Commonwealth Scientific and Industrial Research Organization, Australia

# CSIRO Thirtieth Annual Report 1977/78

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This report of the work of CSIRO for the year ending 30 June 1978 has been prepared as required by Section 30 of the Science and Industry Research Act 1949.

The Executive gratefully acknowledges the valuable help received from Commonwealth and State government departments and instrumentalities, universities and other research bodies, representatives 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.

V. D. Burgmann (*Chairman*)
N. K. Boardman
M. E. Holman
V. E. Jennings
A. E. Pierce
F. M. Wiltshire
H. W. Worner

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

The powers and functions of CSIRO are:

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

the training of scientific research workers and the awarding of studentships

the making of grants in aid of scientific research

the recognition and support of research associations

the maintenance of the national standards of measurement

the dissemination of scientific and technical information

the publication of scientific and technical reports

liaison with other countries in matters of scientific research.

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### Cover

A general view across the Kosciusko alpine area, looking westwards over the forest ranges of the upper Murray River in New South Wales and Victoria. The massed flowering of *Craspedia* is in the tall alpine herb field overlooking Lake Albina, one of the glaciated lakes in the Kosciusko National Park.

Several CSIRO Divisions are involved in ecological research of the Kosciusko alpine area, a region of great scientific interest. Studies of the geology, flora and fauna are contributing to an understanding of this unique Australian environment, an essential step in developing appropriate management and conservation strategies.

Recently the DIVISION OF PLANT INDUSTRY completed an extensive study of all the major plant communities in the alpine region, together with their habitats. The results of the study will be published by CSIRO in a book on the flora of the Kosciusko region.

*Photograph: Colin Totterdell*

### Acknowledgment

The Executive wishes to acknowledge the assistance of Miss Heulwen M. Ridgway in writing and compiling this report.

## Research

# Introduction

Science and technology are potent forces for change. Through scientific research man gains a deeper understanding of the world around him, through technology he employs this knowledge to use natural resources to achieve his own ends. For more than fifty years, CSIRO has contributed significantly to the changing pattern of our society by conducting scientific research not only for the benefit of Australia's agriculture and industry but also for the benefit of the community as a whole.

As an instrument of change, CSIRO has continually interpreted its role in the light of perceived industry, national, and community needs, and its organisational structure and management practices have evolved in accordance with changes required to meet these needs. The establishment, by the Commonwealth Government, of an Independent Inquiry into CSIRO to examine, *inter alia*, the extent to which the Organization retained the flexibility to respond to the changing needs of society in the years ahead was none the less welcomed by those responsible for managing the Organization. The Inquiry came at a time when CSIRO was already undergoing a period of critical self-examination and review and thus provided an opportunity for the Executive to submit its proposals to external scrutiny and to obtain independent views on a course of action for the future.

The Committee of Inquiry, which comprised Professor A. J. Birch, Sir Cecil Looker and Mr. Russell Madigan, OBE, commenced its activities about November 1976. Its report, which was very comprehensive, contained 122 recommendations, and was presented on 25 August 1977 and was tabled in Parliament on 6 October in the same year. On 11 May 1978, the Prime Minister announced in the House of Representatives the Government's decisions on the Inquiry's recommendations. The statement which he made on that occasion, together with a supporting statement made in the Senate by the Minister for Science, Senator J. J. Webster, are reproduced in the pages following this introduction and contain the main substance of the Government's decisions.

The introduction to the Inquiry's report states, 'The Committee has identified the need for changes, but believes that changes should not be lightly undertaken and must take account of strengths built up over a long period'. I am sure that I speak for most, if not all, of the 7000 people who work for CSIRO in saying that the Committee of Inquiry has done an outstanding job in identifying those strengths of CSIRO which must be preserved and those areas where change is either necessary or desirable.

The report and the Government's decisions on it recognise the very considerable contribution that CSIRO has made and continues to make in Australia, and affirm the importance of retaining CSIRO as a single statutory entity financed in the main by specific government vote.

While defining the main role of CSIRO as scientific and technological research in support of Australian industry, community interests and other perceived national objectives and obligations, emphasis has also been placed on the importance of communicating the results of that research to those who can use it. Moreover, the need is seen for CSIRO to expand its role in interpreting and disseminating information from world science and technology for the benefit of technological innovation in Australia and for increased use by Australian industry. Thus, there is a clear message for the Executive that CSIRO will have to become increasingly outward looking. This will require improved lines of communication, some different styles of operation, additional skills, and to some extent, changes in existing attitudes. Therefore, the enhanced advisory bodies that have been recommended will be an important element in developing greater awareness within CSIRO of research and communication needs and perhaps more importantly, in helping establish within the national community, a greater awareness of the contribution that can be made by CSIRO.

