrawn for dismantling and repair.

In addition, the method is extensively applied in research institutions. In Australia alone it is used in 15 Divisions of CSIRO and in university schools of agriculture, physiology, medicine, pathology, mining and metallurgy, botany, geology, chemistry, and applied chemistry.

It is gratifying to report that almost all the Australian laboratories working in atomic absorption spectroscopy have installed Australian-made equipment.—*Division of Chemical Physics.*

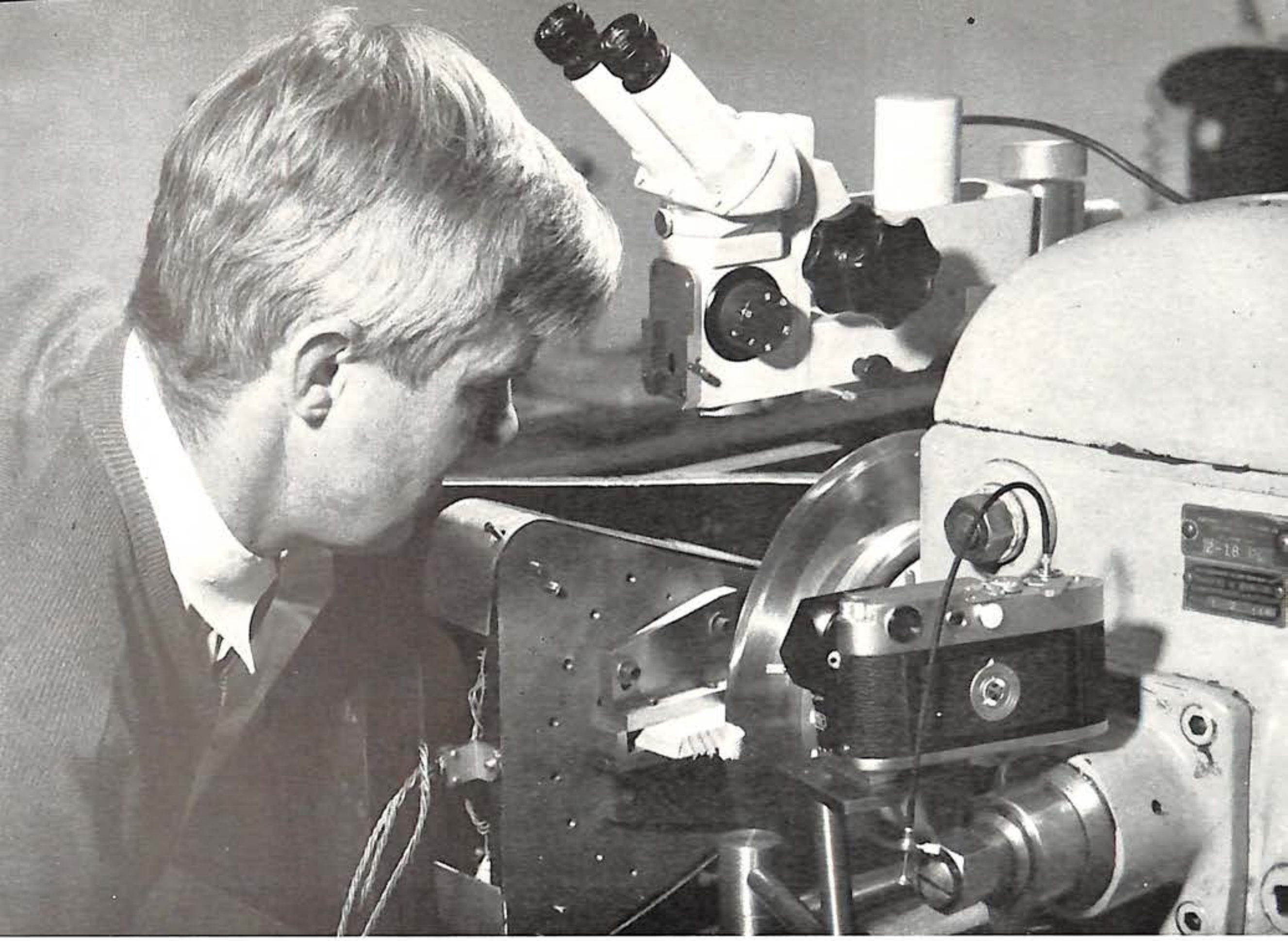
Atomic Spectral Lamps

The special atomic spectral lamps developed by the Division of Chemical Physics for use in atomic absorption spectroscopy have been manufactured since 1959 by Ransley Glass Instruments of Victoria. The demand for these lamps has grown to such an extent that a separate company, Atomic Spectral Lamps Pty. Ltd., has been formed and this firm is devoting itself exclusively to the manufacture of atomic spectral lamps. The majority of the firm's lamps are exported and the demand is rapidly increasing.

A new type of high-intensity atomic spectral lamp has now been developed; it will also be manufactured in Australia under licence from CSIRO. It is expected that this new lamp will provide another valuable export since it makes possible a whole new series of spectroscopic techniques which are applicable in industrial and scientific research.—*Division of Chemical Physics.*

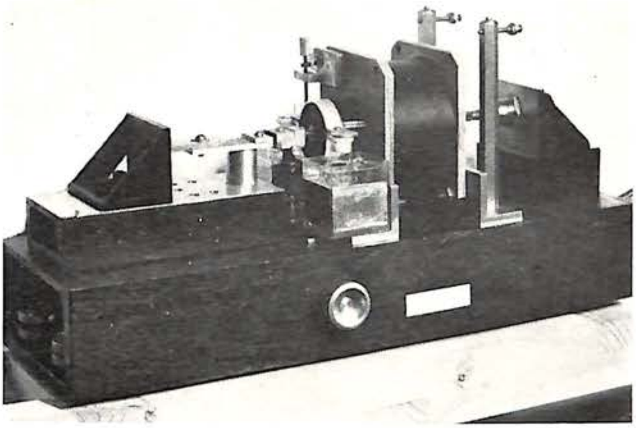
Line Scales Measured in Light Wavelengths

With the adoption of a light wavelength as the international standard of length in 1960 it is essential that line scales and end standards of length, which provide the basis for all precision engineering, be established in terms of the new standard. A special interferometer has been developed that provides a direct transfer from the light wavelength to line scale standards to an accuracy of better than one part in 10 million. The equipment is original in design and includes an interesting feature whereby a 1-metre length may be determined with only two optical settings using interference fringes arising from $\frac{1}{4}$-metre lengths. The scale is mounted in a chamber that can be evacuated and temperature controlled to better than $0 \cdot 01^\circ$C, and a mirror fixed to one end forms part of an interferometer system. A photoelectric microscope, also designed in the Division, is used to set on the scale graduations to better than half a millionth of an inch.—*Division of Applied Physics.*



Fundamental research into the cutting of wood is of great importance in the design of saw teeth and machine cutters. Basic wood cutting situations are studied on this machine.

The strength of a paper sheet is related to the tensile strength of its constituent single wood fibres. This micro-rheometer with associated electronic equipment applies loads of up to 50 grams to a single fibre and measures the fibre extension to 0·001 millimetre. The results are recorded as a graph of load versus elongation.



Basic Wood Cutting

Recently, the benefits of highly inclined cutting obtained by feeding a work-piece to the sharpened edge of a rotating disk were investigated. It was found that, given sufficient inclination, even a somewhat blunt edge could produce very smooth end-surfaces in such timbers as balsa and radiata pine, which are normally very difficult in this regard. This is attributed to the elimination of certain effects of edge bluntness and considerable reduction of deflecting forces at the edge. The principle is promising for application where surface quality or accuracy is paramount.

Factors governing friction and wear of cutters are also being studied. Microscopic methods have enabled wear of cutters to be detected, even after a few inches of slow linear cutting. It has been found that with wood in the green state, mechanical wear is assisted to a considerable degree by the chemical action of acids and polyphenols, which are present in almost all woods. From these observations, various methods of extending cutter life have been suggested.—*Division of Forest Products.*

High-strength Gypsum Plaster

The strength of gypsum plaster is decreased as the porosity of the material increases. The porosity is determined by the amount of water necessary to produce a workable plaster. The physical nature of the particles constituting calcined gypsum (plaster of paris) is such that it is usually necessary to use much more water than is required for the setting reaction.

As a result of recent work it is now possible to use much less mixing water in making workable plasters from ordinary "building plaster". The crushing strength of cast gypsum is usually about 1200 lb per square inch, but with the new techniques cast gypsum can easily be made with a crushing strength of 6000 lb per square inch, i.e. about the same as that of good concrete.—*Division of Building Research.*

Mechanical Properties of Individual Wood Fibres

In order to understand both the behaviour of paper under stress and the nature of the forces which provide the strength of the sheet, it is necessary to obtain information on the mechanical properties of the individual fibres and on the way these may be modified by various treatments, including those to which the fibres are subjected during the processes of pulp and paper manufacture. The delignified wood fibres commonly used for papermaking range from less than 0·1 cm in length in the case of many hardwoods, such as the eucalypts, to 0·2–0·3 cm for softwoods, such as the pines; their diameters are about 0·002 and 0·003 cm respectively, and the thickness of their walls about 0·0004 and 0·0005 cm. Hence the measurement of their rheological properties presents considerable difficulty. An instrument has been constructed in which the load-extension curve of a single fibre can be recorded automatically. The load is produced by an electromagnetic device, controlled electronically so that the rate of loading is constant. The extension is measured by means of a variable inductance differential transformer. Loads up to 50 g may be applied and recorded with a sensitivity of about 0·01 g. Extensions up to 0·2 cm may be measured with a stable magnification of 37,500, allowing deformations of less than 0·00001 cm to be readily detected. The instrument provides for both electrical and vibrational stability and its calibration and performance have been tested with very fine constantan wires. Micromanipulative techniques have been developed for mounting the fibres.—*Division of Forest Products.*

Burning of Coal in Power Stations

The efficiency of electricity generation on coal-fired power stations is often impaired by the formation of inorganic deposits on external surfaces of boiler tubes. The frequency with which it may be necessary to withdraw a steam-raising unit from service for cleaning depends upon the nature of the inorganic constituents in the coal and on the conditions of combustion.

Problems of fouling which are encountered in the burning of Morwell and Leigh Creek coals in power stations in Victoria and South Australia are under investigation. It has been found that the concentration of sodium in the coal is of particular importance in determining the rate of fouling. This element, as well as others, is in the main chemically combined with the coal and not present as a discretely identifiable mineral.

As a result of using Perspex models to study flow patterns in boiler furnaces burning pulverized Leigh Creek coal, slight modifications to a power station unit have been suggested with the aim of improving the efficiency of radiant heat transfer to water tubes at the furnace wall.—*Division of Coal Research.*

Control of Ball Mill Grinding Circuits

The automation of industrial processes has become an engineering science and the application of automation has extended into many spheres. Mineral processing, until recently perhaps better described as an art rather than a science, is now becoming a field for such application. Before automatic control can be applied to mineral processing plants, mathematical functions must be obtained which can be used by control engineers for the design of control systems. These functions describe the working relationships which exist between the process feed material, the operating variables, and the output variables.

As grinding in continuous ball mills is an important and expensive operation common to most mineral processes, a detailed study is being made using a small, continuous, model ball mill. Carefully controlled grinding experiments have been used to investigate the dynamic response of the mill to changes in selected properties of the feed solids by following the resultant changes in the properties of the mill discharge solids as a function of time.

