Commonwealth Scientific and Industrial Research Organization, Australia

CSIRO Twenty-fourth Annual Report 1971/72

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This Report of the work of the Commonwealth Scientific and Industrial Research Organization for the year ending 30 June 1972 has been prepared as required by Section 30 of the Science and Industry Research Act 1949–1968.

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

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

CSIRO, the Commonwealth Scientific and Industrial Research Organization, 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 for the promotion of primary and secondary industries in the Commonwealth and its Territories

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 Commonwealth standards of measurement

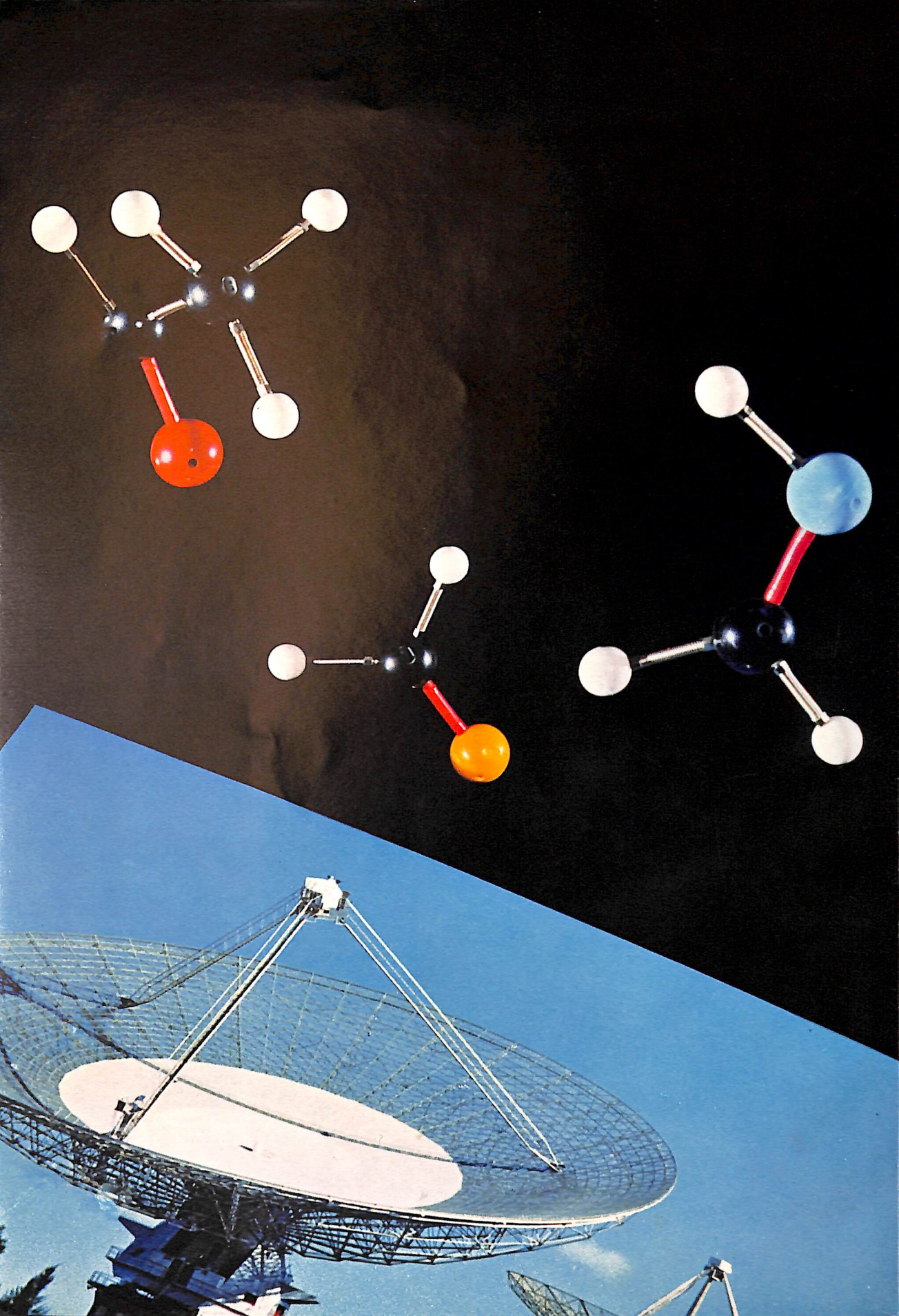
the dissemination of scientific and technical information

the publication of scientific and technical reports.

CSIRO is governed by an Executive of five full-time members and four part-time members. The Executive is responsible to the Minister for Education and Science for the policy and work of the Organization.

For carrying out research, CSIRO is divided into a number of Divisions. Each Division is under the control of a Chief and each Chief is responsible to the Executive for the activities of his Division, within the limits of the funds allocated and the general policy decisions made by the Executive.

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 Secretariat is headed by an Executive Officer and each Branch is under the control of a Secretary.



Contents

During the year radio astronomers from the DIVISION OF RADIOPHYSICS discovered two organic compounds in interstellar space using the 64-metre radio telescope at Parkes, New South Wales, and found a new spectral line from a third (see story on page 43). Three-dimensional models of the molecules are shown opposite. They are, from left to right, acetaldehyde, thioformaldehyde, and methyleneimine.

In order to detect signals from organic molecules, it is usually necessary to operate at wavelengths shorter than 10 cm—the wavelength required in the original 1955 specification for the 64-metre telescope. This has been achieved by the installation of an improved reflecting skin designed and constructed by the Division out to a diameter of 33 metres (the white-painted section). The telescope now operates with precision at wavelengths as short as 1 cm.

The expertise gained from radio astronomy is being turned to novel applications of antenna design and electronics. The Division is currently developing, in collaboration with the Department of Civil Aviation, a new-generation instrument landing system for aircraft which uses microwaves (see story on page 9).

Cover

A remote weather station on the fringe of the Simpson Desert, central Australia. The station, which records information on wind speed, wind direction, and rainfall, is part of a network established by the RANGELANDS RESEARCH UNIT to find out more about the climate of arid Australia. The information obtained by the station is also being used by the University of New South Wales in sand dune studies.

Mr. Malcolm Fraser succeeded Mr. David Fairbairn as Minister for Education and Science in August 1971, following the appointment of Mr. Fairbairn as Minister for Defence. Mr. Fraser was previously Minister for Education and Science from 1968 to 1969.

General

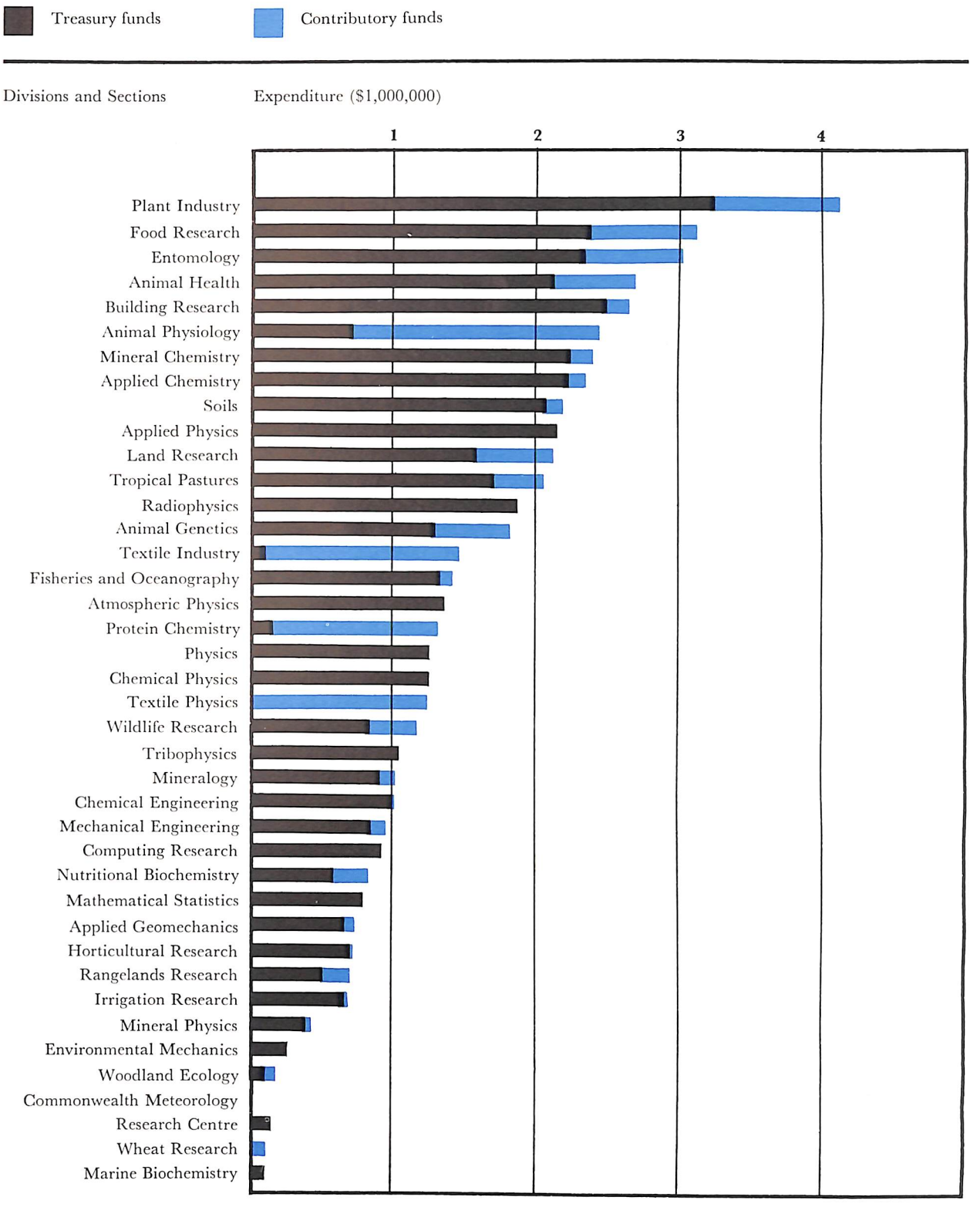
Finance

The table below summarizes the sources of CSIRO funds for 1971/72 and the categories of expenditure. About four-fifths of CSIRO's income for the year was provided directly by the Commonwealth Government. The remainder was contributed by trust funds concerned with the wool, meat, wheat, dairying, tobacco, fishing, and dried fruits industries and by individual companies, Australian and overseas government instrumentalities, and private foundations. The trust funds constitute more than four-fifths of the contributory funds received by the Organization. Most of the funds are derived from a levy on produce supported by a Commonwealth Government contribution.

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

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	50,747,210	1,661,297	1,539,866	53,948,373
Wool Research Trust Fund	7,368,781	—	367,709	7,735,990
Meat Research Trust Account	1,565,071	—	48,131	1,613,202
Wheat Research Trust Account	194,064	—	284	194,348
Dairy Produce Research Trust Account	303,616	—	—	303,616
Tobacco Industry Trust Account	267,783	—	471	268,254
Fishing Industry Research Trust Account	112,699	—	—	112,699
Dried Fruits Research Trust Account	22,448	—	—	22,448
Other contributors	2,282,615	—	633,130	2,915,745
Total	62,864,288	1,661,297	2,589,091	67,114,675

Expenditure on investigations, 1971/72



Treasury funds

During 1971/72 CSIRO spent $50·7 million from Treasury funds on salaries and general running expenses, an increase of $6·6 million over the previous year's expenditure in this category. Most of the additional money was committed to inescapable increases such as salary adjustments arising from Arbitration determinations.

The remainder of the increase was allocated as follows:
$471,000 was used to assist in the redeployment of 54 members of staff whose salaries in the past had been financed from wool and dairy funds. Both funds were unable to support research at the 1970/71 levels of activity.
$176,000 was allocated to develop major projects initiated in earlier years. The most important activities in this category were research on mineral exploration, rock mechanics, grain storage, and prawns in northern Australian waters. $107,000 was allocated to four new projects which commenced during the year. The projects were concerned with water purification, tick resistance in beef cattle, beef cattle fertility, and standards of noise.

Other funds

The amount of finance available to CSIRO from the Wool Research Trust Fund was some $450,000 less than the amount which had been sought by the Executive and which was considered by the Executive to be the minimum sum necessary to maintain the Organization's wool research programme at its 1970/71 level. In view of this the Executive found it necessary to reduce its wool research programme by the redeployment of 50 members of staff.

The funds available from the Dairy Research Trust Account were also limited during 1971/72 and the Australian Dairy Produce Board was obliged to make reductions in the Organization's dairy research proposals. It was necessary, therefore, to transfer four members of staff previously engaged on dairy manufacturing problems to work not directly concerned with the dairy industry.

A sum of $100,000 was provided from the Fishing Industry Research Trust Account for research on prawns in northern Australian waters. This finance has been used principally for the charter of fishing boats and light aircraft.

Landing system for aircraft

It was announced in May 1972 that the Department of Civil Aviation would provide CSIRO with $130,000 during 1972/73 for the first phase of a research programme by the DIVISION OF RADIOPHYSICS to develop a new instrument landing system for aircraft. A similar amount will be allocated to the project by CSIRO. The Division and the Department believe that a microwave landing system suitable for international use can be based on an antenna of novel design that arose from the Division's research in radio astronomy. In the view of the Department, the Division's antenna design promises to have important advantages in meeting the requirements for a new system.

A more flexible system than that currently used will be needed to cope with the rising volume of air traffic, to exercise precise control of flight paths in the interests of noise abatement, and to accommodate the expected introduction of 'short take-off and landing' aircraft. Such a system will have to take into account multiple approaches, curved flight paths, and a variety of elevation angles. It will also have to be capable of guiding aircraft onto a runway in conditions of low, even zero

visibility. These requirements are most likely to be met by the use of an extremely high frequency in the microwave band.

The International Civil Aviation Organization (ICAO) has laid down the operational requirements for a new system and has recommended that member States of ICAO begin developing microwave instrument landing systems for initial assessment early in 1973. Microwave instrument landing systems will probably be introduced to the world's airports towards the end of this decade. Irrespective of whether the Australian system is adopted internationally, the joint research project between CSIRO and the Department of Civil Aviation will provide Australia with the necessary technological background to carry out the design, installation, and operation of such a system in this country.

Grant from BHP

The Broken Hill Proprietary Co. Ltd has agreed to a grant of $100,000 to CSIRO to support further research on the production of electrode carbon from natural gas. The money will be used to finance construction of a large-scale experimental rig at the Port Melbourne laboratories of the DIVISION OF MINERAL CHEMISTRY.

Last year's Annual Report described a process developed by the DIVISION OF MINERAL CHEMISTRY for producing electrode carbon by cracking natural gas and other hydrocarbons at temperatures of about 1100°C in a moving-bed reactor. A reactor at the Division's Sydney Laboratories has produced electrode grade carbon which is being tested at the bench scale for use in anodes for the production of aluminium. The experimental rig, planned for Port Melbourne where natural gas is on pipeline, has been designed with sufficient capacity (about 10 kilogrammes an hour) to produce large samples of carbon for full-scale anode tests and to obtain technical data for the design of a commercial plant.

Electrode carbon used by Australian aluminium smelters is imported at present in the form of petroleum coke at a cost of $3 million a year. If the project proves successful, Australian use of electrode carbon by the late seventies could account for a quantity of gas equivalent to the natural gas needs of Melbourne.

Drought study

A bequest of $18,000 to CSIRO from the estate of former grazier, Mr. Arthur Sulman, of Forrest, A.C.T., will be used to finance a two-year postdoctoral fellowship on droughts.

