Commonwealth Scientific and Industrial Research Organization, Australia

CSIRO Twenty-fifth Annual Report 1972/73

Commonwealth Scientific and Industrial Research Organization, Australia

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This Report of the work of CSIRO
for the year ending 30 June 1973 has been
prepared as required by Section 30
of the Science and Industry Research
Act 1949–1968.

The Executive gratefully acknowledges the
valuable help received from Australian and State
government departments and instrumentalities,
universities and other research bodies,
members of primary and secondary industries,
private individuals, and overseas institutions.

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

J. R. Price (*Chairman*)
V. D. Burgmann
M. F. C. Day
D. L. Ford
L. Lewis
A. E. Pierce
H. B. Somerset
E. J. Underwood
W. J. Vines

CSIRO was established by the Science and Industry Research Act of 1949. Under the Act, CSIRO replaced the former Council for Scientific and Industrial Research established in 1926.

The powers and functions of CSIRO are:

the carrying out of scientific research in connection with Australian primary and secondary industries or any other matter referred to it by the Minister for Science

the training of scientific research workers and the awarding of studentships

the making of grants in aid of scientific research

the recognition and support of research associations

the maintenance of the national standards of measurement

the dissemination of scientific and technical information

the publication of scientific and technical reports.

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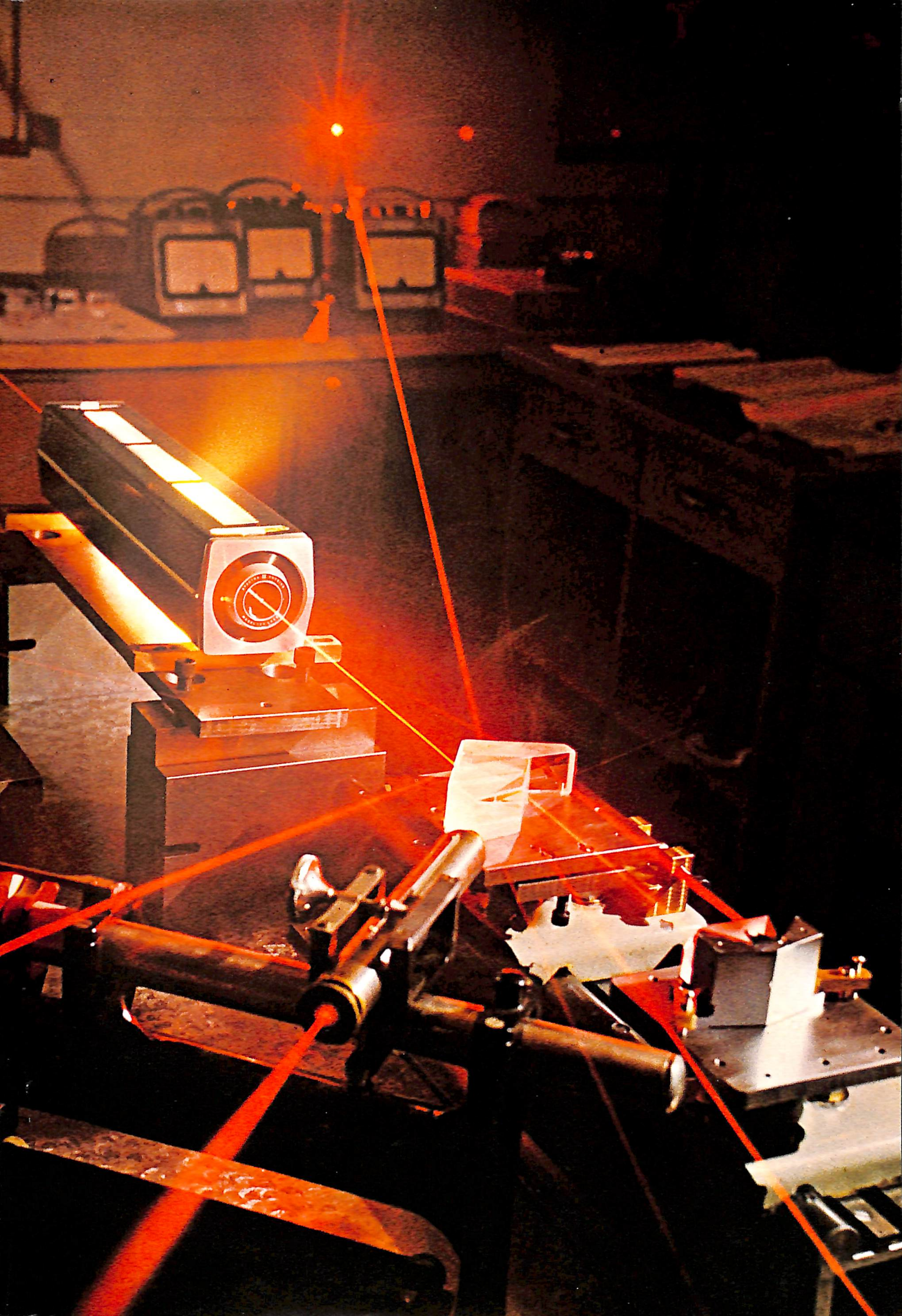
Reflections in a section of the solar absorbing panels associated with the experimental timber-drying kiln operated by the DIVISION OF MECHANICAL ENGINEERING at Griffith, New South Wales. See story on page 44.

Research 21

As the laboratory responsible for maintaining the Australian standards of measurement, the NATIONAL STANDARDS LABORATORY is required to deal with physical quantities of many kinds. Here a laser beam is being used to test a composite prism for an instrument which will measure distances of up to half a metre with an uncertainty of less than one in a million.



Introduction

CSIRO, like all research organizations whose work is primarily mission-oriented, must be continually aware of, and responsive to, changes in the needs and goals of society. Indeed, it might be said that the Organization has a responsibility to undertake research in anticipation of society's needs. The history of CSIRO, and the CSIR before it, reveals a series of such changes made in response to changing national needs and goals.

Until the outbreak of the Second World War research in CSIR was concentrated mainly on agriculture and on the processing of agricultural products. The level of those activities changed little during the war years, except for some expansion of work on forest products and a substantial expansion of that concerned with food preservation and transport. What did happen, however, was the establishment of several major new industrial laboratories—including the National Standards Laboratory and the Divisions of Radiophysics, Aeronautical Research, and Industrial Chemistry—at a level such that, by 1945, the resources available to CSIR had doubled. The post-war era saw an initial swing back towards growth of agricultural research activities but this was followed by further expansion of research geared to the manufacturing and processing industries. In the 1960s, rapid development of the country's mineral resources was accompanied by a marked increase in research on mineral processing and, later, on the techniques of mineral exploration.

CSIRO is now undergoing yet another significant reorientation. One aspect of this is that research programmes are becoming more 'people-oriented' as distinct from 'industry-oriented'. It is unfortunate that these terms are sometimes used in a way that suggests they are irreconcilable. This is not so. Research which benefits 'industry' also benefits 'people', and likewise, research which benefits people usually benefits industry. Nevertheless, the use of such terms serves to highlight a difference in attitude which is expressed in a broadening of research goals. This new emphasis is best illustrated by examples.

CSIRO has for many years been heavily committed to research which is now classified as 'environmental research'. Indeed, two-thirds of the Organization's Divisions are engaged to some extent in work which can be so described. Much of this research was started long before the 'environmental revolution' and had its origin in problems seen at the time as those of industry; and, of course, they are problems of industry, as well as being problems of people. Such research activities relate to the control of pollution arising from man's utilization of resources and, concomitantly, to the delineation of guidelines for natural resource management; to the abatement of the effects of environmental hazards due to both natural phenomena and human actions; to the broad problems of human settlement and living conditions; and to studies of the basic components of the environment. CSIRO is now engaged also on aspects of environmental research, such as those relevant to conservation, with which links to industry are, in the short term, more tenuous.

CSIRO is also extending its work in other directions which take account more of the needs of the community than of individual industries. For instance, a pilot study is being carried out by the Division of Land Use Research, in collaboration with the New South Wales Government authorities, of land use in Eurobodalla Shire in the south coast region of New South Wales. The study, which will take account of all aspects of land use requirements, is designed to provide information for those responsible for making decisions about land use in the area. In a different category, the Division of Building Research is examining the problems and needs of those living in remote communities in northern Australia, with the objective of demonstrating how conditions can be created such that people will be attracted to these communities and residents will enjoy a quality of life as good as or better than that which would be their expectation in developed centres anywhere in Australia.

These kinds of projects, to be effective, require a much closer collaboration with social scientists than has previously been necessary in CSIRO research. At this stage it seems preferable for the Organization to rely mainly on collaboration with social scientists in universities and other institutions, rather than to undertake such research itself. However, effective collaboration requires that within CSIRO there should be some staff competent in the social sciences and a limited number of such people are now being recruited.

Another element in the changing research scene is the attention being paid to the financing of research for industry. This is particularly so in respect of agricultural research, a large part of which is financed from special industry funds. Rapid changes in the profitability of various sectors of rural industry over the past few years and the consequent fluctuations in the industry's contribution to these funds has meant that the level of agricultural research in CSIRO, notably wool production research, has had to be reduced. The difficulties associated with adjustments to research programmes (many of which are inevitably of a long-term nature) as a result of shortage of funds have confirmed our view that it is unsatisfactory to finance major research programmes in this way.

As far as secondary industry is concerned, it has long been the opinion of CSIRO that the research capability of industry itself should be increased; and there appears to be a growing view within industry that one means of achieving this would be for some of the research now done by CSIRO in its own laboratories to be carried out by industry under contract with the Government. On the other hand, it has been suggested that the manufacturing and processing industries should bear more of the costs of research, both by carrying out more research themselves and by letting contracts to government laboratories. These two points of view would appear to be in conflict, yet they could also be seen as complementary. Undoubtedly the work should be carried out where it can be done most effectively and in such a way that it is made use of most effectively, and this could perhaps be achieved by greater use of contractual arrangements in both directions. How much of the research for Australian industry should be financed by government and how much by industry is a complex issue, and the decision must depend to a very large extent on government policy.

An equally important issue is the question of how research results can best be made use of in industry, and in such a way that the interest of the community as a whole is served. One method is the patenting and licensing process, which CSIRO uses whenever appropriate and which is referred to elsewhere in this report. It is important to realize, however, that in the broad spread of CSIRO activities and responsibilities, only a very small proportion of the Organization's research gives rise to patentable inventions or discoveries. It is the case that a number of economically significant inventions have been patented and have proceeded to successful industrial application. But there are very many other results of CSIRO research of great value to Australian industry that have not been patentable, and if the results of this research are to be put to good use it is essential that there be effective communication between CSIRO and industry.

While CSIRO has always considered it necessary to have the best possible communication with industry, the need for similarly effective communication with the community as a whole has assumed a much greater significance with the change in emphasis towards 'people-oriented' research. Steps are now being taken to meet these needs for improved communication with the community, with industry, and, indeed, within the Organization itself. These represent one small aspect of CSIRO's response to changing circumstances.

J. R. Price

Chairman

General

Finance

The table below summarizes the sources of CSIRO funds for 1972/73 and the categories of expenditure. About four-fifths of CSIRO's income for the year was provided directly by the Australian Government. More than three-quarters of the remainder was contributed by trust funds concerned with the wool, meat, wheat, dairying, tobacco, fishing, dried fruits, and chicken meat industries. Most of these funds are derived from a levy on produce supported by an Australian Government contribution.

During 1972/73 CSIRO spent $56·1 million of Treasury funds on salaries and general running expenses, an increase of $5·4 million over the previous year's expenditure. However, after allowing for non-recurrent items, the effective increase was $7·2 million.

About half of the increase was absorbed by salary adjustments arising from Arbitration determinations and by increments, reclassifications, and provision for additional payments in lieu of furlough.

The remainder of the increase was

Source of funds	Salaries and general running expenses ($)	Grants for studentships and grants to outside bodies ($)	Capital works and services, and major items of equipment ($)	Total ($)
Treasury appropriation, including revenue	56,139,023	1,917,449	1,852,513	59,908,985
Wool Research Trust Fund	7,456,750	—	336,424	7,793,174
Meat Research Trust Account	1,695,470	—	36,437	1,731,907
Dairy Produce Research Trust Account	278,461	—	—	278,461
Tobacco Industry Trust Account	264,459	—	—	264,459
Wheat Research Trust Account	176,628	—	—	176,628
Fishing Industry Research Trust Account	120,400	—	—	120,400
Dried Fruits Research Trust Account	25,933	—	—	25,933
Chicken Meat Research Trust Account	4,335	—	—	4,335
Other contributors	2,475,559	—	408,661	2,884,220
Total	68,637,018	1,917,449	2,634,035	73,188,502

allocated as follows:
$430,000 for the planned development of major projects initiated in earlier years including work on mineral exploration, rock mechanics, and grain storage.
$244,000 for eight new projects concerned with geochemistry, control of the screw-worm fly, management of the water buffalo, agronomy of protein grain crops, resource utilization in the Darling Ranges of Western Australia, production and use of edible plant protein, urban building and design, and engineering aspects of grain storage.
$305,000 for additional support for existing projects concerned with northern prawns and the ecological effects of bush fires, and for an expansion of computing research activities.
$851,000 to permit the redeployment of 70 members of staff whose salaries had previously been financed from the Wool Research Trust Fund and the Dairy Produce Research Trust Account. Because of the rising costs of research, these funds were unable to support the research work at the 1971/72 levels of activity.
$1,718,000 to meet increased running costs, extra service charges resulting from the occupation of new buildings, and requirements for ancillary staff.

In addition to the money received from primary industry research funds, a substantial sum is contributed by individual companies, Australian Government and overseas instrumentalities, and private foundations. Major contributions received during the year include:
$130,000 from the Department of Civil Aviation for the first phase of a research programme in the DIVISION OF RADIOPHYSICS on the development of a microwave landing system for aircraft. The Department intends to provide funds for a further two years to undertake phase 2 of the programme which will involve designing, fabricating, installing, and testing a complete microwave landing system under operational conditions.
$70,000 from the United States National Aeronautics and Space Administration to improve scientific research facilities for radio astronomy in the DIVISION OF RADIOPHYSICS. This grant is in recognition of the support given to the Apollo 17 Mission by the Division's radio telescope at Parkes, New South Wales.
$96,000 from the Department of the Northern Territory for CSIRO to take part in an environmental fact-finding study of the Alligator Rivers region of the Northern Territory.

Alta Lipids Australia Pty Ltd, a subsidiary of Dalgety Agri-Lines Pty Ltd, has agreed to provide CSIRO with $370,000 over a three-year period for research in connection with the feed supplement developed by CSIRO for producing meat and milk products with a higher than usual proportion of polyunsaturated fatty acids (see p. 38). Approximately $110,000 was provided during the year under review.

In addition to the money that CSIRO received from the Government and from industry and other contributors, some $4·1 million was spent by the Department of Works and the Department of Services and Property on buildings and other works for CSIRO and on the acquisition of land.

Buildings

A major part of the Organization's building programme for the year under review was concerned with the new NATIONAL STANDARDS LABORATORY being built at Bradfield Park, Sydney, for the DIVISION OF APPLIED PHYSICS and the DIVISION OF PHYSICS. The Laboratory and associated works, which are scheduled for completion in 1976, are expected to cost approximately $15 million. During the year the construction of foundations and the underground portion of the laboratory complex was commenced.

Construction of the following major buildings was authorized during 1972/73:

ANIMAL GENETICS—Laboratory wing at North Ryde, Sydney. $493,000.

ANIMAL HEALTH—Animal breeding house for production of small animals free of specific pathogens, at Badgery's Creek, N.S.W. $97,000.

BUILDING RESEARCH—Laboratory at Highett, Melbourne. $690,000.

COMPUTING RESEARCH—Alterations to laboratory at Black Mountain, Canberra, to accommodate a Control Data CYBER 76 computer. $200,000.

MINERAL CHEMISTRY—Library and services block at Port Melbourne. $251,700.

PLANT INDUSTRY—New herbarium at Black Mountain, Canberra. $240,000.

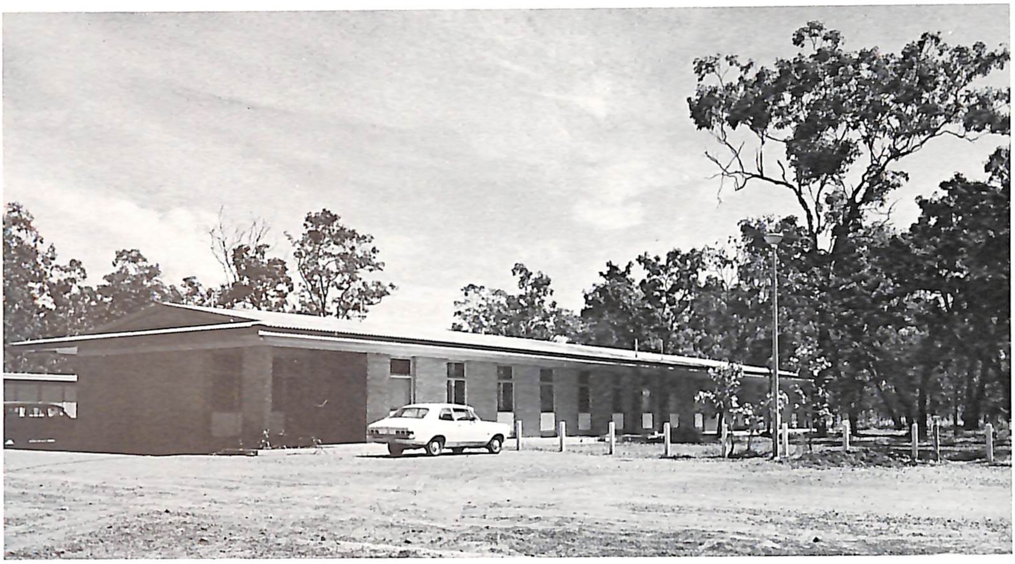
RADIOPHYSICS—Laboratory, office, and workshop building at Australian National Radio Astronomy Observatory at Parkes, New South Wales. $210,000.

Major projects completed during the year include:

ANIMAL HEALTH—Rehabilitation of laboratory at Parkville, Melbourne. $164,200.

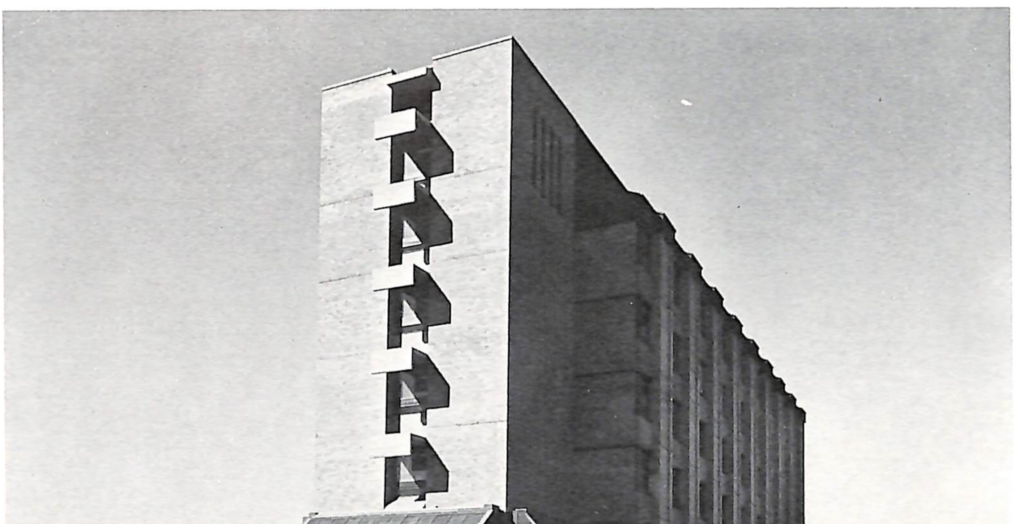
CHEMICAL PHYSICS—Laboratory wing at Clayton, Melbourne. $359,600.

Mr. W. L. Morrison was appointed Minister for Science in December 1972. Mr. Morrison is seen here (right) with Dr. M. Duggin of the DIVISION OF MINERAL PHYSICS following a press conference which he held at the Division to brief journalists on Australia's particular interests in the United States Skylab project.



Above The F. C. Pye Wildlife Research Laboratory in Darwin was officially opened in July 1972. It cost $318,000 of which $103,000 was provided from the F. C. Pye Trust Fund. (The Fund was also used several years ago to finance the construction of the F. C. Pye Field Environment Laboratory in Canberra.)