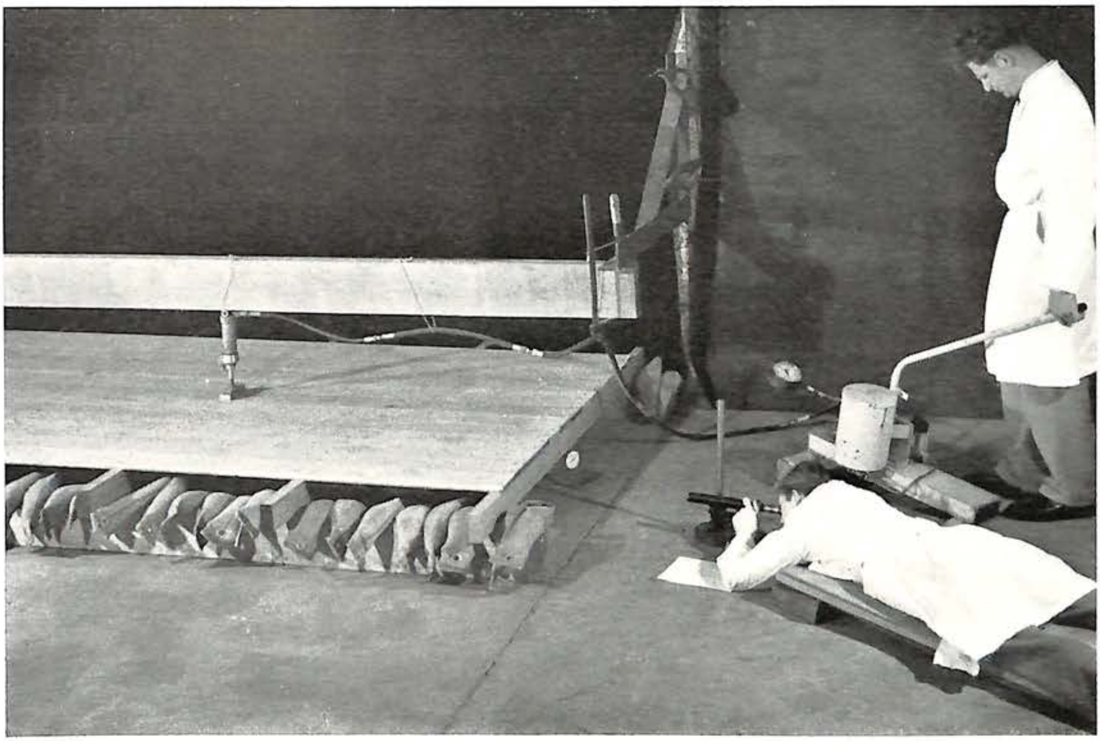
Considerable progress has been made towards the derivation of a satisfactory mathematical model to account for the stages of breakage of selected size ranges and it is probable that an extension of the model will give a realistic representation of breakage in the ball mill.—*Division of Chemical Engineering.*

Load Distribution in Wooden Floors

Floors of structures such as drill halls, factories, highway bridges, and even houses, must be designed for heavy concentrations of load in addition to any uniformly distributed loading. Application of a point load anywhere on the floor surface, for example, when the weight of a heavy piece of furniture, equipment, or machinery is concentrated on a small supporting area, involves some sharing of the load among several of the joists or beams in the flooring support system. This load-sharing has been investigated for wooden floors in order to achieve a greater degree of efficiency in the engineering design of timber-framed structures in which load-sharing between members is a consequence of the common methods of fabrication.

The results of the investigation have indicated that, as the nailing of flooring to joists and joists to bearers has little effect on load distribution, for the practical purposes of deciding the necessary sizes in design the joists and flooring can be considered as simply supported beams. Thus the amount of load-sharing is dependent on the relative stiffness of the flooring and joists and may be calculated from simple engineering theory with an empirical allowance for the number of floor boards effective in distributing the load.—*Division of Forest Products.*

Concentrated load being applied to a floor surface by means of a hydraulic jack in the study of load distribution in wooden floor systems.



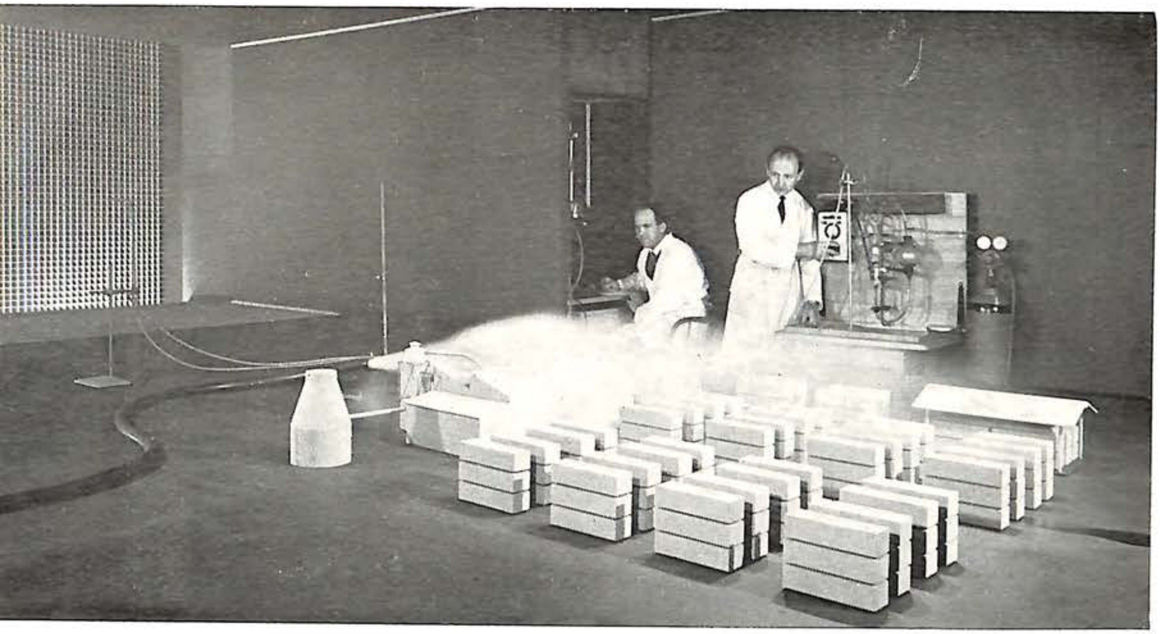
Timber Seasoning

Australian native timbers are predominantly hardwoods, and a considerable number are refractory and slow drying. For many of these, technical and economic factors dictate combined air and kiln seasoning as the preferred process where climates are suitable. As such areas are extensive in Australia, large quantities of timber are air seasoned for at least part of their drying history.

Regrettably, air-drying practices in Australia are still inadequate, possibly because the terminal effects of bad methods are often either unrecognized or underestimated. Some measure of the extent of the problem is shown by the fact that losses due to degrade alone are in the vicinity of £1,000,000 per annum, and unnecessarily prolonged drying in poor yards is costing approximately £500,000 per annum.

The basic cause of much of this wastage, which is common to all wood-processing countries, is a general lack of technical criteria for defining optimum conditions for wind movement through drying yards and drying stacks. Studies have therefore been set up on a model scale, in a wind tunnel designed to correlate air flow conditions and site factors with yard layout, evaporation rates, and drying patterns. Promising results are being obtained in prototype yards laid out by industry on the basis of principles suggested.—*Division of Forest Products.*

Improvement in air-drying techniques results in improved economy and timber quality. A model assembly is shown under test in a wind tunnel as part of a programme to determine the most efficient layout of an air seasoning yard. A smoke trace is used to indicate the pattern of movement of air through the yard.



New Electron Diffraction Camera

It is an important part of the technique of electron diffraction, particularly in its application to structural problems, to obtain as accurate measurements as possible of the intensities of diffracted electron beams. Hitherto these measurements have been made by photographic means with a consequent limitation in accuracy to approximately 8%.

The feasibility of electronic measurement was explored on an existing instrument and it was shown that under favourable conditions an accuracy of 1% could be achieved.

Accordingly a specialized instrument was designed and is nearing completion. Considerable mechanical precision is required in the construction of the column that is associated with control and recording electronic equipment. This permits the pattern of beams to be scanned in a predetermined sequence over a fixed detector while a noise reduction procedure is executed automatically by means of function generators and operational amplifiers.

The specimen is positioned mechanically by sets of flexure strips, and fine setting is achieved by electronic control of the incident electron beam. An electrostatic chopper mounted in the column provides an independent check on the overall linearity of the system. The entire column, as well as the electronics, is heavily screened against extraneous fields.

It is intended to use the instrument mainly in structural studies where exploratory measurements have shown the value of such an approach. In addition, it is planned to test certain predictions in the theory of dynamical scattering that require accuracies beyond the scope of photographic techniques.—*Division of Chemical Physics.*

Solar Air Heater and Rockpile Thermal Storage

Recent developments in directionally and spectrally selective surfaces have led to the design of cheap and efficient solar air heaters. Interesting possibilities exist for the use of these heaters to produce hot air for dehydration, space-heating, and similar applications, where high temperatures are not required.

If hot air is to be delivered continuously and at times when solar energy is not available, some form of thermal storage is required. This can be provided very satisfactorily by a packed bed of graded crushed stones through which the air stream can be passed. This bed combines the two functions of heat storage and heat exchange.

Studies of the thermal characteristics of such a rockpile have been carried out in order to establish heat transfer coefficients for different configurations and different operating conditions. In order to obtain good heat transfer between air and stones, while at the same time avoiding high pressure drops and consequent high fan power consumptions, it appears desirable to use small-sized stones and low air velocities.

Based on the experimental results obtained, a full-scale prototype air heater and thermal storage system are being installed to heat part of a laboratory. The rockpile is also to be provided with water sprays so that it can be evaporatively cooled at night during the summer months and used to supply cool air to the laboratory during working hours.—*Division of Mechanical Engineering.*

High-quality Sand from Low-grade Deposits

Silica is one of the main components of glass, glazes, and other ceramic products, and the main source of supply is quartzite or quartz sand which is crushed to an appropriate size for industrial use. The chief reason for using quartz is its high purity, especially in its low content of iron oxide and other colouring materials.

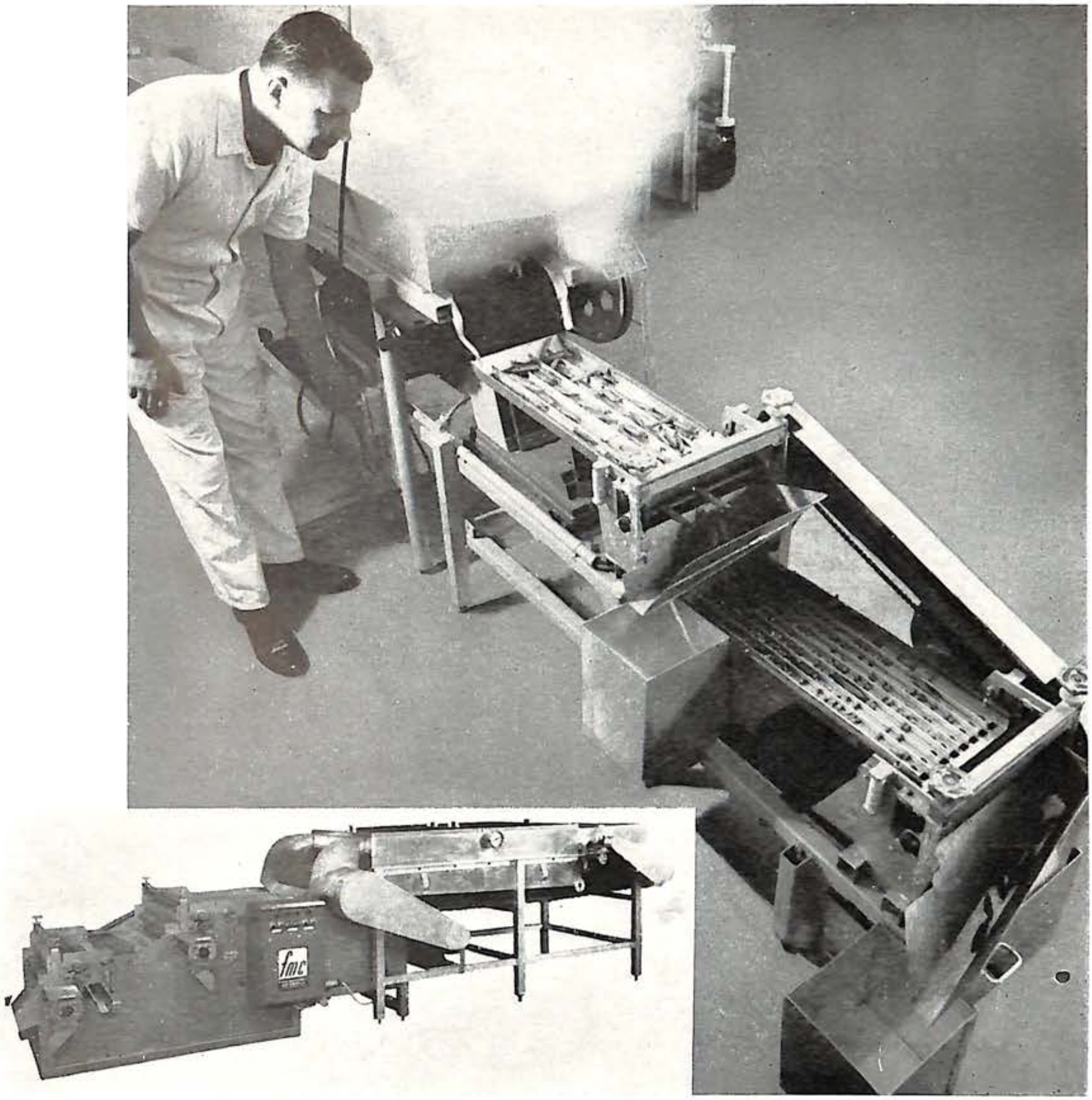
Quartz of the required quality is not always readily available, but a method of producing such material by the inexpensive treatment of low-grade sands has been developed. These sands consist largely of silica but they also contain other minerals which, together with the silica, are usually coated with clay. A simple chemical treatment with a dispersing agent in alkaline solution is used to change the clay into a form which may be washed away. The washed sand is then passed through a magnetic separator to remove particles of iron-containing and other magnetic minerals. One advantage of the method is that the necessary equipment is normally available in any ceramic factory. Sands that give ceramic products of satisfactory whiteness can be produced at less than half the cost of materials from other sources. Some sands are of sufficiently high quality after treatment to be used in the manufacture of clear glass.