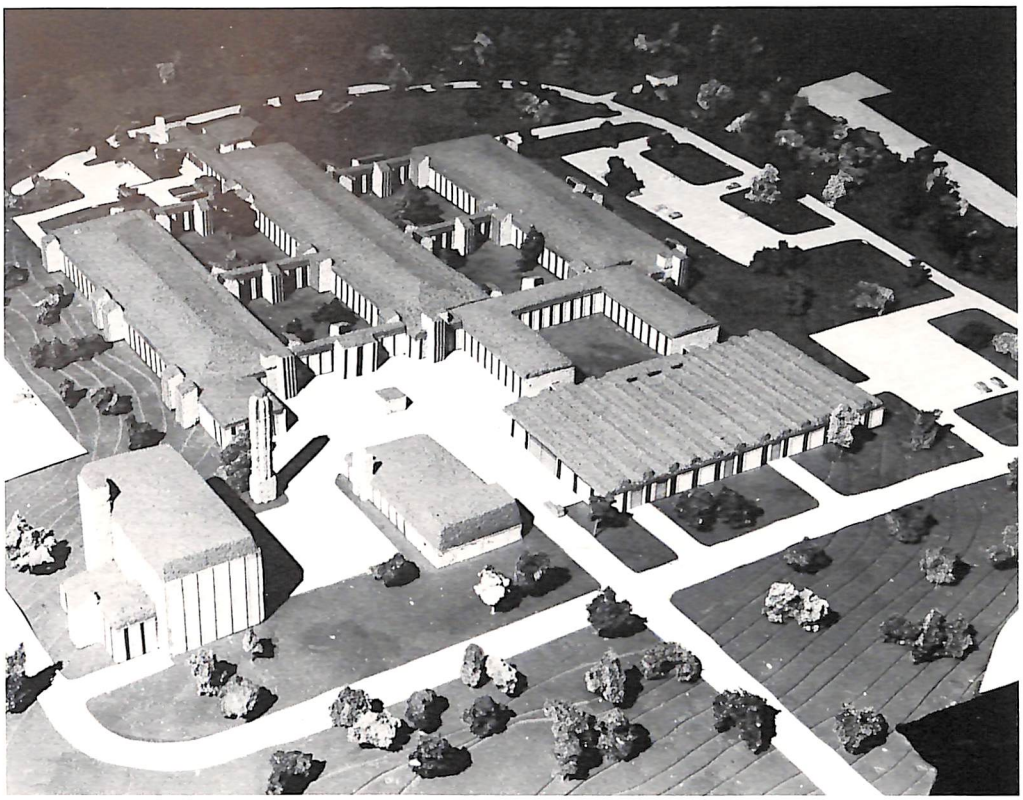
The Fellow to be appointed will work in close collaboration with the Commonwealth Government's Interdepartmental Drought Study Group and will be supervised by the Leader of CSIRO's Rangelands Research Unit.

The Study Group was set up in 1970 by a committee of the Australian Agricultural Council to investigate the longer-term aspects of drought and improve knowledge of droughts, their recognition and occurrence, and their biological and economic consequences at farmer, regional, State, and national levels. The Group considers that the main research need at present is to consolidate existing knowledge into an overall picture as a basis for assessing management strategies and administrative decisions.

Initially, the study will involve a selected area having a single industry, a single rainfall season, and a simple soil and vegetation pattern. But later the study could be extended to other regions representing a variety of industries and climates.

Above Stored Grain Research Laboratory, Black Mountain, Canberra.

Below This model shows how the proposed National Standards Laboratory will look when viewed from the north-west. The buildings have been designed by the Commonwealth Department of Works and the expected total cost of the project is in the order of $16 million.



Buildings

The largest project in the Organization's building programme is the new laboratory complex to rehouse the NATIONAL STANDARDS LABORATORY. Tenders have been called for the main building and all services, and construction is expected to begin within the first half of the next financial year. The 73-acre site for the laboratory complex is at Bradfield Park, seven miles north-west of Sydney. Preparatory site work costing approximately $300,000 has been completed.

Tenders for the following buildings were let during 1971/72:

ANIMAL GENETICS—Poultry breeding house at North Ryde, Sydney. $106,000.

ANIMAL HEALTH—Rehabilitation of laboratories vacated on completion of new wing at Animal Health Research Laboratory, Parkville, Melbourne. $122,000.

CHEMICAL PHYSICS—Extensions to existing laboratory buildings at Clayton, Melbourne. $370,000.

PASTORAL RESEARCH LABORATORY—Extension to Pastoral Research Laboratory, Townsville, Queensland, to provide additional accommodation for the various Divisions located there. $670,000.

Major projects completed during the year include:

ANIMAL HEALTH—Extension to Animal Health Research Laboratory, Parkville, Melbourne. $470,000. Tuberculosis isolation unit, large animals isolation units, and extension to small animals building. $315,000. Of this amount $97,000 was provided from the Meat Research Trust Account.

APPLIED GEOMECHANICS—Rock mechanics laboratory, Syndal, Melbourne. $215,000.

BLACK MOUNTAIN LIBRARY—This library serves all the Divisions located at Black Mountain, Canberra, with the exception of the Division of Computing Research. $445,000.

ENTOMOLOGY—Stored Grain Research Laboratory, Canberra. Funds for this project were made available by the Australian Wheat Board. $305,000.

FOOD RESEARCH—Extension to laboratory and library at North Ryde, Sydney. $302,000.

MINERAL CHEMISTRY—Stage two of development laboratory at Garden City, Port Melbourne. $125,000.

MINERALS RESEARCH LABORATORY—Laboratory at North Ryde, Sydney, for the Divisions of Mineral Chemistry and Mineralogy and the Mineral Physics Section. $2,160,000.

Executive member

Dr. D. L. Ford, Chief Research Chemist of Union Carbide Australia Ltd, was appointed a part-time member of the Executive in November 1971. Dr. Ford's appointment filled the vacancy created by the retirement from the Executive of Dr. K. L. Sutherland, Research Director for the Colonial Sugar Refining Company. Dr. Sutherland had served on the Executive since 1965.

In recent years Dr. Ford has been a member of the Council of the University of New South Wales and a member of its Academic Committee and its Finance Sub-Committee. He played a leading role in the early stages of the development of teaching hospitals for the University of New South Wales. From 1967 to 1969 he was a member of the Australian Research Grants Committee.

Environmental physics

In July 1971 the DIVISION OF METEOROLOGICAL PHYSICS was renamed the DIVISION OF ATMOSPHERIC PHYSICS and was grouped together with the DIVISION OF ENVIRONMENTAL MECHANICS as the ENVIRONMENTAL PHYSICS RESEARCH LABORATORIES. The purpose of this move was to unify all CSIRO research concerned with the physical processes

controlling weather (both global and local), the experimental modification of weather by techniques such as rain-making, the interaction of plants with their environment, and atmospheric aspects of pollution. Dr. C. H. B. Priestley, formerly Chief of the DIVISION OF ATMOSPHERIC PHYSICS, was appointed Chairman of the Laboratories.

Subsequently it was decided that in July 1972 the ENVIRONMENTAL PHYSICS RESEARCH LABORATORIES should be restructured to include a DIVISION OF CLOUD PHYSICS. This Division was formed from the former Cloud Physics Section of the DIVISION OF ATMOSPHERIC PHYSICS.

Coastal plains

The administration of the Coastal Plains Research Station south of Darwin has been transferred from the DIVISION OF LAND RESEARCH to the Northern Territory Administration. Coastal Plains was established in 1959 when the Administration invited CSIRO to set up a research programme to assess the rice-growing potential of the Northern Territory's subcoastal plains. This work has now been largely completed. Agronomic research on rice will be transferred to the Kimberley Research Station at Kununurra, Western Australia. A programme of rice breeding and variety testing will, however, be continued for the time being at Coastal Plains under the direction of Mr. E. C. B. Langfield.

The Animal Industry and Agriculture Branch of the Administration plans to use the facilities at Coastal Plains to expand pasture investigations on the subcoastal plains and on the adjoining higher country. The Station will operate in conjunction with the adjacent Beatrice Hills Experiment Farm to form a major regional agricultural research centre.

Work by the DIVISION OF LAND RESEARCH at the Station has included research on rice breeding, soil suitability, aerial seeding, fertilizer requirements, weed and insect pest control, and diseases of rice. Novel methods of puddling rice lands under natural flooding have been developed in addition to traditional irrigation methods. New, high-yielding rice types have been introduced from the International Rice Research Institute in the Philippines, and some locally bred varieties are also promising.

The Division's work has shown that large quantities of irrigation water would be necessary for commercial rice production in the area and this could only be provided as a result of heavy capital investment.

Committee reports

During the year the Executive received a report on the Organization's wool production and wool textile research programmes from an independent committee under the chairmanship of Mr. L. W. Weickhardt. The committee was set up by the Executive to help clarify the research needs of the wool industry and to evaluate CSIRO's contribution to those needs. The Executive also received reports from two CSIRO committees which it had set up to examine problems relating to wool harvesting and diversification from wool production.

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.

Townsville stylo seed is good feed

During the winter dry season in northern Australia, cattle on Townsville stylo pastures seek out the seed. At a time when other plant material is dead and of low nutritive value this seed provides excellent feed.

Chemical analyses by the DIVISION OF TROPICAL PASTURES have shown that Townsville stylo seed is rich in protein (40–45%), phosphorus (0·4–0·8%), and sulphur (0·3–0·5%), the levels of phosphorus and sulphur being proportional to the amount of superphosphate applied to the pasture. These nutrient concentrations are far higher than those found in grasses and the mature dry foliage of Townsville stylo during the dry winter. More than 50% of the total phosphorus and sulphur in the plant is transferred to the seed at maturity.

As yields of intact seed pods in the field are high (about 450 pounds an acre or 504 kilogrammes a hectare) the seed represents a substantial source of stored, weather-resistant feed of high quality. Up to 80% of the seed, but only 14% of the pod, is digested by cattle. Experiments in conjunction with the Chemistry Department of the James Cook University of North Queensland indicate that the difference is due to the high concentration of structural carbohydrates in the pod.

Another experiment involved feeding sheep and cattle on nothing but intact seed pods. The pods proved to be an important source of dietary protein, phosphorus, sulphur, and calcium and had a high level of digestible energy (55–60%). When cattle were fed different quantities of intact seed pods together with unrestricted amounts of low-quality grass hay, it was found that feeding 1 pound (0·48 kg) a day of the pods increased consumption of hay by 30% and liveweight gain by 1 pound a day.

Improving the quality of tropical pastures

Milk production from grazing dairy cows is being used to measure the quality of different tropical pasture species and mixtures.

While tropical pastures produce substantially higher yields than temperate pastures, they generally produce lower-quality herbage. Since 1966 the DIVISION OF TROPICAL PASTURES has been evaluating the quality of various pasture plants in terms of milk production by grazing dairy cattle. This work has revealed important differences in milk production from grasses at comparable stages of growth. For example, young

pangola is superior to rhodes grass and Kazungula setaria, and spring growth of *Setaria splendida* and pangola is better than spring growth of kikuyu and other setarias. Another significant finding is that in tropical species the decline of quality with increasing maturity is much more rapid in grasses than in legumes. This is a decisive factor in planning the management and integrated use of grass–legume pastures with nitrogen-fertilized grass swards for both dairy and beef cattle.

The Division found important variations in milk composition among cows grazing different pastures. On poorer-quality feeds, milk yield is depressed owing mainly to a low intake of digestible energy. At the same time the percentage butterfat increases while the percentage of solids-not-fat, particularly protein and casein, decreases. The composition of the fat is also changed. When the intake of digestible energy is low, the animals are forced to draw on their reserves of body fat resulting in a higher than usual proportion of long-chain fatty acids in the milk. These changes in milk composition cause some difficulty in processing milk into cheese.

Increasing barley yields

Barley yields can be increased on water-repellent sands by sowing the seed at the bottom of specially contoured furrows.

Large areas of sandy soil in southern and western Australia resist the penetration of rain water. In these areas rain merely wets the surface of much of the soil, only penetrating here and there in narrow columns. In severe cases the dry areas between these columns are still dry at the end of a wet winter.

The DIVISION OF SOILS estimates that in southern Australia these water-repellent sands depress crop yield on more than one million acres of land that receive adequate rainfall for cereal production. Seeds germinate readily on those areas where rain has been able to penetrate the soil after sowing, but on the dry, hard-to-wet patches germination is delayed. Although seeds may continue to sprout on these drier areas throughout the winter as adequate moisture reaches them, they dry off too early in spring to produce much grain.

Experiments with water-repellent sands formed into ridges and troughs in small trays showed that rain water is shed to the troughs and penetrates the soil from there. Barley seeds sown in the troughs germinated readily but those in the crests remained dry and did not germinate.

This method was tested in the field at Karoonda in South Australia in 1971. Plots where barley seeds were planted at the bottom of specially contoured furrows yielded 1200 kilogrammes a hectare (1072 lb an acre) compared with only 500 kilogrammes a hectare (447 lb an acre) where seeds were sown in the crests. However, the resultant plant densities indicated that yields would be further increased if the germination rate could be improved. The Division is attempting to do this by using wetting agents.

Thinning trees with chemicals

Chemical methods of controlling woody regrowth of poplar box and other trees are being investigated as an alternative to ring-barking and 'sucker bashing'.

A typical eucalypt troublesome on grazing land is poplar box, commonly found in semi-arid woodlands in southern Queensland and northern New South Wales—sometimes at densities of

more than 400 stems an acre. The poplar box trees stifle the growth of native grasses, even after quite heavy falls of rain, and increase the cost of mustering.

In the Australian pioneering tradition, extensive areas of poplar box have been ring-barked or sucker-bashed to enhance grass growth. Such treatments have been only partly effective because of the capacity of the species to resprout from dormant buds just below ground level. Mechanical clearing with bulldozers, although common, has many drawbacks on land not destined for cropping or sown pasture. Often the trees snap off at ground level, enabling as many as 30 shoots to resprout from one stem, and such vigorous regrowth is hard to kill.

Over the last few years, research by the Woodland Ecology Unit of the DIVISION OF LAND RESEARCH has helped to alleviate this regrowth problem. The Unit has tested a wide range of chemicals in south-western Queensland on properties in the 20–25-inch-rainfall zone and can now recommend suitable chemical treatments for controlling poplar box and a number of other woody plants. One important finding has been that chemical thinning promotes more herbage growth than ringbarking does. But, unlike mechanical clearing, chemical treatment leaves the soil undisturbed so that weeds do not flourish.

The Unit has highlighted the need for careful application of the chemical. Many failures can be attributed to insufficient chemical reaching the cambium (the region between the bark and the wood); sometimes, for instance, the chemical may merely lodge in the bark. Doses injected at the base of the tree were more effective than those applied in axe cuts at waist height.

The control of individual trees is only the first stage of a basic study in grass–woodland ecology. Already the Unit is taking advantage of another finding that poplar box trees reduce grass production more than shrubs do. In fact, it hopes to develop ways of using the shrubs as a source of feed, particularly during droughts. Other studies concern the control of seedlings that may sprout in the chemically treated areas. In some cases the problem can be overcome by grazing with sheep, and in others buffel grass can be sown.

Photosynthesis and the C_4 pathway

The possession by certain plants of a special chemical pathway for the assimilation of carbon dioxide explains their high potential for photosynthesis and growth and their tolerance to water stress.

Carbon dioxide from the air and water are the two materials from which green plants manufacture glucose and various other carbohydrates by the process of photosynthesis. The incorporation of carbon dioxide into the glucose molecule takes place in a series of chemical steps known as the Calvin cycle.

In recent years research at several Australian laboratories, including the DIVISION OF PLANT INDUSTRY, have shown that in a number of crops including sugar-cane, maize, sorghum, and millet, as well as in several important pasture plants, the assimilation of carbon dioxide involves an additional chemical pathway which has been called the C_4 dicarboxylic acid pathway.