Below The Minerals Research Laboratory at North Ryde, Sydney, was officially opened in October 1972. The building, which cost $2·2 million, houses research groups from the DIVISIONS OF MINERAL CHEMISTRY, MINERAL PHYSICS, and MINERALOGY.



Research vessels

In October 1972 the Government gave approval in principle for CSIRO to acquire a research vessel of about 67 metres for the DIVISION OF FISHERIES AND OCEANOGRAPHY. The Government also approved, as an interim measure, the chartering of suitable vessels by CSIRO for research purposes.

Preliminary design of the vessel has been undertaken by the Department of Transport with the assistance of an overseas consultant experienced in the design of research vessels. When details of costs of construction and annual operation have been determined, the Government will consider the provision of the necessary financial resources to enable the CSIRO vessel to be built and commissioned. Meanwhile, CSIRO has chartered a 36-metre vessel, the *Sprightly*, for work in connection with the western rock lobster.

In May 1973 a 21-metre research vessel, the *Kalinda*, was handed over to the DIVISION OF FISHERIES AND OCEANOGRAPHY. The new research vessel will enable work to begin on scientific problems associated with the prawn fishery in the off-shore areas outside Moreton Bay, Queensland. A study of the oceanic environment of the prawn stocks will be made, their distribution and their migrations will be investigated, and information will be gathered on their spawning and on the movements of the young prawns back into the nursery areas of Moreton Bay. The research project is a joint one between the Division and the Queensland Department of Primary Industries and will be operated from the Department's Fisheries Research Station at Deception Bay, north of Brisbane.

The *Kalinda* was built with funds provided from the Fisheries Development Trust Account.

New Executive members

Dr. A. E. Pierce, who joined CSIRO as Chief of the DIVISION OF ANIMAL HEALTH in 1966, was appointed a member of the Executive in January 1973 following the retirement of Mr. C. S. Christian. Mr. Christian joined CSIRO in 1933 and was the first Chief of the DIVISION OF LAND RESEARCH AND REGIONAL SURVEY. He became a member of the Executive in 1960.

Mr. W. J. Vines, formerly Managing Director of the International Wool Secretariat, was appointed a part-time member of the Executive. He succeeded Mr. E. P. S. Roberts, who retired in March 1973 after 13 years as a part-time member of the Executive. Mr. Vines has been a member of the CSIRO Advisory Council since 1970 and has had a long association with the Organization's wool research programme.

Land resources research reorganized

In March 1973 a number of existing research units were regrouped to form three research Divisions, known collectively as the LAND RESOURCES LABORATORIES. This reorganization was part of a move to coordinate and intensify research on the definition, evaluation, and management of Australia's land resources. The LABORATORIES comprise the DIVISION OF LAND RESOURCES MANAGEMENT, the DIVISION OF LAND USE RESEARCH, and the DIVISION OF SOILS.

The DIVISION OF LAND USE RESEARCH consists of major segments of the former DIVISION OF LAND RESEARCH, including the Rangelands Research Unit and the Woodland Ecology Unit. The Division is based in Canberra and its role is to survey and assess the potential use of land resources and to develop new assessment techniques. The DIVISION

OF LAND RESOURCES MANAGEMENT is based in Perth and consists of former sections of the DIVISIONS OF PLANT INDUSTRY and SOILS located in Western Australia. Its role is the development of management techniques for achieving optimum productivity consistent with conservation of land resources. The Division will also study the environmental implications of changes in land use. The DIVISION OF SOILS continues to be based in Adelaide with major laboratories in Brisbane, Canberra, and Townsville, and is working on the management of soils for the production of crops, pastures, and forests, and on other effects of man's activities on soils.

The LAND RESOURCES LABORATORIES will relinquish the crop research work of the former DIVISION OF LAND RESEARCH. This work, which is being carried out at several regional stations, is being transferred progressively to other Divisions. The Katherine Research Station in the Northern Territory and the Tobacco Research Institute at Mareeba in north Queensland have been transferred to the former DIVISION OF TROPICAL PASTURES. This Division, which has its headquarters in Brisbane, has been re-named the DIVISION OF TROPICAL AGRONOMY.

Work on cotton production, including insect control, breeding of new varieties, agronomy, and plant physiology, is being rationalized by the establishment of a Cotton Research Unit at Narrabri in New South Wales. The Unit will be operated by the DIVISION OF PLANT INDUSTRY.

CSIRO and secondary industry

In November 1971, the Advisory Council established a committee, known as the CSIRO–Secondary Industry Committee, to review the present relationships between CSIRO and secondary industry and to report on future developments in this field. The terms of reference emphasized such areas as communication and information transfer, patents, licences, collaborative research projects, research contracts, liaison, advisory and consultative services, the use by industry of specialized capital equipment in CSIRO, and the identification of organizational and operational features that may inhibit the discharge of responsibilities under the Science and Industry Research Act.

The Committee comprised six members from industry, one from the universities, one member of the CSIRO Executive, and two CSIRO Chiefs. Its meetings extended over the period April to December 1972. The Committee was concerned with the work of some 17 CSIRO Divisions representing about 43% of the non-capital research expenditure by the Organization. Written reports were obtained from the Divisions and thirteen were visited for discussions with senior officers. The views and attitudes of industry were sought by a letter of enquiry addressed to 85 firms representing a wide range of industrial activity.

In general the Committee's conclusions favoured the continuation of existing policy. Specific recommendations were put forward, however, for facilitating the development of CSIRO or joint CSIRO–industry inventions in an industrial environment and for further strengthening communication between CSIRO and industry.

The Committee found CSIRO's present policy and practices in patents and licences generally satisfactory, but recommended increased use of exclusive arrangements and provisions to maintain an Australian equity in CSIRO inventions exploited in world markets. The policy on the licensing of CSIRO patents was subsequently modified by the Minister for Science, Mr. W. L. Morrison (see following item). In the Committee's view, collaborative and sponsored work between CSIRO and industry was capable of further expansion. At the same time CSIRO was seen as having a responsibility to pursue more basic longer-range research programmes on behalf of an industry as a whole.

Patents and licences

The first function of CSIRO defined in Section 9 of the Science and Industry Act 1949–68 is '. . . the initiation and carrying out of scientific researches and investigations in connexion with, or for the promotion of, primary or secondary industries in the Commonwealth'. The research undertaken by CSIRO results each year in many useful discoveries, some of which lead to a number of patentable inventions. Section 27 of the Science and Industry Research Act lays down that CSIRO patents may be made available to industry on such conditions as the Executive, with the approval of the Minister, determines.

Since the establishment of CSIR in 1926 through to the present day, it has been the policy of the Executive that scientific results from all research should be made available for publication. Until the early 1950s it was generally accepted that such publication was all that was necessary for CSIRO to fulfil its obligations. At that time it was generally believed, also, that patents could play no significant part in the activities of CSIRO, since they were thought to be inherently restrictive and incompatible with the spirit of free scientific enquiry and unrestricted publication. However, experience showed that publication of research results does not automatically lead to the results being applied in industry. Industry is often unwilling to enter a new field unless the patent status of work done by CSIRO ensures that, as far as practicable, use of a CSIRO process will not infringe other patents. It was found also that firms were unwilling to pioneer a new invention that was freely available to all, especially if such a course of action involved a considerable financial outlay in the early stages. Patent licensing can overcome this unwillingness by providing a measure of exclusivity to enable the firm to recoup its initial investment before the benefits are shared by its competitors.

CSIRO's patent policy was first formulated in 1953. It can be summarized by the general statement that 'patents will be sought on inventions from CSIRO research whenever this seems desirable in the public interest'. Without excluding other possibilities, the Executive believes it is in the public interest to apply for patents

- —when there is a danger of others obtaining patents covering the results of the Organization's work
- —when it seems likely that an invention will only be developed and exploited commercially if covered by patent
- —when it is desirable for the Organization to maintain an interest in the quality and technical efficiency of production through the licensing of patents
- —when an invention may assist in maintaining or extending the use of Australian products, such as wool, in other countries
- —when substantial royalties are likely to be collected from overseas licensees.

Following a review of the previous policies and practices on the patenting and licensing of CSIRO inventions, the Minister for Science, Mr. W. L. Morrison, has approved the continuation of the existing policy on the patenting of inventions. However, he has made some changes related to the licensing of patents. The effect of these changes is that the Executive is authorized to grant non-exclusive licences in Australia on condition that the licensee is of Australian ownership, and at an annual royalty of $100. All other licences require the Minister's approval. In making recommendations to the Minister, CSIRO is to provide information on the ownership of the firm or firms involved and a report from the Australian Industry Development Corporation. In addition, the Minister requires that CSIRO, in consultation with the Attorney-General's Department, incorporate in licence agreements adequate provisions covering the disposition of the licences in the event that the licensee is taken over by another firm. The requirement that the Corporation provide a report on proposed licences of CSIRO patents is designed to ensure that all the alternatives for the development and exploitation of CSIRO patents have been fully explored from the point of view of achieving the maximum national technological and economic advantage.

In respect of CSIRO patents that can be used in Australia and overseas for the promotion of wool, the Minister has approved, subject to early review, the continuation of the agreement between CSIRO and the International Wool Secretariat, and similar agreements with the New Zealand and South African Wool Boards and the Australian Wool Corporation.

South coast survey

Eurobodalla, a rapidly developing shire in the south coast region of New South Wales, has been chosen for a pilot study in land use by the DIVISION OF LAND USE RESEARCH and the New South Wales Department of Environment. The study has been designed to supply basic information on the environment covering a wide range of interests such as business, industry, housing, recreation, and tourism, so that appropriate local authorities can make decisions on future land use that will be in the best long-term interests of the area and its people.

The first intensive work in the study area began in April 1973 when a team of six scientists commenced a two-and-a-half-month survey of land resources as the first stage of the main study. Using aerial photographs, the team mapped the shire into several thousand distinct land units. The typical ground features of each of these land units were then identified. Soils, vegetation, geology, and water supplies were mapped.

This information has been stored in a computer and can be drawn upon to provide readily accessible information about the relative suitability of different types of land use for each land unit. A large number of local people will be interviewed to find out their views on the best use for land in the area. It is hoped to complete the preliminary studies by the end of 1974. Further studies are likely to continue for some years after that.

Communicating scientific and technological information

Systems for retrieving information to a user's specification or search profile are commonly described by the acronym SDI, for Selective Dissemination of Information. The most commonly used SDI technique is the current awareness service in which the user is regularly provided with a list of references to match his interests, which have been translated into a search profile using a specialized set of logically connected search terms or keywords and which can be read by computer.

Several years ago the Central Library and Information Services of CSIRO began developing their own generalized SDI system using the Organization's computing network. The system is designed to give access to machine-readable data bases of all the major international scientific and technical information services. This system will assist staff in keeping up to date with the world's scientific literature and will also assist in the dissemination of scientific and technical information to the Australian scientific and technical community.

Recently the CSIRO Central Library and Information Services were nominated as an Information Centre in Australia for Chemical Abstracts Services of the American Chemical Society, one of the oldest, best-known, and most advanced abstracting and indexing services in the world and the first to develop a machine-readable data base. This data base, which is known as CA CONDENSATES, includes the bibliographic details and appropriate descriptors or keywords of all the material abstracted and indexed for *Chemical Abstracts* and is one of the largest and most advanced computer-based scientific information systems yet established.

Following a trial of the CA CONDENSATES current awareness service within CSIRO, a licence agreement with Chemical Abstracts Services was completed and became effective in January 1973. With the collaboration of the Royal Australian Chemical Institute, the CA CONDENSATES current awareness service has been made available at cost to a trial group from industry and academic institutions and is to be made generally available if the trial proves successful.

INSPEC, the machine-readable data base developed by the Institution of Electrical Engineers, London, was introduced into CSIRO in February 1973. It covers *Physics Abstracts*, *Electrical and Electronics Abstracts*, and *Computer and Control Abstracts*.

In addition to *Chemical Abstracts*, other major scientific and technical abstracting services which have developed machine-readable data bases of interest to CSIRO include *Biological Abstracts*, *Engineering Index*, and *Bibliography of Agriculture*. Plans are well advanced to make their respective magnetic tape services—BA PREVIEWS, COMPENDEX, and CAIN—accessible to scientific staff. Apart from these large broad-spectrum data bases, there are a number of specialist tape services becoming available, for example in textile and food science, which could be of interest to CSIRO. The Central Library and Information Services are developing a machine-readable, environmental information data base by extracting and merging relevant information from the large data bases.

Commonwealth Scientific Committee

CSIRO was host to the seventh meeting of the Commonwealth Scientific Committee in Canberra in October 1972. About 30 delegates from 18 Commonwealth countries attended the conference. The committee, which consists of representatives from national scientific research organizations of Commonwealth countries, meets every two years to discuss means of ensuring the fullest possible collaboration in scientific matters between members of the Commonwealth.

Chairman for the Canberra meeting was Mr. C. S. Christian, a member of the Executive. Following the conference, delegates made a tour of research laboratories and agricultural field stations in Victoria, New South Wales, and Queensland, and while in Brisbane took part in a seminar on animal production in tropical and subtropical areas.

FID/CAO Assembly

The Second General Assembly of the Commission for Asia and Oceania, International Federation for Documentation, was hosted by CSIRO in Canberra in October 1972. The Federation was founded to promote and coordinate on a world-wide basis the activities of organizations and individuals concerned with the collection, organization, and dissemination of information, particularly in the fields of science and technology.

The Commission was formed in 1968 to promote the objects and activities of the Federation in the Asian and Oceanic region. Australia was represented at the inaugural meeting in Tokyo in 1970 by CSIRO's Chief Librarian, Miss Betty Doubleday, who remains Australia's delegate to the Commission. The Executive positions are filled by two other CSIRO staff members—the Secretary (Administration), Mr. L. G. Wilson, who is President, and the Deputy Chief Librarian, Mr. P. H. Dawe, who is Secretary.

Research

In a report of this size it is not possible to give a full account of all of CSIRO's current investigations. This section contains one or two items of interest from each Division and is designed to show something of the wide range of CSIRO's research activities. More comprehensive information on the Organization's current research activities can be obtained from the separate annual reports published by each Division. A brief description of the fields of research engaged in by each Division is given on pages 59–63 of this report.

Land use affects water supplies in south-western Australia

Land use in the Darling Range of Western Australia is affecting the quality of water supplies in south-western Australia.

The Darling Range, in the high-rainfall area of south-western Australia, is the sole water catchment supplying Perth and its developing industries. However, the Range is increasingly in demand for various other uses such as forestry, agriculture, bauxite mining, housing, and recreation. Removal of the native vegetation by these activities leads to increased salinity in streams, and frequently to accumulation of salts in surface soils.

For the past six years scientists from the DIVISION OF SOILS Western Australian laboratory, now part of the DIVISION OF LAND RESOURCES MANAGEMENT, have been carrying out investigations aimed at predicting more accurately the effects of clearing the native vegetation on water and salt balances of catchments within the Range. This information is essential for planning land use in the area.

Each year small quantities of salts derived from the ocean enter the catchment systems in the rainfall, and these are stored in the ground water held in the deeply weathered country rock of the Darling Range. In areas under natural vegetation the amount of salts gained is offset by losses in streams. However, when the natural vegetation is removed and replaced with agricultural plants, which use less water, ground-water recharge is increased and the catchment yields both more salts and more water. In most areas this means a decrease in water quality.

A drilling programme has enabled the Division to estimate the quantity of salts stored in the soil. At the Division's field station at Yalanbee on the dry eastern side of the Darling Range the weathered top 30 metres of soil contain nearly one million kilograms of salts per hectare (890,000 pounds per acre). In the wetter country further west, the salt content falls to only one-sixth of this figure.

The Division estimates that it will take hundreds of years for most catchments to rebalance themselves and to yield water of acceptably low salinity once they have been disturbed by clearing, but some will achieve a new equilibrium in a much shorter period, perhaps 10 or 15 years. In order to test its predictions, the Division will shortly begin monitoring the water and salt balances in small representative catchments under native forests, and will measure changes occurring when these are later cleared.

Controlling scrub with goats

The possibility of using goats to clear scrubland is being investigated.

In western New South Wales and in parts of Queensland there are large tracts of low-rainfall country that are infested with thick scrub. The land is used for sheep-grazing but on many properties the density of the scrub has increased so much over the last 25 years that sheep-grazing has become less profitable. Normal methods of scrub-clearing, such as bulldozing and ploughing or spraying, are generally not economic in these areas.

The DIVISION OF LAND USE RESEARCH is investigating whether goats could be used on a temporary basis to clear unwanted scrubland so that a return to sheep-grazing would then be possible. At the same time the Division recognizes the need to ensure that heavy goat-grazing would not lead to an increase in the density of the few shrubs that are disliked by goats or to further denudation of an already badly eroded tract of country.

Work on the different diet habits of goats and sheep has already shown that goats eat much more of tree and shrub leaves than do sheep. The diet of goats commonly contained 50 to 90% of these whereas the diet of sheep usually contained less than 20%. The survey showed goats ate a number of herbaceous plants eaten by the sheep, but their preference for grass in particular was much lower than that of the sheep.

Further detailed ecological research is needed because goats do not eat some of the aromatic woody plants that cause woody regrowth problems and these could form a future 'goat-resistant' scrub. It is possible that this could be controlled by other means such as burning.

Cattle, termites, and kangaroos

Studies of the feeding habits of cattle, termites, and kangaroos have so far shown little direct competition among them for forage on the arid and semi-arid rangelands of Australia.

At Hamilton Downs Station, near Alice Springs, the DIVISION OF LAND USE RESEARCH has been working on the feeding interactions of cattle, termites, and kangaroos to find out if there is any competition between them for available forage and also what effect they have on the range. The Division has found that in general there is little direct competition between them and that they tend to complement each other in their dietary preferences.

After there has been a significant general rainfall in an area cattle move onto the open flood-plain and foothill areas while kangaroos disperse widely into the mulga communities. The termites in the mulga woodland communities harvest standing dry grasses.

As the communities dry off, the cattle gradually move back to the woodland areas and finally, in extremely dry conditions, they forage the mulga–perennial grass communities. Red kangaroos move in the reverse direction, gradually concentrate on the woodland communities, and then form large mobile mobs that move to areas which rain storms pass over. Termites generally do not harvest during the dry periods except during cloudy or humid days and then the main species involved, *Drepanotermes* and *Amitermes*, generally take dried perennial grasses, mostly woollybutt (*Eragrostis eriopoda*).

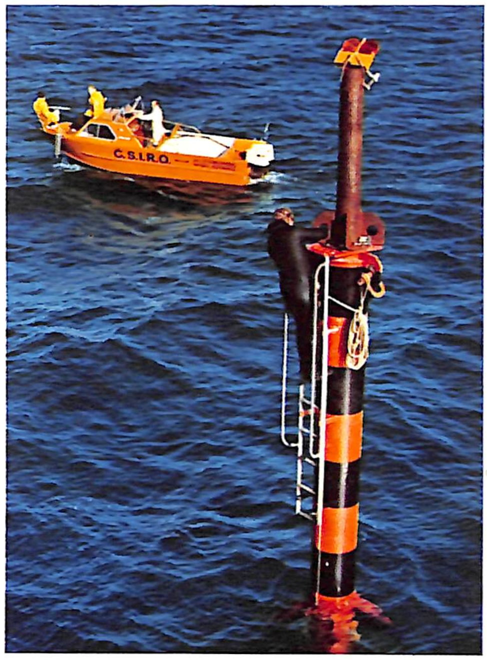
Diet studies indicate that the grasses that kangaroos take in the mulga areas are short-lived grasses which would not be available for the cattle when they moved into that community. The studies also show that neither cattle nor kangaroos take much woollybutt, particularly during dry times when much of the nutritive value has gone out of the grass, so that there is little competition between termites on the one hand and cattle and kangaroos on the other.

There is, however, competition between cattle and kangaroos during dry times on those occasions when light rains result in green growth in the depressions in the flood-plains; both species then concentrate on these areas. There is probably direct competition also between termites and cattle. Both groups prefer the new herbaceous plants. At times caterpillar plagues occur which are large enough to denude areas of succulent plants. Since kangaroos tend to eat mostly grasses, there is little competition between them and the caterpillars.