The treatment is already in commercial use for the production of sand for ceramic products, and other interests in Australia contemplate installing additional treatment plants after further laboratory tests have been made. The demand for glassmaking sand in Australia and elsewhere is large, and the possibilities of developing exports of sands treated in the above way are being investigated by commercial interests.—*Division of Building Research.*

Solid Lubricants and Surface Irregularities

An Australian oil company granted funds to investigate the mechanism of solid lubrication. This led to studies of molybdenum disulphide, which is a mineral found in Australia and is already a well-known solid lubricant. Tests were also made of other inorganic compounds that can be prepared from Australian raw materials and that have a similar crystal structure to molybdenum disulphide. Some of these compounds gave low coefficients of friction when in the form of compressed compacts, but molybdenum disulphide was outstanding in the ability of the powder to adhere to metal surfaces and therefore be a useful lubricant.

By observing the rate at which molybdenum disulphide films built up when the powder was rubbed on metal surfaces with irregularities of different sizes it was found that the powder first filled the hollows in the surface and then built up on itself giving a close-fitting tenacious film. It follows therefore that rougher surfaces which have a larger reserve of lubricant and films formed on them would be more resistant to the attrition caused by continued sliding. However, very rough surfaces would have localized contact areas and the resultant high pressures would be liable to initiate seizure and wear. Thus when a solid lubricant is used the least wear may be expected from a surface with irregularities of moderate size.—*Division of Tribophysics.*



The prototype of the CSIRO pea sheller being tested and (inset) the machine manufactured by a commercial firm under licence.

A New Machine for Shelling Peas

Commercial harvesting of peas is usually carried out with a machine that threshes the peas from the pods while the pods are still attached to the vine, and considerable transport is required to convey the bulky cut vines to the factory to be processed in the viner. Storage of the vines and disposal of the waste after the peas have been stripped also present problems at the factory, so that when a mechanical field pea pod picker was recently developed overseas it appeared that many of these difficulties would be avoided. However, in order to exploit the advantages of the pea pod picker means had to be devised for mechanically removing peas from the pods after the pods had been picked off the vines by the machine.

The growth of mould on painted surfaces is a serious problem in many parts of Australia, and the Division of Building Research is investigating the effectiveness of fungicides in paints. These panels coated with paints of various formulations, both with and without fungicides, are exposed outdoors at Lae, New Guinea, and the resistance to mould growth and changes in content of fungicide are assessed at intervals.

A pea shelling machine has now been designed that is not only simple in principle but has proved highly efficient in practice. The essential feature of the CSIRO pea sheller is a vibratory feed to align the pods for end-on presentation to a pair of rubber-covered fluted rollers, the rotation of which causes the pods to be drawn between them while the peas are ejected from the pods. The peas drop into a collection channel whence they are delivered continuously along a chute.

Trials on a prototype machine installed at the Food Processing Laboratory at North Ryde showed that it is capable of giving higher pea yields and better-flavoured frozen or canned peas than can be obtained by the use of the conventional viner, which tends to cause bruising. These findings have since been confirmed on a machine manufactured by a commercial firm under a licence agreement with CSIRO.

When used in combination with the pea pod picker the new pea shelling machine will contribute materially towards more efficient harvesting and processing: peas may be transported in the pod to the factory and stored thus until required, and shelling need only be undertaken when the processing plant is ready to receive the shelled peas.—*Division of Food Preservation.*

Transport of Fruit

The handling and transport of various kinds of fruit, whether for local distribution in Australia or for export, present many problems requiring investigation and research. Last season, for instance, an investigation was made into the suitability of a new design of louvred railway van for the transportation of bananas in and between New South Wales and Victoria on the new standard gauge. Problems have also arisen in connexion with the shipment of apples and pears overseas.

Transport of apples and pears to overseas markets by ship requires that the type of container used to hold the fruit during transit and the method of stowage employed in the ship's hold do not adversely affect the keeping quality of the fruit. Nor should the ultimate appearance of the fruit at the port of destination suffer, for instance, through bruising during loading and unloading. Economic factors have lately favoured the use of bulk bins of 800–1000 lb capacity for local handling (as against the traditional 40–50 lb bushel box) and these have had limited use for exported apples and pears. Even more recently, use has been made of fibreboard containers, either of the cell pack or tray pack type, which are grouped in pallet units of 40 or more to facilitate loading and unloading by mechanical means.

The new containers have raised special problems of ventilation and cooling of the fruit in transit and have necessitated investigation of stowage arrangements in ships' holds and detailed consideration of container design. Experimental shipments of apples and pears to the United Kingdom in the 1962 season in several ships were followed up in the 1963 season, and further trials were conducted in 1964. An important feature has been the installation in selected ships of special temperature-measuring equipment by officers of the Division, and the inclusion of test packages for detailed examination at the port of discharge.

The shipboard investigations are being carried out with the collaboration of the British Shipowners' Cargo Research Association, and financial and other help is being given by various State Departments of Agriculture, the Apple and Pear Board, the Apple and Pear Shippers' Association, and the Fibreboard Development Council.—*Division of Food Preservation.*

Preventing Browning in Dried Fruits

It has long been known that small amounts of sulphur dioxide retard the browning which occurs when many foods are concentrated or dried, but the mechanism of these non-enzymic browning reactions and their inhibition has been little understood. Fundamental studies prosecuted for a number of years by CSIRO research workers have confirmed that the first step in non-enzymic browning is the interaction of amino compounds and sugars, and lately a major advance has been the isolation in a pure state of various highly reactive intermediates that have indicated the sequence of reactions involved. Inhibition of browning reactions by sulphur dioxide and bisulphites has been shown to be due to the formation of relatively stable sulphonated products from some of the osone intermediates, with a consequent interruption in the chain of reactions that normally lead to the formation of brown pigment.

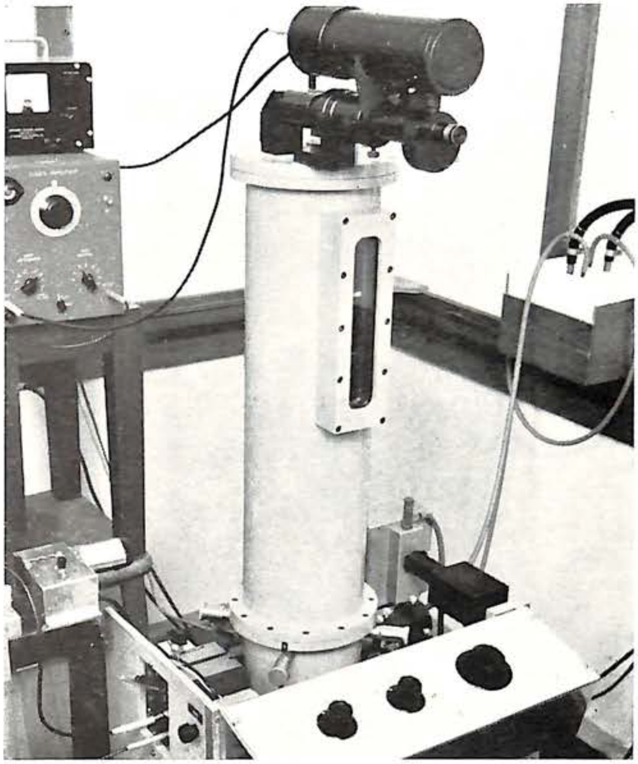
On a practical level, a detailed study has been made of the conditions necessary for the optimum pretreatment with sulphur dioxide gas of apricots, peaches, and pears intended for finishing as dried fruit. Several countries importing Australian dried fruits are strictly enforcing regulations governing the maximum permitted quantity of sulphur dioxide retained in the fruit, and, since fumigation appears to be essential to preserve natural colour and flavour, rigorous control of the sulphuring process has now become a matter of extreme importance.

As a result of the investigations carried out, CSIRO is now able to advise on improved methods which permit of closer control of the principal variables determining uptake and retention of sulphur dioxide by the fruit. An improved method of re-sulphuring apple slices with metabisulphite has also been devised which ensures more uniform distribution of this preservative, thus permitting minimal dosages to be applied.

Application of these results by Australian dried fruit producers should strengthen their position in the export market and provide a sound basis for future expansion of the industry in Australia.—*Division of Food Preservation.*

Last stage of test to destruction of an experimental prestressed flat plate structure of expanded shale concrete, erected at the Division of Building Research. Testing was done by air pressure applied through plastic bags between the concrete slab and the timber reaction frame. The photograph shows the concrete slab sagging down from the edge columns, the bag still partially inflated. The test provided essential design data on punching shear strength of prestressed slabs.

A New Electrical Standard



Modern technology is dependent on the accurate measurement of a very wide range of physical quantities, but a cursory examination will show that these measurements are based on relatively few fundamental standards. It is the function of national standardizing laboratories to establish and maintain fundamental standards of measurement meeting the needs of science and industry. Recent theoretical work at the National Standards Laboratory has led to the construction of one such standard, a calculable form of cylindrical cross-capacitor on which the Laboratory now bases its measurements of capacitance, inductance, and resistance. Previously Australia depended on overseas laboratories, which provided periodical calibrations of resistance standards, to establish the values of these units.

The capacitance method developed is expected to prove at least an order more accurate than older methods, because the value of the standard is obtained from a single length dimension measured directly in wavelengths of light by means of a built-in interferometer.—*Division of Applied Physics.*

Domestic Fresh Water

The provision of fresh water for domestic use in areas where only saline or brackish waters are available is becoming of increasing importance with the expansion of rural and industrial interests. To provide an answer to this problem a small distillation plant has been constructed which will produce about 100 gallons of fresh water daily from seawater or similar waters. This unit is designed to operate in conjunction with the diesel engine of a domestic lighting plant and should be cheap in both capital and operating costs. The simplicity of design and construction should enable the plant to operate with a minimum of attention and maintenance for long periods. The prototype plant has undergone satisfactory preliminary runs although some mechanical modifications have been found to be necessary.—*Division of Chemical Engineering.*

Continuous Wool Dyeing

In the wool industry, where many of the stages in the processing of the raw material are continuous operations, the dyeing stage has, for many years, stood out as a typical batch process. Work has been done on the development of a prototype machine for the continuous dyeing of wool slubbing at a rate which is consistent with other mill operations.

This new process requires the use of a solution of the dyestuff in 75% formic acid. Special equipment is therefore required for the recovery and distillation of the acid, but it is expected that the overall cost of the operation will be comparable with that of conventional dyeing. It has the advantages over the present batch process of avoiding hold-up, achieving dyeing qualities which are a considerable improvement on the existing process, and at the same time avoiding many of the present troubles, such as yellowing and tangling.—*Division of Chemical Engineering and Division of Protein Chemistry.*

Production of Stretch Wool Fabrics

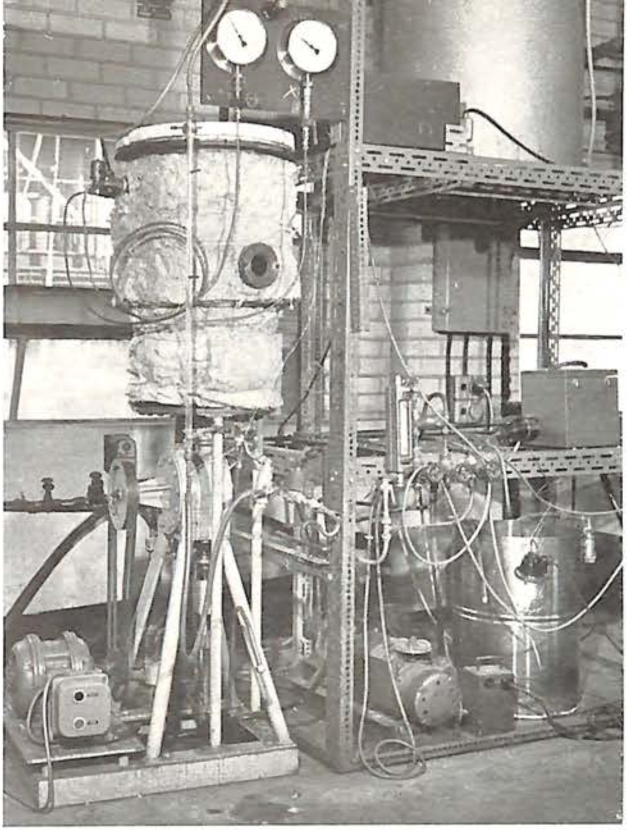
Research has been undertaken to produce stretch woven wool fabrics. By applying appropriate setting techniques and tension in finishing, it has been possible to obtain weft stretch fabrics. This work has been undertaken in close collaboration with technical staff of the Australian Wool Board, who are now extending the results in industry. In addition to chemical methods of imparting stretch, research is in progress on physical techniques to produce similar results. It has been found that two-way stretch fabrics can be produced by special procedures in spinning, twisting, and weaving.—*Division of Textile Industry.*

Merino Wool in Fabrics

One-half of the cross section of most Merino wool fibres is slightly different from the other. This is known as a bilateral structure and is peculiar to Merino-type wool. The two halves are called ortho- and para-cortex. They run the full length of the fibre changing sides with the fibre crimp wave so that the ortho-cortex remains on the outside of the curvature.