In these C_4 plants carbon dioxide from the air is first incorporated into malic and aspartic acids. One or other of these acids is transported to specialized cells in the plant and broken down to release carbon dioxide. The carbon dioxide is then refixed by the chemical reactions of the Calvin cycle, the eventual products being starch and sugar. In C_4 plants, the Calvin cycle

At Merbein, Victoria, the DIVISION OF HORTICULTURAL RESEARCH is crossing both local and introduced grape varieties to produce new varieties better suited to Australian conditions. The breeding programme covers grapes for wine, dried fruit, and the table. More than 200 seedlings from various crosses are being raised each year but testing takes a long time as it could take 10 or more years to produce a new variety. In the case of potential new wine varieties, small quantities of wine must be made to see if the fruit has the right characteristics. One of the new dried fruit varieties being tested gives high yields of seedless black grapes similar to the Currant. Unlike the Currant, however, no special practices are needed to induce fruit set and the ripe fruit is not split by rain. Another hybrid produces a sultana-like fruit with an attractive, mildly acid flavour. The picture above shows a vine flower being emasculated to provide a female parent for hybridization.

depends almost entirely on the carbon dioxide produced by the breakdown of malic and aspartic acids; the Calvin cycle makes little or no direct contribution to carbon dioxide assimilation.

C_4-pathway species have several important characteristics that set them apart from Calvin cycle species; they have a high potential for photosynthesis and growth, they prefer high light and temperature situations, they have a low rate of water usage relative to their rate of growth, and they are drought-tolerant.

These characteristics of C_4 plants can be explained by the operation of a highly efficient system for assimilating carbon dioxide which permits high rates of photosynthesis even with very restricted opening of stomata, the adjustable pores on the leaf surface through which both carbon dioxide and water vapour move. Because of this, the cost of carbon dioxide assimilation in terms of water loss is minimized and the Calvin cycle

can operate optimally by using this carbon dioxide after it has been released again and concentrated in a special compartment of the leaf. By comparison, plants that possess only the Calvin cycle generally cannot assimilate carbon dioxide as fast even when their stomata are fully opened. Therefore, they lose more water relative to the amount of carbon dioxide assimilated. Furthermore, when the supply of water is limited, they must reduce stomatal opening to survive. By so doing, carbon dioxide intake, and therefore growth, are further reduced compared with C_4 plants.

The discovery of the C_4 pathway has opened up the possibility of improving the performance and adaptation of existing agricultural species by hybridizing Calvin cycle and C_4-pathway species. Another possible application is in the development of selective herbicides. Many noxious weeds are C_4 species. Chemical compounds that specifically inhibit one or other of the unique enzymes operating in the C_4 pathway would be most likely to show selective action against C_4 species of weeds in a crop with the Calvin cycle pathway.

Carbon dioxide and plant growth

Day-to-day variations in the amount of carbon dioxide in the air have been shown to affect crop growth.

Studies of plant growth in laboratories where the environment can be controlled have shown that a plant's dry matter production increases with the concentration of carbon dioxide in the air. The DIVISION OF ENVIRONMENTAL MECHANICS has now demonstrated this relationship in the field. At Deniliquin, New South Wales, the Division monitored dry matter production in a wheat crop by measuring the rate at which the crop absorbed carbon dioxide from the air. A reduction of 40% in the rate of carbon dioxide absorption was noted from one day to the next when the average daytime concentration of carbon dioxide in the air decreased from about 340 parts of carbon dioxide per million parts of air (p.p.m.) to 250 p.p.m.

Such day-to-day variations in atmospheric carbon dioxide concentration appear to be associated with changes in the trajectories of air over the land. The concentration of carbon dioxide in air moving across the oceans is fairly uniform at around 320 p.p.m. Air moving over large industrial and urban areas may gain carbon dioxide, but as it travels for long distances over land its carbon dioxide content may be depleted through absorption by vegetation. In the Deniliquin observations the carbon-dioxide-depleted air had travelled for more than 1000 kilometres over land, crossing the coast about Brisbane, while the carbon-dioxide-rich air had travelled only about 200 kilometres, crossing the coast in the vicinity of Melbourne.

An analysis of the expected losses of carbon dioxide near the ground, at increasing distances from the sea, indicates that in the spring and summer when there is rapid plant growth, surface concentrations of 250 p.p.m. or less might well be expected at large distances inland (of the order of 1000 kilometres). In inland Australia, availability of water is generally the limiting factor to plant growth. In those situations where water is available, however, these low concentrations of carbon dioxide could limit the potential dry matter production of plants quite considerably.

The analysis is being extended to examine the influence of carbon dioxide absorption by large vegetated land masses on the global balance of carbon dioxide.

Recharging ground water

Recharge of ground water beneath the Gambier Plain of south-eastern Australia and south-western Victoria is much less under pine forests than it is under pastures.

Earlier work by the DIVISION OF SOILS has shown that the annual recharge of ground water beneath the Gambier Plain is about half a million acre feet. A pilot study of recharge of the underground water beneath a pine forest, however, revealed that the evaporation from the forest equalled the rainfall so that the recharge was zero.

Since pine plantations in the region are extending, the Division decided to investigate the behaviour of a large tract of forest using two different methods. The water level in the porous, water-conducting rock beneath the Gambier Plain oscillates throughout the year, and in the first method these oscillations were used to study the relative rates of recharge beneath forest and pasture. This study indicated that some recharge does occur beneath both forest and pasture, but beneath forest it is less than one-half of that occurring beneath pasture.

In the second method the concentration of tritium, the radioactive isotope of hydrogen, in rain water and in underground water was determined. The tritium concentration of the underground water is related to the time taken for rain water to move through the soil, and hence to the recharge rate. A series of observation wells extending from pasture to forest showed strikingly different tritium concentrations beneath the two plant covers. Under some portions of the forest the age of the water was about 36 years which is about the actual age of the trees. However, on average, it was concluded that some recharge occurred beneath forest, but that the rate was less than one-sixth of that under the surrounding pasture.

The cause of the difference in size of recharge as determined by these two methods has not yet been resolved. It may be that the tritium study was carried out in better-quality forest than the study based on water levels and that the more vigorously growing trees used more water so that the recharge below them was less.

Herbicide residues in the soil

The persistence in the soil of herbicide used to control weeds in maize and sorghum crops could harm the growth of other crops following closely in rotation. Factors affecting the persistence of herbicide in the soil are being investigated.

In the Murrumbidgee Irrigation Areas of New South Wales, atrazine is widely used to control weeds in crops of maize and sorghum. Two closely related chemicals, simazine and propazine, are used with other crops. Changing patterns of land use in the area have led to fears that atrazine might persist in the soil long enough to harm crops such as soya beans, rice, and vegetables following closely in rotation after maize or sorghum.

At Griffith, the DIVISION OF IRRIGATION RESEARCH has been investigating the factors that affect the rate of breakdown of atrazine in the soil. One approach involved a series of laboratory experiments to measure the effect of acidity and temperature on the rate of dissipation of atrazine from soil-free solutions. These experimental results were compared with others from similar tests using a contrasting range of Australian soils. In general, the process was found to be faster in soil than in the soil-free solution.

The Division is now seeking the factors in soil that are responsible for accelerat-

ing the loss of atrazine. Soil sterilization did not slow down this loss to any great extent, suggesting that soil microbes are not involved. The Division is now looking at other possible factors that may affect the breakdown of atrazine—for example, adsorption on clay particles or perhaps the action of catalysts such as iron oxides or humic acids.

So far, the results show that, even within a small area, the persistence of atrazine in the soil can be quite variable. Large differences are found between soil types, but temperature also plays a crucial role as persistence increases markedly at low temperatures. These early findings highlight the need for careful use of the herbicide.

Controlling irrigation flows

Computational techniques have been developed for investigating the design and operation of irrigation systems.

In the day-to-day operation of a large irrigation network, adjustments have to be made to the many regulating structures along the waterway to ensure that enough water, at the right level, arrives at each offtake point. Such adjustments can be made relatively easily in times of steady demand and adequate water supply. But the operator needs much skill and experience to cope with sudden changes in the demand for water, for example after heavy rain. His operational problems become even more severe during droughts—particularly when water must be sent along very long channels, and when there are no supplementary buffer storages near the irrigation areas.

The flow of water in a channel system can be predicted by means of complex mathematical equations, first developed for the study of hammer in pipelines. Before the advent of computers, engineers used a series of simplifying assumptions that made the equations easier to solve. Now the speed of computers has made it feasible to solve the equations in their complete form.

The DIVISION OF IRRIGATION RESEARCH has been using the fluctuating flow equations to investigate the operations of large irrigation networks. In particular, it has studied problems of water control in the Murray River between Lake Hume and the Yarrawonga Weir, for along this section of the river, water is diverted to both Victoria and New South Wales. The Division solved the flow equations in a back-to-front sequence: knowing the downstream demand pattern, it predicted what flows must be released upstream to satisfy the downstream requirements.

The computational techniques developed by the Division provide a valuable tool for investigating both the design and the operation of an irrigation system. Correct settings for regulating structures can be predetermined for a wide range of operating conditions. This would allow reservoir releases to be programmed to deliver correct flows—at the right time—at channel offtakes. The techniques could be adapted to investigate the feasibility of automatic operation of an irrigation network. They could also be used for guiding the operation of flood releases from reservoirs.

Copper deficiency in cattle

An unusual type of copper deficiency has been detected in seemingly healthy cattle. A simple blood test has been developed to diagnose the condition, which can be corrected by a subcutaneous injection of copper glycinate.

The occurrence of copper deficiency of livestock in certain areas of Australia can usually be related to soil type, and particularly to the availability to plants of copper, molybdenum, and sulphate compounds in the soil. In some cases there is simply too little copper in the pastures. In other cases high levels of molybdenum and sulphate in the pasture can interfere with copper utilization by the animal, causing copper deficiency even when there is no shortage of it in the pastures.

The symptoms of copper deficiency are usually obvious and clear-cut. However, copper deficiency has recently been detected by the DIVISION OF ANIMAL HEALTH in seemingly healthy beef calves in Gippsland, Victoria. Despite the absence of any obvious symptoms, the copper levels in the blood and livers of the calves clearly pointed to a copper deficiency. Subcutaneous injections of copper glycinate markedly improved the calves' growth rates and overcame the deficiency for a period of about five months.

The Division found that changes in copper status of the cattle could be related to seasonal fluctuations in the copper and molybdenum content of the pastures. Copper deficiency is usually associated with alkaline soils, but these cases of inapparent copper deficiency occurred on acid soils.

The Division has developed a simple blood test for determining the copper status of an animal based on the fact that most copper in blood plasma occurs in a protein called ceruloplasmin. Since the test does not measure other copper substances, there is no need for extreme cleanliness when taking the blood sample. Previous methods of determining copper status required great skill and care, both in the taking of blood and liver samples from the animal and in the subsequent laboratory analysis. The ceruloplasmin method lends itself to a general survey of the copper status of cattle and should help the Division obtain a better understanding of how the complex relations between soil, plant, and animal can affect the copper requirements of grazing cattle.

Controlling tick fever in cattle

A single vaccination at weaning may be all that is needed to protect cattle against tick fever.

The microscopic blood parasite *Babesia argentina*, which is responsible for the majority of outbreaks of tick fever of cattle in Australia, is transmitted by cattle ticks. In heavily tick-infested areas cattle are constantly exposed to infection with this parasite and develop an immunity to the symptoms of the disease, that is, they show no obvious symptoms of the disease even though the parasite may be present in their blood. On the other hand, if an animal is 2 or 3 years old before it becomes infected with the parasite, the results can be fatal.

Cattle owners have always been worried lest eradication of ticks from an area would lead to an eventual loss of immunity to tick fever among their animals and leave the cattle vulnerable to the disease if ticks ever managed to re-establish themselves in the area. In situations where tick numbers are being kept down by dipping or pasture spelling, therefore, vaccination against tick fever is generally recommended. The current practice is that calves vaccinated at

under 1 year of age are re-vaccinated 6–12 months later.

It has been known for some time that cattle have a natural immunity to the disease for the first 6–9 months of their life. Recent investigations by the DIVISION OF ANIMAL HEALTH have shown that infection of these immune calves during this period with *Babesia* induces an immunity to tick fever that will persist for at least 4 years in the absence of further infection by ticks. A single vaccination at weaning (9 months of age) should therefore render most beef animals immune for life.

Diagnostic methods developed by the Division make it possible to detect the level of infection in weaner animals. Use of these methods to calculate the rate at which infection occurs in a herd makes it possible to estimate the future risk of tick fever in the herd and to identify those animals in need of preventive vaccination.

Simulating animal parasites

The life cycle of an internal worm parasite of sheep is being simulated by computer as an aid to devising improved measures for parasite control.

The DIVISION OF COMPUTING RESEARCH has been collaborating with the DIVISION OF ANIMAL PHYSIOLOGY in developing a comprehensive mathematical model of the various stages in the life cycle of a particular internal worm parasite of sheep.

The part of the model concerned with the free-living stages of the life cycle has been formulated. This part starts from a given time history of deposition of eggs (which will eventually be computed by the rest of the model) and, taking account of day-by-day weather variations and the conditions necessary for development, computes the number of eggs that will hatch each day, the number that will develop to the stage where they can re-infect the animals, and the concentration of these infective larvae on the pasture.

This sub-model has been checked against field data obtained by the DIVISION OF ANIMAL PHYSIOLOGY at its Pastoral Research Laboratory, Armidale, and predictions based on the model have been in close agreement with actual observation.

More eggs per bird

A novel method of selection is being used to breed hens that can lay more frequently than once every 26 *hours.*

A novel breeding method in which the environmental factors that control egg production are removed has been tested successfully by the DIVISION OF ANIMAL GENETICS. The method has been used to change by selective breeding a relatively invariable characteristic in the fowl. This characteristic, the very strong tendency for hens to ovulate and lay only once a day, is found in even the most highly productive strains which have been developed by many generations of selective breeding from the best layers in a normal commercial environment.

Because the average interval between eggs is about 26 hours, fowls lay a clutch of several eggs on succeeding days in daylight before the approach of night inhibits the next ovulation, causing the fowl to skip a day in the sequence. By keeping the flock in continuous light and noise this normal egg-laying rhythm is disrupted and the birds lay at any time of the day or night. Accurate and automatic recording of the time at which each egg is laid enabled the Division to

select as breeders those birds with the greatest hereditary potential to lay more frequently than once every 26 hours. This has now been done in three different flocks for 11, 9, and 3 generations respectively.

The results show that it is possible to select for a higher rate of ovulation and eventually, by this method, for more eggs per bird. In less than 10 generations the average time between eggs was reduced from 26 to 24 hours, and a large part of this response was retained when the first flock returned to a normal commercial environment of 14 hours light and 10 hours dark.

Birds with patterns of abnormally short intervals between egg laying produce eggs with defective shells. If these birds are avoided as breeders the higher rate of ovulation should mean greater total (commercially acceptable) egg production per bird. This is being tested in two of the flocks.

These experiments give hope that the new method of selection could provide a means of improving productivity in flocks that have ceased to respond to the simpler, cheaper, conventional breeding methods. They may also encourage novel approaches towards breeding to change apparently invariable production characteristics in other farm animals.

Choosing the best breeders

Measuring the amount of luteinizing hormone in the blood of young sheep may simplify selection of the animals most likely to increase twinning rate.

Different breeds and strains of sheep vary considerably in their tendency to produce twins and triplets. Selection for multiple births involves identifying the most fecund animals in the flock. Until now, this has been done either by using animals from multiple births or by selecting animals on the performance of themselves or their relatives. These techniques not only involve keeping records but may postpone selection till later in life. Recent work by the DIVISION OF ANIMAL GENETICS may make it possible to assess fecundity before puberty.

Litter size depends on the number of eggs shed at ovulation and this is partly controlled by the amount of luteinizing hormone (LH) produced by the pituitary gland. Following the development of sensitive methods of measuring blood levels of LH, the DIVISION OF ANIMAL GENETICS has been investigating the use of these levels as a guide to fecundity. Since it was known that LH levels in adult animals fluctuate too widely to allow useful comparisons, measurements were made before puberty at about 30 days of age, and have proved promising as early indicators of fecundity.