The new top management structure decided by the Government for CSIRO together with the proposed grouping of Divisions into Institutes, are broadly similar to the proposals advanced by the Executive to the Inquiry. They will provide the Executive with the means of achieving improved effectiveness in determining policies and priorities and in allocating resources. The fact that the Directors of the Institutes will actively participate in the decision-making processes of the Executive will ensure the cohesiveness of the Organization and the streamlining of its managerial processes.

The requirement to enhance the reporting processes of the Organization will ensure the openness of the Organization to Government, parliamentary and public scrutiny.

Following the Government's announcement of its decisions in May, the Executive developed appropriate arrangements to enable the Government's decisions to be implemented as quickly as possible. The task, however, is a substantial one. In many cases consultation will be required between Ministers, between CSIRO and Government Departments, and with other bodies. Some decisions may involve significant changes for groups of staff and the introduction of these changes will have to be managed carefully and sympathetically to minimise any possible adverse effect on staff morale and productivity.

A number of the Government's decisions, including the reconstitution of the Executive, require changes to the Science and Industry Research Act of 1949. Information has already been submitted to the Minister for Science so that the necessary amending legislation can be prepared. Provided this proceeds without undue delay, it is expected that the major decisions on structure and Institute composition will be carried out within the next 12 months.

The last few years have seen CSIRO exposed not only to intensive external scrutiny but also to considerable self-examination and self-questioning. While this has been a healthy and desirable situation, it has resulted, at times, in uncertainty and distraction from our main task. However, with restructuring of the Executive and the appointment of Institute Directors, we can look forward to a period of new and strengthened leadership that will facilitate decision-making and enable the Organization to move forward, more responsive to change, and more conscious than ever of its social commitment.

It is now 29 years since the passing of the Science and Industry Research Act which in 1949 transformed the former Council for Scientific and Industrial Research (CSIR) into CSIRO. Everyone in CSIRO, indeed all

Australians, can look back at the achievements of those years with pride. It is only fitting, therefore, that we should pay tribute to those Members of the Executive, both full-time and part-time, who helped guide and shape the Organization's destiny in that time with such skill and dedication. When the new Science and Industry Research Act is passed, CSIRO will embark on a new era, an era that promises to be even more challenging and exciting. I am confident that everyone in CSIRO will respond to that challenge and that the years ahead will add still further to the Organization's proud record of achievement. My confidence is strengthened by the announcement on June 30th of the appointment of Dr. J. P. Wild as the next Chairman.

V. D. BURGMANN
Chairman

# Independent Inquiry into CSIRO

*Statement by the Prime Minister, the Rt Hon. Malcolm Fraser, C.H., M.P., to the House of Representatives, 11 May 1978.*

Mr Speaker,

I ask leave of the House to make a Statement concerning the Government's decisions on the recommendations of the Report of the Independent Inquiry into CSIRO.

In 1976 a comprehensive review was initiated to see whether government programs for the development and coordination of Australia's science and technology effort were as effective as they might be. One inquiry established at that time concerned the role of a permanent Australian Science and Technology Council, and as a result of that review, I introduced a Bill last month to establish ASTEC as a permanent and independent statutory authority.

Honourable Members will be aware that in 1976 an Independent Committee of Inquiry was also established to review the objectives, structure and programs of the Commonwealth Scientific and Industrial Research Organization. The members of the Inquiry were:

> Professor Arthur Birch, Professor of Organic Chemistry at the Australian National University,
>
> Sir Cecil Looker, Former President of the Australian Associated Stock Exchanges, and
>
> Mr Russell Madigan, O.B.E., Chairman of Hamersley Holdings Limited.

The Inquiry's Report was presented on 25 August last year and was tabled on 6 October 1977 (Hansard, p. 1721).

The Inquiry's Report included 122 recommendations. In considering these, the Government has been mindful of the important contribution which CSIRO has made to science and technology in Australia over the past fifty years. The Committee of Inquiry observed that 'the world reputation of CSIRO is a source of pride and morale to its scientists, and to Australia' (page xi). If any reminder were needed of the great contribution which CSIRO has made, it is sufficient to refer to the decision last month of the International Civil Aviation Organization All Weather Operations Division to adopt internationally the INTERSCAN microwave aircraft landing system developed by CSIRO in collaboration with the Department of Transport.

The structure of CSIRO was last reviewed and reorganised in 1949. At that time CSIRO was employing 2500 persons in 12 Divisions. It now employs 7000 persons in 37 Divisions. In the light of the findings of the Inquiry and other advice available to the Government, it has been decided that CSIRO should again be substantially reorganised.

CSIRO will remain a single multi-disciplinary research entity responsible to the Minister for Science but much of the day to day management of CSIRO activities at present undertaken by the Executive, will be devolved to Directors of new functional groupings of Divisions to be called Institutes. Under the new arrangements, the Executive will concentrate on policy issues including the determination of research strategy and priorities. The Executive will be assisted in this task through revitalised advisory and consultative arrangements which I will outline shortly.