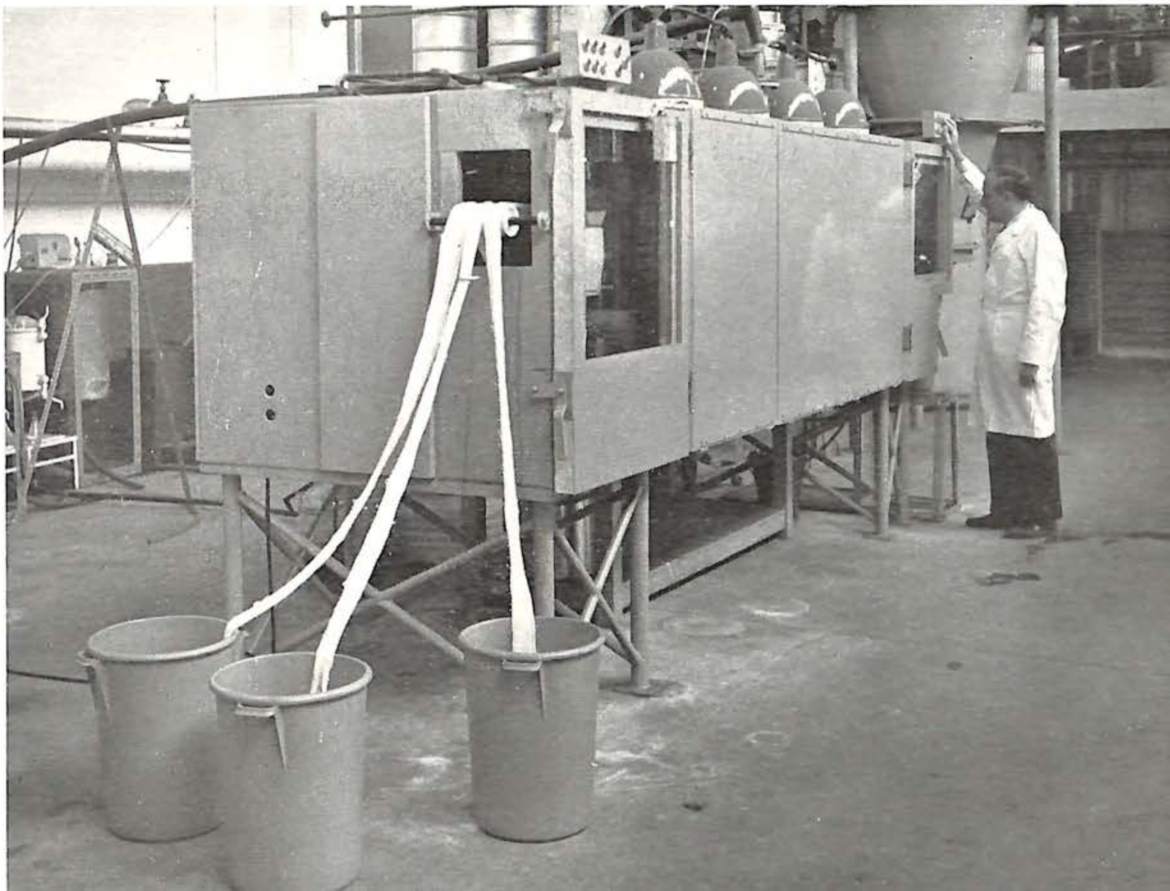
Two discoveries have been made concerning the effect of this bilateral structure in fabrics. One is that bending of the fibres during weaving of the yarns across each other causes the fibres to rotate so that most of the bent fibre arcs have the ortho-cortex on the outside. The other is that after the fabric has been set (by steaming, hot water, or chemicals) the fibre arcs straighten out on wetting to a very much greater extent than would be expected from a simple theory based on changes in the diameter of the fibre due to its absorbing water.

Changes in the amount of moisture in a fabric cause changes in dimensions; this is due to the straightening of the fibre arcs as they increase in moisture content. These new observations on ortho-para-cortex orientation and behaviour in fabrics have made it possible to calculate the dimensional changes to be expected in fabric and indicate rules for avoiding difficulties in manufacture due to these changes.—*Division of Textile Physics.*



A prototype domestic desalination unit being developed at the Division of Chemical Engineering for producing up to 100 gallons of fresh water per day from saline water.

An experimental plant developed in the Division of Chemical Engineering using the process devised by the Division of Protein Chemistry for the continuous dyeing of wool with a solution of dyestuff in formic acid.



Measuring Forces on Wool Fibres in Machines

Apparatus has been developed which can measure the forces acting on wool fibres as they pass through machines in processing. The equipment includes a small transmitter built into part of the machine being studied; it transmits signals that are received at a distance from the machine. In this way, it is possible to measure forces generated when fibres pass through the rapidly moving machinery used in operations such as wool combing and gilling. Previous methods could not achieve this satisfactorily as the connections required between the moving parts of the machine and the measuring equipment created mechanical difficulties. The new equipment is being used to assess the effects of lubricants added to the wool in processing, particularly in reducing the forces between the fibres and metal "teeth" in the machines.—*Division of Textile Industry.*

Freight Savings by Denser Dumping of Wool

For shipping overseas, Australian wool bales, which have a density of about 14 lb/cu ft, are pressed and banded. The density of the resulting "dumped" bale is 22·5 lb/cu ft on the average. Freight charges on wool are about £30,000,000 per annum. Savings in freight would be possible if bales could be economically made denser and if the wool could still be processed satisfactorily in textile mills. Processing trials on densely packed wool have now been carried out.

A uniform lot of wool was obtained. One half was pressed and banded to a density of 30 lb/cu ft, the other half was left baled at 14 lb/cu ft. After storage for 6 months the wool was processed. In addition, trials were made on another lot of wool for the effect of the dense packing on the sorting rate in the mill.

It was found there was no appreciable difference in the processing of the normal and densely packed wool. Combing noilage was about the same, as was fibre length. The densely packed wool when stored at low temperatures was slower in sorting unless some pre-heating was carried out. However, heating is usually practised in cold climates in any case.

It appears therefore that there are good prospects for the acceptance of wool which has been more densely packed than is the present practice.—*Division of Textile Physics.*

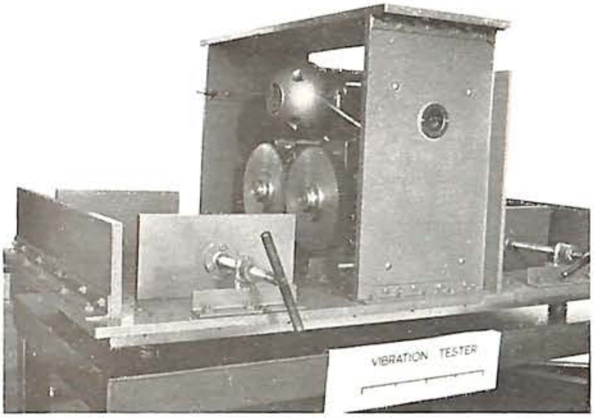
Predicting Corrosion in Cans Containing Foods

Measurement of the concavity of the ends of a can during storage of a canned food, using an instrument designed for this purpose by officers of the Division of Food Preservation, has hitherto provided a convenient means of following the course of corrosion. The method cannot be used, however, to predict the likely course of the corrosion processes, and a simple test cell has now been developed for investigating pitting corrosion in canned foods. This cell enables an operator to predict how various steels will perform in contact with a given food product, and thereby provides information previously only available after extended storage trials.

The test cell indicates whether pitting corrosion is likely and, if so, whether this will occur even though the tin coating is not attacked—a type of corrosion frequently associated with premature failure. It also enables the canner to ascertain whether the food itself has abnormally high corrosion characteristics. He can then decide whether additional safeguards are necessary, such as an internal coating of lacquer, or even modification of the food formula to render the food less aggressive to the container.

The technique has been successfully used to investigate several instances where unusually short shelf life was reported, and its application in industry should help materially towards reducing economic losses due to wastage caused by premature can corrosion.—*Division of Food Preservation.*

Checking air speed in a belt-trough dryer assembled in the workshops of the Division of Food Preservation. Air, heated by drawing through the combustion chamber at left, is delivered by ductwork to the underside of a moving woven stainless steel belt, where it passes through a continuously tumbling bed of foodstuffs. Water is removed from the foodstuffs uniformly, rapidly, and efficiently, particularly in the early stages of drying. Belt speed and inclination may be adjusted to suit the flow characteristics of a variety of foodstuffs. The dryer can evaporate 200 pounds of water per hour using drying temperatures up to 350° F. The partially dried foods delivered by the equipment may be subsequently frozen, canned, or dried.



A transport vibration shock simulator in which eccentric revolving weights generate vibrations similar to those experienced in road or rail transport. The machine, built in the Division of Food Preservation, is being used in banana packaging and transport investigations conducted by CSIRO, the N.S.W. Department of Agriculture, and the Queensland Department of Primary Industries. The vibration simulator and a device simulating impact during transport are likely to be used in studies of the bruising of apples and pears during transport and marketing.

Wheatland Disk Ploughs

Since 1960, field studies have been made of the effects of many variables on the soil forces acting on plough disks and the counteracting forces that can be generated by towed wheels. Sufficient data have been collected for one soil type to show which of the variables are of practical importance and to provide the quantitative information required for design work by industry.

Of particular interest to designers is the finding that there is a critical relationship between the spacing of the disks and their attitude angles; this relationship has a great effect on the draught and the required weight of the whole plough. Paradoxically, the plough designed for minimum draught requires the most weight. Also, it can be recommended that to increase the rate of work the total width of cut of the plough should be increased, in preference to increasing the speed.

One manufacturer has lent the Division a 14-disk plough to check the predictions made from the experimental work; two sets of jump arms have been provided to give two specific relationships between disk spacing and attitude angle.—*Division of Mechanical Engineering.*

Density Measurements

A hydrometer has been developed which embodies special features that make it particularly suitable for industrial use. The reading index is separated from the liquid surface, and temperature compensation is provided whereby the reading of the hydrometer in any particular class of liquid indicates the density of that liquid at a specified temperature, even if the temperature of the liquid departs from the reference temperature by as much as 10°C.

This instrument is now in commercial production.—*Division of Applied Physics.*

3

Published Papers

THE FOLLOWING PAPERS were published during the year ending December 31, 1963. Letters Patent granted to CSIRO during this period are also included.

ANIMAL RESEARCH LABORATORIES

DIVISION OF ANIMAL GENETICS

ADAMS, K. M., VAN WAGTENDONK, W. J.,* and BRODY, J. I.*—The characteristics of early *in vitro* cultures of human leukaemic lymphocytes. *Med. J. Aust.*, 1963, **1**, 137.

ALLEN, T. E., PAN, Y. S., and HAYMAN, R. H.—The effect of feeding on evaporative heat loss and body temperature in Zebu and Jersey heifers. *Aust. J. Agric. Res.*, 1963, **14**, 580.

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4

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Assistant Secretary—B. F. McKeon, B.Ag.Sc. (Hons.)
Assistant Secretary—L. G. Wilson, M.Sc.
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Senior Finance Officer—M. F. Combe
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See Chemical Research Laboratories

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Headquarters: Stowell Avenue, Hobart

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See Wool Research Laboratories

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Experimental Officer—S. G. Gray, M.Sc.Agr.

Plant Nutrition and Soil Fertility

Principal Research Officer—C. S. Andrew, M.Agr. Sc.
Senior Research Officer—E. F. Henzell, B.Agr.Sc. (Hons.), Ph.D.
Research Officer—R. E. White, B.Agr.Sc., Ph.D.
Experimental Officer—I. Vallis, B.Agr.Sc.(Hons.)

Plant Physiology

Principal Research Officer—C. T. Gates, M.Sc. (Agric.)
Research Officer—J. R. Wilson, M.Sc.(Agric.), Ph.D.

Plant Chemistry

Senior Research Officer—M. P. Hegarty, M.Sc., Ph.D.

Experimental Officer—R. D. Court, B.Sc.
Experimental Officer—M. F. Robins, B.Sc. (Agric.)

Ecology

Principal Research Officer—J. E. Coaldrake, M.Sc.
Research Officer—J. C. Tothill, B.Agr.Sc., Ph.D.

Legume Bacteriology

Senior Principal Research Officer—D. O. Norris, D.Sc.(Agric.)

At Cooper Laboratory, Lawes, Qld.:

Pasture Evaluation and Animal Nutrition

Senior Research Officer—R. Milford, B.Agr.Sc. (Hons.), Ph.D.
Senior Research Officer—D. J. Minson, B.Agr.Sc. (Hons.), Ph.D.

Agrostology

Research Officer—J. J. Yates, B.Sc.(Agric.) (Hons.), Ph.D.
Experimental Officer—M. J. Russell, B.Sc.(Agric.), D.T.A.(Trin.)