Three Merino flocks with low, high, and very high incidence of multiple births were surveyed, and average LH levels in the flocks were found to rank in the same order as fecundity. Furthermore, the LH levels in lambs of both sexes from the flock with highest fecundity could be ranked according to whether the lambs were born single, twin, or triplet.

Further evidence that LH levels are related to an inherited factor that controls fecundity came from measurements of LH in the daughters of two rams from the highest fecundity group. The daughters of one sire had LH levels more than twice as high as those of the other.

The Division has also obtained evidence that selection for fecundity increases the libido or sexual drive of rams. Rams of highest libido came from the highly fecund flock, which had the

highest LH levels in its lambs. Selection of rams with high LH levels may help therefore in overcoming the problem of sexual inhibition in young rams which was outlined in last year's Annual Report.

Further work is needed on this new method of selection, but the Division is hopeful that the technique will eventually prove practicable for both sheep and cattle.

Prostaglandins and animal production

Prostaglandins—a group of recently rediscovered substances with potent biological properties—may be the key to a greatly improved level of control of the oestrous cycle in livestock.

In sheep, goats, and cattle, the length of the reproductive cycle depends on the function of the corpus luteum, a small gland in the ovary that secretes a hormone called progesterone. After a length of time specific to each species (14–15 days in the sheep), this gland regresses and the concentration of progesterone in the blood falls, allowing another ovulation. Just before ovulation, the animal displays oestrous behaviour, at which time fertile mating can occur.

The DIVISION OF ANIMAL PHYSIOLOGY has been working on the control of the oestrous cycle and has developed a method of measuring as little as twenty million-millionths of a gramme of prostaglandin in the blood. When prostaglandin was injected into the uterine vein of sheep early in the oestrous cycle, the corpus luteum regressed and progesterone concentration in the blood fell; the animals then returned to oestrus prematurely. Prostaglandin has now been shown to be present in the blood leaving the uterus in ewes, cows, and sows that have a regressing corpus luteum. This suggests that prostaglandin is the hormone responsible for the regression of the corpus luteum, and thus for the regularity of the oestrous cycle. Hence, in these species it may be possible to find practical ways of using prostaglandin to synchronize oestrus.

After a fertile mating, the presence of an embryo in the uterus appears to block the otherwise normal release of prostaglandin by the uterus; thus the corpus luteum continues to secrete progesterone, which is necessary to maintain the uterus in a quiescent state during pregnancy.

The Division is investigating the use of prostaglandin to control the oestrous cycle in cattle and pigs; this is likely to be of practical value in conjunction with artificial insemination, since all animals could be brought into oestrus and inseminated at one time. Prostaglandin cannot be administered by intramuscular or intravenous injection for this purpose because it is rapidly destroyed when the blood passes through the lungs. However, intra-uterine administration of prostaglandin is comparatively easy in cattle and pigs and has proved very effective in cattle to date. Preliminary results from related research in Britain indicate that fertility is normal in cows synchronized by intra-uterine injection of prostaglandin.

In addition to their effect on the oestrous cycle, prostaglandins also appear to play a major role in controlling the metabolism of a number of tissues, such as body fat, the gut, and the kidney. Some of the implications of these functions in connection with animal production will be investigated by the Division.

Crows and lambs

Although crows are commonly found near dead lambs, they are not the pest many people believe them to be.

A recently completed eight-year investigation by the DIVISION OF WILDLIFE RESEARCH on crows and ravens and their interaction with lambing flocks of sheep revealed five different species of crows and ravens where only three had been recognized before. Field and aviary studies suggest that only two of these species (*Corvus coronoides* and *C. tasmanicus*), both of which are large and have massive bills, could kill lambs. Two smaller species, the little raven (*C. mellori*) and the little crow (*C. bennetti*), do not appear strong enough to attack and kill a healthy lamb. The fifth species, the Australian crow (*C. orru*), occurs mainly outside the sheep-breeding zone except in the north-west of Western Australia.

Post-mortem examination of lambs that had died showed that most of them had died of starvation after failing to establish or maintain a sucking relationship with the ewe. In nearly all cases those lambs which had been killed by crows or other predators were already weak when attacked and would have died within a few hours if left alone.

During some hundreds of hours of watching flocks of lambing ewes, few serious attacks on healthy lambs by crows were noted. On two of these occasions the lambs were caught soon afterwards and were found to be completely unmarked, in spite of what had appeared to be a vicious attack.

Although crows and ravens are often found together with lambs, most of their feeding consists of scavenging. Analysis of the food eaten by 1490 individuals showed that insects form a large part of their diet. Grasshoppers, army grubs, and phasmatids are eaten extensively by nomadic flocks, although at other times orchards, vineyards, and fields of sown grain receive their attention.

New enemies for an old weed

Three organisms introduced from overseas—a rust fungus, an insect, and a mite—are being used against skeleton weed, a major weed of wheat crops in southern Australia.

Skeleton weed, a native to the Mediterranean region and central and southern Europe, has been present in Australia since 1914. Its success here has been due to the absence of those insects and other organisms which, in its native habitat, have made it a plant of no great significance. Since 1966 the DIVISION OF ENTOMOLOGY has been searching in Europe, North Africa, and the Middle East for organisms that could be introduced to Australia to aid in the biological control of skeleton weed.

In the last year three of these organisms, a rust fungus, a gall mite, and a gall midge, have been liberated. Before releasing them, however, an extensive and thorough screening programme was necessary to make sure that they would restrict their attention to skeleton weed and not attack any plants of economic importance.

The rust fungus, *Puccinia chondrillina*, has spread over the entire skeleton weed area in New South Wales from its initial liberation sites at Canberra, Tamworth, and Wagga. It has also spread extensively in Victoria and South Australia. At the most heavily infested sites it has reduced the vigour of the skeleton weed stands quite noticeably.

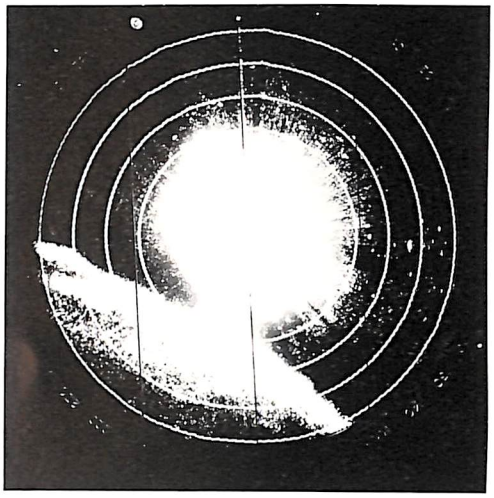
The gall mite, *Aceria chondrillae*, and the gall midge, *Cystiphora schmidtii*, are securely established, but have not had time yet to make much impression on the weed. The gall mite causes stunting and reduces seeding by converting the flowers and flowering stems into leafy galls. The larvae of the gall midge attack the leaves and stems. They are extremely damaging to skeleton weed in the hot dry areas of Greece and should prove of great value in controlling the weed in its drier Australian habitats.

Gum trees and Christmas beetles

The large showy Christmas beetles (genus Anoplognathus) *of eastern Australia can be a serious pest in eucalypt plantations. The use of forestry practices based on a knowledge of their ecology greatly reduces the damage they cause.*

When eucalypts were planted on a large scale in the Coffs Harbour area of New South Wales for the production of paper pulp, Christmas beetles feeding on the leaves of the young saplings had a disastrous effect on their early growth. Ecological studies by the DIVISION OF ENTOMOLOGY showed that the beetles tended to lay their eggs in the sward between young trees, and that if this was supplanted by a vigorous growth of tropical legumes, breeding was reduced. In addition, the use of fertilizers was found to stimulate early canopy formation, and this further inhibited grass growth between the trees and reduced the suitability of the plantation for the beetles. To divert damage from the main crop, *Eucalyptus grandis*, a preferred food species, *E. dunnii*, was interplanted to act as a trap crop: the beetles concentrated their attack on these plants, resulting in reduced damage to *E. grandis*.

The Division also found that the beetle larvae, which have a two-year life cycle, occurred in two 'cohorts', maturing in alternate years. One of these cohorts is considerably smaller than the other, so that every second year there are very large beetle flights alternating with smaller flights in other years. It is possible therefore to time eucalypt planting so as to avoid the exposure of first-year saplings to the large flights.



Photograph of a radar screen showing a line of advancing echoes from a swarm of insects, including locusts, approaching from the south-west during the night. Such lines can be detected at ranges of up to 50 kilometres and even individual insects can be tracked up to 3 kilometres away. It is possible to differentiate between species and often between male and female locusts by analysing the wing beat frequencies of the echoes received by the radar unit.

Tracking locusts with radar

Radar tracking is proving a valuable new technique for plague locust research.

Large numbers of the Australian plague locust, *Chortoicetes terminifera*, can suddenly appear in an area where they have not been noticed before, without any large-scale flight activity being observed. It was only a few years ago that the DIVISION OF ENTOMOLOGY was able to account for this when it found that individual locusts take off immediately after sunset and fly at night. The direction of their flight is down wind so that they are often carried into cold fronts where rain is likely to fall and promote the growth of fresh grass.

Using a modified marine radar operating at a wavelength of 3

centimetres, the Division has been able to follow the movement of swarms of locusts and other insects up to 50 kilometres away at night, and to interpret their formation and history in relation to weather patterns. Swarms may form by a concentration of vast numbers of individuals along wind-shift lines. Dense concentrations up to 80 kilometres long and containing many thousands of kilogrammes of insects have been observed. The locusts in these swarms take off soon after sunset and, within half an hour, some of them may be at heights of 2000 metres. The duration of the flights is affected by weather conditions but, unless weather changes possibly leading to rain are in evidence, most flights only last for an hour or two.

The Queensland king prawn fishery

New statistical techniques have been developed for handling data obtained from prawn tagging programmes.

Conventional methods for the statistical treatment of data on fish populations are not applicable to prawn populations. This is because the pressure of fishing on prawn stocks can vary significantly depending on the weather. Moreover, because of the short life span of prawns, even week-to-week fluctuations in fishing pressure are significant. The DIVISION OF FISHERIES AND OCEANOGRAPHY has developed new statistical techniques to cope with this problem in relation to the king prawn fishery of southern Queensland.

Since 1969, the Division has tagged 15,000 juvenile and 10,000 adult prawns in the region. This tagging programme has shown that juvenile king prawns, which are abundant in Moreton Bay during the summer, undertake rapid migrations. Within six weeks they reach the adjacent off-shore areas, where they grow to maturity in a few months. Application of the new statistical model to data obtained from the tagging programme can be used to estimate the proportion of the available prawn stock caught by fishermen. This statistical model is applicable to other prawn populations in Australia.

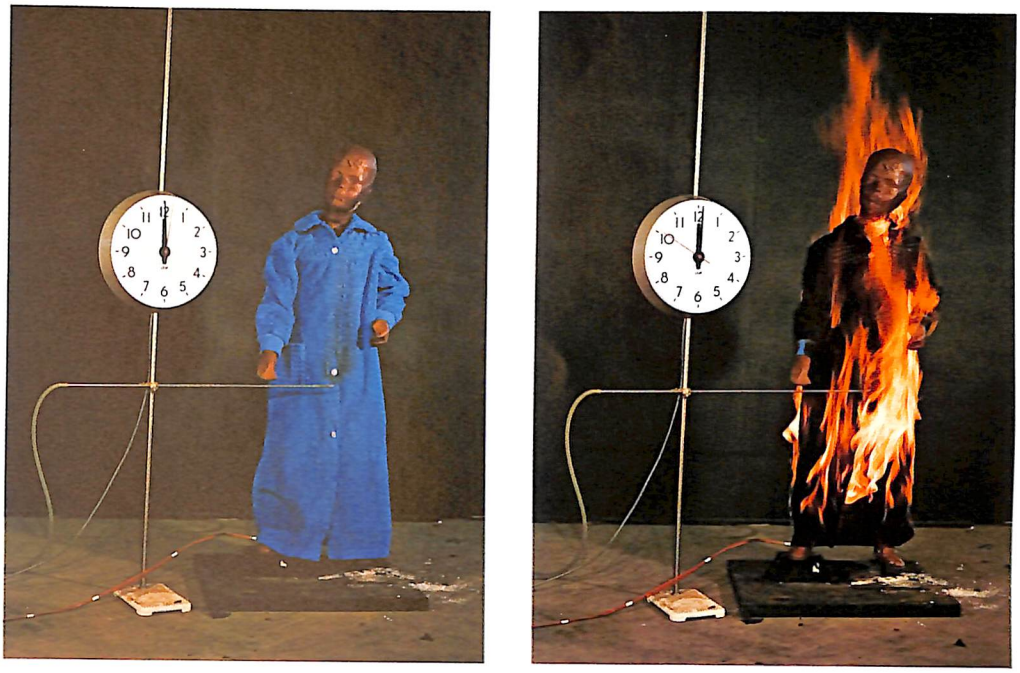
Brighter pastel shades for wool drapes

The use of high-grade pigments instead of soluble dyes to create wool fabrics in bright pastel shades prevents colour deterioration when the fabric is exposed to sunlight or washed.

Until recently, wool fabrics in pastel shades have found only limited use in drapes because of their tendency to fade. The DIVISION OF TEXTILE INDUSTRY has overcome this problem by developing a successful method of applying pigments to wool. The new technique is based on knowledge gained by the Division during the development of the chlorine–resin shrink-resist process.

Pigment dyeing has been successfully used on open-weave wool drapes on a fully industrial level and its market potential is now being assessed by the Australian Wool Board.

In pigment dyeing, the pigment is dispersed in a shrink-proofing resin and applied to prechlorinated wool, providing an even layer which completely covers each fibre. The colour is evenly distributed throughout the fabric and will not fade when exposed to daylight. To improve the applied pigment's resistance to damage from rubbing, the fabric is coated with a soft polymer. This coating also adds to the shrink-proofing effect and improves the drape of loosely woven curtaining.



The development of more realistic standards of textile flammability has involved studying clothing fires on fireproof models. The picture at left shows a model wearing a dry cotton chenille dressing gown. A half-second application of a small flame is all that is needed to ignite the garment. The picture at right shows the model less than two minutes later completely enveloped in flame.

Textile flammability

Research is providing a basis for the development of more realistic standards of textile flammability.

Conventional methods of measuring the flammability of textiles used for clothing are misleading. The most commonly used method assesses the rate of burning but takes no account of other important factors such as ease of ignition, formation of molten droplets, and ease of extinguishing. The DIVISION OF PROTEIN CHEMISTRY has been investigating these factors in order to develop more realistic standards of textile flammability. The first standard based on the Division's work has now been published by the Standards Association of Australia and others are expected to follow shortly.

The Division is cooperating with the Burns Research Unit of the Royal Children's Hospital, Melbourne, in an investigation of clothing fires. Burn accidents to children are investigated from medical, sociological, and textile aspects and up-to-date statistics are being obtained. One of the unexpected results obtained so far is that the problem of girls' nightwear catching fire is far less than the problem of boys' daywear catching fire. As many burning accidents are from flammable solvents, prevention is more important than increasing the flame resistance of textiles.

Diameter variation in wool

Fast and accurate techniques for assessing variation in fibre diameter in wool samples are being developed.

The fibres in the fleece of a single sheep vary considerably in diameter. The mixing of fleeces during manufacture leads to still further variation. Too great a spread of diameter is believed to have an adverse effect on spinning and on certain fabric properties, but there is little information on what degree of variation is acceptable. In the preparation, handling, and marketing of wool there are a number of operations concerned with maintaining a distinction between wools of different diameter. If more mixing of wools of different diameters were found to be acceptable, procedures might be simplified and costs reduced.