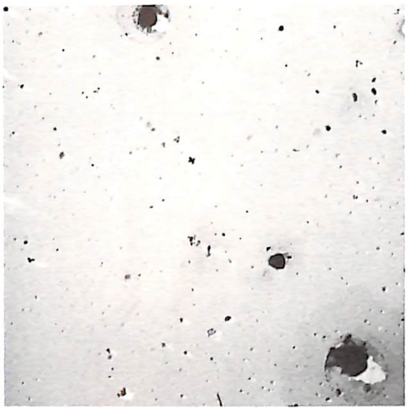
Smoke and weather

Individual particles that are important in weather behaviour can be sampled from the atmosphere and chemically tested.

New techniques developed by the DIVISION OF CLOUD PHYSICS will help in understanding how air pollution may



Interactions between the atmosphere and the Earth's surface, three-quarters of which is covered by water, govern many atmospheric processes. To find out more about the interaction between air and sea the DIVISION OF ATMOSPHERIC PHYSICS has installed an instrument tower in Port Phillip Bay, about 2 kilometres off shore from the Melbourne suburb of Aspendale. The photographs show the tower during construction on land and during installation in the Bay. A superstructure (not shown) consists of a platform with guide rails and masts for mounting instruments. The instruments will measure the transfer of heat and water vapour between sea and air, the braking effect of the sea surface on winds, the sea surface temperature, and the temperature difference between sea and air. Information recorded by the instruments will be radioed back to the Division's laboratory. The tower will also be used to test instruments designed for ocean-going buoys.



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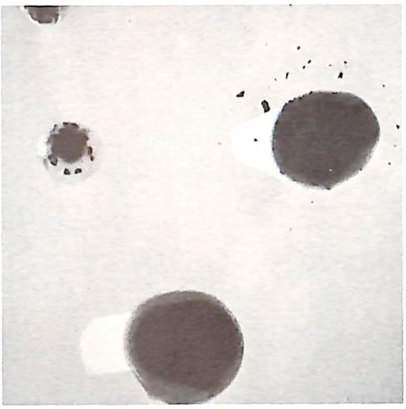

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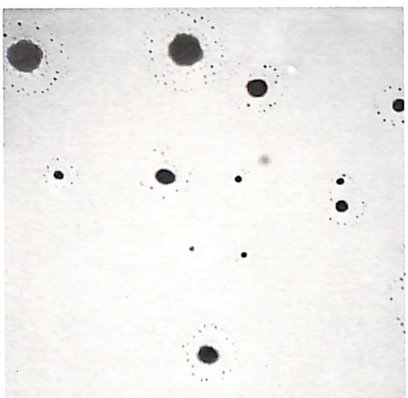

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modify the ability of clouds to rain.

Particles in the atmosphere come from many sources, both natural and man-made. A small percentage of the particles serve as nuclei around which cloud droplets form. The chemistry of these particles is not understood.

Study of the particles has been difficult because they are very small: 99% of them cannot be seen with the best optical microscope. Chemical analysis of large samples obtained by sampling great volumes of air is possible but then vital information on the size distribution of the particles—vital because their effect on the environment depends markedly on their size—is lost.

Particles are captured on electron microscope screens and coated in a vacuum chamber with an extremely thin layer of reagent by boiling the reagent at a distance from the screens. When the screens are exposed to the vapour of a suitable solvent, particular substances react to form concentric rings that can be compared with those from laboratory samples.

The pictures here show electron microscope photographs ($\times 2000$) of typical particles collected (1) in Sydney air, (2) in air at an altitude of 3 kilometres over inland Australia, and (3) in stratospheric air at an altitude of 20 kilometres.

These studies will lead to a better understanding of the behaviour of particle nuclei in the formation of clouds, and will provide information on how smoke pollutants affect the atmosphere.

Weather watch

Meteorological predictions can now be produced numerically for the Southern Hemisphere.

One of the major research interests of the Commonwealth Meteorology Research

Centre, staffed jointly by the DIVISION OF ATMOSPHERIC PHYSICS and the Commonwealth Bureau of Meteorology, is in improving mathematical representations of pressure, temperature, and wind patterns. As a result of this work a significant proportion of Australia's contribution to the World Weather Watch programme can now be produced by computer.

World Weather Watch is a major project of the World Meteorological Organization and involves the collection, analysis, and redistribution of weather data on a global basis. The National Meteorological Analysis Centre in Melbourne, part of the Commonwealth Bureau of Meteorology, is one of the three World Centres for this programme. Charts of broad-scale features of present and forecast atmospheric conditions over the Southern Hemisphere are made available to other countries from the World Meteorological Centre.

The charts are produced by computer at 12-hourly intervals. At each interval, meteorologists' interpretations of current data from weather satellites are used in conjunction with data from conventional weather stations to update automatically an estimate of present conditions derived from a previous computer forecast. The computer program then produces further prediction charts which are broadcast by radio to World Weather Watch participants.

What happens to a sea breeze?

The fate of the sea breezes that blow inland from Australia's coast is being studied by computer.

The DIVISION OF ATMOSPHERIC PHYSICS has developed a series of mathematical equations that can be used to represent the behaviour of Australia's sea breezes in a variety of situations.

Scientists in the Division see the model as an aid to understanding the interaction of some of the very complex systems that determine the weather. At the same time, a knowledge of the behaviour of sea breezes could help in designing pollution control measures.

Basically, a sea breeze is an on-shore wind that develops on sunny afternoons in coastal areas. By day the air just above the land is warmer than that over the sea. The warm air rises and lowers the pressure just above the ground. This causes a wind from the sea. At night, the air is cooler over the land than over the sea and a land breeze is produced which is usually quite weak.

This simple overall picture becomes much more complicated when studied in detail. Other factors, such as the intensity of sunshine, the shape of the coastline, the nature of the land, and pressure conditions over the whole region, have to be considered. The numerical model of a sea breeze was developed by members of the Division who began by assuming a straight coastline and a dry atmosphere. Complicating factors are being built into the program as the work continues.

Cutting orange trees down to size

Pruning excessively large orange trees has a number of economic advantages even though it may initially result in lower yields.

Improvements in management techniques have resulted in an increasing tendency for orange trees to attain an excessive size. This is now causing difficulties in pest control and harvesting procedures. Such problems are further aggravated by rising labour costs.

At Griffith, in the Murrumbidgee Irrigation Area of New South Wales, a

long-term experiment to investigate the effect of different cultural and fertilizer treatments on orange trees was established by the DIVISION OF IRRIGATION RESEARCH in 1947. By 1969 many trees, initially planted at 6·7 metre by 6·7 metre spacings, were meeting between the rows and were up to 6·1 metres in height. A pruning programme was therefore initiated immediately after the 1969 harvest. Trees were pruned with a light-weight chain saw, on the top to a maximum height of 4·3 metres and on the east and west sides to a maximum width of 4·5 metres.

To maintain these dimensions a topping and hedging machine was developed which can be fitted to a standard fork lift on a tractor. It comprises a cutting arm, 2·7 metres long, driven by a hydraulic reversible motor which consists of two adjacent sets of high-tensile harvester knife-sections operating in parallel but opposite directions. This can be used in both horizontal and vertical positions at heights up to 5 metres.

The amount of fresh material removed in 1969 varied from nil to 80 kilograms per tree, according to the vigour and size of each tree, and averaged 19 kilograms per tree. The most severe pruning represented a loss of only 8% of the total canopy, consequently pruning had only a small effect on the subsequent yields.

In the two-year period 1970–71 after pruning it was found that the loss in yield due to pruning was about 3 tonnes/hectare (1 tonne/hectare is about 900 pounds/acre). However, in 1972 the highest yields ever recorded from the experiment were obtained. The annual yields for the two three-year periods 1967–69 and 1970–72 before and after pruning were almost the same (50·2 and 49·7 tonnes/hectare respectively).

Furthermore, the trees are carrying a high crop load in 1973 for the third successive year, suggesting that the pruning treatments have not only increased over-all yields, but have also reduced the extent of biennial bearing (alternate heavy and light crops). The latter alone could be of considerable economic advantage. Pruning has also enabled harvesting costs to be reduced and more efficient pest control to be achieved.

To be continuously effective in

controlling tree size, the pruning machine is being used every two years. Tops and sides are pruned in alternate years. This procedure removes less than 1% of the total canopy and can be expected to have a negligible adverse effect on subsequent yields.

Keeping a watch on cadmium

A continual monitoring of cadmium levels in locally grown foodstuffs appears to be desirable, even though the levels measured to date in Australia have been less than those recorded in the United States.

Cadmium has long been known to be highly toxic to man and there are on record cases of people being poisoned after breathing noxious fumes containing the metal, a hazard known to industrial workers in smelters and foundries. But cadmium is also known to be present in small quantities in superphosphate, a product derived from the rock phosphate imported to Australia from Christmas Island and Nauru.

The success of large-scale agriculture in this country depends greatly on the use of this superphosphate and since each year farmers spread about four million tons of the fertilizer on soil and pastures, the introduction of further amounts of cadmium to the environment automatically follows. Since much heavier applications of fertilizer are generally given to root and leaf vegetables than to cereals and pastures, it would seem that plants such as carrots, potatoes, celery, and cabbage are more likely to have a higher cadmium content than, say, wheat or oats.

At present scientists do not know at what levels cadmium intake may prove harmful, but reports from overseas countries, particularly Japan and the United States, have led the DIVISION OF PLANT INDUSTRY to investigate the amount of cadmium that passes into the food we eat from plants that have been grown in areas on which superphosphate has been spread.

The Division found that when land is top-dressed with superphosphate the cadmium tends to lodge in the top 10 centimetres of the soil where it is easily reached by plants. Plant intake varies, but even after heavy top-dressing most plants appear to take up only traces of cadmium. Measurements of the cadmium contents of plants revealed much lower levels than have been recorded in the United States. Nevertheless, continued monitoring of cadmium levels in Australian crops would appear to be desirable until more is known about the amounts of cadmium that can be tolerated by humans.

Zinc, enzymes, and photosynthesis

The enzyme carbonic anhydrase may not have the role in photosynthesis that has been attributed to it.

Carbon dioxide reacts with water to form carbonic acid. In many organisms, including green plants, this reaction is catalysed by an enzyme known as carbonic anhydrase. Carbonic acid is much more soluble in water than is carbon dioxide, and for a long while it has been thought that carbonic anhydrase plays an important role in photosynthesis by facilitating the absorption of atmospheric carbon dioxide by plants and its transport to the centres of photosynthetic activity in the plant tissues.

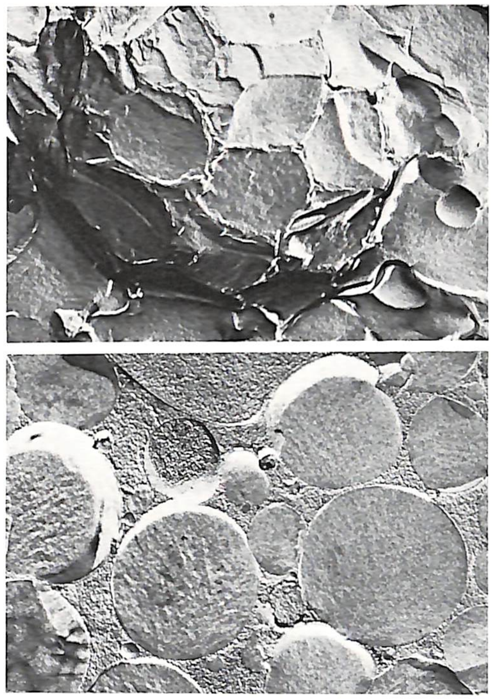
Since carbonic anhydrase is a zinc-containing protein, the DIVISION OF PLANT INDUSTRY has been investigating the possibility of using the level of carbonic anhydrase activity in a plant as an indication of whether the plant has enough zinc. The Division found that while the level of activity of this enzyme was low in zinc-deficient plants, there were other factors operating, so that a low level of enzyme activity was not in itself an absolute guide to the zinc status of a plant. Experiments were then conducted to see whether the application of zinc to zinc-deficient plant tissues increased the level of carbonic anhydrase activity. The Division found that there was a considerable delay from the time the zinc was added until a response occurred. Unexpectedly, however, it also found that there was very little relationship between enzyme activity and the rate of photosynthesis, even when the level of carbon dioxide in the atmosphere was varied. These results suggest that carbonic anhydrase does not have the important physiological role in photosynthesis that has been attributed to it.

How seeds survive

Electron microscope studies are revealing how seeds survive desiccation.

Although many plants are adapted to survive under dry conditions, they do so mostly by preventing loss of water from their tissues. Relatively few plants can survive any degree of drying of their tissues. By contrast, many plant seeds can survive with a water content as low as 4% by weight. Some animals, too, including certain plant parasitic nematodes, can withstand desiccation for long periods.

To learn how some cells manage to survive with so little water, the DIVISION OF HORTICULTURAL RESEARCH has been using an electron microscope to examine the structural organization in cells of dry seeds and low-moisture forms of plant parasitic nematodes. By using the new technique of freeze etching, dry cells can be examined without prior treatment with chemicals dissolved in water. Picture 1 shows oil droplets in the tissue of an air-dry almond nut. The droplets are closely packed and distorted. Picture 2 shows droplets in air-dry almond nut tissue that has been put in water for a few seconds. The oil droplets are rounded and separated.



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Electron micrographs of tissue from almond nut after freeze-etching. **1**, Air-dry; **2**, after exposure to water. Both × 12,000.

The change occurs rapidly and whole seeds can be wetted and dried a number of times without affecting their eventual germination. The ability of seed tissues to resist complete desiccation can be explained by the formation by the packed oil droplets of a barrier that prevents the loss of residual water. Almost instantaneous changes in the oil droplets allow the re-hydration of the tissue when water becomes available once more.

Similar differences have been found between normal and low-moisture forms of some nematodes. These involve changes in the shape of oil droplets and in the thickness of the outermost fatty membrane of the nematode larvae.

New plants for the north

Two close relatives of the tropical legume Townsville stylo show considerable promise for improving pastures in northern Australia.

Research over the last ten years by the DIVISION OF TROPICAL AGRONOMY has demonstrated the valuable role that can be played by the legume Townsville stylo (*Stylosanthes humilis*) in increasing beef production in those areas of monsoonal northern Australia that have a rainfall of 60 centimetres or more a year. However, this work has also shown that Townsville stylo has some deficiencies as a pasture legume. It grows well on only a limited range of soils and heavy grazing of Townsville stylo pastures that have been fertilized with superphosphate is often followed by invasion of the pastures by undesirable annual grasses and weeds.

Nevertheless, Townsville stylo has been a considerable success in many areas of northern Australia, and this has encouraged pasture scientists to look for even better tropical legumes, particularly among those legumes belonging to the genus *Stylosanthes*. By the late 1960s a collection of several hundred *Stylosanthes*, collected originally from central and South America and Africa, had been assembled in Australia. In collaboration with State Departments of Agriculture in New South Wales, Queensland, and Western Australia, and with the Primary Industries Branch of the Northern Territory Administration, the Division has been testing and evaluating the *Stylosanthes* collection at a dozen different sites. This work has been backed by an intensive programme of glasshouse, laboratory, and field studies carried out by the Division's Townsville laboratory. The Division has also developed new mathematical methods for evaluating field results and for classifying the plant material.

The most promising varieties to emerge from these experiments are being tested on grazed pastures at widely different locations in Queensland. So far two selections have been quite outstanding. One of these is *Stylosanthes hamata* 38842. This plant appears to have all the virtues of Townsville stylo, with the added advantage that it is a perennial rather than an annual. In tests so far it has substantially outyielded Townsville stylo, particularly in the drier areas. *S. hamata* also grows on a much wider range of soil types than Townsville stylo. The other promising selection is *Stylosanthes subsericea* 38605 which has a number of features similar to *S. hamata* and which performs better on heavy soils.

These two selections came from material introduced in the mid 1960s. Much more material has been introduced in recent years as a result of intensive collecting in selected regions of central and South America and Africa and the Division is optimistic that even better lines will be found among this later material as the programme of testing and evaluation proceeds.

Fleece quality is skin deep

Owners of Merino studs may soon be able to make an early culling of breeding stock at weaning on the basis of wool follicle curvature.

A survey by the DIVISION OF ANIMAL GENETICS of vertical skin sections of Merino sheep has shown that some

An area of *Stylosanthes hamata* being grown for seed near Townsville.

Merinos have very straight wool follicles and some have very curved follicles. Most Merinos, however, have degrees of follicle curvature between the two extremes.

Experiments showed that degree of follicle curvature is highly inherited, and that measurements of follicle curvature made at weaning (four to six months of age) give an indication of the type of fleece produced later in life. Straight follicles were found to be correlated with smooth skin and with certain desirable fleece characteristics such as high clean scoured yield, high fibre density, long staple, and low fibre diameter. Although straight follicles produce finer wool, the number of crimps per inch is lower. At the other end of the scale very curved follicles produce more grease and have a strong tendency to be associated with wrinkled skin. The fleeces are generally less dense (fewer fibres per square centimetre) and the staple is likely to be short. In addition, the fibre diameter is higher although the number of crimps per inch is also higher.

A simple method of preparing vertical skin sections from which the degree of follicle curvature can be estimated has been devised. These sections can be prepared on the property and can be used by stud owners to make a skin survey of their breeding stock. The technique will allow stud owners to make a preliminary culling at weaning of rams with highly curved follicles since neither they nor their progeny are likely to produce fine, heavy fleeces. Final selection on a later fleece weight and average fibre diameter would, however, still be needed.

The Division has sounded a note of caution at this stage since sheep giving a very high clean scoured yield are susceptible to fleece rot, particularly in areas with high rainfall. In order to determine how far one can go in selecting straight follicles without running into this secondary problem, the Division has commenced a study of the skin glands that produce wool grease, the lack of which predisposes sheep to fleece rot.

Sex drive in rams is inherited

A simple test of libido (sex drive) may assist in stud ram selection programmes.

Sexual inhibition in young rams has not usually been recognized as a problem in Australia, but recent research by the DIVISION OF ANIMAL PHYSIOLOGY showed that in some strains of Merinos a number of apparently normal young rams are, in fact, sexually inhibited at the start of their first mating season. Though most begin to mate after a while, they remain unsatisfactory sires throughout their lives. In one instance, 44% of rams from a flock were found to be inhibited.

The results of early studies on ram libido were described in the 1970/71 Annual Report. Since then further research on factors controlling libido has been undertaken. The Division has also investigated the libido of rams in relation to flock fertility.

The new results indicate that after a ram is 18 months of age its libido remains relatively stable for several years at least. It cannot be appreciably increased by diet, shearing, or treatments with hormones such as testosterone or gonadotrophin. The ineffectiveness of hormone treatments is surprising because in the rams that were studied, the high-libido rams tended to have higher blood levels of testosterone than the low-libido animals.

An investigation was also made into the relative importance of heredity and the method of rearing. Rams that had been sired by either high- or low-libido rams were reared in the presence or absence of ewes. In normal husbandry, sexes are segregated before puberty and it was thought that this segregation might cause rams to miss an important conditioning to ewes. However, the method of rearing had no long-term effects on libido.

On the other hand, the type of sire had a significant effect. The sons of high-libido sires tended to have higher libido than those sired by rams with low libido. Furthermore, in pairs of rams matched for body weight and sire type, the ram with the higher libido of the pair usually had a higher daily sperm production than the lower-libido ram.

These findings suggest that a simple libido test could profitably be included in the ram selection programmes of studs. Selection of rams for working ability should increase flock fertility, particularly when the proportion of rams used is low, because rams with good libido cover more ewes, and also tend to produce more sperm.

Controlling worms in sheep

Control of worm infections by preventive drenching may be ineffective if drenched sheep continue to be exposed to large numbers of infective worm larvae on the pasture.

Moderate infections of sheep by round-worm parasites can reduce wool production by 30%. More severe infections can cause heavy mortality, particularly in young sheep.

The life cycle of round worms involves development on the pasture of eggs deposited in the droppings, through two larval stages to an infective third larval stage. Infective larvae migrate to the herbage where they may be eaten by the sheep and continue their development to the fourth larval and adult egg-laying stages. Essentially the numbers of infective larvae available on the pasture at any time determine the rate of infection of animals grazing it.

The DIVISION OF ANIMAL HEALTH has found that the free-living larval stages can survive in pastures for much longer than was previously thought. Infective larvae developing from eggs deposited on pasture in autumn are capable of prolonged survival over the winter and may still be available to infect host animals in the early spring. On the other hand, most of the free-living eggs and larvae are killed by lengthy periods of hot, dry weather in summer, a situation that can be exploited for control purposes in regions with a reliable summer drought.