At Pastoral Research Laboratory, Townsville, Qld.:

Officer-in-Charge—L. A. Edye, B.Agr.Sc.(Hons.), M.Sc.

Agrostology

Research Officer—P. Gillard, B.Sc.(Hons.), Ph.D.
Experimental Officer—D. A. Cameron, B.Agr.Sc. (Hons.)
Experimental Officer—A. C. Robinson, B.Agr.Sc. (Hons.)

Plant Nutrition

Research Officer—R. K. Jones, B.Agr.Sc.(Hons.), Ph.D.

At "Lansdown" Pasture Research Station, Woodstock, Qld.

Officer-in-Charge—J. B. Ritson, B.Agr.Sc.

UPPER ATMOSPHERE SECTION

Headquarters: Harben Vale, Camden, N.S.W.

Officer-in-Charge—D. F. Martyn, D.Sc., Ph.D., F.A.A., F.R.S.
Principal Research Officer—E. B. Armstrong, B.Sc., Ph.D.
Senior Research Officer—R. A. Duncan, B.Sc. (Hons.)
Experimental Officer—D. G. Cartwright, B.Sc. (Hons.)
Experimental Officer—T. W. Davidson, M.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—R. C. Rossiter, B.Sc.Agr., D.Sc.(Agric.)
Administrative Officer—J. P. Brophy
Scientific Librarian—Miss J. C. Kahan, B.Sc.

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 Officer—J. Wilson Lee, B.Sc. (Hons.), Ph.D.
Research Officer—D. J. Winzor, B.Sc.(Hons.), Ph.D.
Experimental Officer—J. K. Raison, B.Sc.(Hons.), Ph.D. (*seconded to Division of Plant Industry*)
Experimental Officer—J. A. Ronalds, B.Sc.
Experimental Officer—M. Wootton, B.Sc.
Experimental Officer—C. W. Wrigley, M.Sc. (*on leave*)
Experimental Officer—Mrs. P. M. Wrench, M.Sc.

DIVISION OF WILDLIFE RESEARCH

Headquarters: Barton Highway, Canberra

Administration

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

Marsupial Biology

Principal Research Officer—G. B. Sharman, D.Sc.
Senior Research Officer—J. H. Calaby, Dip.App. Chem.
Research Officer—W. E. Poole, B.Sc.(Hons.)
Experimental Officer—P. T. Bailey, Dip.Agric. Ent., B.Sc.
Experimental Officer—Miss M. J. Clarke, B.Sc. (Hons.)
Experimental Officer—F. K. Keysell, B.A.

Rabbit Biology

Principal Research Officer—K. Myers, B.Sc. (Hons.)
Senior Research Officer—R. Mykytowycz, D.V.M.
Research Officer—J. D. Dunsmore, B.V.Sc., Ph.D.
Research Officer—P. J. Fullagar, B.Sc.(Hons.)
Research Officer—R. L. Hughes, B.Sc.(Hons.)
Experimental Officer—B. S. Parker, B.Sc.
Experimental Officer—Mrs. E. M. Stodart, B.Sc. (Hons.)

Rabbit Control

Scientific Services Officer—B. V. Fennessy, B.Agr. Sc.

Field Ecology

Principal Research Officer—D. L. Serventy, B.Sc. (Hons.), Ph.D. (*at Perth*)
Senior Research Officer—M. G. Ridpath, B.Sc. (Hons.)

Senior Research Officer—I. C. R. Rowley, B.Agr. Sc.
Research Officer—G. F. van Tets, M.A., Ph.D.
Experimental Officer—L. W. Braithwaite, B.Sc.
Experimental Officer—S. J. J. F. Davies, B.A. (Hons.) (*on overseas studentship*)
Experimental Officer—K. E. Gamble, B.S.
Experimental Officer—F. N. Robinson, B.A.

Bird Population Studies

Senior Principal Research Officer—R. Carrick, B.Sc.(Hons.), Ph.D.
Experimental Officer—Miss S. E. Ingham, B.A. (Hons.)

Animal Physiology

Principal Research Officer—M. E. Griffiths, D.Sc.

WOOL RESEARCH LABORATORIES

Wool Textile Research Committee

F. G. Lennox, D.Sc. (*Chairman*)
V. D. Burgmann, B.Sc., B.E.
M. Lipson, B.Sc., Ph.D.
C. Garrow, B.Com., D.P.A. (*Secretary*)

DIVISION OF PROTEIN CHEMISTRY

Headquarters: 343 Royal Parade, Parkville, Vic.

Chief—F. G. Lennox, D.Sc.
Assistant Chief—W. G. Crewther, M.Sc.
Laboratory Secretary—C. Garrow, B.Com., D.P.A.
Senior Principal Research Officer—R. D. B. Fraser, Ph.D., D.Sc.
Senior Principal Research Officer—H. Lindley, B.A., Ph.D.
Principal Research Officer—J. M. Gillespie, D.Sc.
Principal Research Officer—B. S. Harrap, M.Sc., Ph.D.
Principal Research Officer—M. A. Jermyn, M.Sc., Ph.D.
Principal Research Officer—S. J. Leach, B.Sc. Tech., Ph.D.
Principal Research Officer—I. J. O'Donnell, M.Sc.
Principal Research Officer—T. A. Pressley, B.Sc., Ph.D.
Principal Research Officer—W. E. Savige, M.Sc., Ph.D.
Principal Research Officer—E. O. P. Thompson, M.Sc., Dip.Ed., Ph.D.
Principal Research Officer—E. F. Woods, M.Sc., A.R.M.T.C.
Senior Research Officer—A. S. Inglis, M.Sc.
Senior Research Officer—J. A. Maclaren, M.Sc., Ph.D.
Senior Research Officer—T. P. MacRae, M.Sc.
Senior Research Officer—B. Milligan, B.Sc., Ph.D. (Adel. and Cantab.)
Senior Research Officer—F. H. C. Stewart, B.Sc., Ph.D. (Belfast and Cantab.)
Senior Research Officer—J. F. K. Wilshire, B.Sc., Ph.D.
Research Officer—R. A. De Deurwaerder, Ph.D.
Research Officer—M. G. Dobb, B.Sc., Ph.D.
Research Officer—R. Ledger, B.Sc.(Hons.), Ph.D.
Research Officer—A. Miller, Ph.D.
Research Officer—B. G. Newsom, B.Sc., Ph.D.
Research Officer—B. J. Sweetman, M.Sc., Ph.D.
Research Officer—E. Suzuki, B.Eng.
Research Officer—J. R. Yates, M.A., 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—P. Jakobsen, B.Sc.Agr., Dip.App.Chem.
Experimental Officer—I. H. Leaver, B.Sc.
Experimental Officer—A. B. McQuade, B.Sc.
Experimental Officer—D. E. Rivett, A.B.T.C.
Experimental Officer—R. J. Rowlands, B.Sc.
Experimental Officer—C. M. Roxburgh, B.Sc., Ph.D.
Experimental Officer—I. W. Stapleton, B.Sc.
Experimental Officer—K. I. Wood, A.R.M.T.C.
Scientific Services Officer—J. P. E. Human, M.Sc., Ph.D.
Librarian—Miss M. M. Clippingdale, B.A.

DIVISION OF TEXTILE INDUSTRY

Headquarters: Princes Highway, Belmont, Geelong, Vic.

Chief—M. Lipson, B.Sc., Ph.D.
Administrative Officer—J. H. G. Watson, A.A.S.A.
Senior Principal Research Officer—G. W. Walls, B.Sc.
Principal Research Officer—A. J. Farnworth, M.B.E., M.Sc., Ph.D., A.G.Inst.Tech. (*seconded to Australian Wool Board*)
Principal Research Officer—J. R. McPhee, B.Sc., D.Phil.
Principal Research Officer—D. S. Taylor, B.A., B.Sc., Ph.D.
Principal Research Officer—G. F. Wood, B.Sc., Ph.D.
Senior Research Officer—C. A. Anderson, B.Sc., Ph.D.
Senior Research Officer—R. E. Belin, M.Sc.
Senior Research Officer—J. Delmenico, B.Sc., Ph.D.
Senior Research Officer—D. E. Henshaw, B.Sc.
Senior Research Officer—W. V. Morgan, B.Sc.
Senior Research Officer—V. A. Williams, B.Sc., Ph.D.
Research Officer—A. J. Pratt, M.Sc., Ph.D.
Engineer—B. B. Beard, A.G.Inst.Tech.

Experimental Officer—G. M. Abbott, B.Sc.
Experimental Officer—L. A. Allen, B.Sc.
Experimental Officer—I. B. Angliss, A.G.Inst. Tech.
Experimental Officer—K. D. Broadfoot, B.E., F.S.A.S.M.
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—G. N. Freeland, A.G.Inst. Tech.
Experimental Officer—R. G. Ganly, A.G.Inst. Tech.
Experimental Officer—R. J. Hine, A.G.Inst.Tech.
Experimental Officer—H. J. Katz, B.Sc., Ph.D.
Experimental Officer—B. O. Lavery, Nat.Cert. in Mech.Eng.
Experimental Officer—A. R. W. Lee, B.Sc., Dip. Ed.
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.
Experimental Officer—J. L. Woo, M.Sc.
Scientific Services Officer—J. M. Preston, D.Sc.
Scientific Services Officer—G. C. West, A.G.Inst. Tech.

DIVISION OF TEXTILE PHYSICS

Headquarters: 338 *Blaxland Road, Ryde, N.S.W.*

Chief—V. D. Burgmann, B.Sc., B.E.
Administrative Officer—R. D. Whittle
Librarian—Miss H. G. Barr, B.A.
Senior Principal Research Officer—J. G. Downes, B.Sc.
Senior Principal Research Officer—M. Feughelman, B.Sc., A.S.T.C.
Principal Research Officer—Mrs. K. R. Makinson, M.A.
Principal Research Officer—P. Mason, M.Sc., Ph.D.
Senior Research Officer—K. Baird, M.Sc., Ph.D.
Senior Research Officer—E. G. Bendit, B.Sc. (Eng.), M.Sc.
Senior Research Officer—H. G. David, B.Sc.
Senior Research Officer—A. R. Haly, M.Sc.
Senior Research Officer—H. W. Holdaway, B.Sc., B.E.
Senior Research Officer—P. Nordon, B.Sc., Ph.D., A.S.T.C.
Senior Research Officer—I. C. Watt, M.Sc., Ph.D.
Research Officer—M. W. Andrews, B.Sc., Ph.D.
Research Officer—E. F. Denby, B.Sc., Ph.D., D.I.C.
Research Officer—J. F. P. James, M.Sc.
Research Officer—D. T. Liddy, B.Sc.
Research Officer—B. H. Mackay, B.Sc., A.S.T.C.
Research Officer—B. J. Rigby, M.Sc., A.S.T.C.
Research Officer—I. M. Stuart, M.Sc. (Syd. and Cantab.)
Engineer—Z. Laicans, B.Sc.(Chem.Eng.)
Engineer—H. W. Lunney, B.Sc., B.E.
Experimental Officer—J. E. Algie, B.E., A.S.T.C., M.Sc.
Experimental Officer—N. W. Bainbridge, B.Sc. (Eng.)
Experimental Officer—P. G. Burton, B.Sc. (*overseas*)
Experimental Officer—E. R. Cawthron, B.Sc. (Hons.)
Experimental Officer—R. L. D'Arcy, B.Sc., A.S.T.C.
Experimental Officer—R. A. F. Foulds, B.Sc.
Experimental Officer—Miss J. C. Griffith, M.Sc., Ph.D., A.S.T.C.
Experimental Officer—Miss D. R. McKelvie, B.Sc.
Experimental Officer—G. B. McMahon, B.Sc.
Experimental Officer—R. K. Mann, B.Sc.(Hons.)
Experimental Officer—T. W. Mitchell, A.S.T.C.
Experimental Officer—R. M. Rabbidge, A.S.T.C.
Experimental Officer—A. McD. Richardson, B.E.
Experimental Officer—K. D. Sinclair, A.S.T.C.
Experimental Officer—L. J. Smith, A.S.T.C.
Experimental Officer—A. E. Stearn, B.Sc.
Experimental Officer—G. L. Stott, A.S.T.C.
Experimental Officer—D. J. Ward, B.Sc.