The DIVISION OF TEXTILE PHYSICS has been developing techniques that will enable it to make more extensive surveys of diameter variation in Australian wools. One method is an extension of the Coulter technique which was developed originally for estimating the size of biological cells. It is particularly suited to wool samples where the fibres are parallel, for example in the 'top' stage of manufacture.

In another technique, liquid containing oriented fibre 'snippets' flows through a narrow tube past a light beam from a laser. A photo-electric device detects the amount of light cut off as each snippet passes the beam, and the electrical output is calibrated in terms of fibre diameter.

Both methods have the advantage that many thousands of fibres can be examined in a few minutes, so ensuring high overall precision of the measurement.

Processing the purple passionfruit

A technique for concentrating passionfruit juice without affecting its flavour has led to a successful commercial operation in Papua New Guinea and could open up potential markets overseas for Australian passionfruit.

The purple passionfruit (*Passiflora edulis*), which is grown widely in Australia and Papua New Guinea, has an intense tropical flavour and is used as a flavouring base for many drinks and fruit blends. Heat sterilization of passionfruit products markedly degrades the flavour and hence juice of high quality is handled frozen. If the juice of the purple passionfruit could be concentrated for frozen storage and transport without impairing its delicate volatile flavour or aroma, a large market for the juice could be developed overseas, as well as in Australia.

The DIVISION OF FOOD RESEARCH has been studying the volatile constituents of fresh passionfruit juice in order to identify those which contribute to its characteristic odour. Seventy-one compounds have been identified in fresh passionfruit juice. Three of these constituents, one of which was a previously unknown chemical compound and has an intense 'rose-like' aroma, are considered essential to the passionfruit aroma. Fourteen other components are also regarded as important.

The Division has also been working on the design and construction of special distillation equipment for concentrating fruit juice essences. The emphasis in this work has been on the use of extremely short heating periods to minimize heat damage and on efficient recovery of the volatile aroma by condensation during the removal of water from the juice. The condensate, which is recovered as several fractions, is added back to the concentrated juice to give a product which, when recom-

bined with water, has the full natural flavour of the original juice.

Information gained from the flavour investigations gives a clear understanding of how heat processing can affect the essential flavour constituents during the production of passionfruit juice concentrate. A process has now been developed which concentrates the juice three and a half times without interfering with its characteristic flavour. The process is being used commercially in Papua New Guinea.

Tenderizing meat

Tenderness is probably the most sought-after quality of meat. Suspending sides of beef, mutton, or lamb from the aitchbone or pelvis instead of from the tendon of Achilles can bring about a marked improvement in tenderness.

Meat consists mainly of muscle together with some fat and a small amount of connective tissue. Until recently, the tenderness of meat was thought to be affected mainly by the amount and type of connective tissue in the meat and by the extent to which the connective tissue was softened during cooking. However, it is now realized that tenderness depends to a considerable extent on the state of contraction of the muscle.

The Meat Research Laboratory of the DIVISION OF FOOD RESEARCH has been experimenting with ways of making meat more tender by reducing or preventing muscle contraction in meat carcasses and has followed up earlier work at the Texas Agricultural and Mechanical University. This work has shown that the way in which a carcass is hung while rigor mortis is developing has a big influence on tenderness. When sides of beef were suspended from the aitchbone or pelvis, rather than from the Achilles tendon of the leg, the hind leg dropped to a position at right angles to the carcass, tensioning those muscles from which come the cuts known as rump, knuckle, topside, cube roll, and striploin. This method of hanging, called 'tenderstretch', improves the tenderness of these cuts, which together represent 35% of the value of a carcass.

Tenderstretched beef has been found to be as tender after 24 hours of hanging as conventionally hung beef aged for 3 weeks in a chiller at about 1°C. Aging adds about 5 or 6 cents a pound (11 to 13 cents a kilogramme) to the cost of beef, so if tenderstretching replaces aging, premium table beef could become a little cheaper. During aging, carcasses lose about 3% of their weight by evaporation, but evaporative loss from tenderstretched meat is insignificant because it is kept for only a short time. Furthermore, cuts of tenderstretched meat lost only half as much fluid by weeping as normal cuts. This fluid represents salable weight and its loss accounts for part of the cost of aging.

Tenderstretched meat can be on sale in butchers' shops within two or three days of slaughter. This is already happening in Queensland, where at least one meatworks is supplying tenderstretched beef to about 45 Brisbane butchers. There appear to be no problems with the overhead carrying rails used in meatworks. Hot carcasses are processed in the usual way, hanging from the Achilles tendon; then, before going into the chilling rooms, they are simply re-suspended by the pelvis. Floor clearance under tenderstretched carcasses is actually improved.

The Meat Research Laboratory has also obtained good results with tenderstretched lamb and mutton, although the industry is not yet using the new method for sheep carcasses.

Raw sugar crystallization

A computer has been linked to a large sugar crystallizer in Queensland to test computer control of crystallization in an industrial environment.

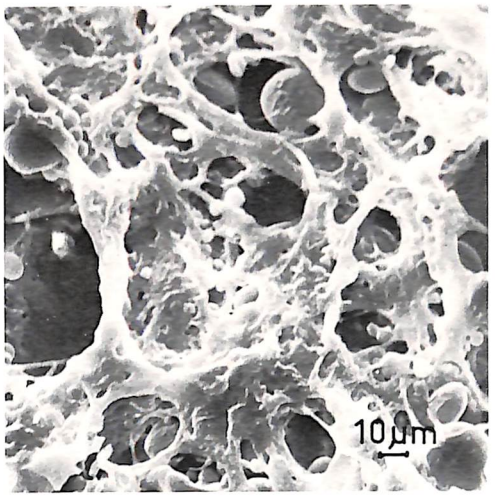
The crystallization of sucrose from the impure syrup is an important step in the production of raw sugar. The DIVISION OF CHEMICAL ENGINEERING is working with the Sugar Research Institute to develop techniques of controlling this step by computer. It is hoped that this will lead to increased productivity in the sugar industry.

The Division's studies have involved the application of optimal control theory to a mathematical model, based on a model developed originally by the Institute, of a single crystallizer. The results indicated that throughput of sugar could be considerably increased by using computers to regulate the factors influencing supersaturation.

Information on material inflow and outflow is fed into the computer along with various basic measurements such as temperature, pressure, and change in boiling point. This provides an accurate knowledge of the amounts of crystal, water impurities, and dissolved sucrose, all of which affect supersaturation.

A laboratory-scale crystallizer was built at the DIVISION OF CHEMICAL ENGINEERING and linked to the Division's hybrid computer. Successful operation of this unit demonstrated the feasibility of computer control in this field.

The techniques are now being tested in a mill in Mackay where a full-scale production crystallizer has been coupled to a caravan-mounted computer made available by the Sugar Research Institute.



This picture of dough made from a hard wheat was taken by the WHEAT RESEARCH UNIT with a scanning electron microscope during a study of the structure of wheat flour and the changes that occur during dough formation. A network of protein strands can be seen surrounding spherical starch granules. The study has also shown that fats or lipids play a much more important part than was previously realized in giving structure and volume to loaves of bread.

New machine for curd production

A machine for producing curd for cheesemaking on a semi-continuous basis is being developed.

In stage one of the Bell–Siro system of automated cheddar cheese manufacture, milk is converted by a batch process into a mixture of curds and whey and then cooked. The Bell–Siro system was developed by the Dairy Research Laboratory of the DIVISION OF FOOD RESEARCH in collaboration with the food machinery manufacturing firm of Bell Bryant Pty. Ltd. The Laboratory is now working with Bell Bryant on the development of a machine that will enable stage one of the cheesemaking process to be carried out on a fully instrumented, semi-continuous basis.

The proposed machine, which incorporates what has been called the 'cascade' system of curd preparation, consists of

three vats built into one vertical container about 27 feet (8 m) high and 9½ feet (3 m) in diameter. Each vat will be used for a separate stage in the process. In the top vat, milk that has been previously standardized to the required casein/fat ratio will be treated with rennet and starter at the setting temperature. When the curd has set to the right consistency, it is cut into small pieces by rotating blades to allow the curd to shrink and whey to separate. The curd/whey mixture is then transferred by gravity to the middle vat and 'cooked'. During cooking, the curd particles contract and become more acid. In the bottom vat, the mixture is held until the shrinking and firming processes are complete and is then pumped out to be processed into cheese. All three chambers can be working at the same time, providing a semi-continuous supply of curd/whey mixture. Four such units can provide a continuous supply.

The three-level container is completely enclosed and supplied with filtered air to prevent contamination. Extensive instrumentation ensures that the process is closely controlled. Use of the new machine is expected to result in a more uniform product, less wastage, a smoother flow of product through the manufacturing process, and reduced labour costs.

Utilizing whey

Studies of whey utilization have led to trials of a new filtration process that will convert the whey to a high-protein stock feed and avoid the pollution problems caused when it is disposed of as waste.

During manufacture of cheese and casein in Australia some 90,000 tons (91,800 tonnes) of food solids are produced annually as a by-product in the form of whey. If the whey is disposed of as waste, the solids are lost as a food and constitute a pollution problem.

An extensive investigation into the various methods for utilizing whey is therefore being undertaken on a collaborative basis by the Dairy Research Laboratory of the DIVISION OF FOOD RESEARCH and the DIVISION OF CHEMICAL ENGINEERING in association with the Victorian Department of Agriculture and the Victorian Whey Utilization Association, an industry body formed specifically for the purpose.

To date, much of the work has been concerned with the application of ultrafiltration to whey processing. This process, which uses special semi-permeable membranes, enables the composition of whey to be modified by increasing its protein content in relation to other ingredients. Calf-feeding experiments have shown that this protein concentrate has excellent potential as an ingredient for stock feed. Further research suggests possible uses as a human food.

Work is also being carried out on the concentration of the protein-free remainder by another membrane process known as reversed osmosis and on the crystallization of lactose from the concentrate.

Technological and economic studies have indicated that the ultrafiltration process can be satisfactorily applied commercially. The Whey Utilization Association is therefore arranging for the first small-scale plant to be tested in a commercial situation early in 1972/73. The establishment of larger plants in dairy factories is expected to follow shortly after.

Polyunsaturated meat and dairy products

An improved technique has been developed for producing a polyunsaturated feed supplement which, when fed to sheep and cattle, increases the proportion of polyunsaturated fats in the meat and milk. The taste and keeping properties of polyunsaturated meat and dairy products are being examined.

The 1969/70 Annual Report mentioned that the DIVISION OF ANIMAL PHYSIOLOGY, in conjunction with the Dairy Research Laboratory of the DIVISION OF FOOD RESEARCH, had devised a method of increasing the proportion of polyunsaturated fats in dairy products and the meat of sheep and cattle. The method involved feeding the animals a special dietary supplement prepared from polyunsaturated vegetable oil. Originally this supplement consisted of a fine powder made by spray-drying an emulsion of sunflower or safflower oil and protein. The powder was then treated with formalin, which reacted with the protein forming a coating that protected the oil from conversion to saturated forms in the rumen of the animal. This protective coat was subsequently digested in the small intestine, releasing the oil which was then absorbed into the animal's bloodstream. Polyunsaturated fatty acids from the oil were incorporated into both milk and body fats. The proportion of polyunsaturated fat in milk increased from about 3% to 20–30% within one or two days of feeding the supplement. Similar increases were observed in the meat of lambs and beef cattle fed the supplement for about six weeks before slaughter.

A much cheaper supplement can now be made as a result of efforts to simplify and improve the production process. Whole oil seeds such as safflower and sunflower are now being used instead of oil extracted from crushed oil seeds. Spray-drying has been eliminated by simply taking the whole oil seeds, homogenizing them to produce a slurry (which contains more solids than earlier preparations), and formalin-treating the slurry directly.

Experiments to follow the fate of the formaldehyde in the supplements when they were fed to animals showed that it is effectively broken down by ruminants and does not accumulate in the meat or milk.

The DIVISION OF FOOD RESEARCH is examining the processing technology of polyunsaturated foodstuffs. It is also studying their taste, keeping properties, and texture, which may prove to differ in some respects from those of the conventional products.

The two Divisions have been providing polyunsaturated foodstuffs to the Department of Clinical Science at the Australian National University, Canberra, for use in experiments to test the effects of feeding polyunsaturated meat and milk products to human beings. Preliminary trials showed that a diet containing polyunsaturated meat, milk, butter, cheese, and cream in place of the normal foods lowers the blood cholesterol level in man. More extensive clinical trials are being planned.

Iron ore pellet production increased

Identifying and eliminating drying delays during the production of iron ore pellets has led to a marked increase in output at the Dampier pelletizing plant of Hamersley Iron Pty Ltd.

The fine iron ore that makes up 40–50% of production by Hamersley Iron Pty Ltd is either agglomerated for the blast furnace in the customer's own steelworks or made into pellets for export by Hamersley. The fines cannot be used in the blast furnace in the form of dust

because they restrict gas circulation in the furnace and interfere with the iron-making process.

In the pelletizing process, the iron ore fines and lime-sand are ground to a fine powder consistency and then, following addition of water, are rolled into small pellets. The unfired pellets are fed into a travelling grate furnace which has three main sections: in the first section, the pellets are dried out; the second section fires the pellets; and cooling takes place in the third before discharging. The pellets then have sufficient strength and abrasion resistance and are ready for export.

Towards the end of 1969, production limitations were experienced at Hamersley's pelletizing plant at Dampier, Western Australia, when the pellets started to spall, or explode into dust, in the drying section. The company sponsored research in the DIVISION OF MINERAL CHEMISTRY to identify the cause of spalling and to recommend ways of dealing with it. Experiments established that the spalling was due to the fact that the drying conditions in the furnace could not accommodate variations in the composition of the ore. A drying pattern suitable for an ore with a small amount of goethite (a hydrated iron oxide found with haematite) caused spalling in ores containing greater amounts of goethite.

Knowing this, the Division was able to suggest ways of minimizing the effect of spalling and thus increase plant throughput. The amount of goethite in the incoming ore could be monitored using a simple, reliable method devised by the Division. The drying conditions for any particular goethite content could then be set using information obtained in laboratory experiments.

The adoption of the Division's suggestions, in conjunction with certain changes originated by the company, has reduced production restrictions caused by spalling during drying.

The success of the project has led the company to sponsor further research by the Division into other limitations to the process.

Iron in ilmenite

The removal of iron from natural ilmenite is facilitated by a method of avoiding interference from impurities during the thermal reduction of the ore.

Ilmenite, a compound of iron and titanium oxides found in beach sands, is a source of titanium dioxide which is used widely as a paint pigment. Any iron remaining in the final product becomes a major problem to industry because of its persistent colour. In one industrial treatment of ilmenite, complete removal of iron is preceded by reduction of the chemically bound iron oxide to elemental iron.

In some cases processors have been concerned to find iron oxide persisting after the reduction treatment should have been completed. The DIVISION OF MINERAL CHEMISTRY was asked by industry to investigate this problem.

Microscopic examination of ilmenite grains after treatment showed that while the iron oxide in most of the grains had been chemically reduced to completion, some grains displayed an unaltered core that would not reduce however prolonged the treatment. Under polarized light a dark rim, scarcely one-hundredth of a millimetre wide, could be discerned around each such core and electron probe microanalysis disclosed these rims to be greatly enriched in manganese and magnesium titanates present as impurities in the ilmenite.

These impurities are immune to reduction and the Division concluded that as the reduction of each grain of

ilmenite proceeded from the surface of the grain to the centre, magnesium and manganese titanate impurities retreated inward until they had accumulated a protective shell around the remaining iron-rich core of the grain, isolating it from further reduction.

A preliminary heat treatment was found to disorder the natural crystal structure of each grain so that reduction proceeded simultaneously from innumerable centres inside each grain rather than over one front advancing from the outside. The pretreatment allowed the reduction to reach completion before any protective shells of impurity could build up in any grain.

Origin of nickel ores in Western Australia

Gaining a better understanding of the origins of various nickel ores in Western Australia could help future exploration for nickel.