Other studies in the Division have emphasized the importance of the relaxation of resistance to parasites that occurs in the lambing ewe. This relaxation may not only cause pre-adult larval stages undergoing a temporary stage of arrested development in the ewe to resume development, but also make the ewe much more susceptible to newly acquired infection by worms over the lambing and lactation period. The practical implications of these findings are being explored by the Division in the Western District of Victoria, at Armidale, New South Wales (in collaboration with the DIVISION OF ANIMAL PHYSIOLOGY), and at Canberra (in collaboration with the DIVISION OF PLANT INDUSTRY).

It is clear that in the past drenching with anthelmintic drugs has been practised much too often and not always at the most appropriate time for maximum benefit. It is also clear that there is little benefit to be gained from drenching, particularly in the case of lambing ewes and lambs at weaning whose level of resistance is likely to be low, unless the drenched animals are protected from immediate re-infection by movement to pastures that have been freed of gross contamination with worm eggs and infective larvae. In regions with a hot, dry summer, two drenches during summer when re-infection is minimal have proved more effective than several drenches during winter when most parasite transmission takes place. In areas with a wetter summer the production of clean pastures will have to depend more on other management practices and this will require some degree of forward planning. Pastures can be 'cleansed' of infective larvae by leaving them ungrazed, by grazing them with cattle, or by grazing them with drenched sheep. The practicability of these methods is now being investigated by the DIVISION OF ANIMAL HEALTH in collaboration with other CSIRO Divisions.

Immunity to worms in cattle

Immunity of cattle to certain intestinal worm parasites may be stimulated by an enzyme produced by the worms.

Worm infections in calves, particularly in the wetter coastal dairy areas of Australia, can cause the calves to lose 25–50 kilograms of body weight in their first year of life. The availability of a vaccine to protect calves during the early susceptible period in their lives before they have developed a natural immunity to worms would be a valuable aid to increasing growth rate and reducing deaths.

It is generally accepted that the substances which stimulate immunity to intestinal worms in the host animal are produced by the worms, but the antigens responsible for the stimulation of this immunity have been difficult to determine. Recent studies by the DIVISION OF ANIMAL HEALTH have indicated that some worm parasites contain an enzyme, acetylcholinesterase, which is secreted by glands in the worm and which may function as a protective antigen in the host/parasite relationship.

Studies have been concentrated on the nodular worm, a parasite in the large bowel of cattle, which secretes relatively large quantities of the enzyme. The acetylcholinesterase is located mostly in the excretory glands in the head region of the worm.

In attempts to protect calves against infection with the nodular worm, the excretory glands were removed from adult worms recovered from infected calves. The glands were homogenized and injected into susceptible calves two weeks before they were infected with worm larvae. It was found that calves which had received the injections became only lightly infected with the parasites while calves that had not been injected became heavily infected. Further efforts are being made to isolate and purify the substances in worm extracts that are responsible for inducing this immunity.

Cobalt deficiency in sheep

Research on cobalt deficiency in sheep has thrown new light on pernicious anaemia in humans.

Minute but regular quantities of cobalt are required by sheep and cattle to maintain their health. Cobalt is an integral part of vitamin B_{12}. This vitamin is produced in the digestive tract of grazing animals by micro-organisms. Humans have no such micro-organisms and must rely on their diet to provide them with the vitamin B_{12} they need.

The human disease of pernicious anaemia results from a vitamin-B_{12} deficiency, brought about by a constitutional inability to absorb vitamin B_{12} from the small intestine. Many of the effects of vitamin-B_{12} deficiency in experimental animals and humans, however, are attributable, not directly to the absence of vitamin B_{12}, but to an insufficiency of a second B vitamin, folic acid. An adequate supply of vitamin B_{12} seems to be necessary to ensure normal retention in the body of dietary folic acid.

For several years the DIVISION OF NUTRITIONAL BIOCHEMISTRY has been using vitamin-B_{12}-deficient (cobalt-deficient) sheep to study the mechanism by which the two vitamins interact. Recent results indicate that the active transport of folic acid into body cells depends upon an adequate supply of the amino acid methionine. Since vitamin B_{12} is essential for the synthesis of methionine, a deficiency of vitamin B_{12} in the diet could produce a methionine deficiency which would in turn interfere with the uptake and retention of folic acid by the cells of the body. This finding has led to a better understanding of cobalt deficiency in sheep and of pernicious anaemia in humans.

Outsmarting the flu virus

Basic research on the genetics of viruses has led to the development of a new influenza vaccine which, it is hoped, will prove effective against any influenza strains that arise between now and 1978.

The influenza virus is surrounded by a coat of protein. When a person becomes infected by the virus, certain chemical groupings on the protein coat are recognized as non-self, that is they stimulate the production of antibodies in the infected person's body. These antibodies combine with the protein coat at the antigenic sites and inactivate the virus. Moreover, the antibodies remain in the body and render the person immune for life against any further attack by that particular strain of influenza virus.

The antibodies are highly specific and if the protein coat of the virus is altered slightly the virus is able to escape their lethal attention: antibody production to the 'new' virus has to begin all over again. Vaccination, which aims at stimulating the body's production of antibodies, has been of limited success so far in preventing influenza because of the disconcerting frequency with which the influenza virus has been able to outwit the vaccine by changing its protein coat.

The Pasteur Institute in Paris has developed a new type of influenza vaccine which may be able to anticipate changes in the influenza virus and provide protection against any new strains that arise in the next few years. The vaccine has been developed as a result of a theory put forward by Dr. Stephen Fazekas de St Groth of the DIVISION OF ANIMAL GENETICS. This theory arose out of his basic research on virus genetics and the evolution of viruses. He had selected the influenza virus as a convenient organism for use in this work.

The commonly held view among scientists was that the protein coat of the influenza virus was a mosaic of the different alternative antigens, each of which could stimulate the production of an antibody specific to itself. If such a theory were correct, one would expect new antigens to arise at random in an unpredictable manner. However, research by Dr. Fazekas demonstrated that the virus coat contains one type of haemagglutinating antigen, and that infection with a particular strain of influenza virus will stimulate the production of an antibody specific for only one type of antigen.

Dr. Fazekas then classified influenza viruses according to their antigenic properties, that is, by comparing their reactions with antibodies raised against a representative set of viruses. He showed that they fall into groups (subtypes). Relationship within subtypes is close, between subtypes distant. In the past, new subtypes have arisen every 10 to 15 years and have been responsible for major epidemics such as those of 1933, 1946, 1957, and 1968 (Hong Kong). Dr. Fazekas also showed that within any one subtype these strains can be ranked in a kind of immunological pecking order. The strain at the top, the most senior strain, can stimulate the production of an antibody that is effective against all strains in the same subtype. The next most senior strain stimulates the production of an antibody that is effective against that strain and against all other strains in the subtype that are junior to it, but not against the most senior strain. Finally, one reaches the most junior strain whose antibody is effective only against that one strain and is ineffective against all other strains within the same subtype. In nature, new subtypes always emerge in their most junior form and evolve towards senior forms.

Calculation suggests that each antigenic site on the influenza virus particle consists of 10 to 12 amino acids. According to Dr. Fazekas's theory a new strain of a subtype is formed when a genetic mutation results in the substitution of one of these amino acids by a different amino acid. Moreover, replacement of one amino acid by a bigger and bulkier one gives rise to a more senior strain while replacement with a smaller amino acid gives rise to a junior strain.

Although mutations occur at random, the phenomenon of seniority will ensure that, in the presence of antibodies resulting from a previous epidemic, natural selection will favour the emergence of new influenza strains in a predictable sequence so that each emergent strain is senior to its predecessor. When no more antigenic changes are possible, that is when the most senior strain has emerged, natural selection will force the emergence of an entirely new subtype against which existing antibodies are ineffective.

In order to test the theory Dr. Fazekas developed a technique of incubating influenza virus in serum containing hostile antibodies. This enabled him to imitate the process of virus evolution in the laboratory at a rate ten times faster than occurs in nature. Laboratory strains produced in this way were subsequently compared with the virulent new field strain that emerged in Europe during the severe influenza epidemics of 1971–72–73. The laboratory strains were found to be senior to the field strains, so confirming the validity of the theory.

The theory, which was published in the scientific literature in 1969 and 1970, has provoked considerable controversy and has not yet gained wide acceptance among scientists; nevertheless, the Pasteur Institute in France has collaborated with Dr. Fazekas in his influenza work and developed a vaccine based on senior virus strains isolated in the laboratory. The French vaccine, which went on sale in France early in 1973, is expected to be effective until at least 1978 when, according to the theory, a new influenza subtype is due to emerge.

The Pasteur Institute has applied for a patent on its vaccine production process. However, in recognition of the pioneering work carried out by Dr. Fazekas, the Institute has offered to share royalties with CSIRO on the basis of 25% to CSIRO. In addition, vaccines sold in France will be royalty-free. CSIRO will have exclusive rights in Australia and the right to sublicense Australian manufacturers.

It now remains to test the theory of influenza virus evolution and to determine whether it is possible to devise techniques of breeding a new subtype from an existing one. If the theory is correct, there should be six or seven subtypes of which four are already known and exist in laboratory cultures. It should then be possible to induce the remaining two or three subtypes in the laboratory; once their senior strains had been bred up, a vaccine could be produced that would be effective against all possible influenza viruses.

White-tailed black cockatoos

Studies of the white-tailed black cockatoo, a pest of Western Australian forests and orchards, have shown that there are two distinct types of this bird.

In the south-west area of Western Australia the white-tailed black cockatoo (*Calyptorhynchus baudini*) is regarded as a serious pest of both pine plantations and apple and pear orchards. In the pine forests the cockatoos have been held responsible for eating much of the seed crop. Moreover, by nipping off the terminal shoots they also destroy the symmetry of the pine trees.

Some years ago, the DIVISION OF WILDLIFE RESEARCH with the assistance of the Western Australian Department of Forests began a long-term study of the birds with a view to developing an effective means of control of the bird population in those areas where they can cause damage. This work has shown that there are in fact two very distinct types of birds, not one as was previously thought. The two types have different habits and it is considered that they may even be different species of the white-tailed black cockatoo.

The major difference between the two is that one bird has a longer bill and a slightly longer wing than the other. The long-billed cockatoo is found in the heavily forested south-west corner of the State, to the south-west of a line from Perth to Albany. The short-billed type is found to the south-west of a line from Geraldton to Esperance. Collections will be made during the next breeding season in an attempt to clarify the breeding distribution of the two types.

Studies of food preferences have shown that the long-billed birds eat mainly *Eucalyptus calophylla* (marri) seeds and insect larvae found under the bark of some trees while the short-billed cockatoos concentrate on pine seeds and seeds from Proteaceous shrubs which have small, hard seed-pods. Analysis of birds shot in apple and pear orchards reveals that the damage to those trees is caused exclusively by the long-billed type. Orchardists maintain the trouble is at its worst when the marri fruit crop, their native food, is poor.

Before any control experiments can be commenced, further detailed data on the breeding distribution and behaviour, flock interaction, and movement of both types need to be assembled and studied.

Set a mite to catch a mite

A predatory mite has been imported from North America to control two important pests of Australian orchards—the two-spotted mite and the European red mite.

The two-spotted mite (*Tetranychus urticae*) is a pest of apple, pear, and peach orchards in mainland Australia. The European red mite (*Panonychus ulmi*) is a pest of apple and pear orchards in Tasmania. These mites feed mainly on the under-surface of leaves, causing bronzing and premature leaf-drop, and this reduces the yield and quality of the fruit. Satisfactory control of the mites is becoming more difficult and more costly because they have developed resistance to the commonly used organophosphorus insecticides.

Ecological studies of these mites by the DIVISION OF ENTOMOLOGY have shown that in situations where no insecticides are used the mites are kept in check by a variety of natural enemies, the most important being a group of small black ladybird beetles known as *Stethorus*. In commercial orchards, where organophosphorus insecticides are used for controlling pests such as the codling moth, the black ladybird beetles and other natural enemies succumb readily even to minute traces of insecticide. On the other hand, the mites, because of their resistance to the insecticides, remain relatively unaffected and are free to increase in numbers and reach pest proportions.

In order to combat this problem, therefore, the Division has introduced another mite, *Typhlodromus occidentalis*, which is predatory upon both the two-spotted mite and the European red mite. The introduced mite comes from a special strain that has been found in North American orchards and is resistant to organophosphorus insecticides. The mite has been established in a commercial orchard in Canberra and has successfully controlled the two-spotted mite in spite of repeated applications of azinphosmethyl and other organophosphorus insecticides.

Experimental releases of the predatory mite have now been made in small blocks of apples throughout mainland Australia and Tasmania so that its usefulness under different climatic conditions can be evaluated.

Protecting stored grain

The storage of grain in inert atmospheres may become an important method of protecting grain against attack by insect pests.

Concern over pesticide residues in foodstuffs and the increasing resistance of insect pests to the few insecticides that are permitted in international trade has led to a new look at an ancient method of preventing insects from attacking stored grain. The method is to deprive the insects of oxygen, an essential requirement for their survival.

Airtight storage of grain is one effective application of this method. The respiration of the insects and of the grain soon depletes the oxygen present in the intergranular air. However, on a commercial scale it is an expensive proposition to produce storage structures that are sufficiently airtight for this purpose.

An alternative approach, being investigated by the DIVISION OF ENTOMOLOGY, involves purging out the air with gases such as nitrogen, or a mixture of carbon dioxide and air. The gases are taken to the silos by road transport and passed through a heat exchanger to a distribution system at the base of the silos. The gas then moves upwards as a front through the grain, displacing the air in the process. Large welded silos holding more than a quarter-million bushels of wheat have so far been used and trials are now being extended to vertical concrete silos.

Since insects may take some time to die in a low-oxygen atmosphere, the method would be most useful in country areas where the bulk of Australia's grain is stored and where the grain is held for long periods. Further trials are aimed at assessing the feasibility of the process when applied on a large scale.

Insect chemistry

Studies of the chemistry of insects add to the knowledge that helps to keep insect pests under control.

The DIVISION OF APPLIED CHEMISTRY is working towards understanding how certain compounds attack the nervous systems of insects. With this knowledge, chemists may be able to 'build' insecticides with controlled potency, specificity, and persistence.

To this end, work is continuing on the synthesis and testing of insecticides that are comparable with DDT in toxicity to insects but of low toxicity to humans and animals. In collaboration with the Department of Zoology of the University of New South Wales, CSIRO scientists have developed a technique to test the nervous responses resulting from the application of a particular insecticide to the taste receptor of a house fly. The size of the structural components in a molecule of the insecticide under test has been correlated with the nervous responses of the fly and with the potency of the insecticide.

In another project, several aspects of the biochemistry of insect hormones are being investigated by the Division in collaboration with the Department of Genetics at the University of Melbourne.

Moulting hormones play an important role in insect growth and development. The amount of these hormones in an insect is extremely small, but their importance to the development of the insect is so great that scientists are studying their production within the insect larvae with a view to a greater understanding of the insect's growth. The origin and development of the hormones have been traced by injecting blowfly larvae with radioactive compounds and analysing the products formed during moulting.

Tracking ocean buoys by satellite

Instrumented buoys that can be tracked by satellite are providing valuable information on ocean currents around Australia.

The DIVISION OF FISHERIES AND OCEANOGRAPHY has begun a programme to develop techniques that will allow it to make use of earth-orbiting satellites in oceanography. Already it has made use of the American satellite, Nimbus III, to trace the fluctuations of the East Australian Current. At the end of 1972, the Division began a series of experiments in cooperation with the French space organization, Centre National d'Études Spatiales (CNES), using one of the Centre's transponders. This was mounted on a floating buoy and then set adrift in the Tasman Sea and tracked by the French EOLE satellite.

The buoy carried instruments to measure the temperature of the water at the surface and the temperature of the air. Each time the satellite passed over the buoy it picked up the environmental data broadcast by the transponder and relayed them to France. The information, together with the exact position of the buoy on its ocean drift, was sent back to the Division.

The CSIRO buoy, carrying the French transponder and working to the French satellite, was released 50 kilometres east of Cronulla and was locked into the East Australian Current by a sea anchor. Before the transmission ended 33 days later, the buoy had drifted for 1500 kilometres. The information it sent out showed that its track in general agreed with the qualitative estimates of current flow made from data collected by ships and an aircraft-borne infrared sensor.

Four months after its release, the buoy was washed ashore in northern New South Wales with its sea anchor missing. The buoy itself and the transponder, though, were still intact and can be used again. A second buoy was released in the Tasman Sea in April 1973 and a third one in the Indian Ocean in July 1973.

It is planned to relase 10 buoys off Western Australia late in 1974 to study currents that carry western rock lobster larvae in their planktonic form up to several hundred kilometres out to sea and back. This will be a cooperative venture with the United States National Aeronautics and Space Administration.

Polyunsaturated meat and dairy products

A wide range of meat and dairy products with a high proportion of polyunsaturated fatty acids has been produced from sheep and cattle fed a protected oilseed supplement.

The DIVISION OF ANIMAL PHYSIOLOGY and the DIVISION OF FOOD RESEARCH, in collaboration with the Ellinbank Dairy Research Station of the Victorian Department of Agriculture, have expanded the research reported in last year's Annual Report into production of polyunsaturated meat and dairy products. These products are obtained by feeding cattle and sheep a supplement with a high proportion of polyunsatur-

Pied heron and water buffalo—two of the wildlife species being studied in northern Australia by the DIVISION OF WILDLIFE RESEARCH. At present little is known about what part of Asia the pied heron migrates from or what route it takes on its way to Australia. Nor is anything known about what exotic diseases, if any, the heron can carry to the buffalo or to domestic cattle. Much more also needs to be learnt about the buffalo before it can be determined whether the buffalo is a pest or a valuable resource well adapted to land that is useless to other cattle.

ated fats that have been protected against the saturating action of the bacteria in the rumen. The supplement consists of a powder composed of minute globules of sunflower-seed oil clad in a skin of protein hardened by formalin treatment. After passage through the rumen, the protected polyunsaturated oil is released in the small intestine and absorbed into the tissues of the animal.

It is now possible to produce a new range of food products of more than 20% polyunsaturation. By replacing conventional food products from cattle and sheep, these foodstuffs could permit a significant increase in the levels of polyunsaturation in the diet of man. The milk may be better for infant feeding than that of cows fed a conventional diet as the fats in it more closely resemble those of human milk.

The Department of Clinical Science at the Australian National University, Canberra, has confirmed that diets containing polyunsaturated meat and dairy products in place of conventional products lower the blood cholesterol level in man.

The changed chemical and physical properties of the new types of food will allow considerable diversification of food products derived from ruminant animals, particularly in the dairy industry. For example, it will be possible to produce a more easily spread butter, or lamb that does not have the strong mutton flavour that some consumers dislike. These products may be achieved at a level of polyunsaturation lower than that necessary for modifying the diet on medical grounds.

The high level of polyunsaturation in the milk produced by the protected lipid process does make it more liable to attack by oxygen, resulting in the production of oxidized flavours described as cardboardy, nutty, or oily. This oxidation can be controlled by the addition of anti-oxidants. Those used are the ones currently permitted as additives to a number of food products. A change in the relevant Acts would be required to permit the addition of anti-oxidants and their carriers to dairy products before such products could be put on the market. No such change is likely to be required for meat, as preliminary evidence shows that meat does not suffer the same problem of oxidation.

So that the research findings could be translated into commercial practice, CSIRO advertised for a collaborator in the development and commercial production of polyunsaturated meat and dairy products.

Dalgety Agri-Lines Pty Ltd was selected from many international and local applicants because of its expertise and experience in feed-supplement manufacture, animal production, and food processing, marketing, and merchandizing. The company and its associates are pursuing development programmes in Australia and in other countries.

Carbohydrate-free milk for infants

Research has led to a concentrated milk formula that can be digested by children who must avoid the carbohydrate normally found in milk.

The Royal Children's Hospital in Melbourne contacted the Dairy Research Laboratory of the DIVISION OF FOOD RESEARCH about the need for a local supply of carbohydrate-free foods for infants and young children whose intolerance of carbohydrate, particularly lactose, could aggravate gastro-enteritis.

Initially, infants depend solely on milk for their food. In the past, hospitals have tried to replace the milk fed to carbohydrate-intolerant infants with an imported protein substitute at considerable cost.