UNATTACHED OFFICERS

Chief Research Officer—F. G. Nicholls, M.Sc. (*seconded to United Nations Program of Technical Assistance*)
Senior Principal Research Officer—G. H. Munro, D.Sc. (*seconded to Electrical Engineering Department, University of Sydney*)
Senior Principal Research Officer—D. B. Williams, B.Sc.Agr., B.Com., Ph.D. (*seconded to Melbourne University*)
Senior Principal Research Officer—A. J. Vasey, B.Agr.Sc. (*seconded to British Commonwealth Scientific Committee*)
Principal Research Officer—J. C. M. Fornachon, B.Agr.Sc., M.Sc. (*seconded to Australian Wine Research Institute*)
Principal Research Officer—T. B. Paltridge, B.Sc. (*seconded to Commonwealth Office of Education*)
Principal Research Officer—L. A. Thomas, M.Sc. (*seconded to Queensland Department of Agriculture*)
Experimental Officer—A. C. Blaskett, B.Sc. (*on leave*)
Experimental Officer—K. E. Dixon, M.Sc. (*on leave*)
Experimental Officer—L. Heisler, B.Sc. (*seconded to Electrical Engineering Department, University of Sydney*)
Experimental Officer—T. E. Treffry, B.Agr.Sc. (*on leave*)

5

Finance

A summary of the Organization's receipts and expenditure from July 1, 1963 to June 30, 1964 has been given on page 4. Details are given below:

Expenditure

	£	£	£
Salaries and Contingencies*			**513,719**
Investigations			
Animal Research Laboratories			
Gross Expenditure		1,484,997	
LESS Contributions from—			
Cattle and Beef Research Trust Account ..	36,489		
Wool Research Trust Fund	699,586		
Dairy Produce Research Trust Account ..	8,800		
General Donations	242		
Ian McMaster Bequest	3,425		
Alexander Fraser Memorial Fund	317		
U.S. National Institutes of Health	12,884		
Burdekin Bequest (Drought feeding)	841		
The Population Council Inc.	37		
Merck, Sharp & Dohme (Aust.) Pty. Ltd. ..	2,048		
Roche Products Pty. Ltd.	500		
Special Revenue Funds—"Belmont" Field Station ..	7,846		
Total Contributions		773,015	
Net Treasury Expenditure			711,982

* 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.

	£	£	£
Plant Research—			
Plant Industry			
Gross Expenditure		1,332,496	
LESS Contributions from—			
Tobacco Industry Trust Account	77,107		
Wheat Research Trust Account	8,360		
North Queensland Tobacco Growers' Co-operative Association	195		
U.S. National Institutes of Health	3,331		
Brown Rot Trust Fund	9		
Colonial Sugar Refining Co.	3		
Dairy Produce Research Trust Account ..	6,022		
Department of Primary Industry	11,135		
International Atomic Energy Agency	555		
Wool Research Trust Fund	290,617		
Cattle and Beef Research Trust Account ..	19,560		
Wollogorang Pastoral Co.	500		
Australian Fertilizers Ltd. and Sulphide Corporation Pty. Ltd.	320		
Rockefeller Foundation	295		
Australian Apple and Pear Board	395		
Sulphur Institute of America	1,878		
National Capital Development Commission ..	2,661		
Fisons Pest Control and J. R. Geigy	15,824		
Australian Pastoral Research Trust	3,787		
Total Contributions		442,554	
Net Treasury Expenditure			889,942
Tropical Pastures			
Gross Expenditure		345,258	
LESS Contributions from—			
Cattle and Beef Research Trust Account ..	26,482		
Dairy Produce Research Trust Account ..	2,918		
Imperial Chemical Industries of Australia & New Zealand Ltd.	328		
Special Revenue Fund—Samford Farm ..	2,929		
Total Contributions		32,657	
Net Treasury Expenditure			312,601
Suspense (Overseas transactions)			680

	£	£	£
Entomology			
Gross Expenditure		584,747	
LESS Contributions from—			
Department of Health	39,475		
Wheat Research Trust Account	1,284		
U.S. National Institutes of Health	2,295		
Cattle and Beef Research Trust Account ..	11,767		
Wool Research Trust Fund	16,696		
Dairy Produce Research Trust Account ..	3,761		
World Health Organization	3,010		
River Murray Commission and Snowy Mountain Hydro-Electric Authority	3,452		
Department of Primary Industry	1,318		
Total Contributions		83,058	
Net Treasury Expenditure			501,689
Soils and Irrigation—			
Soils			
Gross Expenditure		448,602	
LESS Contributions from—			
Wool Research Trust Fund	4,564		
Australian Mineral Industries Research Association	567		
Australian Fertilizers Ltd. and Sulphide Corporation Pty. Ltd.	543		
S. Aust. Woods and Forests Department, W.A. Forests Department, and Australian Paper Manufacturers Ltd.	5,927		
Rockefeller Foundation	350		
Wheat Research Trust Account	10,037		
Australian Fertilizers Ltd., A. C. F. Shirleys Ltd., and Imperial Chemical Industries of Australia & New Zealand Ltd.	200		
Bureau of Mineral Resources	336		
Commonwealth Fertilisers & Chemicals Ltd., Australian Fertilizers Ltd., Cuming Smith and Mt. Lyell Farmers Fertilizers Ltd.	1,935		
Total Contributions		24,459	
Net Treasury Expenditure			424,143
Plant Nematology			
Net Treasury Expenditure			4,896

	£	£	£
Soil Mechanics			
Gross Expenditure		122,134	
LESS Contributions from—			
Department of the Army	600		
Broken Hill Pty. Ltd.	2,060		
S. Aust. Housing Trust	2,449		
Lime Manufacturers' Association of Australia ..	1,925		
Water Research Foundation of Australia ..	672		
Tasmanian Department of Health	2		
Westernport Waterworks Trust	584		
Total Contributions		8,292	
Net Treasury Expenditure			113,842
Horticultural Research Section, Merbein, Vic.			
Gross Expenditure		124,527	
LESS Contributions from—			
Dried Fruits Control Board	463		
Australian Wine Board and Department of Primary Industry	890		
Packing Companies and Co-operative Dried Fruit Sales Pty. Ltd.	650		
Special Revenue Fund—Coomealla	711		
Total Contributions		2,714	
Net Treasury Expenditure			121,813
Irrigation Research Laboratory, Griffith, N.S.W.			
Gross Expenditure		162,715	
LESS Contributions from—			
N.S.W. Water Conservation and Irrigation Commission	10,157		
Special Revenue Fund—Irrigation Research Laboratory, Griffith, N.S.W.	7,811		
Total Contributions		17,968	
Net Treasury Expenditure			144,747
Suspense (Overseas transactions)			2,545

	£	£	£
Food Preservation			
Gross Expenditure		481,102	
LESS Contributions from—			
Cattle and Beef Research Trust Account ..	7,608		
N.S.W. Department of Agriculture	3,576		
Metropolitan Meat Industry Board	542		
Queensland Meat Industry Board and Australian Meat Board	1,800		
Banana Research Fund	217		
Australian Egg Board	1,220		
Australian Banana Growers Council	1,329		
Department of Primary Industry	5,086		
Various Contributors	10,217		
U.S. Department of Agriculture	8,049		
Australian Canned Fruits Board	2,471		
Australian Dried Fruits Association	84		
Broken Hill Pty. Ltd.	4,667		
Australian Apple and Pear Board	440		
Peanut Marketing Board	99		
Total Contributions		47,405	
Net Treasury Expenditure			433,697
Forest Products			
Gross Expenditure		497,007	
LESS Contributions from—			
Australian Paper Manufacturers Ltd. Associated Pulp and Paper Mills Ltd. Australian Newsprint Mills Pty. Ltd. New Zealand Forest Products Ltd. ..	8,879		
Department of Territories	3,581		
General Donations	1,466		
Australian Plywood Board	13,104		
Department of Forestry, Fiji	2,916		
Total Contributions		29,946	
Net Treasury Expenditure			467,061
Mining and Metallurgy			
Gross Expenditure		74,349	
LESS Contributions from—			
Broken Hill Mine Managers' Association ..	1,342		
Australasian Institute of Mining and Metallurgy ..	2,128		
State Electricity Commission of Victoria ..	468		
General Donations	1,755		
Total Contributions		5,693	
Net Treasury Expenditure			68,656

	£	£	£
Radio Research—			
Upper Atmosphere Section			
Net Treasury Expenditure			41,891
Radio Research Board Activities	39,624		
LESS Contributions from—			
Postmaster-General's Department, Australian Broadcasting Control Board, and Overseas Telecommunications Commission	18,773		
Total Contributions		18,773	
Net Treasury Expenditure			20,851
Research Services			
Gross Expenditure		581,577	
LESS Contributions from—			
Wool Research Trust Fund	21,363		
Miscellaneous Contributors	410		
Wheat Research Trust Account	17,466		
Total Contributions		39,239	
Net Treasury Expenditure			542,338
Chemical Research Laboratories			
Gross Expenditure		1,186,456	
LESS Contributions from—			
Cement and Concrete Association of Australia ..	7,879		
U.S. National Institutes of Health	1,111		
N.S.W. Rutile Mining Co. Ltd.	665		
State Electricity Commission of Victoria, Gas and Fuel Corporation of Victoria, and Australian Paper Manufacturers Ltd.	747		
Smith, Kline, and French Laboratories (U.S.A.) ..	8,613		
Mary Kathleen Uranium Ltd.	255		
Reserve Bank of Australia	6,114		
W.A. Chamber of Mines	123		
Hardman Chemicals Pty. Ltd.	587		
Wool Research Trust Fund	21,459		
Union Carbide Aust. Ltd.	12,870		
Colonial Sugar Refining Co. Ltd.	3,550		
Total Contributions		63,973	
Net Treasury Expenditure			1,122,483

	£	£	£
Fisheries and Oceanography			
Gross Expenditure		333,754	
LESS Contributions from—			
Department of Navy	4,920		
Department of Primary Industry	23,500		
Department of Harbours and Marine	8,053		
Total Contributions		36,473	
Net Treasury Expenditure			297,281
Mathematical Statistics			
Net Treasury Expenditure			127,722
National Standards Laboratory			
Gross Expenditure		1,002,319	
LESS Contributions from—			
Length Measurement Research Fund	92		
U.S. National Aeronautics and Space Administration	18,646		
U.S. Air Force	8,234		
Total Contributions		26,972	
Net Treasury Expenditure			975,347
Tribophysics			
Gross Expenditure		143,756	
LESS Contributions from—			
Various Contributors	115		
Union Carbide Aust. Ltd.	1,568		
Total Contributions		1,683	
Net Treasury Expenditure			142,073
Building Research			
Gross Expenditure		257,008	
LESS Contributions from—			
Associated Fibrous Plaster Manufacturers of Australia, Australian Plaster Industries Ltd., and Colonial Sugar Refining Co. Ltd.	4,396		
General Donations	354		
Housing Commission of Victoria, State Electricity Commission of Victoria, Victorian Railways Department	831		
Cement and Concrete Association of Australia ..	256		
Whitelaw Monier Pty. Ltd.	1,012		
Jayworth Besser Ltd.	67		
Total Contributions		6,916	
Net Treasury Expenditure			250,092

	£	£	£
Biochemistry and General Nutrition			
Gross Expenditure		209,065	
LESS Contribution from—			
Wool Research Trust Fund	78,695		
Total Contributions		78,695	
Net Treasury Expenditure			130,370
Fodder Conservation			
Gross Expenditure		45,474	
LESS Contribution from—			
Dairy Produce Research Trust Account ..	2,917		
Total Contribution		2,917	
Net Treasury Expenditure			42,557
Radiophysics			
Gross Expenditure		586,176	
LESS Contribution from—			
U.S. National Aeronautics and Space Administration	16,314		
Total Contribution		16,314	
Net Treasury Expenditure			569,862
Metallurgical Research			
Net Treasury Expenditure			22,587
Computing Laboratory			
Net Treasury Expenditure			75,845
Meteorological Physics			
Gross Expenditure		159,186	
LESS Contribution from—			
Tobacco Research Trust Account	678		
Total Contribution		678	
Net Treasury Expenditure			158,508
Dairy Research			
Gross Expenditure		169,144	
LESS Contribution from—			
Dairy Produce Research Trust Account ..	58,051		
Total Contribution		58,051	
Net Treasury Expenditure			111,093

	£	£	£
Wool Research			
Gross Expenditure		973,204	
LESS Contributions from—			
Blanket Freight Equalization Fund	228		
Wool Research Trust Fund	940,530		
Wool Buying and Selling Account	15,756		
Total Contributions..		956,514	
Net Treasury Expenditure			16,690
Fuel Research			
Gross Expenditure		375,338	
LESS Contributions from—			
Electricity Trust of South Australia	3,416		
Department of External Affairs	208		
State Electricity Commission of Victoria ..	7,988		
General Donations	8		
Total Contributions		11,620	
Net Treasury Expenditure			363,718
Wildlife Research			
Gross Expenditure		256,641	
LESS Contributions from—			
M. A. Ingram Trust	200		
Wool Research Trust Fund	67,345		
Department of Civil Aviation	8,207		
Total Contributions		75,752	
Net Treasury Expenditure			180,889
Land Research and Regional Survey			
Gross Expenditure		459,963	
LESS Contributions from—			
Australian Meat Board	5		
Department of National Development	3,277		
Northern Territory Administration	49,577		
Cattle and Beef Research Trust Account ..	5,935		
Department of Territories	57,151		
F. C. Pye Research Fund	42		
W.A. Department of Agriculture	2,601		
Total Contributions		118,588	
Net Treasury Expenditure			341,375

	£	£	£
Miscellaneous			
Patent Fees		8,616	
Extra-mural Investigations		59,837	
Furlough and Compensation		28,171	
Unattached Officers		11,821	
Wheat Research		30,384	
Grants to Scientific Workers		1,439	
Geological Microbiology		1,925	
Various		32,195	
Gross Expenditure		174,388	
LESS Contributions from—			
Science and Industry Endowment Fund ..	1,439		
Wheat Research Trust Account	25,590		
Mining Research Association	1,325		
Wm. McIlrath Fund	2,500		
Total Contributions		30,854	
Net Treasury Expenditure			143,534
Total Treasury Expenditure—Investigations			**9,875,400**
Other Services			
Research Associations—Grants			
Bread Research Institute	15,100		
Wine Research Institute	5,000		
Tobacco Research Trust	10,500		
Coal Association (Research) Ltd.	20,000		
		50,600	
Overseas Research Studentships		143,626	
Other Grants			
Commonwealth Agricultural Bureaux	82,276		
Standards Association of Australia	109,000		
National Association of Testing Authorities ..	23,422		
National Institute of Oceanography	1,567		
Minor International Associations	5,668		
		221,933	
Total Other Services			**416,159**
Total Salaries and Contingencies, Investigations, and Other Services			**10,805,278**
LESS receipts from sales of equipment, publications, etc., and revenue earned by Divisions and Sections, details of which are shown on page 186			101,629
Total Treasury Expenditure			**10,703,649**

Contributions

This Section shows receipts and disbursements during the year 1963–64 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 183–5. Of the total expenditure of £3,480,591 recorded in this Fund, £3,011,773 refers to normal research activities and £468,818 to capital works. The following table summarizes the sources of these funds and the activities on which they are expended.