Studies by the DIVISION OF MINERALOGY of certain nickel sulphide ores of Western Australia have confirmed that they were introduced with partly molten rocks from deep in the earth. Most of the ores, including those from Kambalda, where the first discovery was made in 1966, are associated with ultramafic rocks, that is, rocks rich in magnesium and iron silicates. But not all ultramafic rocks contain economic nickel deposits. Virtually all the discoveries so far lie in the Eastern Goldfields Belt which runs from Norseman in the south to Wiluna in the north.

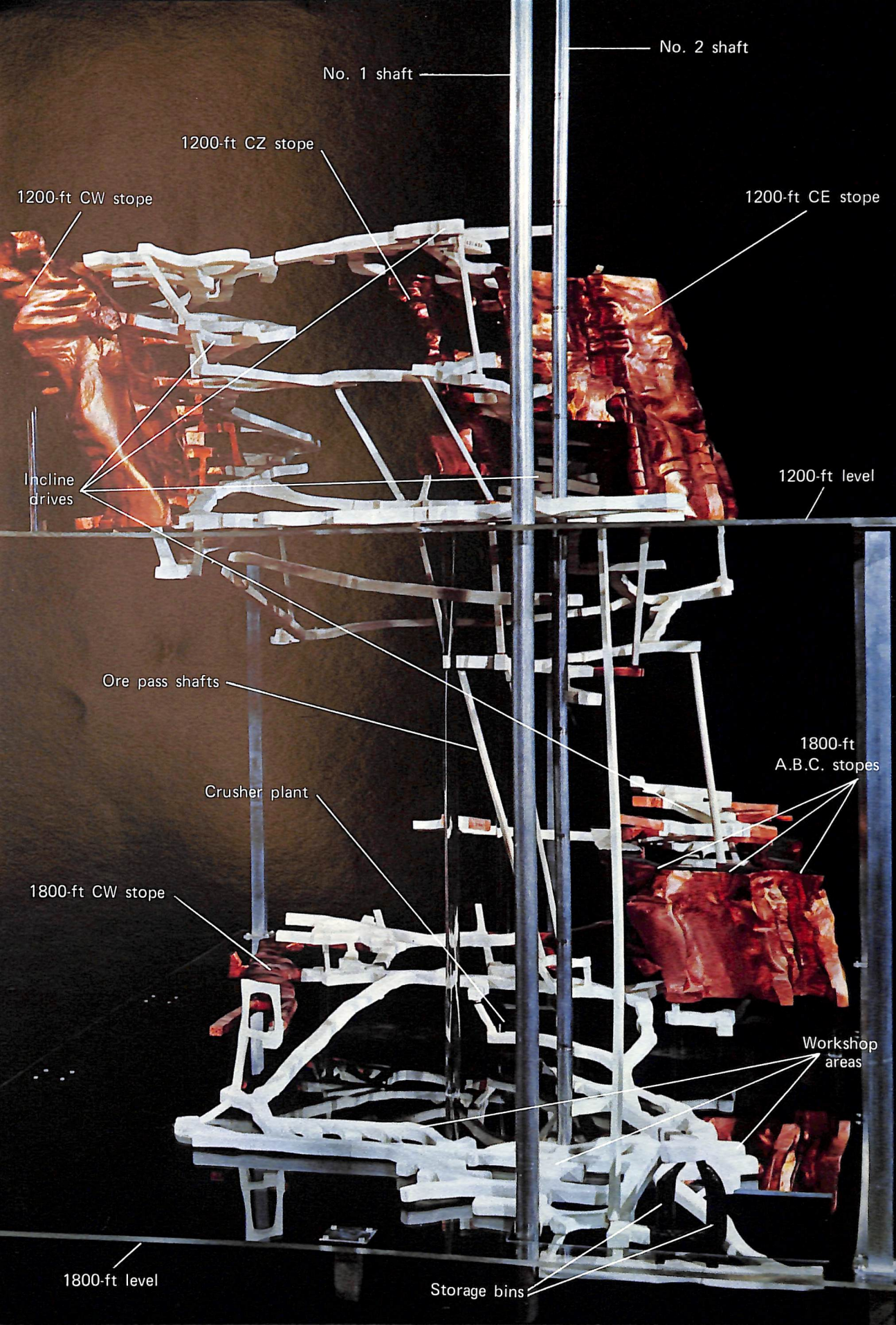
The Division is undertaking regional geochemical studies to find out why ultramafic rocks in other areas appear less productive. It is also working on the problem of how the ore bodies in the favourable areas became localized as very small targets in a large mass of ultramafic rock. Clear evidence that the ores are magmatic, that is, derived by separation from molten rock, is an important step in understanding how they became localized.

At temperatures above about 1100° C the magma would comprise a mush of crystals of olivine, which is a magnesium iron silicate, and chromite, along with a viscous silicate liquid and droplets of a very fluid dense sulphide liquid containing the nickel. At Spargoville, south of Coolgardie, solidified droplets of sulphide have been found trapped in olivine crystals.

As the magma was introduced as a thin horizontal sheet, components of the magma would segregate under gravity. The sulphide liquid would settle with some chromite towards the base and might form a dense mass of ore essentially free of silicates. Above this would be a layer in which nickel-rich sulphide liquid fills the space between olivine crystals and becomes the continuous phase of the matrix ore. The top of this zone is the upper limit of the coalesced sulphide liquid. Above that the olivine would be surrounded by silicate liquid with only rare droplets of uncoalesced sulphide liquid. This zone would solidify to an ultramafic rock, which would contain disseminated sulphides of low grade.

At Kambalda the massive ore and the matrix ore are the rich material that is being mined. Studies of the composition of these ore zones have shown what has happened as the ore solidified on cooling. It was found that the ore became progressively enriched in the iron oxide, magnetite, away from the base of the massive ore. This is definite evidence that the sulphide was originally molten.

Further studies are aimed at obtaining a better understanding of how the ore was localized.


No. 2 shaft
No. 1 shaft
1200-ft CZ stope
1200-ft CW stope
1200-ft CE stope
Incline drives
1200-ft level
Ore pass shafts
1800-ft A.B.C. stopes
Crusher plant
1800-ft CW stope
Workshop areas
1800-ft level
Storage bins

High-rise stope mining

Geomechanical studies in the CSA copper mine at Cobar are aimed at predicting the extent to which ore bodies can be mined by a method involving the creation of underground sand-filled cavities higher than any attempted previously in mining.

In the steep, narrow ore bodies of the CSA Mine of Cobar Mines Pty Ltd, mining proceeds by blasting ore from the roof of an excavation to form a cavity, or stope, in the lower regions of the ore body. The broken ore is taken away through horizontal access tunnels for delivery to an underground crusher and transport to the surface. After each break the height of the stope is about 25 feet (7·5 metres). The current access tunnel is bricked up and a thick slurry of waste material from the concentrating plant on the surface is pumped into the stope to a depth of about 15 feet (4·5 metres). Provision is made for excess water to drain away. The sandy material remaining forms a firm new working floor for the mining equipment to prepare for blasting of the next 15-feet-thick slab of ore from the stope roof. In this way, mining proceeds upwards in 15-feet steps. Cobar Mines plans to raise the height of the sand-filled stopes up to 600 feet, two to three times higher than present mining practice.

Under the financial sponsorship of the Australian Mineral Industries Research Association, and with assistance from Cobar Mines Pty Ltd, the DIVISION OF APPLIED GEOMECHANICS is studying the complications which arise when the high-rise stope method is used at depths of up to 1800 feet (550 metres). At Cobar, N.S.W., some 720,000 tons (732,000 tonnes) a year of copper and copper–zinc ores are mined from depths of this order and mining to much greater depths is planned. Answers are required well in advance to questions concerning the margins of safety in future years and the ultimate extent of ore extraction.

The compressive forces experienced in rock at appreciable depths are variable and can be very great. The removal of large volumes of ore therefore raises important questions regarding the redistribution of stresses and possible deformation of the surrounding rock.

Investigations must also be made into the possible conditions that might lead to instability in the large body of moist compacted sand fill that provides a working floor and may help to resist deformation of the surrounding rock.

The approach being adopted in the investigations is to treat the CSA mine itself as a full-scale model which is being extensively instrumented in order to provide information continuously about the conditions pertaining in both the sand fill and the rock.

Measurements are being made of the engineering properties of the sand-fill material, the sand mass in place in the mine, and the rock itself. Rock structures near the stopes are being surveyed using newly developed photogeological techniques and the stresses and strains occurring in these structures are measured as mining proceeds. In addition, rock stress levels are monitored using acoustic emission techniques. The information gained will be used to predict the margins of safety under various possible conditions of extraction. The predictions will be made by calculation, using a computer, and by observations on models in the laboratory.

Opposite: This model of the mine at Cobar is being continually updated as mining proceeds.

Minerals exploration by photography

High-altitude reconnaissance is being tested as a tool in mineral exploration.

Rockets, satellites, and high-flying aircraft are being considered for use in exploration for minerals on a large scale. The MINERAL PHYSICS SECTION is investigating the use of multispectral photography carried out in these high-flying vehicles.

Multispectral photography is a technique which combines optical and infrared methods of photography. The work of the Section involves the study of four-colour photography from high-flying aircraft and at present a programme of evaluating various filters to resolve features of the terrain is being carried out.

Concurrently, the use of satellite altitude photography is being investigated in collaboration with the British Department of Trade and Industry. Multispectral photographs taken from a Skylark research rocket at an altitude of 160 miles (258 km) are being compared with photographs taken from aircraft at a much lower altitude. This experiment is designed to determine the effect of the atmosphere on the resolution and colour response of high-altitude camera systems.

The ultimate aim of the project is to use data from satellites orbiting the earth in the search for minerals. Facilities are therefore being established in the Section to analyse photographs from the United States Earth Resources Technology Spacecraft (ERTS).

Removing salt from brackish water

A process for removing salt from brackish water is now successfully operating on a pilot scale in three States.

Australia, in common with other arid countries, is concerned with the production of drinkable water from saline water that occurs underground, in rivers or lakes, or in the sea. To be useful for domestic and industrial purposes, the total dissolved solids of such water should be reduced to below 500 parts per million.

A new desalination process, known under the trade name Sirotherm, for purifying water for domestic and industrial use, is being developed jointly by ICI Australia Limited and the DIVISION OF APPLIED CHEMISTRY. It uses a novel ion-exchange technique in standard equipment to lower the salinity of water and is effective for water containing up to 3000 parts per million of salt. The process reduces salinity in brackish water from bores, streams, and lakes to levels suitable for town supply. It is not intended for sea water.

Under a research contract jointly financed by CSIRO and the South Australian Mines Department, the Australian Mineral Development Laboratories (Amdel) have been actively taking part in the project since its inception.

The original Sirotherm concept was a CSIRO invention which has been complemented by several joint CSIRO/ICI improvement inventions relating to an ion-exchange resin that can be regenerated by hot water. This represents a considerable advance over most commercial ion-exchange resins which require large amounts of relatively expensive acids and alkalis for their regeneration. In the Sirotherm pilot plants, brackish water is passed through a resin bed that adsorbs salt. When the salt content of the outlet water rises, indicating that the resin has adsorbed its capacity of salt, the bed is regenerated by passing hot water through it. This results in the removal of the salt in a concentrated effluent.

Sirotherm pilot plants have been installed in Perth to treat bore water, in

Adelaide to desalinate surface water, and at ICI's Yarraville plant where an experimental continuous process is being tested. Throughout this part of the project, research teams from CSIRO and ICI have collaborated in an extremely close working relationship, jointly planning and developing each stage from the production and evaluation of large-scale batches of Sirotherm resin to the installation and commissioning of the pilot plants.

Millions of gallons of water have already been treated by the new process which is capable of being scaled up to much greater capacities.

Quieter air conditioning

Research has shown how the design of room air conditioners can be improved to reduce noise and increase performance.

With the general increase in the use of air conditioning, the demand for small packaged air conditioners is growing, but sales have, until recently, been inhibited by excessive noise. In 1968, realizing that noise was the largest single obstacle to more widespread use of room air conditioners, Kelvinator Australia Limited approached the DIVISION OF MECHANICAL ENGINEERING and sponsored research aimed at producing a quieter unit.

A series of experiments established that by far the most important source of noise was highly disturbed air flow inside the casing of the unit. The Division found that the noise level could be reduced considerably by redesigning the aerodynamic characteristics of the unit so as to reduce this disturbance in the air stream.

Smoother and more uniform flow also promoted a greater penetration of the air stream into the room. Re-design of the evaporator fan not only reduced the noise but provided a greater throughput of air, thus increasing the thermal performance of the unit. Noise was further reduced by lining the air passages with sound-absorbing materials.

The suggested design alterations were accepted by Kelvinator who had the industrial experience to translate them into manufacturing procedures. The room air conditioner, marketed by Kelvinator as the 'Quiet Australian', won a Certificate of Merit in the 1971 Prince Philip Prize for Australian Design competition conducted by the Industrial Design Council of Australia.

Pulping wood chips

A new process of pulping wood chips could simplify the problem of effluent treatment during paper-making.

To prevent pollution by mill effluents the paper industry has developed methods of recycling the aqueous solutions of sodium and other salts used in the pulping process. The plant required for recycling is complex and can be operated economically only on a large scale.

A joint research programme between the DIVISION OF CHEMICAL ENGINEERING, the Forest Products Laboratory of the DIVISION OF APPLIED CHEMISTRY, and Australian Paper Manufacturers Pty Ltd is examining a new pulping process in which wood chips are treated with liquid sulphur dioxide at temperatures above 100°C. All effluents from the new process can be burnt without residue and the sulphur dioxide recovered and recycled back to the digester. The process produces pale pulps with strengths that approach those of commercial sulphite practice. Using a specially designed high-pressure batch digester the two Divisions are now studying the yields and paper-making qualities of pulps made with sulphur dioxide under varying process conditions.

Bonding ceramics to metals

A reaction that joins ceramics and metals could lead to new bonding techniques in a variety of industries.

Ceramics are hard, strong, brittle materials, with a range of mechanical, thermal, and electrical properties that make them useful in applications from building materials to space research. Joining ceramics to metals or other ceramics is a complex and costly operation since conventional methods of joining materials such as soldering, welding, and brazing are not applicable.

Some years ago a research scientist, now with the Flinders University of South Australia, found that an extremely strong joint could be created between pieces of ceramic and graphite by means of a reaction with each on either side of a platinum sheet. Electron microscope studies by the DIVISION OF CHEMICAL PHYSICS have shown that the extremely strong bond involved in such reactions can be used to join a wide range of materials.

In conjunction with Flinders University, the Division has taken out patents covering the bonding process in a number of countries. In its simplest form, the bond is made by placing the metal in contact with the ceramic and heating it to below the melting point of the metal.

Throughout the reaction, all temperatures are below the melting points of the components. No protective atmosphere is necessary since the reaction takes place in any atmosphere compatible with all of the components at the operating temperature. To date, most experiments have been carried out in air at temperatures between 900 and 1200°C. It has been found that only slight pressure between the solid components is necessary.

Holding crystals steady

The development of a new mounting mechanism for X-ray diffraction studies will assist the collection of fundamental information about atoms and molecules.

By bombarding a single crystal of a substance with X-rays and studying the way in which they are transmitted or diffracted, basic information can be obtained on the arrangement of atoms and molecules within the crystal. A goniometer, which is an instrument for measuring angles, is the mounting system used in these X-ray diffraction studies. The crystal being examined is mounted on the goniometer head at a precise angle to the incoming X-rays so

Opposite: Transmitting light from a helium–neon laser through a liquid-filled optical fibre.

A single beam of light can carry vastly more information than an electrical current. It can, for example, carry the equivalent of more than 1,000,000 telephone conversations. A number of countries are therefore working on the development of optical fibres for use in guided light beam systems since these systems offer the most likely prospect for coping with the enormous growth in communications in the next few decades.