The Dairy Research Laboratory has developed a carbohydrate-free sterile liquid concentrate, called CF1, which is based on milk protein and milk fat. Sufficient vitamins and minerals are included to supply the full daily requirements of infants fed on milk alone. Hospital trials to date have shown that the infants and children find the new product quite acceptable.

Further development is taking place in collaboration with the Nestlé Company (Aust.) Ltd.

Rats help food research

Rats are being used as natural detectors in studying flavour components in food. The result could be a clearer understanding of flavour changes during food processing.

Flavour chemists can use the latest instrumental techniques to identify several hundred volatile chemical compounds that could contribute to the flavour of a food.

By using their noses and the instrumental detectors they can reduce the number to perhaps a score, or even less, compounds which make up the over-all flavour pattern. Each compound contributes its own particular nuance or 'note'.

At this point, scientists engaged in flavour research run into problems of not understanding the way the compounds combine their individual effects and not completely knowing the precise mechanism of the human sense of smell.

The DIVISION OF FOOD RESEARCH is collaborating with Macquarie University to find out whether animals can be used as natural detectors to further our knowledge of the sense of smell.

The use of rats as suitable animals for comparison with humans has met with some success. An 'olfactometer', an apparatus that delivers known amounts of odour compounds in air direct into the rat's nose, has been developed.

By studying the behaviour of the rats on receiving an odour, the scientists have found that rats and humans have a similar sensitivity to smell. The rats can also distinguish between odours by their quality. For instance, they are able to choose easily between 'almond-like' and 'fruity' aromas. With more difficulty, they can also differentiate between two almond odours which human subjects found similar.

Now rats are being used to study how the presence of one flavour component affects another in a mixture and how this will influence the final effect on the human taster.

Australian abalone

Research is helping the rapidly growing abalone export industry.

In the last ten years the abalone industry in Australia has grown to be worth approximately $9 million a year.

Although abalone is seldom eaten locally, there is a ready market in Japan and South-east Asia. The bulk of Australia's catch of abalone is sold, either canned in brine or frozen in blocks, to Asian buyers, although some has been successfully air-freighted live to Japan.

The Tasmanian Food Research Unit of the DIVISION OF FOOD RESEARCH was approached in the early sixties by exporters to look into certain quality problems of the industry. Since then the Division has carried out a comprehensive programme of research not only into the handling and processing of abalone but also into the industry's marketing practices. The research effort was intensified in 1971 with the aid of a two-year grant from the Fishing Industry Research Trust Account.

Studies of the basic biochemistry and physiology of the abalone have led to changes in processing. For example, it was established that the quality of frozen abalone was improved by completely draining the abalone of blood before freezing. Again, it was found that the rate of thawing from the block is more important in terms of quality than the rate of freezing.

Market studies suggest that both dried and live abalone will be more profitable than abalone canned or frozen. The Division, in conjunction with the University of Tasmania, has therefore been studying drying processes and has experimentally produced two forms of dried abalone that show promise.

The research programme to date has enabled the Division to advise abalone processors on improvements to colour, texture, and yield and on the maintenance of quality between catching and processing. A code of practice suggested by the Division has been adopted throughout the industry.

Sounding wool fineness

Instruments that measure the mean diameter of wool with sound waves have been developed to a commercial stage.

Fineness is the most significant single attribute of wool, controlling spinning performance and fabric handle and largely determining price.

Merino fleece fibres range from about 18 to 25 micrometres in diameter, and on typical prices each increase in fineness of 1 micrometre adds 6 cents per kilogram to the value of clean wool. Subjective assessment of fineness is difficult and inevitably relative; certainly a judgment to 1 micrometre is impossible, hence the importance of having objective measurement by instruments.

Instruments that measure wool diameter with sound waves have been devised by the DIVISION OF TEXTILE PHYSICS of the CSIRO Wool Research Laboratories and developed to a commercial stage in cooperation with Paton Industries Pty Ltd.

Sonic fineness testers are available in two models. Model A is intended for use by test houses and research laboratories, while model B is a portable instrument for brokers, wool-classers, and stud breeders.

In both models of the sonic fineness tester, a small loud-speaker generates a sound wave which is passed through a chamber containing the wool sample. A transducer on the other side of the chamber gives an electrical signal, the strength of which depends on how much the wool has attenuated the sound. The attenuation depends on the diameter of the wool. A metering circuit indicates the strength of the signal, and hence the fineness.

Model A has been tested by the Australian Wool Testing Authority and approved by the Standards Association of Australia as a recognized fineness testing method. In association with the International Wool Textile Organization, European laboratories are testing and evaluating the instrument, and approval as a test method for issuing international fineness certificates is expected.

The digital output of model A will enable future adaptation to automatic print-out or computer processing of numerous test results.

Model B has been field tested by eight potential users in New South Wales, Victoria, and Western Australia. Woolgrowers, brokers, and Department of Agriculture extension officers all reported favourably on the performance of the instrument.

Shrinkproofing improvements

Wool processing could be made easier by a new water-soluble shrinkproofing agent that can be applied to wool without a preliminary chlorine treatment.

Wool fabric is shrinkproofed by coating the fibres with a thin layer of certain polymers. The coating is applied to the wool fibres in the form of partly polymerized material either dissolved in organic solvents or emulsified in water.

Later the wool is heated to cure the polymer which forms an insoluble, flexible film on the fibres and prevents shrinking during washing.

It is easier and cheaper to handle the shrinkproofing agent in an aqueous system but in the past the agents that could be used with water were successful only if the wool had been given a preliminary chlorine treatment.

A group of polymers known as polyisocyanates are effective shrinkproofing compounds for which no preliminary chlorination treatment is necessary. However, polyisocyanates cannot be applied from aqueous systems because they react very rapidly with water. Even when dissolved in organic solvents they must be used under water-free conditions.

Following some earlier German work, the DIVISION OF PROTEIN CHEMISTRY has found that polyisocyanates can be combined with sodium bisulphite to give a product that is water-soluble and can be stored in aqueous solution. Experiments by the Division established the curing conditions that would obtain the best performance from the new shrinkproofing agent.

The process is being developed by the DIVISION OF TEXTILE INDUSTRY. The Division has found that the process provides wool fabric with excellent shrink resistance which is stable through repeated launderings.

Purifying scouring liquors

Methods of overcoming problems associated with the effluent liquors discharged after wool has been scoured are being investigated.

An average of 1000 kilograms of contaminants, including grease, burrs, and dirt, is contained in every 17 bales of raw wool. Most of this is removed during the scouring process in which the wool is washed with detergent and rinsed with water. The wool moves on for further processing leaving an effluent that is difficult and expensive to treat. The DIVISION OF TEXTILE INDUSTRY is investigating methods of reducing this problem.

Tests by the Division in collaboration with industry have resulted in the selection of three biodegradable detergents suitable for scouring in terms of cost, scouring efficiency, and ease of handling. These are now being used by the industry to replace detergents that are not biodegradable.

The Division is also studying flocculation and biological oxidation methods of treating effluent. Trials of these methods have been conducted in pilot plants in the Division and nearby mills. Early results indicate that grease can be more readily broken down in biological systems than had previously been recognized.

Research is continuing into the basic scouring process itself. By modifying the process, it might be possible to produce an effluent that is easier to purify.

Using more of the tree

Processes to use the bark from certain trees in paper-making or as a base for adhesives are being investigated.

One way of conserving forest resources is to use more of the bark of each tree that is cut down. Research has shown that the bark of some young eucalypts can be pulped with the wood, to make paper. In addition, extracts from the bark of radiata pine are currently being tested as a base for adhesives in timber board products.

Bark is one of the major forestry residues. Whereas wood offcuts from saw-mills can be converted to wood chips for the production of paper pulp, the leaves, twigs, roots, sawdust, and bark are often discarded and contribute to pollution problems. It is estimated that in Australian forests only about 20% of a tree's substance is used at present. In the Forest Products Laboratory, the DIVISION OF APPLIED CHEMISTRY and the DIVISION OF BUILDING RESEARCH are investigating processes to reduce this waste.

The regrowth that usually comes from older roots after a eucalypt is cut down is called coppice and is of special interest, because many species of eucalypt that regenerate in this way have often been found to grow more quickly and more prolifically when young than trees grown from sowing or planting.

The DIVISION OF APPLIED CHEMISTRY has shown that logs from the fast-growing young coppice of manna gum up to an age of 6 to 8 years can yield satisfactory pulp without the bark being removed.

The rapid coppice growth of certain selected eucalypts can be enhanced with suitable fertilizer treatments. This opens up possibilities of intensive cultivation of short-term-rotation forest crops close to a pulp mill, which would reduce haulage costs for pulpwood.

The DIVISION OF APPLIED CHEMISTRY is collaborating with a commercial company and with forest authorities to assess the pulp and paper-making qualities of coppice and seedling material from other smooth-barked eucalypts.

Another important tree that grows fast in Australia is radiata pine. Work in the DIVISION OF APPLIED CHEMISTRY shows that the bark of this species contains chemicals that are valuable as a base for wood adhesives. The DIVISION OF BUILDING RESEARCH has developed adhesives from the bark extracts for bonding particle-boards, wood-boards, and timber laminates. The trials to date have been sufficiently encouraging for the Divisions to undertake joint surveys of bark extracts from various radiata pine plantations.

Putting the Sun to work

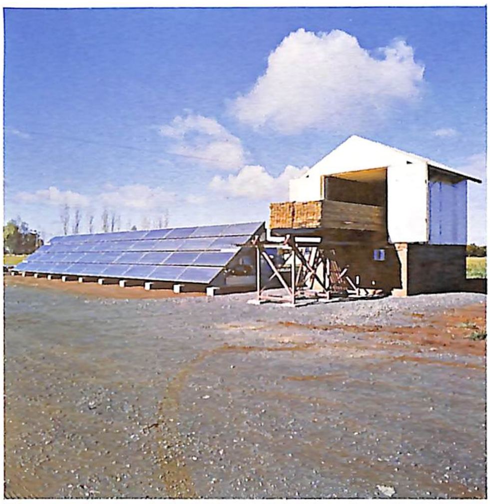
The production and use of low-grade heat from solar energy is being studied using a timber-drying kiln.

As part of its programme of research into the use of solar energy to produce low-grade heat for domestic and industrial use, the DIVISION OF MECHANICAL ENGINEERING has designed an experimental timber-drying kiln at Griffith, New South Wales.

The kiln is fuelled by sunshine striking corrugated panels inside which air is heated and ducted into the kiln which contains the timber to be dried. The air is then either returned to the absorbing panels for reheating or circulated through a rock-pile which stores up heat underneath the kiln. Heat collected in the rock-pile during sunny periods can be used during the night or during cloudy periods.

Humidity is controlled in the kiln by wall vents operated automatically at a predetermined moisture level.

Results indicate that timber can be dried successfully by this process. Experiments are continuing so as to obtain a better understanding of the over-all operating characteristics of the kiln.



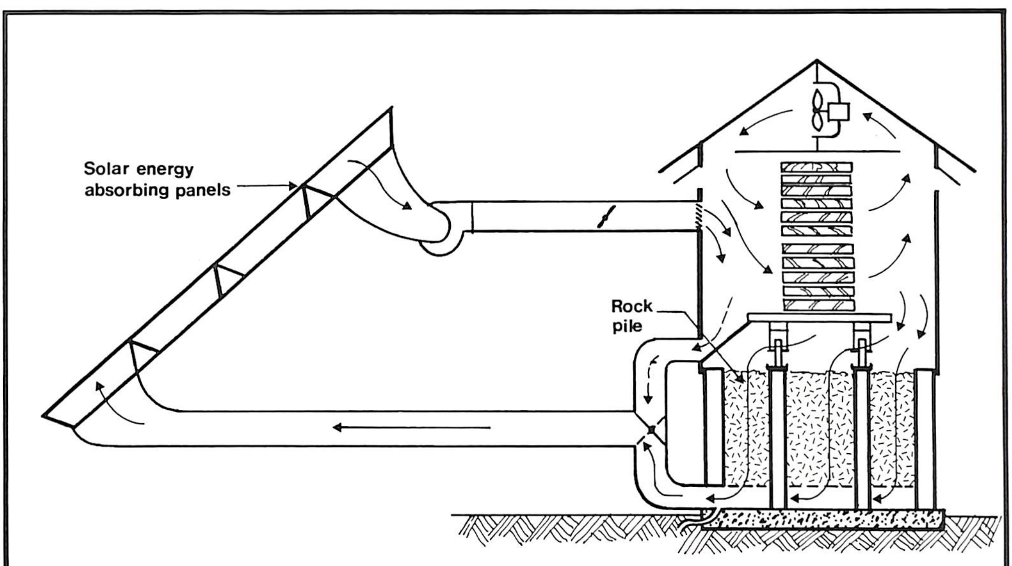
Melbourne underground

Simulation studies using physical models will provide design information for the construction of Melbourne's underground railway loop.

The Melbourne underground railway loop is a major engineering project involving the driving of two miles of tunnels and the construction of three underground stations beneath the central city area.

The design of the underground openings and rock supports is of major importance, involving problems of ground surface stability and prediction of surface subsidence. The difficulties are accentuated by the complex geology of the area and the presence of weak, weathered rock.

A considerable amount of research has been carried out on the stability of excavations at large depths, such as mine shafts, but up to now little has been done on the relatively shallow depths at which the Melbourne tunnel will be driven.



Scientists from the DIVISION OF APPLIED GEOMECHANICS and the University of Melbourne are providing design information for the construction of the loop. They will use physical models of the underground structures for simulation studies. A model of the tunnel, constructed from plastic, when loaded and illuminated by polarized light reveals the magnitude and location of stresses as a pattern of bands. Construction procedures can be simulated and the resultant deformations observed at each stage.

When construction begins, observations will be made of loads, stresses, and deformations, and the results compared with theoretical predictions made from the models. This procedure will improve the accuracy of further predictions that will be used to design later construction.

Living way out

A research team is trying to discover the conditions needed to increase permanency of residence in remote areas.

As the minerals and other industries have developed, opportunities for employment have occurred at many places in tropical Australia, and a great deal of money has been invested in local communities. There is, however, a high rate of population turnover throughout the remote tropical regions.

The Remote Communities Environment Unit of the DIVISION OF BUILDING RESEARCH is investigating a number of aspects of living in remote tropical communities, including community facilities, economics, and the effects of isolation. The studies are to assist town and regional planners, architects, and company executives design a more pleasant environment.

The Unit has conducted surveys at Newman, Dampier, Kununurra, Mount Isa, and Katherine; these towns cover a wide range of characteristics such as age, size, proximity to coast, mining or agricultural base, arid or humid climate, company town or not. The major aim was to ascertain from the residents which aspects of their living patterns were thought to be the most important, and whether the present environment was regarded favourably or unfavourably with respect to each of these. Occupiers of randomly selected houses in each town were invited to participate in the study. One per cent of householders in the larger town of Mount Isa were interviewed and ten per cent in the other towns.

Attitudes to living in the community were elicited by a questionnaire containing incomplete statements such as: 'living here would be ... if it wasn't for ...' and 'I wish it wasn't so ...'. The questionnaire was designed to avoid suggesting that any aspect of life was more important than another, or that any of the living conditions were good or bad.

The replies were classified into various categories and viewed against an impartial description of what exists in the town. A profile of each town was compiled that included information on the size and composition of the population, economic base, services and utilities, climatic data, community facilities, town administration, and other pertinent facts. The significance and unfavourability the community attributed to each aspect of life could then be determined. Since many factors may work together to determine a particular preference, computer techniques and mathematical models are being developed to rapidly evaluate, in terms of these aspects, the ultimate worth of many possible changes to different parts of the system.

Measurement in 3D

Problems of measurement in engineering are being studied using lasers to create three-dimensional images.

A hologram is a photographic transparency which provides a three-dimensional image when illuminated with a laser. There are many applications of holograms in the fields of non-destructive testing and engineering metrology, because they can be used to detect any changes in the shape or size of an object.

A hologram is made of the object in its original form. If a second hologram of the same object after alteration is made on the same transparency, any change in shape can be seen as a pattern of interference fringes on the object's surface.

The DIVISION OF APPLIED PHYSICS has developed techniques for using holograms in three-dimensional metrology applications. For instance, the swelling of concrete due to water absorption can be measured precisely using holograms made before and after swelling.

The swelling of a concrete block when it has absorbed water can be seen in the hologram as a series of fringes on the surface of the block's three-dimensional image. These fringes are then used as a precise scale for measurement of the concrete deformation.

Two aspects of this work, which is being carried out in collaboration with the School of Civil Engineering, University of Sydney, are of particular importance to the users of concrete in civil engineering practice. One is that the cement and aggregate materials from certain places may contribute to excessive deformation; the other is that both reinforced and prestressed concrete are particularly affected in many structures by changes in humidity.

Cleaning the smoke from power stations

A new agglomerating agent has been found which could lower the cost of equipment for removing dust from the smoke emitted from power station chimneys.

Over 33 million tonnes of coal are now burnt each year in Australian power stations and nearly 3 million tonnes of incombustible ash are left. Most of this is a fine dust called fly-ash, which can be used as land-fill and in some building materials.

The power stations are provided with equipment called electrostatic precipitators, which remove a large proportion of the fly-ash from the smoke before it enters the chimney.

The DIVISION OF MINERAL CHEMISTRY has been clarifying the factors that determine the performance of electrostatic precipitators. The Division has designed combustion and precipitation equipment that duplicates the formation and collection of fly-ash in actual power stations.

In past years, it was widely believed that the efficiency with which fly-ash was collected from the burning coal smoke was related to the sulphur content of the coal. Experiments using the laboratory-designed electrostatic precipitator showed, however, that collection efficiency, which varies from below 85% to over 99%, depends on the size of the particles of fly-ash as they enter the precipitator. The Division, therefore, looked for some way of agglomerating the finest particles of the fly-ash before it enters the precipitator.

Adding to the smoke a very small amount of an organic compound that acts as an agglomerating agent gave a remarkable improvement. For one coal from the fields south of Sydney, the catch of fly-ash in a precipitator was raised from 84% to 99·7%; that is, the dust in the smoke was reduced to less than a fiftieth of the amount emitted when no additive was used.

Regulations under the various State Clean Air Acts set upper limits for emission of dust from chimneys such that the electrostatic precipitator in a power station usually needs to collect over 99% of the fly-ash.

The development of the new additives means that a precipitator of a particular size and cost can be given increased efficiency to cope with different coals of higher ash content. Alternatively, the precipitator for a proposed power station can be kept smaller and therefore less expensive because its efficiency can be improved by the additive.

Observing gas molecules

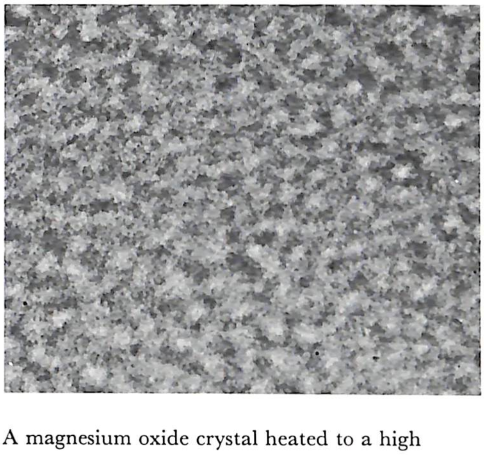
It is now possible to see, through an electron microscope, the actual gas molecules adsorbed on a surface.

When a gas encounters a solid surface it either bounces or sticks to that surface—the process of adsorption—or passes into the solid—the process of absorption. Adsorption of a gas is important in many industrial contexts, for instance the petrochemical industry, where chemical reaction is promoted by adsorption on a catalyst.

The DIVISION OF CHEMICAL PHYSICS is developing a method of observing by transmission electron microscopy individual gas molecules adsorbed on a solid surface. This will enable closer study of adsorption mechanisms.

Scientists in the Division recognized that most crystal surfaces have minute steps of molecular size which make it impossible to distinguish through an electron microscope whether or not gas molecules are adsorbed. Investigations showed, however, that certain crystals of magnesium oxide grew as plates with their major surfaces perfectly flat. These crystals have enabled the gas adsorption process to be studied directly through an electron microscope for the first time.

The plate-like, defect-free crystal of magnesium oxide is mounted in a specially designed manipulator and placed in a high-resolution electron microscope that has been modified to provide a clean enclosure. The crystal is heated to a temperature high enough to remove adsorbed gases and then slowly cooled to the point where gas molecules can just be re-adsorbed. The growth of the adsorbed layer can be followed from a few molecules to a complete coverage.