	ACTIVITY		TOTAL
SOURCE OF FUNDS	*Investigations* £	*Capital Works* £	£
Wool Research Trust Fund	2,140,855	261,631	2,402,486
Contributions (other than Wool)	870,918	207,187	1,078,105
	3,011,773	468,818	3,480,591

The details are as follows:

	Receipts 1963–64 & *Balances brought forward* 1962–63 £	*Expenditure* 1963–64 £
Wool Research Trust Fund (*details are shown on pages 183–5*)	2,370,710	2,402,486*
General Donations—*Myxomatosis Investigations* ..	914	242
Dairy Produce Research Trust Account—*Infertility in Dairy Cattle*	4,000	3,878
Alexander Fraser Memorial Fund—*Fluke Investigations* ..	502	317
Dairy Produce Research Trust Account—*Virus Diseases of Dairy Cattle*	3,359	2,922
Estate of the late Captain Ian McMaster—*Scholarship* ..	3,712	3,425
Dairy Produce Research Trust Account—*Endoparasites of Dairy Cattle*	2,000	2,000
Burdekin Bequest—*Drought Feeding Investigations* ..	3,776	841
Cattle and Beef Research Trust Account—*Genetic Studies* ..	17,511	15,535
U.S. National Institutes of Health—*Chemical, Physical, and Genetic Studies of Myxoma Virus*	16,203	12,884
Merck, Sharp & Dohme (Aust.) Pty. Ltd.—*Anthelmintics Research*	6,595	2,048
Cattle and Beef Research Trust Account—*Virological Diseases of Cattle*	24,350	9,875
Special Revenue Fund—"*Belmont*" *Field Station, Rockhampton, Qld.*	38,582	7,846
Cattle and Beef Research Trust Account—*Acquisition of Property at Jimbooma for Cattle Tick Investigations* ..	NIL	21,050*
Cattle and Beef Research Trust Account—*Nutritional Studies*	20,053	19,371
Beef Cattle Nutrition Account (Animal Physiology) ..	89	NIL
U.S. National Institutes of Health—*Visit of Dr. Druger* ..	25	NIL

* Expenditure on this work in excess of receipts will be recovered in 1964–65.

	Receipts 1963–64 *& Balances brought forward* 1962–63 £	*Expenditure* 1963–64 £
General Donations (Animal Health)	3	NIL
Roche Products Pty. Ltd.—*Overseas Visit of Dr. M. C. Franklin*	500	500
The Population Council Inc.—*Studies on Induced Infertility* ..	722	37
Trust Fund Brown Rot Investigations—*Brown Rot Survey* ..	9	9
Wollogorang Pastoral Co.—Rhizobium *Studies*	500	500
North Queensland Tobacco Growers' Co-operative Association Ltd.—*Investigations in Burdekin Valley* ..	739	195
Western Australian Golf Association—*Research on Grasses* ..	50	NIL
Australian Tobacco Research Trust—*Tobacco Investigations* ..	84,960	77,785
Rockefeller Foundation—*Contribution towards Overseas Visit to U.S.A. of Dr. D. J. Cosgrove*	670	295
International Atomic Energy Agency—*Measurement of Mutation Rates in Plants*	558	555
Australian Fertilizers Ltd. and Sulphide Corporation Pty. Ltd.—*Phosphate Soil Testing*	700	320
Acquisition and Development of Baker's Hill Field Station ..	20,424	14,809
Sulphur Institute of America—*Plant Nutrient Element Deficiencies*	2,963	1,878
Australian Pastoral Research Trust—*Pasture Utilization Development*	4,274	3,787
Australian Apple and Pear Board—*Contribution to Expenses of Experimental Shipments to U.K.*	1,200	395
Dairy Produce Research Trust Account—*Nutrition of Dairy Pastures in Western Australia*	6,806	6,022
Fisons Pest Control and J. R. Geigy—*Chemical and Plant Antifungal Investigations*	40,154	15,824
U.S. National Institutes of Health—*Genetic Studies* ..	5,534	3,331
Estate of J. O. Holston—*Alpine Ecology*	350	NIL
Colonial Sugar Refining Co.—*Genetics Research* ..	5	3
National Capital Development Commission—*Cotter River Catchment Investigations*	3,000	2,661
Pipeline Technologists Pty. Ltd.—*Thermal Conductivity Investigations*	250	NIL
Department of Primary Industry—*Biochemical Studies of Weed Killers*	6,800	4,840
Cattle and Beef Research Trust Account—*Genetic Breeding Investigations*	9,200	8,283
Cattle and Beef Research Trust Account—*Pasture Nitrogen Project*	8,900	8,784
Special Revenue Fund—*Grazing Trials, Samford Farm* ..	3,488	2,928
Department of Primary Industry—*Ecology of Skeleton Weeds*	8,767	6,295
Various Contributors—*Soybean Harvester*	198	NIL
Cattle and Beef Research Trust Account—*Pasture Plant Collecting and Testing*	6,738	6,566
Imperial Chemical Industries of Australia and New Zealand Ltd.—*Nitrogen Grazing Experiments*	1,950	328
Dairy Produce Research Trust Account—*Pastures of Coastal Plains, Southern Queensland*	2,918	2,918
Cattle and Beef Research Trust Account—*Pasture Development and Plant Nutrition Investigations*	30,936	30,756

	Receipts 1963–64 *& Balances brought forward* 1962–63 £	*Expenditure* 1963–64 £
Special Revenue Fund—*Cattle Tick Investigations, Ingham* ..	198 Dr.	*
Cattle and Beef Research Trust Account—*Acaracide Problems*	18,169	15,939
General Donations (Entomology)	1,086	NIL
Cattle and Beef Research Trust Account—*Tick Survival* ..	13,531	11,460
U.S. National Institutes of Health—*Multiplication of Insect Polyhedron Virus*	2,004	2,295*
Dairy Produce Research Trust Account—*Black Beetle Investigations*	4,201	3,761
Snowy Mountains Hydro-Electric Authority and River Murray Commission—*Phasmatid Investigations*	3,724	3,452
World Health Organization—*Insecticide Resistance in Cattle Tick*	1,826	1,826
Department of Primary Industry—*Locust Outbreak Analysis* ..	1,000	1,640
Australian Cattle and Beef Research Committee—*Acquisition of Land at Amberley for Cattle Tick Investigations* ..	8,425	8,368
World Health Organization—*Insecticide Resistance in House Flies*	2,564	1,184
Department of Health—*Sirex Wasp Investigations* ..	57,450	48,024
Department of Primary Industry—*Ecological Studies* ..	1,600	1,319
S. Aust. Woods and Forests Department, Australian Paper Manufacturers, W.A. Department of Forests—*Problems of Growth,* Pinus radiata	7,052	5,927
Australian Minerals Industries Research Association—*Purchase of X-ray Spectrograph*	654	567
Australian Fertilizers Ltd. and Sulphide Corporation Pty. Ltd.—*Phosphate Requirements of Soils*	895	543
Commonwealth Fertilisers and Chemicals Ltd., Cuming Smith and Mt. Lyell Farmers Fertilizers Ltd., and Australian Fertilizers Ltd.—*Bacterial Fertilizers*	3,402	1,935
Rockefeller Foundation—*Interactions of Plant Roots and Micro-organisms*	6,679	350
Tasmanian Department of Health—*Foundation Investigations in Tasmania*	1,103	2
Broken Hill Pty. Ltd.—*Jaspalite Beneficiation Project* ..	2,060	2,060
S. Aust. Housing Trust—*Research in Soil Mechanics and Land Use in Urban Areas*	3,999	2,449
Lime Manufacturers Association of Australia—*Lime Stabilization of Soil*	451	1,925*
Australian Fertilizers Ltd., A. C. F. Shirleys Ltd., and Sulphide Corporation Pty. Ltd.—*Contribution towards Overseas Visit of J. D. Colwell*	800	200
Department of the Army—*Soil Stabilization Project* ..	7,000	600
Water Research Foundation of Australia—*Water Retention in Earth Dams*	2,500	672
Westernport Waterworks Trust—*Almurta Reservoir Investigations*	277	584*
Bureau of Mineral Resources—*Microbiological Prospecting for Oil*	1,506	336

* Expenditure on this work in excess of receipts will be recovered in 1964–65.

	Receipts 1963–64 & Balances brought forward 1962–63 £	Expenditure 1963–64 £
Department of Primary Industry and Australian Wine Board—*Wine Grape Crop Forecasting*	3,800	890
Packing Companies and Co-operative Dried Fruits Sales Ltd.—*Dried Vine Fruit Investigations*	2,811	650
N.S.W. Water Conservation and Irrigation Commission (Irrigation Research Laboratory)	10,613	10,157
Dried Fruits Control Board—*Dried Fruits Investigations*	2,431	463
Nyah-Woorinen Dried Fruits Inquiry Committee—*Dried Fruits Investigations*	93	NIL
Special Revenue Fund—*Coomealla*	3,908	711
Special Revenue Fund (Irrigation Research Laboratory)	10,334	7,810
Ground-Water Salt and Reclamation Revenue Account	553	NIL
Metropolitan Meat Industry Board of New South Wales—*Meat Investigations*	573	542
Queensland Meat Industry Board and Australian Meat Board—*Meat Investigations*	1,300	1,800*
Department of Primary Industry—*Fruit Fly Investigations*	NIL	39*
Australian Apple and Pear Board—*Apple and Pear Investigations*	1,581	198
Australian Dried Fruits Association and Australian Dried Tree Fruits Committee—*Dried Tree Fruits*	84	84
Various Contributors (Food Preservation)	15,902	10,217
Australian Banana Growers' Council—*Banana Research*	4,060	1,329
Broken Hill Pty. Ltd.—*Research on Tinplate Containers*	5,383	4,667
Australian Egg Board—*Egg Investigations*	1,760	1,220
Peanut Marketing Board—*Storage of Peanut Kernels*	99	99
Department of Primary Industry—*Spray Residue Investigations*	85	85
Cattle and Beef Research Trust Account—*Problems on Beef Quality*	26,000	20,241
U.S. Department of Agriculture—*Investigations into the Cyclopropenoid Compounds found in Cotton Seed*	13,153	7,268
U.S. Department of Agriculture—*Study of Differences in the Chemical Structure of Albumin and S-Ovalbumin*	2,322	780
Australian Meat Board—*Contribution towards Cost of Physical Chemistry Laboratory*	10,000	2,357
Australian Canned Fruits Board—*Damage through Condensation on Cans of Export Fruits*	2,500	2,471
Banana Research Fund—*Banana Transport Investigations*	250	218
Australian Apple and Pear Board—*Experimental Shipment of Apples and Pears*	750	242
N.S.W. Department of Agriculture—*Fruit and Vegetable Storage Investigations*	4,910	3,576
Department of Primary Industry—*Fruit Fly Commodity; Treatment of Citrus Fruits and Pears*	7,980	4,963
Paper Companies and New Zealand Forest Products—*Paper Pulp Investigations*	9,141	8,879
General Donations (Forest Products)	6,340	1,466
Department of Territories—*Development of Pulp and Paper Industry in New Guinea*	5,122	3,581

* Expenditure on this work in excess of receipts will be recovered in 1964–65.