The optical fibre in this picture was developed by the DIVISION OF TRIBOPHYSICS and is made of fused quartz filled with tetrachloroethylene. At a wavelength of 900 nanometres the loss of signal is less than 10 decibels per kilometre, a low enough level to make the new fibre suitable for long-distance optical transmission systems. Although its bore is finer than a human hair, the optical fibre can transmit as much information as existing wide-band submarine cables. Its ultimate capacity is expected to be much greater.

The new optical fibre has been made available to the Australian Post Office for its research laboratories to evaluate the fibre's potential in the development of Australia's telecommunications network.

Patent protection has been sought for the CSIRO fibre.

that the angles of diffraction can be measured very accurately.

A goniometer head of radically new design which enables a sample to be positioned with considerable accuracy has been developed by the DIVISION OF CHEMICAL PHYSICS. The new head is so stable that, once set, no movement can be detected in operation. It is extremely simple in design—it consists basically of only four components—and is correspondingly simple to produce. Leading overseas manufacturers of X-ray diffraction equipment have shown considerable interest in the new head and a non-exclusive agreement has been negotiated with the Dutch firm of Enraf-Nonius to produce these units under licence from CSIRO.

Weather forecasting

Weather forecasting in the Southern Hemisphere is being improved by incorporating data obtained from satellites.

In the Southern Hemisphere, one of the major problems facing meteorologists is the lack of conventional weather observations over the vast ocean areas. At the Commonwealth Meteorology Research Centre, staffed jointly by the DIVISION OF ATMOSPHERIC PHYSICS and the Bureau of Meteorology, considerable progress towards a solution of this problem has been made by using information from weather satellites in numerical forecasting models.

Satellite cloud photographs over data-sparse regions can be interpreted to provide information not previously available, such as the temperatures of various layers in the atmosphere. This information, when combined with the more conventional balloon soundings over land areas, can be used to update a previous forecast to provide an analysis that is the best possible representation of existing conditions. Using a number of these analyses, a mathematical model based on the complete equations of atmospheric flow is undergoing a period of extensive operational testing at the World Meteorological Centre in Melbourne. Preliminary results of these tests are encouraging: the prediction of broad-scale wind and pressure patterns for one to four days has an accuracy comparable with, or better than, conventional methods.

In addition, general circulation models of the Southern Hemisphere are improving our knowledge of the mechanisms controlling the characteristic patterns of motion in the atmosphere. In future, weather forecasts may be further improved by the incorporation of some of these results into numerical prediction models.

Cirrus clouds and climate

Optical studies of the effect of cirrus cloud cover on the Earth's climate are providing meteorologists with much useful information.

Cirrus clouds are white, delicate-looking clouds that occur at heights between $7\frac{1}{2}$ and $10\frac{1}{2}$ kilometres. Since they are composed of ice crystals and are relatively cold, they emit much less radiation than the warm Earth below them and so they reduce the radiant heat loss from the Earth to space. Cirrus clouds also scatter out a fraction of the Sun's radiation, thus decreasing the solar energy input to the Earth. Whichever process is the larger will determine whether a cirrus cloud cover will have on average a net warming or cooling effect on the Earth's climate.

It is important to know the net effect of cirrus clouds on the Earth's climate for several reasons. For example, some

meteorologists have expressed concern that the increasing numbers of jet aircraft in the upper troposphere (8–12 kilometres) may inadvertently increase the natural cirrus cover through the condensation of water vapour from the engines' exhausts. Again, the numerical models of the atmosphere currently being developed and used in weather forecasting do not adequately incorporate radiation fluxes, which control the Earth's energy budget.

Determining the net effect of cirrus clouds on the Earth's climate has proved a problem for atmospheric scientists because of the high altitudes at which these clouds occur. However, a ground-based, remote-sensing infrared radiometer developed by the DIVISION OF ATMOSPHERIC PHYSICS, used in conjunction with lidar (optical radar) equipment made available by the University of Adelaide, has overcome this problem. The radiometer responds to radiation from the clouds using a wavelength to which the atmosphere is transparent, while the lidar equipment measures the height, thickness, and relative optical density of the clouds using visible wavelengths.

Combined measurements made on certain types of cirrus at Adelaide showed that these clouds emitted radiant heat, on average, at 25% efficiency (75% transparency), a lower figure than was previously thought. The measurements also predicted that scattering of solar radiation from the clouds would depend considerably on solar angle, that is on latitude and season.

These findings are being used to assist in the interpretation of infrared and visible pictures taken from satellites. What the satellite 'sees' depends on the transmissivity, reflectivity, and height of the clouds beneath as well as on the nature of the Earth's surface.

The Division's work has also provided a means for distinguishing between ice and water clouds. The lidar radiation backscattered from cirrus clouds was found to be less than that theoretically predicted for clouds of water drops or ice spheres. The reason lies in the nature of the cirrus ice crystals, which are known to have an irregular geometry and which tend to form conglomerates. Whereas spheres have a maximum scattering in the 'back' direction, irregular particles scatter diffusely.

Detecting molecules in space

Highly sensitive microwave receivers installed at the 64-metre (210-foot) radio telescope at Parkes, New South Wales, have detected signals from several organic compounds in interstellar space. Two new molecules have been discovered, adding to the small but growing list of organic molecules that have now been found in the depths of space.

A molecular line of thioformaldehyde (CH_2S) at a wavelength of 9 cm was detected in September 1971 with the Parkes radio telescope operated by the DIVISION OF RADIOPHYSICS. It was the first interstellar molecule to be discovered from outside the United States. Three months later a new molecular line from acetaldehyde (CH_3CHO) was detected near the same wavelength of 9 cm. Both compounds were detected near the centre of our Galaxy in the radio source Sagittarius B2 which is believed to be a cloud of gas in the process of condensing into a star–planet system like our own solar system.

The discovery of interstellar molecules depends critically on accurate laboratory measurements of transition frequencies. The Division has therefore been collaborating closely with the Department of Chemistry at Monash University which is well equipped to measure the natural frequencies of suggested compounds.

As a result of this collaboration, the molecule methyleneimine (CH_2NH) was discovered in May 1972 by its emission line radiation at a wavelength of 6 cm. Although methyleneimine exists only fleetingly on Earth, chemists at Monash University were able to synthesize it and measure a characteristic group of six spectral lines during the few seconds that it survived in the laboratory. Ten days later the Division's radio telescope picked up faint signals from the region of Sagittarius B2 at a wavelength of 6 cm. The signals matched perfectly the line profile recorded at Monash.

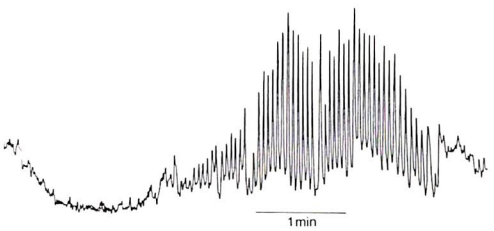
The arrangement of the atoms in the methyleneimine molecule and in another molecule that has been found in interstellar space, formic acid (HCOOH), is such that if they could be combined a synthesis of the amino acid glycine (CH_2NH_2COOH) might result. Glycine is the simplest of the amino acids—the units from which proteins are built up. The discovery of methyleneimine therefore provides evidence for the new idea that the ingredients of carbon-based life may start to form in space long before planets condense from clouds of gas into solid bodies.

Cosmic rays from the Sun

Regular pulses from the Sun provide a clue to the origin of solar cosmic rays.

On 27 September 1969, a rare event on the Sun was recorded by the Culgoora radiospectrograph. This instrument, located in northern New South Wales, is operated by the DIVISION OF RADIOPHYSICS and maintains a regular watch on the Sun by recording the spectrum of radio waves.

The spectacular event on the Sun began as a typical solar flare, which produced a large burst of radio waves, but then suddenly the radio emission broke into sharp pulses of striking regularity, spaced at intervals of 2·7 seconds. After about fifty pulses the emission returned, with equal suddenness, to its former continuous character, while the intensity diminished and faded. At the same time a solar shock wave was seen to be travelling out from the flare explosion; and shortly after, cosmic rays were observed by detectors on an American satellite.



The Division has now developed a simple theory which explains the whole sequence of events—the rise in radio intensity, the sudden pulsations, and the generation of cosmic rays. According to the theory the complete phenomenon is the natural consequence of an arch-shaped magnetic field above the flare being disturbed and set in oscillation by the shock wave passing through it. A few similar events since observed fit the same pattern. The important contribution of these observations is that they not only link together a series of observed characteristics but, in addition, provide the first observational clue as to how solar cosmic rays are generated.

Measuring temperatures more accurately

Quicker and more accurate measurements of temperature can now be made with platinum resistance thermometers following the development of a new type of resistance bridge.

Although the mercury-in-glass thermometer is widely used for measuring temperatures in the range −35°C to 500°C, there are many situations in industry and science where temperatures must be measured more accurately than is possible with thermometers of this type. Many of these measurements are made with platinum resistance thermometers. If the temperature of a platinum wire is raised, its electrical resistance increases by about 4% for every 10°C. For any particular platinum resistance thermometer the relation between temperature and electrical resistance can be determined precisely and temperatures can then be measured by measuring the electrical resistance of the platinum wire.

A precise knowledge of temperature is important in practically all of the measurements made in the NATIONAL STANDARDS LABORATORY. A few years ago, measurements accurate to about a hundredth of a degree were sufficiently accurate and these could be made with mercury-in-glass thermometers. Now the accuracy required in many measurements makes it necessary for temperatures to be known and in some cases to be controlled to within less than a thousandth of a degree. Measurements to this accuracy with conventional platinum resistance thermometry equipment are time-consuming and difficult. A new resistance bridge developed in the DIVISION OF APPLIED PHYSICS makes such measurements much quicker and gives improved accuracy.

The new bridge makes use of techniques developed in the Division for using specially constructed transformers to give very precise ratios. Following the successful testing of a bridge of this type, twelve bridges have now been constructed and tested in various applications in the Laboratory.

An immediate application for one of these bridges was found in the DIVISION OF PHYSICS which calibrates several hundred mercury-in-glass thermometers a year for other users. Because of the difficulty of using the conventional equipment, the earlier practice was to calibrate high-quality mercury-in-glass thermometers by reference to the Laboratory's standard platinum resistance thermometers and to use these mercury thermometers as standards for the calibration of those from clients. The ease of use of the new bridge has made it possible for thermometers of this type to be calibrated directly against reference platinum resistance thermometers. This change has been accompanied by a time-saving of about 20% and in the case of some special calibrations as much as 50%.

The bridge is also being used in the DIVISION OF PHYSICS in a detailed investigation of phenomena associated with the freezing of water which provides the basic reference point for the measurement of temperature. To make these experiments possible it was necessary to be able to detect differences of temperature as small as a few millionths of a degree and this sensitivity has been achieved by using some supplementary equipment to process the information provided by the bridge. Although the phenomena investigated have been of interest to physicists concerned with temperature measurement for many years, this is the first time that equipment has been available with sensitivity sufficient to make the experiments possible.

Locating defects in microwave systems

An instrument has been developed which detects and measures defects in microwave systems.

In radar, long-distance telephony, and satellite communications, extensive use is made of systems involving the passage of electrical energy through waveguides. These are precisely made metal tubes, usually rectangular in section, which are used instead of wires to carry electrical energy in the form of currents alternating at very high frequencies. If there are mechanical imperfections in the waveguides or in the fittings used to connect the lengths of waveguide together, energy is reflected from these and the equipment cannot perform with maximum efficiency.

Until recently, it was possible to measure the total effect of these reflections but not to locate and measure individual reflections when several were present. A locating reflectometer developed in the DIVISION OF APPLIED PHYSICS makes it possible to locate individual reflections precisely and to measure the extent to which they reflect energy. The locations of individual reflections in a component can be displayed on an oscilloscope screen or recorded on a paper chart. If this chart is made the actual size of the component it can be placed beside the component to indicate where the reflections are occurring.

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Chemical Research of Industrial Interest			
Chemical Engineering	983,134	27,877	1,011,011
Applied Chemistry	2,269,237	140,699	2,409,936
Chemical Physics	1,244,970	11,721	1,256,691
Protein Chemistry	127,059	1,149,756	1,276,815
Fisheries and Oceanography			
Fisheries and Oceanography	1,315,168	100,000	1,415,168
Marine Biochemistry	70,232	—	70,232
Processing and Use of Mineral Products			
Mineral Chemistry	2,232,888	179,276	2,412,164
Mineralogy	910,992	32,087	943,079
Mineral Physics	386,394	38,463	424,857
Baas Becking Geobiological Group	12,000	85,427	97,427
Physical Research of Industrial Interest			
Physics	1,251,176	9,848	1,261,024
Applied Physics	2,176,124	2,974	2,179,098
General Physical Research			
Radiophysics	1,878,997	13,718	1,892,715
Atmospheric Physics	1,382,475	—	1,382,475
Commonwealth Meteorological Research Centre	124,400	—	124,400
Environmental Mechanics	262,028	7,852	269,880
Radio Research Board	40,000	65,857	105,857
General Industrial Research			
Building Research	2,495,458	160,806	2,656,264
Tribophysics	1,042,248	12,691	1,054,939
Applied Geomechanics	660,978	79,970	740,948
Mechanical Engineering	821,115	109,049	930,164
Research Services			
Computing Research	897,779	—	897,779
Mathematical Statistics	793,663	230	793,893
Rural Sciences Laboratory	300,367	—	300,367
Extramural investigations	76,878	—	76,878
Australian Mineral Development Laboratories	59,997	—	59,997
Developmental projects	149,796	—	149,796
Miscellaneous	456,999	30,024	487,023
Grants			
Research Associations	372,517	—	372,517
Research Studentships	293,321	—	293,321
Other grants and contributions	995,459	—	995,459
Total expenditure	52,408,507	12,117,077	64,525,584

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	3,417	—	3,417
Animal Health and Reproduction			
Animal Genetics	65,399	53,232	118,631
Animal Health	17,698	22,260	39,958
Animal Physiology	—	73,414	73,414
Nutritional Biochemistry	20,634	3,717	24,351
Plant Industry	89,812	7,036	96,848
Entomology and Wildlife			
Entomology	7,250	337,721	344,971
Wildlife	7,611	5,477	13,088
Soils	45,256	3,335	48,591
Horticulture and Irrigation			
Horticultural Research	27,204	—	27,204
Irrigation Research	50,782	—	50,782
Tropical Pastures	118,879	3,853	122,732
Land Research			
Land Research	747	471	1,218
Rangelands Research	38,155	2,072	40,227
Processing of Agricultural Products			
Food Research	67,295	1,365	68,660
Textile Industry	—	93,276	93,276
Textile Physics	—	282,636	282,636
Information and Publications			
Film Unit	2,605	—	2,605
Chemical Research of Industrial Interest			
Chemical Engineering	1,780	—	1,780
Applied Chemistry	87,513	—	87,513
Protein Chemistry	—	124,846	124,846
Fisheries and Oceanography	137,077	34,154	171,231
Processing and Use of Mineral Products			
Mineral Chemistry	91,715	360	92,075
Mineralogy	7,025	—	7,025
Mineral Physics	18,644	—	18,644
Physical Research of Industrial Interest			
Physics	55,071	—	55,071
Applied Physics	51,696	—	51,696
General Physical Research			
Radiophysics	106,870	—	106,870
Atmospheric Physics	31,102	—	31,102
General Industrial Research			
Building Research	48,233	—	48,233
Tribophysics	61,223	—	61,223
Applied Geomechanics	13,744	—	13,744
Mechanical Engineering	67,726	—	67,726
Research Services			
Computing Research	196,586	—	196,586
Mathematical Statistics	267	—	267
Rural Sciences Laboratory	850	—	850
Total capital expenditure	1,539,866	1,049,225	2,589,091

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Division of Tropical Pastures

Headquarters: Cunningham Laboratory, St. Lucia, Qld.