A magnesium oxide crystal heated to a high enough temperature to remove adsorbed gases (*top*) and cooled until it is completely covered with gas molecules (*bottom*).

Coal seam studied

A study of the Bulli coal seam, in southern New South Wales, could provide a basis for future management of the region's coal resources.

During the past three years, the DIVISION OF MINERALOGY has conducted a survey of the Bulli coal seam which is the most important source of coking coal in the Southern Coalfield of New South Wales.

Detailed examination and measurement of the seam have enabled scientists to understand its regional characteristics sufficiently to predict patterns of variation over wide areas, including those where there was little information available from exploratory drilling. The variations in coking qualities that occur within the seam were investigated to see how coals with uneven quality could best be blended or upgraded to meet industry standards.

The Division demonstrated that normal specifications could be met using coal with varying coking qualities from the poorer parts of the seam. It could be either blended with better coking coal or crushed and screened to extract the fraction with better coking qualities.

Activated carbon from local char

Low-price, high-quality activated carbon with applications in pollution control can now be made locally from brown coal.

Three grades of high-quality activated carbon are now being manufactured from brown coal. The cost of the material, produced locally in the granular form for the first time on a commercial basis, is about half that of similar carbons currently available in Australia.

Activated carbon is used as an industrial filter to clarify dry-cleaning fluids and industrial water supplies and to remove gaseous pollutants and odours from gas streams.

The DIVISION OF CHEMICAL ENGINEERING had found in experiments designed for other purposes that brown coal char possessed some purifying properties. The manufacturer of the char, Colonial Gas Holdings Limited, who had been using the char to remove pollutants from water, confirmed this fact and the Division suggested to the company the possibility of preparing activated carbon from the brown coal char.

A series of experiments were done jointly by the Division and Colonial Gas Holdings. These were successful and led to full-scale trials. It was found that it is possible to produce high-quality activated carbon in the company's existing char plant.

Production is now well established and the product is being sold internationally. Research is continuing into increasing the range of product types available.

Simulating minerals evolution

Studies of the way lead and zinc ore deposits have come into existence are being undertaken to assist future exploration.

The DIVISION OF MINERALOGY is engaged in a joint study with the Bureau of Mineral Resources, Geology and Geophysics and a number of mining companies to examine the features of some known ore deposits and attempt to simulate in the laboratory the mechanisms by which they were formed.

Layered zinc and lead deposits could have been formed in various ways, possibly involving such diverse processes as the biological action of bacteria and algae, sedimentation, and the diffusion of fluids through sediments. A knowledge of the mineralogical features associated with these processes could reduce the area that has to be explored to locate deposits.

In an attempt to combine some of the relevant factors in a large-scale model of an environment for ore deposition, scientists have prepared a sedimentation tank with beds of calcium and magnesium carbonates, clay, and organic matter. Sulphate-reducing bacteria are active in some of these sediments and algae are active in the water above the beds. At the same time, sulphide-forming metals in solution are being added to the tank.

After four months there has been marked localized enrichment of lead and zinc in the sediments just below the sediment/water interface. Moreover, these metals occur within a succession of newly formed thin layers similar to those in some important Australian stratiform ore deposits.

Over the same period, but occurring somewhat deeper in the sediment pile, there has been biological reduction of sulphate accompanied by the formation of dark-coloured iron sulphides. These early results indicate how this new technique of simulating minerals evolution can help our understanding of processes leading to the formation of some economic base metal deposits.

Disposing of coal waste

A method of burning the waste material washed from coking coal has been developed to reduce the environmental problems posed by the accumulation of over nine million tonnes of this material a year.

The DIVISION OF MINERAL CHEMISTRY has set up a fluidized-bed combustion rig to study the disposal of coal washery reject material. After coking coal has been mined, it is washed with water to remove unwanted solids. The reject material from coal washeries takes the form of either coarse shaly material or slurries of fine coal and clay.

Over the past 10 years, refuse has accumulated at coal washeries at a much greater rate than previously because of the intensive mechanization of coal mining, increased production, and the more widespread demand for clean coal. Output has increased of coal which has to be upgraded, by washing, for metallurgical coke production and export.

During the past year, about 40 million tonnes of coking coal were cleaned in about 55 washeries in New South Wales and Queensland. In the process some 9 million tonnes of refuse (22% of the raw coal feed) were accumulated in dumps. As well as being unsightly, these dumps are liable to spontaneous combustion, and the fine coal and dirt from slurry ponds may be wind blown or washed into gullies or streams to cause atmospheric or water pollution. In addition, it is expensive to transport the rejects from the washeries to dumping sites.

The Division is carrying out fluidized-bed combustion trials on samples taken from typical washeries. To date, these have shown that coarse reject materials can be burnt without difficulty and are a potential source of energy. When the coal has been burnt away, the remainder is a light-coloured, inert granular product that could be suitable for use as road-fill or light-weight aggregate.

The work is currently being extended to examine methods of firing slurries, which are more difficult to fire because of their high water content.

In collaboration with the coal industry, the Division is designing a pilot plant for installation at a washery to assess the commercial feasibility of the process and potential uses for the product.

Analysing ore on a conveyor belt

A technique that measures the average grade of ore on a conveyor belt has been developed.

Ores on a conveyor belt can be analysed automatically by a technique developed by the DIVISION OF MINERAL PHYSICS. The technique is currently being applied to the measurement of iron and aluminium in ores of these metals and in other ores where these metals occur as impurities.

The ore is irradiated with fast neutrons from a source under the belt and the resultant gamma-rays and slow neutrons are measured. When this information is combined in a simple computer, the ore grade and the water content of the ore can be found.

Because every particle of the ore contributes to the measurement, a far more meaningful average analysis is obtained than when individual samples are taken from the bulk of the ore and separately analysed. Another advantage is that the analysis is available immediately at the end of the period of measurement.

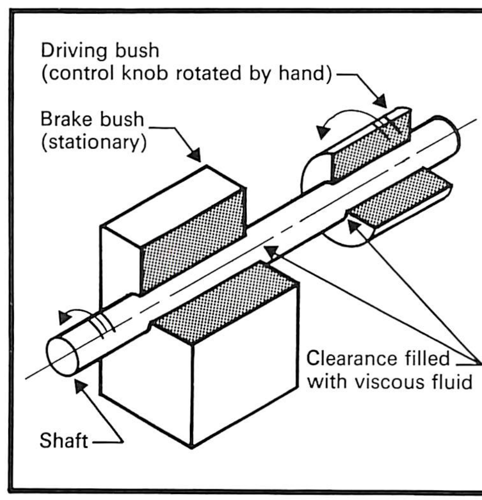
Extensive laboratory tests of the technique have been made by the Division. Field tests are to start soon at Hamersley Iron Pty Ltd in the Pilbara to determine the sensitivity of the method under practical operating conditions.

Viscous drive for speed reduction

A device has been invented that uses highly viscous fluids to achieve speed reduction ratios in excess of 50,000 : 1.

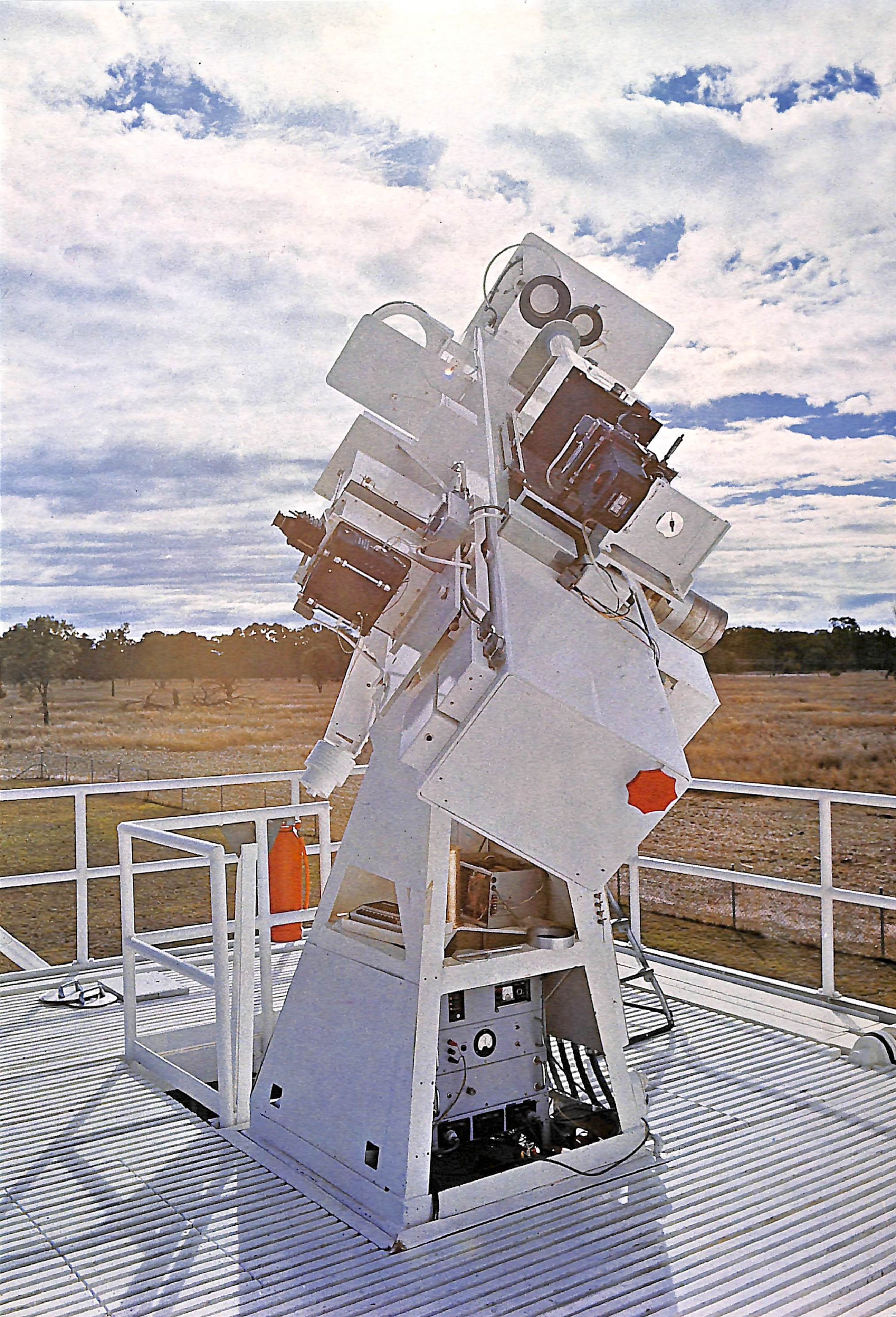
A device that provides a simple means of moving machine components at very low speeds and with very uniform motion has been invented by the DIVISION OF APPLIED PHYSICS. Previously, motion of this type required elaborate and expensive mechanisms, particularly for moving large components. The new device has given speed reduction ratings in excess of 50,000 : 1.

The device (illustrated) can be considered to have three solid parts: the primary drive component (1), the shaft (2), and the brake (3). High-viscosity fluid is placed between the shaft and each of the other components. The relative sizes of the components and the viscosities of the fluids are chosen to provide the required drive reduction.



When the driving component is rotated, the shaft will tend to rotate at near the same speed because of the viscous coupling between them. But with the brake bush held stationary, the viscous fluid between it and the shaft will resist rotation. The result is a reduction in speed of the shaft compared with that of the primary drive.

There is no sudden jerk when movement starts because the torque applied by the viscous fluid between the drive and the shaft is opposed by the brake coupling drag immediately the shaft starts rotating. Creep and backlash are eliminated because, with this arrange-



ment, no energy is stored elastically by the fluids.

The viscous drive principle has been applied to control knob, hand-wheel, and gear-box applications and can be extended to variable-speed motor drives and torque braking mechanisms.

Stop that noise!

Research is being undertaken into problems of noise measurement so that suitable acoustic standards can be established.

Noise is one of the undesirable features of modern cities but it is difficult to control unless the offending sound can be measured objectively and compared with acceptable standards.

The quantity usually measured is the sound pressure, which is the effective value of the pressure changes created by the sound waves.

In the DIVISION OF APPLIED PHYSICS a small group has been formed to establish suitable acoustic standards and to do research on problems of noise measurement. The first priority for the new group is the development of facilities for calibrating noise meters and other instruments for measuring sound pressure.

The main optical telescope at CSIRO's Solar Observatory at Culgoora, New South Wales, is this 30-cm refractor which can resolve details of the Sun's surface as small as 500 km in diameter. It is mounted on a tower to aid the observation of fine detail.

The Observatory, operated jointly by the DIVISIONS OF PHYSICS (optical astronomy) and RADIOPHYSICS (radio astronomy), was established in the mid 1960s and has taken its place as a leading centre for research on the Sun. The optical and radio instruments at Culgoora provide a unique combination of facilities for studying simultaneously the behaviour of solar events over a great range of depths in the Sun's atmosphere.

Computer-constructed crystal images

Computer-constructed crystal images provide an effective technique for basic research into materials.

During recent years the performance of commercial electron microscopes has improved to such an extent that it is now possible to resolve distances of 0·3 nm (1 nm equals one-thousand-millionth of a metre). These distances are about the same as the spacings between atoms in crystals. Two CSIRO Divisions, in a collaborative programme, have established experimental conditions that are necessary to interpret the atomic structure of crystals direct from high-resolution electron microscopy.

After experimental observations on crystals over a number of years, scientists at the DIVISION OF TRIBOPHYSICS came to the view that crystal images could tell us not only about the regular part of the crystal, but about imperfections in it as well. A theoretical basis for the interpretation of crystal images had been proposed by scientists at the DIVISION OF CHEMICAL PHYSICS some years earlier. The theory has been used by the two Divisions for computations that determine the range of experimental conditions under which the observed images can be relied upon to represent the structure.

Using the theory, the scientists calculated with a computer what the lattice image would look like from a knowledge of the crystal structure, the thickness, and orientation of the specimen and the focusing conditions in the microscope. The effects of lens aberrations were also computed. The results were presented as a half-tone image on a computer print-out or on a cathode-ray oscilloscope in seven levels of grey. The effect of changing the thickness or position of the specimen can be seen on the oscilloscope screen as a change in the computed half-tone image—so also can the effects of changes in focusing conditions. A sequence of such changed pictures can be made into a moving film representing the lattice image under changing input conditions.

Results here and overseas have shown that the theory is sound and under what conditions images can provide structural details direct.

Magnetic fields and the Sun

Current studies of the effects of magnetic fields seek to explain two phenomena associated with the Sun.

Theoretical astrophysical research at the DIVISION OF PHYSICS includes studies of magnetic fields and their effects in different parts of the universe. Recent studies show promise of explaining two important phenomena related to the behaviour of the Sun's gases.

The Sun has magnetic fields directed eastwards in one hemisphere and westwards in the other. These fields grow and decay in an 11-year cycle, and then mysteriously reverse for the next 11-year cycle. They give rise to sunspots and are the cause of the 11-year peaks of sunspot activity. All of these effects were explained previously in terms of dynamo action with the whole solar magnetic field confined to a shell just below the surface of the Sun.

Research by the Division's scientists has shown that the dynamo theory is incorrect. They suggest that it is necessary to revive an even older theory, which states that the Sun's magnetic field is deeply embedded within the Sun and has two permanent magnetic poles. Steady solar rotation combined with varying north–south gas motions winds this permanent field into east–west fields which float to the surface, create sunspots, and then are lost. Meanwhile, reverse east–west fields are generated to replace the old, the whole process taking 22 years.

The magnetic field studies also explain why the Sun's atmosphere, which one would expect to be cooler than its surface, is up to one hundred times hotter. It has been generally accepted that this effect is caused by sound-waves generated by rising bubbles of gas just below the surface. However, the Division has found by observation that the actual subsurface motions appear to be quite different from this. It seems probable that the gas bends and twists tubes of magnetic force and these bends and twists travel upwards as hydromagnetic waves, like transverse waves on a stretched string. The waves stir the atmosphere violently and so heat it to a temperature of a million degrees or more. In this way we can explain not only the hot solar atmosphere but also the solar wind that blows out past the Earth with speeds of several hundred miles per second. The gas near the surface is heated by the waves and expands outwards as the solar wind. At the same time, gases from the body of the Sun move into the lower atmosphere.

Understanding gas reactions

Studies of gas reactions on a molecular scale are providing knowledge of the ways in which energy from various sources affects the atmosphere.

When sufficient energy is supplied to a gas, electrons may be stripped off the molecular constituents, leaving them in a charged and excited state. These charged particles, known as ions, may then react extremely rapidly with the surrounding gas molecules. Such ion–molecule reactions provide excellent opportunities to test fundamental theories concerned with chemical reactions.

The DIVISION OF PHYSICS is studying the accurate measurement of the rates of ion–molecule reactions and how the rates are affected by the internal energy of the ion.

To date, measurements have been made of rates of reactions in mixtures of hydrogen and a number of gases including nitrogen, carbon monoxide, carbon dioxide, and nitrous oxide.

These experimental studies are useful in explaining the interaction of high-energy particles with gases. For example, when high-energy solar radiation enters the Earth's atmosphere, a chain of rapid ion–molecule reactions is initiated. Rate measurements in the laboratory are an invaluable guide to the interpretation of these atmospheric processes.

Similarly, high-energy nuclear radiation initiates ion–molecule reactions in gases and liquids. An understanding of the complicated chain of reactions that can occur in even simple gas mixtures is important for an evaluation of the effects of nuclear radiation.

Discovering distant pulsars

Radio signals that might reveal the details of unknown pulsars at a great distance from Earth are being monitored and studied.

As explained in the Annual Report of 1969/70, pulsars are radio sources that emit energy in short, periodic bursts, about every second. About 100 pulsars, most of them in the Milky Way, have been discovered to date.

The radio signals from pulsars at great distances from the Earth—some come from over 40,000 light years away—become dispersed in frequency as they travel through space; the lower frequency components are delayed more than the higher ones. By the time the pulses reach the Earth, the signal is often so weak and the dispersion so great that they are lost in background noise.

The DIVISION OF RADIOPHYSICS uses the 64-metre radio telescope at Parkes to search for distant pulsars in the Milky Way. The signal at different frequencies is sampled many thousands of times and fed into a computer. Scientists, using mathematical techniques, then extract from these data any periodic pulses along with the dispersion associated with them.

A pulsar can be identified once its periodicity, dispersion, and position are known. In this way, eight pulsars have been discovered by the Division.

Organization

CSIRO has a total staff of some 6600 people located in more than 100 laboratories and field stations throughout Australia. About one-third of the staff are scientists.

CSIRO is governed by an Executive comprising a full-time Chairman, four other full-time members, and four part-time members. Most of the members of the Executive are scientists. The Executive is responsible to the Minister for Science for the policy and work of the Organization.

CSIRO has 36 research Divisions, each led by a Chief who is responsible to the Executive for the work of that Division. There are also three smaller research Units, each led by an Officer-in-Charge. The staff of a Division consists of research scientists, experimental officers, other professional staff engaged on a variety of service functions, and supporting technical, administrative, and trades staff. A number of Divisions have been linked together in what are known as group laboratories.

The Executive is assisted in the development, administration, and implementation of its policies by a Secretariat comprising an Administrative Branch, an Agricultural and Biological Sciences Branch, and an Industrial and Physical Sciences Branch. The Executive and Secretariat are located at the Organization's Head Office in Canberra. Some of the administrative functions of Head Office have been decentralized by the creation of Regional Administrative Offices in Brisbane, Canberra, Melbourne, and Sydney.

CSIRO maintains offices in London, Tokyo, and Washington. These offices serve as recruiting centres for scientific staff, as sources of information about CSIRO and science in Australia, and as collection centres for information about science in Europe, Japan, and North America.