	Receipts 1963–64 *& Balances brought forward* 1962–63 £	*Expenditure* 1963–64 £
Australian Plywood Board—*Veneer, Gluing, and Plywood Research*	16,072	13,104
Government of Fiji—*Timber Research in Fiji*	3,793	2,916
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	7,031	2,128
General Donations (Ore Dressing)	2,275	1,755
State Electricity Commission of Victoria—*Geological Consultations*	1,870	468
Miscellaneous Contributors (Mineragraphic Investigations) ..	487	NIL
Postmaster-General's Department, Australian Broadcasting Control Board, and Overseas Telecommunications Commission—*Radio Research Board Activities*	21,063	18,774
General Donations (Division of Mechanical Engineering) ..	200	NIL
Miscellaneous Contributors—*Construction of Forced Circulation Solar Hot Water Service*	NIL	410*
Broken Hill Mine Managers Association—*Contribution towards Salary of Dr. S. M. Richards*	1,500	1,342
N.S.W. Rutile Mining Co. Ltd.—*Titanium Oxide Project* ..	665	665
Hardman Chemicals Pty. Ltd.—*Chlorination of Tin Project* ..	587	587
Miscellaneous Contributors (Chemical Research Laboratories)	13,202	NIL
State Electricity Commission of Victoria and Gas & Fuel Corporation of Victoria—*Clinkering of Brown Coal Ash* ..	760	747
U.S. National Institutes of Health—*Plant Alkaloids* ..	485	1,111*
Western Australian Chamber of Mines (Inc.)—*Cyanidation of Gold*	5,165	123
Union Carbide (Aust.) Ltd.—*Semi-polymers*	16,855	12,870
Cement and Concrete Association of Australia—*Cement Investigations*	8,849	7,879
Reserve Bank of Australia—*Fuel Cell Project*	14,993	6,114
Colonial Sugar Refining Co. Ltd.—*Sugar Research* ..	6,852	3,550
Mary Kathleen Uranium Ltd.—*Water Evaporation Control* ..	609	255
Smith, Kline, and French Laboratories, U.S.A.—*Phytological Survey and Drug Plant Collection*	478	8,613*
Fisheries Development Trust Account—*Sperm Whale Investigations*	12,335	10,832
Department of Harbours and Marine—*Gulf Prawn Survey* ..	6,476	8,053*
Department of Primary Industry—*Tuna Search, New South Wales and South Australia*	12,512	12,669*
Department of the Navy—*Marine Fouling Investigations* ..	5,800	4,920
Electricity Commission of New South Wales—*Fly Ash Program*	373	NIL
Miscellaneous Contributors (Mathematical Statistics) ..	5	NIL
U.S. Air Force—*Thermal Expansion of Solids at Low Temperatures*	2,343	8,234
Various Contributors—*Length Measurement Research Fund*	860	92
U.S. National Aeronautics and Space Administration—*Cinematograph Study of Solar Magnetic Fields*	4,709	18,646*
Machinability Donations Account (Applied Physics) ..	114	NIL
General Donations (Applied Physics)	510	NIL

* Expenditure on this work in excess of receipts will be recovered in 1964–65.

	Receipts 1963–64 & Balances brought forward 1962–63 £	Expenditure 1963–64 £
General Donations (Tribophysics)	115	115
Union Carbide (Aust.) Ltd.—*Catalytic Oxidation of Olefins* . .	5,978	1,568
Associated Fibrous Plaster Manufacturers of Australia, Australian Plaster Industries, and Colonial Sugar Refining Co. Ltd.—*Fibrous Plaster Research*	4,848	4,396
General Donations (Building Research)	8,788	354
Cement and Concrete Association of Australia—*Concrete Research*	2,069	256
Whitelaw Monier Pty. Ltd.—*Research into Cement Tiles* . .	2,095	1,012
Jayworth Besser Ltd.—*Efflorescence on Concrete Blocks* . .	68	67
Housing Commission of Victoria, Victorian Railways Department, and State Electricity Commission of Victoria—*Mould Infestation in Dwellings*	812	831*
Dairy Produce Research Trust Account—*Silage Studies* . .	3,300	2,917
General Donations (Radiophysics)	25	NIL
Ford Foundation—*Construction of Radio Heliograph* . .	105,498	77,511
U.S. National Aeronautics and Space Administration—*Radio Astronomy*	50,551	16,314
Various Contributors—*Rain and Cloud Physics Research* . .	8,000	NIL
Dairy Produce Research Trust Account (Dairy Research) . .	83,553	58,051
Leather Research—*Residual Funds of Australian Leather Research Association*	1,221	25,000*
Wool Buying and Selling Account	18,047	15,756
General Donations (Protein Chemistry)	141	NIL
Donations for Worsted Processing Research	1,370	NIL
General Donations (Textile Industry)	279	NIL
Associated Woollen and Worsted Textile Manufacturers of Australia—*Blanket Freight Equalization Fund* . .	941	228
General Donations (Textile Physics)	2	NIL
General Donations (Coal Research)	5,328	8
Department of External Affairs—*Survey of Coal from North Borneo*	917	208
Colonial Sugar Refining Co. Ltd.—*Purchase of Special Equipment for Coal Research*	54	NIL
Electricity Trust of S. Aust.—*Investigations into Boiler Gas Path Problems*	18,953	3,416
State Electricity Commission—*Brown Coal Investigations* . .	13,901	7,988
Petfoods Ltd.—*Food for Budgerigars*	79	NIL
N.S.W. Public Trustee—*Purchase of Metal Bird Bands* . .	200	200
Department of Civil Aviation—*Investigations into Bird Fouling of Jet Aircraft*	10,000	8,207
W.A. Department of Agriculture—*Cattle and Beef Research Project, Kimberley*	1,176	2,601*
Department of National Development—*Kimberley Research Station*	3,758	3,277
Cattle and Beef Research Trust Account—*Investigations in Northern Territory High Rainfall Areas*	7,182	5,935
Department of Territories—*Resources Survey in Papua and New Guinea*	64,014	57,151

* Expenditure on this work in excess of receipts will be recovered in 1964–65.

	Receipts 1963–64 *& Balances brought forward* 1962–63 £	*Expenditure* 1963–64 £
Australian Meat Board—*Pasture Development in Central Australia*	5	5
Northern Territory Administration—*Rice Research* ..	53,703	49,577
Cattle and Beef Research Trust Account—*Beef Cattle Research, Katherine, N.T.*	6,000	2,999
F. C. Pye Research Fund—*Installation of Lysimeter, Katherine, N.T.*	42	42
William McIlwrath Fund—*Grant to University of Sydney* ..	2,500	2,500
Sundry Contributors (Commonwealth Scientific and Industrial Research Organization)	183	NIL
Science and Industry Endowment Fund	1,439	1,439
Wheat Research Trust Account	70,947	62,736
Australian Minerals Industry Research Association—*Geological Microbiology*	1,326	1,325
David Rivett Memorial Fund	164	NIL
	3,803,653	**3,480,591**

Wool Research Trust Fund

Details of transactions during 1963–64 are as follows:

	£	£	£
RECEIPTS			
Balance brought forward from 1962–63		21,715	
Received from Department of Primary Industry during 1963–64		2,349,000	**2,370,715**
EXPENDITURE			
Investigations			
Biological Research—			
Animal Research Laboratories—			
Division of Animal Physiology,			
Ian Clunies Ross Animal Research Laboratory ..	323,265		
Regional Laboratory and "Chiswick" Field Station, Armidale, N.S.W.	146,809	470,074	
Division of Animal Health,			
McMaster Laboratory	58,911		
Animal Health Laboratory	15,763	74,674	
Division of Animal Genetics,			
Sheep Breeding, Cunnamulla, Qld.	46,305		
Animal Genetics Investigations, Sydney ..	76,249		
Sheep Breeding, North Ryde, N.S.W.	31,294	153,848	

	£	£	£
Suspense (Overseas transactions)		990	699,586
Plant Industry—			
Headquarters, Canberra	145,808		
Regional Pastoral Laboratory, Falkiner Memorial Field Station, Deniliquin, N.S.W.	57,656		
Field Investigations, Armidale, N.S.W. ..	13,749		
Western Australian Investigations	73,404	290,617	290,617
Entomology—			
Field Investigations, Armidale, N.S.W. ..		16,696	16,696
Soils—			
Cobalt Work in Tasmania		4,564	4,564
Research Services—			
Agricultural Liaison Unit		21,207	
Wool Publications		156	21,363
Biochemistry and General Nutrition—			
Nutrition Laboratory, Adelaide		49,846	
Field Studies at Glenthorne, S. Aust.		28,849	78,695
Wildlife Research—			
Wildlife Investigations		67,345	67,345
			1,178,866
Wool Research—			
Wool Research Laboratories—			
Protein Chemistry, Melbourne	278,783		
Textile Physics, Sydney	373,909		
Textile Industry, Geelong, Vic.	284,925		
Suspense (Overseas transactions)	2,913	940,530	
Chemical Research Laboratories—			
Physical Chemistry	9,231		
Organic Chemistry	12,179		
Suspense (Overseas transactions)	49	21,459	961,989
TOTAL INVESTIGATIONS			**2,140,855**

	£	£	£
Capital Works			
CSIRO EXPENDITURE			
Biological Research—			
Animal Research Laboratories—			
Laboratory Equipment	21,305		
Plant Industry—			
Laboratory Equipment	9,949		
Biochemistry and General Nutrition—			
Laboratory Equipment	1,000		
Wildlife—			
Laboratory Equipment	1,479	33,733	
Wool Research—			
Wool Research Laboratories—			
Laboratory Equipment and Textile Machinery ..		89,937	
		123,670	
EXPENDITURE ON CSIRO BUILDINGS BY DEPARTMENT OF WORKS			
Biological Research	59,672		
Wool Research	11,761	71,433	
EXPENDITURE ON BUILDINGS BY CSIRO			
Wool Research		10,000	
ACQUISITIONS			
Biological Research	45,872		
Wool Research	10,656	56,528	
TOTAL CAPITAL WORKS			**261,631**
TOTAL EXPENDITURE			**2,402,486**

The expenditure in excess of receipts is £31,771 and this will be recovered during 1964–65.

During the year £83,142 was received from sales of sheep, wool, and other produce from CSIRO Field Stations and Laboratories financed from wool funds. This amount was paid to the Department of Primary Industry for credit to the Wool Research Trust Fund.

Miscellaneous Receipts

During 1963–64 miscellaneous receipts amounted to £101,629. Details of the receipts are as follows:

	£	£
Sale of Publications	12,387	
Sale of Equipment Purchased in Former Years, and Other Receipts	20,301	
Sale of Produce by Field Stations and Laboratories ..	27,360	
Royalties from Patents	3,283	
Testing Fees	25,823	
Sale of Animals	8,018	
Miscellaneous	4,457	**101,629**

The receipts from the sale of produce represent revenue earned by Divisions and Sections apart from the Special Revenue included under Contributions.

The amount of £101,629 was credited to the Treasury appropriation and consequently reduced the requirements from the Treasury by that amount (*see* Expenditure).

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			
McMaster Field Station—Badgery's Creek, N.S.W.	1,119		
North Ryde, N.S.W.	2,722	3,841	
Animal Physiology			
Pasture Research Station—Samford, Qld. ..		9,553	
Plant Research			
Plant Industry			
Canberra Laboratories	38,223		
Development of Phytotron	43,996	82,219	
Tropical Pastures			
Townsville Field Station—Establishment ..	30,028		
Townsville Field Station—Development ..	13,486		
Cunningham Laboratory	2,834		
Samford Farm	3,471		
Cooper Laboratory	1,172		
Spear Grass Research Centres	1,372		
Brigalow Research Centre	2,477		
Beerwah	3,761	58,601	

	£	£	£
Entomology			
Canberra Laboratories		23,332	
Administrative Office—Canberra		7,650	
Soils and Irrigation			
Soils			
Adelaide		22,142	
Soil Mechanics			
Syndal Laboratory		5,072	
Horticultural Research Section			
Merbein, Vic.	5,208		
Adelaide	14,144	19,352	
Irrigation Research Laboratory			
Griffith, N.S.W.		8,113	
Food Preservation			
Gosford, N.S.W.	1,384		
North Ryde, N.S.W.	19,305	20,689	
Forest Products		14,861	
Ore-Dressing		210	
Mechanical Engineering		15,084	
Publishing		10,620	
Chemical Research Laboratories			
Clayton, Vic.	9,436		
Mineral Chemistry—Port Melbourne, Vic. ..	2,500		
Fishermen's Bend, Vic.	33,437	45,373	
Fisheries and Oceanography			
Cronulla Laboratory		410	
Physics		5,433	
Applied Physics		10,764	
Building Research		3,000	
Fodder Conservation		439	
Radiophysics			
Narrabri, N.S.W.	53,674		
Parkes, N.S.W.	2,725		
Giant Radio Telescope, N.S.W.	103,698	160,097	
Computing Research Section		37,446	
Meteorological Physics			
Aspendale		3,438	
Dairy Research		6,730	
Fuel Research			
Coal Research Laboratory		736	
Wildlife Research		8,597	
Regional Laboratory, Western Australia ..		108	
TOTAL TREASURY EXPENDITURE			**583,910**

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