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At Narayen Research Station via Mundubbera, Qld.

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Wheat Research Unit

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

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Division of Wildlife Research

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Wool Research Laboratories

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Division of Protein Chemistry

Headquarters: 343 Royal Parade, Parkville, Vic.

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Division of Textile Industry

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G. G. West, A.G.Inst.Tech.
SCIENTIFIC SERVICES OFFICER
J. F. Sinclair

Division of Textile Physics

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

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Unattached Officers

G. B. Gresford, B.Sc., A.R.M.T.C.
(seconded to United Nations as Director for Science and Technology, Department of Economic and Social Affairs)

PRINCIPAL RESEARCH SCIENTIST
Miss S. H. Allen, B.Sc.
(seconded to the Institute of Medical and Veterinary Science, Frome Road, Adelaide, S.A.)

Finance

Annual Expenditure

The following summary gives details of expenditure by CSIRO Divisions and Sections on other than capital items from 1 July 1971 to 30 June 1972.

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.	4,003,299	11,823	4,015,122
Research Programmes			
Animal Health and Reproduction			
Animal Genetics	1,291,341	558,032	1,849,373
Animal Health	2,098,862	609,497	2,708,359
Animal Physiology	683,300	1,742,447	2,425,747
Nutritional Biochemistry	585,596	225,636	811,232
Plant Industry	3,243,600	898,310	4,141,910
Entomology and Wildlife			
Entomology	2,403,217	667,579	3,070,796
Wildlife Research	855,880	339,695	1,195,575
Soils	2,105,095	134,805	2,239,900
Horticulture and Irrigation			
Horticultural Research	705,064	27,815	732,879
Irrigation Research	652,136	37,451	689,587
Tropical Pastures	1,718,699	363,949	2,082,648
Land Research			
Land Research	1,579,605	545,604	2,125,209
Rangelands Research	487,694	202,965	690,659
Woodland Ecology	93,201	63,941	157,142
Processing of Agricultural Products			
Food Research	2,421,513	720,647	3,142,160
Wheat Research	24,099	88,381	112,480
Textile Industry	93,088	1,366,754	1,459,842
Textile Physics	—	1,253,121	1,253,121
Information and Publications			
Central Library	422,446	—	422,446
Editorial and Publications Section	753,712	—	753,712
Film Unit	103,211	300	103,511

Contributions

This table summarizes receipts and expenditure during 1971/72 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, including several United States Government agencies.

DIVISION OR SECTION	**Receipts 1971/72 and balances brought forward** ($)	**Expenditure 1971/72** ($)
Animal Genetics		
Wool Research Trust Fund	452,763	437,344
Meat Research Trust Account	113,223	116,668*
Other contributors	73,002	57,252
Animal Health		
Wool Research Trust Fund	346,348	320,795
Meat Research Trust Account	297,009	271,718
Dairy Produce Research Trust Account	21,620	20,875
Other contributors	34,937	18,369
Animal Physiology		
Wool Research Trust Fund	1,872,400	1,711,792
Meat Research Trust Account	81,435	77,606
Other contributors	41,654	26,463
Nutritional Biochemistry		
Wool Research Trust Fund	239,550	229,353
Plant Industry		
Wool Research Trust Fund	773,969	721,058
Wheat Research Trust Account	13,899	12,338
Dairy Produce Research Trust Account	12,880	11,241
Tobacco Industry Trust Account	54,210	52,573
Other contributors	132,381	108,136
Entomology		
Wool Research Trust Fund	66,102	63,491
Meat Research Trust Account	384,561	338,144
Wheat Research Trust Account	24,244	17,480
Other contributors	623,204	586,185
Wildlife Research		
Wool Research Trust Fund	257,926	223,166
Meat Research Trust Account	122,231	117,061
Other contributors	6,218	4,945
Soils		
Wheat Research Trust Account	31,221	25,895
Other contributors	163,983	112,245
Horticultural Research		
Dried Fruits Research Trust Account	19,100	15,539
Other contributors	16,048	12,276
Irrigation Research		
Other contributors	73,080	37,451
Tropical Pastures		
Meat Research Trust Account	194,905	195,358*
Dairy Produce Research Trust Account	74,409	73,305
Other contributors	162,002	99,139
Land Research		
Meat Research Trust Account	38,380	34,867
Tobacco Industry Trust Account	230,116	215,681
Other contributors	365,194	295,527
Rangelands Research		
Wool Research Trust Fund	221,772	186,419
Other contributors	45,539	18,618

* Expenditure in excess of receipts will be recovered in 1972/73.

DIVISION OR SECTION	Receipts 1971/72 and balances brought forward ($)	Expenditure 1971/72 ($)
Woodland Ecology		
Other contributors	79,066	63,941
Food Research		
Meat Research Trust Account	549,684	461,780
Dairy Produce Research Trust Account	215,292	198,194
Fishing Industry Research Trust Account	16,090	12,699
Dried Fruits Research Trust Account	6,910	6,910
Other contributors	61,295	42,429
Wheat Research		
Wheat Research Trust Account	89,522	87,854
Other contributors	1,881	527
Textile Industry		
Wool Research Trust Fund	1,693,002	1,445,274
Other contributors	30,443	14,756
Textile Physics		
Wool Research Trust Fund	1,282,256	1,154,601
Other contributors	621,080	381,156
Film Unit		
Other contributors	3,300	300
Chemical Engineering		
Other contributors	46,271	27,877
Applied Chemistry		
Other contributors	200,595	140,699
Chemical Physics		
Other contributors	32,004	11,721
Protein Chemistry		
Wool Research Trust Fund	1,318,033	1,230,874
Other contributors	39,599	43,728*
Fisheries and Oceanography		
Fishing Industry Research Trust Account	100,000	100,000
Other contributors	58,962	34,154
Mineral Chemistry		
Other contributors	275,343	179,636
Mineralogy		
Other contributors	31,141	32,087*
Mineral Physics		
Other contributors	49,167	38,463
Baas Becking Geobiological Group		
Other contributors	86,285	85,427
Physics		
Other contributors	13,290	9,848
Applied Physics		
Other contributors	8,256	2,974
Radiophysics		
Other contributors	190,700	13,718
Atmospheric Physics		
Other contributors	13,866	—
Environmental Mechanics		
Other contributors	19,975	7,852
Radio Research Board		
Other contributors	81,843	65,857
Building Research		
Other contributors	260,390	160,806
Tribophysics		
Other contributors	35,321	12,691
Applied Geomechanics		
Other contributors	115,622	79,970

* Expenditure in excess of receipts will be recovered in 1972/73.

DIVISION OR SECTION	Receipts 1971/72 and balances brought forward ($)	Expenditure 1971/72 ($)
Mechanical Engineering		
Wheat Research Trust Account	54,913	50,781
Other contributors	103,981	58,268
Mathematical Statistics		
Other contributors	372	230
Head Office		
Wool Research Trust Fund	13,400	11,823
Miscellaneous		
Other contributors	327,997	30,024
Total contributions	15,808,662	13,166,302

General Revenue

During 1971/72, general revenue amounting to $1,343,050 was received by the Organization. Details of the receipts are as follows:

Sale of publications	62,442
Sale of equipment purchased in former years, and other receipts	173,193
Sale of produce, including livestock	114,323
Royalties from patents	135,880*
Testing fees	81,352
Computing charges to outside users	743,484
Miscellaneous receipts	32,376
Total	1,343,050

Of the above sum $1,214,507 was spent during 1971/72 and a further $134,000 was spent from the balance remaining in the Special Account as at 1 July 1971. This expenditure was approved by the Minister for Education and Science and the Treasurer as part of the general estimates.

* A further $51,834 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 $44,000 for the self-twist spinning machine.

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

6 August, 1972

The Honourable the Minister for
Education and 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, the Organization has submitted financial statements for the year ended 30 June 1972 for my report thereon. 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.) V.J.W. SKERMER

(V.J.W. SKERMER)
AUDITOR-GENERAL FOR THE COMMONWEALTH

Summary of Receipts and Payments

	Funds held 1 July 1971 ($)	Receipts ($)	Total funds available ($)	Payments ($)	Funds held 30 June 1972 ($)
Special Account					
Parliamentary Appropriation: Operational	— (—)*	51,060,000.00 (44,541,000.00)	51,060,000.00 (44,541,000.00)	51,060,000.00 (44,541,000.00)	— (—)
Parliamentary Appropriation: Capital	3,617.26 (26,893.25)	1,540,000.00 (1,596,000.00)	1,543,617.26 (1,622,893.25)	1,539,865.62 (1,619,275.99)	3,751.64 (3,617.26)
Revenue and Other Receipts	240,382.80 (155,781.05)	1,343,050.12 (1,140,713.25)	1,583,432.92 (1,296,494.30)	1,348,507.27 (1,056,111.50)	234,925.65 (240,382.80)
Total: Special Account	244,000.06 (182,674.30)	53,943,050.12 (47,277,713.25)	54,187,050.18 (47,460,387.55)	53,948,372.89 (47,216,387.49)	238,677.29 (244,000.06)
Specific Research Account	2,698,111.73 (3,231,738.44)	13,110,550.76 (12,460,475.98)	15,808,662.49 (15,692,214.42)	13,166,302.50 (12,994,102.69)	2,642,359.99† (2,698,111.73)
Other Trust Moneys‡	12,100.91 (32,653.38)	340,297.13 (207,674.69)	352,398.04 (240,328.07)	333,475.38 (228,227.16)	18,922.66 (12,100.91)
Cafeteria Account§	10,882.95 (9,565.96)	74,015.64 (99,303.05)	84,898.59 (108,869.01)	78,719.06 (97,986.06)	6,179.53 (10,882.95)
Total	**2,965,095.65** **(3,456,632.08)**	**67,467,913.65** **(60,045,166.97)**	**70,433,009.30** **(63,501,799.05)**	**67,526,869.83** **(60,536,703.40)**	**2,906,139.47** **(2,965,095.65)**

* Figures in brackets refer to 1970/71 financial year.
† Includes investments totalling $1,223,550.00.
‡ Moneys held temporarily on behalf of other organizations and individuals.
§ Operating receipts and expenses of CSIRO cafeterias at Melbourne and Sydney.

J. R. Price (*Chairman*)

R. W. Viney (*Finance manager*)

Consolidated Statement of Payments

1970/71 ($)		1971/72 ($)
	Head Office (including Regional Administrative Offices)	
2,442,558	Salaries and allowances	2,982,016
258,235	Travelling and subsistence	256,731
216,981	Postage, telegrams, and telephone	225,491
620,625	Incidental and other expenditure	550,884
3,538,399		4,015,122
	Research programmes	
	Agricultural research	
6,966,831	Animal health and reproduction	7,794,711
4,502,451	Plant industry	4,141,910
3,728,449	Entomology and wildlife	4,266,371
2,017,435	Soils	2,239,900
1,224,673	Horticulture and irrigation	1,422,466
1,964,626	Tropical pastures	2,082,648
1,958,232	Land research	2,973,010
5,344,868	Processing of agricultural products	5,967,603
1,090,798	Information and publications	1,279,669
4,880,280	Chemical research of industrial interest	5,954,453
1,241,176	Fisheries and oceanography	1,485,400
3,417,310	Processing and use of mineral products	3,877,527
3,016,522	Physical research of industrial interest	3,440,122
3,288,173	General physical research	3,774,991
3,027,677	General industrial research	5,382,315
1,827,973	Processing of forest products*	—
1,845,953	Research services	2,278,710
523,185	Miscellaneous	487,359
51,866,612		58,849,165
	Grants	
329,859	Research associations	372,517
348,974	Research studentships	293,321
856,892	Other grants and contributions	995,459
1,535,725		1,661,297
	Capital Works and Services	
1,945,941	Buildings, works, plant, and developmental expenditure	1,341,326
456,000	Scientific computing equipment	499,889
745,515	Other equipment	694,886
48,299	Development of Queensland cattle station	—
73,999	Development of Ginninderra field station	52,990
3,269,754		2,589,091
	Other Trust Moneys	
109,326	Remittance of revenue from investigations financed from industry Trust Accounts	190,342
118,901	Other miscellaneous remittances	143,133
228,227		333,475
	Cafeteria Account	
97,986	Operating expenses of CSIRO cafeterias at Melbourne and Sydney	78,719
97,986		78,719
60,536,703	**Total Payments**	**67,526,869**

* As from 1 July 1971, the research activities of this Division were integrated with general industrial research and chemical research of industrial interest.

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

Statement of Payments—Special Account*

1970/71 ($)		1971/72 ($)
	Head Office (including Regional Administrative Offices)	
2,428,461	Salaries and allowances	2,971,326
257,599	Travelling and subsistence	255,598
216,981	Postage, telegrams, and telephone	225,491
608,281	Incidental and other expenditure	550,884
3,511,322		4,003,299
	Research Programmes	
	Agricultural research	
3,815,196	Animal health and reproduction	4,659,099
3,078,596	Plant industry	3,243,600
2,829,495	Entomology and wildlife	3,259,097
1,864,099	Soils	2,105,095
1,173,193	Horticulture and irrigation	1,357,200
1,639,497	Tropical pastures	1,718,699
1,640,798	Land research	2,160,500
2,295,196	Processing of agricultural products	2,538,700
1,090,798	Information and publications	1,279,369
3,678,697	Chemical research of industrial interest	4,624,400
1,241,093	Fisheries and oceanography	1,385,400
3,140,999	Processing and use of mineral products	3,542,274
3,005,774	Physical research of industrial interest	3,427,300
3,217,696	General physical research	3,687,900
2,844,997	General industrial research	5,019,799
1,681,098	Processing of forest products†	—
1,845,295	Research services	2,278,480
467,547	Miscellaneous	456,999
40,550,064		46,743,911
	Grants	
329,859	Research associations	372,517
348,974	Research studentships	293,321
856,892	Other grants and contributions	995,459
1,535,725		1,661,297
	Capital Works and Services	
417,986	Buildings, works, plant, and developmental expenditure	379,988
456,000	Scientific computing equipment	499,889
622,992	Other equipment	606,999
48,299	Development of Queensland cattle station	—
73,999	Development of Ginninderra field station	52,990
1,619,276		1,539,866
47,216,387	**Total Payments**	**53,948,373**

* 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.

† As from 1 July 1971, the research activities of this Division were integrated with general industrial research and chemical research of industrial interest.

J. R. Price (*Chairman*)

R. W. Viney (*Finance manager*)

Statement of Payments—Specific Research Account

1970/71 ($)		1971/72 ($)
	Head Office (including Regional Administrative Offices)	
14,097	Salaries and allowances	10,690
636	Travelling and subsistence	1,133
—	Postage, telegrams, and telephone	—
12,344	Incidental and other expenditure	—
27,077		11,823
	Research Programmes	
	Agricultural research	
3,151,635	Animal health and reproduction	3,135,612
1,423,855	Plant industry	898,310
898,954	Entomology and wildlife	1,007,274
153,336	Soils	134,805
51,480	Horticulture and irrigation	65,266
325,129	Tropical pastures	363,949
317,434	Land research	812,510
3,049,672	Processing of agricultural products	3,428,903
—	Information and publications	300
1,201,583	Chemical research of industrial interest	1,330,053
83	Fisheries and oceanography	100,000
276,311	Processing and use of mineral products	335,253
10,748	Physical research of industrial interest	12,822
70,477	General physical research	87,091
182,680	General industrial research	362,516
146,875	Processing of forest products*	—
658	Research services	230
55,638	Miscellaneous	30,360
11,316,548		12,105,254
	Capital Works and Services	
1,527,955	Buildings, works, plant, and developmental expenditure	961,338
122,523	Other equipment	87,887
1,650,478		1,049,225
12,994,103	**Total Payments**	**13,166,302**

* As from 1 July 1971, the research activities of this Division were integrated with general industrial research and chemical research of industrial interest.

J. R. Price (*Chairman*)

R. W. Viney (*Finance manager*)

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