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Dr. J. A. Allen

Administrative Branch
Secretary (Administration)
L. G. Wilson

Agricultural and Biological Sciences Branch
Secretary (Agricultural and Biological Sciences)
A. F. Gurnett-Smith

Industrial and Physical Sciences Branch
Secretary (Industrial and Physical Sciences)
J. P. Shelton

Overseas Offices
Chief Scientific Liaison Officer, London
Dr. G. N. Lance
Counsellor (Scientific), Tokyo
E. E. Adderley
Counsellor (Scientific), Washington
Dr. E. G. Bowen

Executive

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V. D. Burgmann
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L. Lewis
Dr. A. E. Pierce
Dr. D. L. Ford, *part-time*
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Professor E. J. Underwood, *part-time*
W. J. Vines, *part-time*

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Animal Health	Dr. D. F. Stewart, *acting*
Animal Physiology	Dr. I. W. McDonald
Nutritional Biochemistry	Dr. A. T. Dick
Environmental Physics Research Laboratories	
Atmospheric Physics	Dr. G. B. Tucker
Cloud Physics	J. Warner
Environmental Mechanics	Dr. J. R. Philip
Land Resources Laboratories	
Land Resources Management	Dr. M. J. Mulcahy, *acting*
Land Use Research	Dr. R. J. Millington, *acting*
Soils	Dr. E. G. Hallsworth
Minerals Research Laboratories	
Chemical Engineering	Dr. T. H. Blakeley, *acting*
Mineral Chemistry	Dr. D. F. A. Koch
Mineral Physics	Dr. K. G. McCracken
Mineralogy	A. J. Gaskin
National Standards Laboratory	
Applied Physics	F. J. Lehany
Physics	Dr. R. G. Giovanelli
Wool Research Laboratories	
Protein Chemistry	Dr. F. G. Lennox
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Textile Physics	J. G. Downes
Applied Chemistry	Dr. S. D. Hamann
Applied Geomechanics	Dr. G. D. Aitchison
Building Research	Dr. R. W. R. Muncey
Chemical Physics	Dr. A. L. G. Rees
Computing Research	Dr. P. J. Claringbold, *acting*
Entomology	Dr. D. F. Waterhouse
Fisheries and Oceanography	K. Radway Allen
Food Research	M. V. Tracey
Horticultural Research	Dr. J. V. Possingham
Irrigation Research	E. R. Hoare
Mathematical Statistics	Dr. G. W. Hill, *acting*
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Plant Industry	Dr. L. T. Evans
Radiophysics	Dr. J. P. Wild
Tribophysics	Dr. J. R. Anderson
Tropical Agronomy	Dr. E. M. Hutton
Wildlife Research	Dr. H. J. Frith

Research Units and their Officers-in-Charge

Agro-industrial Research	G. A. Stewart
Marine Biochemistry	Dr. G. F. Humphrey
Wheat Research	E. E. Bond

Environmental Physics Research Laboratories
Chairman
Dr. C. H. B. Priestley

Land Resources Laboratories Committee
Chairman
Dr. E. G. Hallsworth

Minerals Research Laboratories
Director
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Wool Research Laboratories Committee
Chairman
Dr. M. Lipson

Editorial and Publications Section
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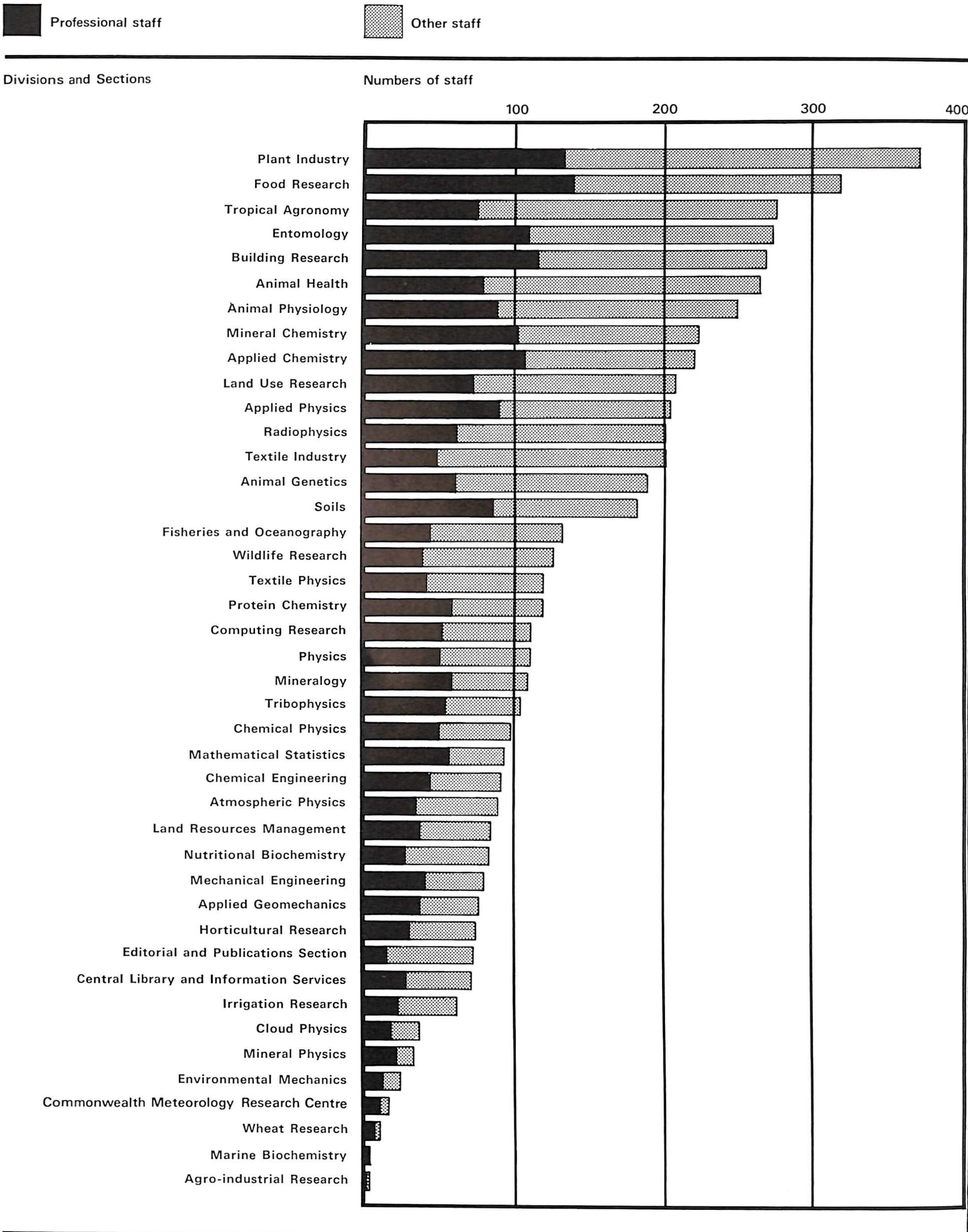
Professional staff
Other staff
Divisions and Sections
Numbers of staff
100
200
300
400
Plant Industry
Food Research
Tropical Agronomy
Entomology
Building Research
Animal Health
Animal Physiology
Mineral Chemistry
Applied Chemistry
Land Use Research
Applied Physics
Radiophysics
Textile Industry
Animal Genetics
Soils
Fisheries and Oceanography
Wildlife Research
Textile Physics
Protein Chemistry
Computing Research
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Environmental Mechanics
Commonwealth Meteorology Research Centre
Wheat Research
Marine Biochemistry
Agro-industrial Research

Research Activities

The various CSIRO Divisions, their fields of research, and the location of their laboratories and field stations are as follows:

ANIMAL GENETICS

Genetics and its application to the improvement of beef cattle, dairy cattle, sheep, and poultry through breeding and selection; genetics and the control of rabbits by myxomatosis.
Sydney, with a laboratory and field station at Rockhampton, Qld., field stations at Armidale and Badgery's Creek, N.S.W., and a field investigation unit at Wollongbar, N.S.W.

ANIMAL HEALTH

Diseases of livestock and poultry caused by bacteria, viruses, mycoplasmas, protozoa, and plant poisons; external parasites—cattle tick, lice, and biting insects—as potential transmitters of disease; worm parasites of sheep and cattle; immunology.
Melbourne, with laboratories in Sydney, Brisbane, Perth, and Townsville, Qld., and field stations at Maribyrnong, Werribee, and Tooradin, Vic., Badgery's Creek, N.S.W., and Jimboomba and Magnetic Island, Qld.

ANIMAL PHYSIOLOGY

Physiology, endocrinology, nutrition, and ecology of sheep and cattle in relation to reproductive performance and the production of wool and meat; production of meat and dairy products with a higher than normal proportion of polyunsaturated fats; control of reproductive cycles in sheep and cattle; prevention of hormonal disorders arising from pasture consumption; marsupial physiology.
Sydney, with the Pastoral Research Laboratory at Armidale, N.S.W., the Beef Cattle Research Unit at Townsville, Qld., and the Bloat Research Unit at Melbourne.

APPLIED CHEMISTRY

Application of chemistry to problems of national and industrial importance. Investigations are concerned with: synthesis of potentially useful new chemicals; natural and synthetic biologically active compounds; organometallic compounds and catalysis; water and waste-water purification; polymer chemistry; mechanisms of chemical reactions at normal and high pressures; nucleation and growth of crystals; surface chemistry; physical chemistry; bush fire prevention and control; nature and properties of wood and its constituents; utilization of plant fibres for paper, packaging, and building materials.
Melbourne.

APPLIED GEOMECHANICS

Properties and behaviour of soils and rocks in relation to the design of civil and mining engineering structures such as building foundations, earthen embankments, and road pavements and to the design of surface excavations and underground openings.
Melbourne, with a laboratory in Adelaide and a field station at Cobar, N.S.W.

APPLIED PHYSICS

Establishment and maintenance of the Commonwealth legal standards of length, mass, and time interval, and of mechanical and electrical quantities derived from them; problems associated with precision measurements; magnetic and dielectric properties of materials.
Sydney.

ATMOSPHERIC PHYSICS

Physical and chemical atmospheric processes that underlie and control the weather and are responsible for the distribution of airborne material

including gases; the physical basis of climate and variations in climate; development of numerical and laboratory models that simulate atmospheric behaviour and application of these models to improving the accuracy and time-scale of weather predictions.
Melbourne. The Division also has a group of officers located at the Commonwealth Meteorology Research Centre, Melbourne. The Centre is operated jointly by the Commonwealth Bureau of Meteorology and the Division.

BUILDING RESEARCH
Development of the built environment, community planning, and urban design; systems research; physical performance of buildings in relation to the well-being of occupants; building operations and economics; structural design and engineering; conversion of forest products for the production of wood-based building elements; design and improvement of building components and systems; development, processing, and properties of building materials.
Melbourne, with offices in Sydney and Port Moresby.

CHEMICAL ENGINEERING
Selected unit operations related to the minerals and other process industries.
Melbourne.

CHEMICAL PHYSICS
Development and application of chemical–physical techniques and instruments in the fields of spectroscopy, mass spectroscopy, electron diffraction, electron microscopy, X-ray diffraction, theoretical chemistry, and solid-state chemistry.
Melbourne.

CLOUD PHYSICS
Natural mechanisms of cloud and rain formation; artificial induction of rainfall by techniques such as cloud-seeding; studies of atmospheric particles.
Sydney.

COMPUTING RESEARCH
Computer science and the application of computers to research and development projects. The Division also provides a computer service to other Divisions, certain Commonwealth Government Departments, and some universities.
The Division operates a computer network which has its centre in Canberra and is linked by Australian Post Office lines to subsidiary installations in Adelaide, Brisbane, Melbourne (various locations), Perth, Sydney (various locations), Armidale and Griffith, N.S.W., and Rockhampton and Townsville, Qld.

ENTOMOLOGY
Taxonomy, ecology, population dynamics, genetics, behaviour, physiology, and biochemistry of insects, particularly in relation to the development of methods of control that reduce or eliminate the disadvantages commonly associated with the use of pesticides.
Canberra, with laboratories in Brisbane, Perth, and Sydney, and field stations at Armidale, Trangie, and Wilton, N.S.W., Rockhampton, Qld., and Hobart. The Division also has biological control units at Cuiaba, Brazil; Montpellier, France; Tehran, Iran; and Pretoria, South Africa.

ENVIRONMENTAL MECHANICS
Transfer processes in the natural environment (physical interactions between soils, plants, and the lowest layers of the atmosphere involving the exchange of energy, water, and carbon dioxide) and their effect on plant growth; mathematical and physical aspects of ecology.
Canberra.

FISHERIES AND OCEANOGRAPHY
Survey and appraisal of certain marine fishery resources; biology of the

western rock lobster and prawn species of commercial importance; biological, chemical, and physical oceanography of south-east Indian Ocean and south-west Pacific Ocean.
Sydney, with laboratories in Brisbane and Perth and field stations at Darwin and Groote Eylandt, N.T., Karumba and Weipa, Qld., and Sams Creek, W.A.

FOOD RESEARCH
Properties, preservation, processing, packaging, storage, and transport of foods; properties of bacterial spores; membrane structure and biochemistry; identification and evaluation of flavours; polyunsaturated meat and dairy products; new protein and dairy foods; treatment and utilization of processing wastes, plant physiology (at Macquarie University).
Headquarters and Food Research Laboratory, Sydney; Meat Research Laboratory, Brisbane; Dairy Research Laboratory, Melbourne; Tasmanian Food Research Unit, Hobart.

HORTICULTURAL RESEARCH
Development of varieties of fruit-trees and grape-vines better suited to Australian conditions; plant physiology and biochemistry; orchard ecology; management and production of grape crops; plant parasitic nematodes.
Adelaide, with a laboratory and field station at Merbein, Vic., and a laboratory at Hobart.

IRRIGATION RESEARCH
Hydroscience and irrigation; soil–plant–atmosphere interactions; growth, management, and quality of irrigated crops; plant biochemistry; engineering aspects of intensive agricultural production; data capture and processing systems.
Griffith, N.S.W.

LAND RESOURCES MANAGEMENT
Management techniques for achieving optimum productivity consistent with conservation of land resources; the environmental implications of changes in land use.
Perth, with an experimental farm at Baker's Hill, W.A.

LAND USE RESEARCH
Survey of land resources and assessment of their potential use; development of techniques for assessment of land resources.
Canberra, with laboratories and field stations at Deniliquin, N.S.W., Alice Springs and Coastal Plains, N.T., and Kununurra, W.A.

MATHEMATICAL STATISTICS
Mathematical statistics and the development of suitable methods for statistical design and analysis of experiments for research in physical, chemical, and biological sciences. The Division also provides advice and consultation services to other Divisions on statistical matters.
Adelaide, with officers stationed with a number of Divisions at Brisbane, Canberra, Hobart, Melbourne, Perth, and Sydney, and at Townsville, Qld., and the University of Melbourne.

MECHANICAL ENGINEERING
Controlled-environment engineering; utilization of solar energy; industrial fluid dynamics; physical methods of preservation of grain; agricultural mechanization.
Melbourne.

MINERAL CHEMISTRY
Application of chemistry and metallurgy to mineral beneficiation and utilization and to improving the efficiency of existing mineral treatment processes; development of new mineral processing techniques.
Melbourne, with a laboratory in Sydney.

MINERAL PHYSICS

Application of physical techniques to mineral exploration; exploitation of physical properties of minerals in processing and extraction.
Sydney, with a laboratory in Melbourne.

MINERALOGY

Role of physical and chemical factors in the origin of mineral deposits and the effect of these factors on the relationships between mineral deposits and the surrounding rocks; application of this knowledge to mineral exploration and to the characterization of known ore bodies.
Perth, with laboratories in Canberra and Sydney.

NUTRITIONAL BIOCHEMISTRY

Biochemistry of nutritional processes in sheep and cattle with particular emphasis on the utilization of food for the production of useful animal products.
Adelaide, with a field station at O'Halloran Hill, S.A.

PHYSICS

Establishment and maintenance of the Commonwealth legal standards of measurement related to temperature, humidity, viscosity, light, and radiation; provision of facilities for precise measurements in related fields, including optics; solid-state physics; solar physics; molecular collisions; air glow.
Sydney, with an optical observatory at the CSIRO Solar Observatory, Culgoora, N.S.W.

PLANT INDUSTRY

Research in the plant sciences as a basis for the development and utilization of crops and pastures better adapted to Australian conditions; ecology and conservation of plant communities.
Canberra, with laboratories in Brisbane and Narrabri, N.S.W., and an experimental farm at Canberra.

PROTEIN CHEMISTRY

Structure and chemistry of wool fibres as a basis for developing new and improved wool manufacturing processes; tanning and leather manufacture; meat proteins; plant proteins; biologically active proteins.
Melbourne.

RADIOPHYSICS

Cosmic and solar radio astronomy; development of microwave instrument landing systems for aircraft.
Sydney, with the Australian National Radio Astronomy Observatory at Parkes, N.S.W., and a radio observatory at the CSIRO Solar Observatory, Culgoora, N.S.W.

SOILS

Physics, chemistry, and biology of soils, in relation to growth and health of plants and animals, water supply, and other aspects of their utilization by man.
Adelaide, with laboratories in Brisbane, Canberra, Hobart, and in Townsville, Qld.

TEXTILE INDUSTRY

Development of new and improved methods and machinery for processing wool; development of new and improved textile products from wool; relationships between fleece properties and processing; new uses for wool; cotton processing.
Geelong, Vic.

TEXTILE PHYSICS

Development of methods of testing wool as an aid to marketing and manufacturing; physical properties and behaviour of wool and wool products.
Sydney.

TRIBOPHYSICS

Properties, behaviour, and utilization of industrially important metals, alloys, ceramics, and refractories; structure of these materials in relation to bulk properties such as strength and plasticity and surface reactions such as catalysis,

adsorption, and oxidation.
Melbourne.

TROPICAL AGRONOMY

Development of efficient systems for beef production in northern Australia (excluding arid zones); research on some tropical crops; agronomic research integrated with work on introduction, selection, and breeding of new pasture and crop varieties; studies on pasture and crop nutrition, genetics, physiology, biochemistry, and on legume nodulation and animal nutrition.
Brisbane, with laboratories at Townsville and Lawes, Qld., and field stations at Beerwah, Mareeba, Mundubbera, Samford, and Townsville, Qld., and at Katherine, N.T.

WILDLIFE RESEARCH

Biology of birds and mammals, both native and introduced, in relation to pest control and conservation. Species investigated include those which are clearly pests, such as the rabbit and wild pig, those which are exploited, such as the water-fowl and quail, and those which need to be conserved.
Canberra, with laboratories at Perth and Darwin, and staff located at Alice Springs, N.T.

In addition to the above Divisions, CSIRO also has three small research units. They are:

AGRO-INDUSTRIAL RESEARCH UNIT

Potential innovations in agricultural technology, in particular the year-round harvesting of tropical crops, the industrial processing of crop products, and the feeding of animals on crop and industrial by-products.
Canberra.

MARINE BIOCHEMISTRY UNIT

Biochemistry of phytoplankton and the role of phytoplankton in the marine food chain.
Sydney.

WHEAT RESEARCH UNIT

The structure and biochemistry of the wheat grain and their relationship to flour quality.
Sydney.

Staff

The following is a list of professional and senior staff of the Organization as at 30 June 1973.

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Limestone Avenue, Campbell, A.C.T.

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Sir Henry Somerset, C.B.E., M.Sc. (part-time)
Professor E. J. Underwood, C.B.E., Ph.D., D.Rur.Sc., D.Sc.(Agric.), F.A.A., F.R.S. (part-time)
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Finance

As indicated earlier in this report, a number of CSIRO Divisions have been restructured during the year. However, for accounting purposes it has been necessary to record income and expenditure for the whole of the financial year under the original headings shown in the 1972/73 estimates. In other words, income and expenditure are shown as they would have been if none of the organizational changes had occurred. These changes will become effective for accounting purposes as from 1 July 1973.

Annual Expenditure

The following summary gives details of expenditure by CSIRO Divisions and Sections on other than capital items from 1 July 1972 to 30 June 1973.

DIVISION OR SECTION	Treasury funds ($)	Contributory funds ($)	Total ($)
Head Office			
The main items of expenditure under this heading are salaries and travelling expenses of the administrative staff at Head Office and the Regional Administrative Offices, salaries and expenses of officers at the Liaison Offices in London, Washington, and Tokyo, and general office expenditure.	4,456,162	12,268	4,468,430
Research Programmes			
Animal Health and Reproduction			
Animal Genetics	1,389,407	593,087	1,982,494
Animal Health	2,330,914	682,052	3,012,966
Animal Physiology	952,577	1,694,281	2,646,858
Nutritional Biochemistry	620,852	147,631	768,483
Plant Industry	3,682,596	782,345	4,464,941
Entomology and Wildlife			
Entomology	2,635,422	784,717	3,420,139
Wildlife Research	1,016,699	397,867	1,414,566
Soils	2,292,413	72,050	2,364,463
Horticulture and Irrigation			
Horticultural Research	776,083	30,113	806,196
Irrigation Research	659,747	36,520	696,267
Tropical Agronomy	1,923,025	375,077	2,298,102
Land Research			
Land Research	1,730,806	550,604	2,281,410
Rangelands Research	644,744	208,175	852,919
Woodland Ecology	104,997	115,066	220,063
Processing of Agricultural Products			
Food Research	2,669,924	795,009	3,464,933
Wheat Research	42,532	89,697	132,229
Textile Industry	92,425	1,639,808	1,732,233
Textile Physics	58,049	1,374,175	1,432,224
Information and Publications			
Central Library and Information Services	463,972	—	463,972
Editorial and Publications Section	817,318	—	817,318
Film Unit	110,416	3,859	114,275
Chemical Research of Industrial Interest			
Chemical Engineering	1,025,786	18,822	1,044,608
Applied Chemistry	2,521,681	108,524	2,630,205
Chemical Physics	1,356,371	11,777	1,368,148
Protein Chemistry	247,250	1,063,798	1,311,048

DIVISION OR SECTION	Treasury funds ($)	Contributory funds ($)	Total ($)
Fisheries and Oceanography			
Fisheries and Oceanography	1,610,576	100,008	1,710,584
Marine Biochemistry	68,461	—	68,461
Processing and Use of Mineral Products			
Mineral Chemistry	2,513,202	84,626	2,597,828
Mineralogy	1,040,626	27,548	1,068,174
Mineral Physics	647,507	25,654	673,161
Baas Becking Geobiological Group	13,400	63,137	76,537
Physical Research of Industrial Interest			
Physics	1,368,468	6,447	1,374,915
Applied Physics	2,330,931	—	2,330,931
General Physical Research			
Radiophysics	2,037,640	92,159	2,129,799
Atmospheric Physics	949,256	10,624	959,880
Cloud Physics	564,019	—	564,019
Commonwealth Meteorological Research Centre	146,050	—	146,050
Environmental Mechanics	313,593	18,413	332,006
Radio Research Board	45,000	68,495	113,495
General Industrial Research			
Building Research	2,694,404	151,501	2,845,905
Tribophysics	1,193,906	13,853	1,207,759
Applied Geomechanics	790,850	101,028	891,878
Mechanical Engineering	872,793	108,511	981,304
Research Services			
Computing Research	246,996	—	246,996
Mathematical Statistics	901,567	—	901,567
Rural Sciences Laboratory	332,003	—	332,003
Extra-mural investigations	73,877	—	73,877
Australian Mineral Development Laboratories	59,976	—	59,976
Developmental projects	177,288	—	177,288
Miscellaneous	524,466	38,669	563,135
Grants			
Research Associations	454,984	—	454,984
Research Studentships	315,990	—	315,990
Other grants and contributions	1,146,475	—	1,146,475
Total expenditure	58,056,472	12,497,995	70,554,467

Capital Expenditure under CSIRO Control

The table which follows shows capital expenditure from funds made available directly to CSIRO. It includes expenditure on capital and developmental works and on items of equipment costing more than $10,000 each.

DIVISION OR SECTION	Treasury funds ($)	Contributory funds ($)	Total ($)
Head Office	13,514	—	13,514
Animal Health and Reproduction			
Animal Genetics	49,505	8,940	58,445
Animal Health	83,503	5,420	88,923
Animal Physiology	85,756	33,440	119,196
Nutritional Biochemistry	4,002	—	4,002
Plant Industry	115,690	—	115,690
Entomology and Wildlife			
Entomology	25,513	5,844	31,357
Wildlife	2,621	—	2,621
Soils	42,025	85	42,110
Horticulture and Irrigation			
Horticultural Research	12,001	—	12,001
Irrigation Research	5,836	—	5,836
Tropical Agronomy	32,990	11,863	44,853
Land Research			
Land Research	520	1,025	1,545
Rangelands Research	38,519	8,526	47,045
Woodland Ecology	11,817	—	11,817
Processing of Agricultural Products			
Food Research	28,580	25,364	53,944
Textile Industry	—	189,341	189,341
Textile Physics	—	268,718	268,718
Information and Publications			
Editorial and Publications	13,580	—	13,580
Chemical Research of Industrial Interest			
Chemical Engineering	37,593	—	37,593
Applied Chemistry	31,564	—	31,564
Chemical Physics	30,397	—	30,397
Protein Chemistry	7,170	50,636	57,806
Fisheries and Oceanography	54,714	151,974	206,688
Processing and Use of Mineral Products			
Mineral Chemistry	156,265	—	156,265
Mineralogy	1,140	—	1,140
Mineral Physics	104,911	—	104,911
Physical Research of Industrial Interest			
Physics	21,991	—	21,991
Applied Physics	85,186	—	85,186
General Physical Research			
Radiophysics	1,779	20,346	22,125
Atmospheric Physics	33,549	—	33,549
Environmental Mechanics	8,888	—	8,888
Cloud Physics	13,805	—	13,805
General Industrial Research			
Building Research	78,332	—	78,332
Tribophysics	44,776	—	44,776
Applied Geomechanics	600	—	600
Mechanical Engineering	60,336	—	60,336
Research Services			
Computing Research	504,561	—	504,561
Rural Sciences Laboratory	6,286	—	6,286
Miscellaneous	2,698	—	2,698
Total capital expenditure	1,852,513	781,522	2,634,035

Contributions

This table summarizes receipts and expenditure during 1972/73 of funds provided by contributors and recorded in a special account entitled 'Specific Research Account'. The largest amounts contributed for specific research projects are provided from joint Commonwealth–Industry Research Funds such as the Wool Research Trust Fund and the Meat Research Trust Account. However, sums which are quite substantial in total are contributed by industrial organizations and other bodies.

DIVISION OR SECTION	Receipts 1972/73 and balances brought forward ($)	Expenditure 1972/73 ($)
Animal Genetics		
Wool Research Trust Fund	447,696	416,946
Meat Research Trust Account	128,316	122,595
Other contributors	80,733	62,487
Animal Health		
Wool Research Trust Fund	387,445	365,799
Meat Research Trust Account	285,924	271,637
Dairy Produce Research Trust Account	19,164	18,036
Other contributors	56,731	32,000
Animal Physiology		
Wool Research Trust Fund	1,732,750	1,596,574
Meat Research Trust Account	95,082	76,240
Other contributors	122,755	54,906
Nutritional Biochemistry		
Wool Research Trust Fund	172,045	147,632
Plant Industry		
Wool Research Trust Fund	685,947	639,304
Wheat Research Trust Account	10,889	10,347
Dairy Produce Research Trust Account	12,600	11,326
Tobacco Industry Trust Account	29,529	28,314
Other contributors	143,092	93,054
Entomology		
Wool Research Trust Fund	66,489	62,625
Meat Research Trust Account	429,802	388,996
Wheat Research Trust Account	22,508	16,940
Other contributors	388,949	322,000
Wildlife Research		
Wool Research Trust Fund	266,121	247,333
Meat Research Trust Account	118,502	115,784
Other contributors	36,748	34,750
Soils		
Wheat Research Trust Account	9,017	7,948
Other contributors	92,528	64,187
Horticultural Research		
Dried Fruits Research Trust Account	31,347	19,108
Other contributors	41,644	11,005
Irrigation Research		
Other contributors	68,904	36,519
Tropical Agronomy		
Meat Research Trust Account	199,965	202,141*
Dairy Produce Research Trust Account	52,355	52,115
Other contributors	195,788	132,685
Land Research		
Meat Research Trust Account	37,978	34,253
Tobacco Industry Trust Account	266,140	236,146
Other contributors	352,349	281,231
Rangelands Research		
Wool Research Trust Fund	196,471	196,345
Other contributors	44,521	20,355

* Expenditure in excess of receipts will be recovered in 1973/74.

DIVISION OR SECTION	Receipts 1972/73 and balances brought forward ($)	Expenditure 1972/73 ($)
Woodland Ecology		
Other contributors	127,418	115,066
Food Research		
Meat Research Trust Account	575,158	520,262
Dairy Produce Research Trust Account	210,136	196,984
Fishing Industry Research Trust Account	22,703	20,400
Chicken Meat Research Trust Account	5,000	4,335
Dried Fruits Research Trust Account	6,800	6,825*
Other contributors	203,015	71,568
Wheat Research		
Wheat Research Trust Account	94,767	86,044
Other contributors	5,635	3,652
Textile Industry		
Wool Research Trust Fund	1,964,353	1,809,285
Other contributors	55,548	19,864
Textile Physics		
Wool Research Trust Fund	1,272,596	1,234,612
Other contributors	410,284	408,281
Film Unit		
Other contributors	8,000	3,859
Applied Chemistry		
Other contributors	210,349	108,524
Chemical Physics		
Other contributors	23,033	11,776
Protein Chemistry		
Wool Research Trust Fund	1,215,026	1,064,450
Other contributors	49,270	49,984*
Fisheries and Oceanography		
Fishing Industry Research Trust Account	100,000	100,000
Other contributors	158,957	151,982
Chemical Engineering		
Other contributors	23,193	14,704
Mineral Chemistry		
Other contributors	11,241	6,867
Mineralogy		
Other contributors	3,881	—
Mineral Physics		
Other contributors	1,387	1,387
Baas Becking Geobiological Group		
Other contributors	78,080	63,137
Minerals Research Laboratories†		
Other contributors	214,656	133,693
Physics		
Other contributors	24,246	6,447
Radiophysics		
Other contributors	385,787	112,506
Atmospheric Physics		
Other contributors	10,841	10,624
Cloud Physics		
Other contributors	13,866	—
Environmental Mechanics		
Other contributors	26,818	18,412
Radio Research Board		
Other contributors	75,986	68,495

* Expenditure in excess of receipts will be recovered in 1973/74.

† Accounts have been established for a number of broad research programmes concerned with the minerals industries and grouped under the Minerals Research Laboratories, a complex comprising the Divisions of Chemical Engineering, Mineral Chemistry, Mineralogy, and Mineral Physics.

DIVISION OR SECTION	Receipts 1972/73 and balances brought forward ($)	Expenditure 1972/73 ($)
Building Research		
Other contributors	239,015	151,500
Tribophysics		
Other contributors	32,422	13,853
Applied Geomechanics		
Other contributors	127,052	101,028
Mechanical Engineering		
Wheat Research Trust Account	64,837	55,348
Other contributors	118,650	53,163
Mathematical Statistics		
Other contributors	142	—
Head Office		
Wool Research Trust Fund	14,000	12,268
Miscellaneous		
Other contributors	343,066	38,669
Total contributions	15,856,038	13,279,517

General Revenue

During 1972/73, general revenue amounting to $594,205 was received by the Organization. Details of the receipts are as follows:

Sale of publications	55,301
Sale of equipment purchased in former years and other receipts	113,833
Sale of produce, including livestock	124,197
Royalties from patents	147,066
Testing fees	103,734
Miscellaneous receipts	50,074
Total	594,205

The foregoing amount was spent during 1972/73 and a further $136,266 was spent from the balance remaining in the Special Account as at 1 July 1972. This expenditure was approved by the then Minister for Education and Science and the Treasurer as part of the general estimates.
A further $151,229 was received as royalties on CSIRO patents and was paid to the Commonwealth Department of Primary Industry for credit to the Wool Research Trust Fund. The patent royalties included $141,126 for the self-twist spinning machine.

AUDITOR-GENERAL'S OFFICE
CANBERRA, A.C.T.

9 August, 1973

The Honourable the Minister for
Science,
Parliament House,
CANBERRA, A.C.T.

Dear Sir,

Commonwealth Scientific and Industrial Research Organization

In compliance with section 30(2.) of the Science and Industry Research Act 1949–1968, financial statements of the Commonwealth Scientific and Industrial Research Organization for the year ended 30 June 1973 have been submitted for my report. These comprise—

Summary of Receipts and Payments
Consolidated Statement of Payments
Statement of Payments—Special Account
Statement of Payments—Specific Research Account

One set of the statements, which are in the form approved by the Treasurer, is attached.

I now report, in terms of section 30(2.) of the Act that, in my opinion—

(a) the accompanying statements are based on accounts and financial records kept in accordance with the Act;
(b) the statements are in agreement with the accounts and financial records and show fairly the financial operations of the Organization; and
(c) the receipt, expenditure and investment of moneys, and the acquisition and disposal of other property, by the Organization during the year have been in accordance with the Act.

Yours faithfully,

(Sgd.) D. R. STEELE CRAIK

(D. R. STEELE CRAIK)
AUDITOR-GENERAL

Summary of Receipts and Payments

	Funds held 1 July 1972 ($)	Receipts ($)	Total funds available ($)	Payments ($)	Funds held 30 June 1973 ($)
Special Account					
Parliamentary Appropriation: Operational	—	57,326,000.00	57,326,000.00	57,326,000.00	—
	(—)*	(51,060,000.00)	(51,060,000.00)	(51,060,000.00)	(—)
Parliamentary Appropriation: Capital	3,751.64	1,893,000.00	1,896,751.64	1,852,513.64	44,238.00
	(3,617.26)	(1,540,000.00)	(1,543,617.26)	(1,539,865.62)	(3,751.64)
Revenue and Other Receipts	234,925.65	594,204.84	829,130.49	730,471.38	98,659.11
	(240,382.80)	(1,343,050.12)	(1,583,432.92)	(1,348,507.27)	(234,925.65)
Total: Special Account	238,677.29	59,813,204.84	60,051,882.13	59,908,985.02	142,897.11
	(244,000.06)	(53,943,050.12)	(54,187,050.18)	(53,948,372.89)	(238,677.29)
Specific Research Account	2,642,359.99	13,213,677.69	15,856,037.68	13,279,517.09	2,576,520.59†
	(2,698,111.73)	(13,110,550.76)	(15,808,662.49)	(13,166,302.50)	(2,642,359.99)
Other Trust Moneys‡	18,922.66	551,620.52	570,543.18	444,299.38	126,243.80
	(12,100.91)	(340,297.13)	(352,398.04)	(333,475.38)	(18,922.66)
Cafeteria Account§	6,179.53	64,362.55	70,542.08	62,929.48	7,612.60
	(10,882.95)	(74,015.64)	(84,898.59)	(78,719.06)	(6,179.53)
Total	**2,906,139.47**	**73,642,865.60**	**76,549,005.07**	**73,695,730.97**	**2,853,274.10**
	(2,965,095.65)	**(67,467,913.65)**	**(70,433,009.30)**	**(67,526,869.83)**	**(2,906,139.47)**

* Figures in brackets refer to 1971/72 financial year.
† Includes investments totalling $1,696,850.
‡ Moneys held temporarily on behalf of other organizations and individuals.
§ Operating receipts and expenses of CSIRO cafeterias at Melbourne and Sydney. The Sydney cafeteria ceased operations on 30 November 1971.

J. R. Price (*Chairman*) R. W. Viney (*Finance manager*)

Consolidated Statement of Payments

1971/72 ($)		1972/73 ($)
	Head Office (including Regional Administrative Offices)	
2,982,016	Salaries and allowances	3,275,893
256,731	Travelling and subsistence	240,892
225,491	Postage, telegrams, and telephone	303,774
550,884	Incidental and other expenditure	647,871
4,015,122		4,468,430
	Research Programmes	
	Agricultural research	
7,794,711	Animal health and reproduction	8,410,801
4,141,910	Plant industry	4,464,941
4,266,371	Entomology and wildlife	4,834,705
2,239,900	Soils	2,364,463
1,422,466	Horticulture and irrigation	1,502,463
2,082,648	Tropical agronomy	2,298,102
2,973,010	Land research	3,354,392
5,967,603	Processing of agricultural products	6,761,619
1,279,669	Information and publications	1,395,565
5,954,453	Chemical research of industrial interest	6,354,009
1,485,400	Fisheries and oceanography	1,779,045
3,877,527	Processing and use of mineral products	4,415,700
3,440,122	Physical research of industrial interest	3,705,846
3,774,991	General physical research	4,245,249
5,382,315	General industrial research	5,926,846
2,278,710	Research services	1,791,707
487,359	Miscellaneous	563,135
58,849,165		64,168,588
	Grants	
372,517	Research associations	454,984
293,321	Research studentships	315,990
995,459	Other grants and contributions	1,146,475
1,661,297		1,917,449
	Capital Works and Services	
1,341,326	Buildings, works, plant, and developmental expenditure	1,064,283
499,889	Scientific computing equipment	539,952
694,886	Other equipment	804,936
52,990	Development of Ginninderra field station	39,594
—	Expansion of CSIRO computer network	185,270
2,589,091		2,634,035
	Other Trust Moneys	
190,342	Remittance of revenue from investigations financed from Industry Trust Accounts	306,588
143,133	Other miscellaneous remittances	137,711
333,475		444,299
	Cafeteria Account	
78,719	Operating expenses of CSIRO cafeterias at Melbourne and Sydney. The Sydney cafeteria ceased operations on 30 November 1971	62,929
78,719		62,929
67,526,869	**Total Expenditure**	**73,695,730**

J. R. Price (*Chairman*) R. W. Viney (*Finance manager*)

Statement of Payments—Special Account*

1971/72 ($)		1972/73 ($)
	Head Office (including Regional Administrative Offices)	
2,971,326	Salaries and allowances	3,264,751
255,598	Travelling and subsistence	240,435
225,491	Postage, telegrams, and telephone	303,774
550,884	Incidental and other expenditure	647,202
4,003,299		4,456,162
	Research Programmes	
	Agricultural research	
4,659,099	Animal health and reproduction	5,293,750
3,243,600	Plant industry	3,682,596
3,259,097	Entomology and wildlife	3,652,121
2,105,095	Soils	2,292,413
1,357,200	Horticulture and irrigation	1,435,830
1,718,699	Tropical agronomy	1,923,025
2,160,500	Land research	2,480,547
2,538,700	Processing of agricultural products	2,862,930
1,279,369	Information and publications	1,391,706
4,624,400	Chemical research of industrial interest	5,151,088
1,385,400	Fisheries and oceanography	1,679,037
3,542,274	Processing and use of mineral products	4,214,735
3,427,300	Physical research of industrial interest	3,699,399
3,687,900	General physical research	4,055,558
5,019,799	General industrial research	5,551,953
2,278,480	Research services	1,791,707
456,999	Miscellaneous	524,466
46,743,911		51,682,861
	Grants	
372,517	Research associations	454,984
293,321	Research studentships	315,990
995,459	Other grants and contributions	1,146,475
1,661,297		1,917,449
	Capital Works and Services	
379,988	Buildings, works, plant, and developmental expenditure	412,198
499,889	Scientific computing equipment	539,952
606,999	Other equipment	675,499
52,990	Development of Ginninderra field station	39,594
—	Expansion of CSIRO computer network	185,270
1,539,866		1,852,513
53,948,373	**Total Expenditure**	**59,908,985**

* Special Account refers to moneys paid to CSIRO out of the Consolidated Revenue Fund of the Commonwealth and other related moneys specifically covered by Section 26C of the Science and Industry Research Act 1949–1968.

J. R. Price (*Chairman*) R. W. Viney (*Finance manager*)

Statement of Payments—Specific Research Account

1971/72 ($)		1972/73 ($)
	Head Office (including Regional Administrative Offices)	
10,690	Salaries and allowances	11,142
1,133	Travelling and subsistence	457
—	Postage, telegrams, and telephone	—
—	Incidental and other expenditure	669
11,823		12,268
	Research Programmes	
	Agricultural research	
3,135,612	Animal health and reproduction	3,117,051
898,310	Plant industry	782,345
1,007,274	Entomology and wildlife	1,182,584
134,805	Soils	72,050
65,266	Horticulture and irrigation	66,633
363,949	Tropical agronomy	375,077
812,510	Land research	873,845
3,428,903	Processing of agricultural products	3,898,689
300	Information and publications	3,859
1,330,053	Chemical research of industrial interest	1,202,921
100,000	Fisheries and oceanography	100,008
335,253	Processing and use of mineral products	200,965
12,822	Physical research of industrial interest	6,447
87,091	General physical research	189,691
362,516	General industrial research	374,893
230	Research services	—
30,360	Miscellaneous	38,669
12,105,254		12,485,727
	Capital Works and Services	
961,338	Buildings, works, plant, and developmental expenditure	652,085
87,887	Other equipment	129,437
1,049,225		781,522
13,166,302	**Total Expenditure**	**13,279,517**

J. R. Price (*Chairman*)

R. W. Viney (*Finance manager*)

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