The Executive of CSIRO will comprise a slightly smaller governing body than at present. There will be a Chairman, who will also be Chief Executive, and two other full-time members together with between three and five part-time members. The full-time members may or may not be drawn from within CSIRO. The part-time members will all be drawn from outside the Organization.

The Government has agreed with the Committee of Inquiry that there be up to six Institutes created from within CSIRO, each headed by a very senior scientist as Director. Each Director will be appointed by the Executive for terms of up to five years, with provision for reappointment. Although the main role of the Institute Directors will be managerial, they will be actively consulted by the Executive in matters of policy.

The Committee of Inquiry favoured Institute Directors being appointed by the Executive and holding office on the Executive in an ex-officio capacity, thereby providing a direct link between the work points of the Organization and the Executive. The Government, however, after fully considering all aspects of this matter including advice received from ASTEC on the issue, has decided that Institute Directors should not be members of the Executive but should only have an advisory role. For the information of Honourable Members I table the advice dated 28 September 1977 which I received from ASTEC.

The Committee of Inquiry recognised that much of the success of CSIRO in the past can be attributed to a policy of leaving scientific decisions in the hands of scientists. The Government agrees with the Inquiry that this policy should remain unchanged, and accordingly, the basic research unit in CSIRO will continue to be the Division headed by a Chief of Division.

The Inquiry drew attention in its Report to the importance of consultative machinery which could help the Executive to incorporate policy advice and the advice of users of research results in its determination of strategy and program priorities for CSIRO. Accordingly, the Advisory Council will be strengthened to enable it to act effectively as the major source of advice to the Executive. Its membership will be reorganised along the lines proposed by the Inquiry and will include representatives from a wide range of interests. It will be completely independent of the Executive of CSIRO, have its own Secretariat and members of the CSIRO Executive will not be members of the Council. It is envisaged that the Advisory Council will set up ad hoc work groups to investigate particular areas related to CSIRO activities. Advisory Council advice and initiatives will be incorporated in the CSIRO Annual Report.

The Advisory Council will be linked with reconstituted State Committees, which will be the main source of advice to the Advisory Council. The State Committees will provide grass roots contact with industry, centres of education, and the community generally. Each of them will maintain close contacts with CSIRO Divisions in its own State. The Chairmen of the State Committees will be members of the Advisory Council. The Government will also be looking to CSIRO to encourage its scientists to take initiatives in broadening their own contacts both within and outside CSIRO, so that their contribution in the formulation of policies at the Institute level can be strengthened.

I now turn to the research activities of CSIRO and its future role. The Government agrees with the Inquiry that the main role of CSIRO should be defined more clearly in CSIRO's constituting legislation, the Science and Industry Research Act 1949. Amending legislation which will be introduced in the Budget sittings will make it clear that the main role for CSIRO will be scientific and technological research in support of Australian industry, community interests, and other perceived national objectives and obligations.

CSIRO research for Australian industry will continue to include work in support of the rural and mining sectors, the manufacturing sector, the construction sector and the services sector, such as transport. CSIRO research will support such community interests as the better protection of our environment, flora and fauna, and consumer interests.

The Report of the Inquiry made a number of other recommendations on the scope and emphasis of CSIRO's research effort which the Government has accepted. The main concern of CSIRO research will continue to be the physical and biological sciences. The types of research to be undertaken will be longer term research for the community's benefit which industry and other research organisations are unable to carry out, and fundamental and short-term problem oriented research if it is related to the role of the Organization.

Research into economics and the other social sciences will not be undertaken, but steps are to be taken to utilise the requisite expertise from these fields in program conduct, evaluation and planning. Research in human medicine will not be a direct objective of CSIRO but research results in biological and physical sciences will be assessed for their possible significance and application in human medicine.

Individual scientists will be encouraged to follow up their research as far as practical into the development stage.

CSIRO will have a major role in helping Australia meet its international obligations. For example, CSIRO will continue to undertake basic research, such as in astronomy, atmospheric physics and oceanography, to increase man's knowledge of the region in which we live.

CSIRO will also assist the Government in meeting Australia's international obligations to developing countries. The Government is most conscious of the vital role that developing countries will increasingly play in world affairs and of our need constantly to review government policies to take this factor fully into account. To this end, the Government recently established a Committee to review Australia's relations with the Third World. Consistent with this policy approach, CSIRO will contribute to the scientific and technical needs of these countries as part of Australia's foreign aid program through work carried out both in Australia and abroad. CSIRO will also have the opportunity to contribute through other arrangements such as the Consultative Group on Energy established at the recent Commonwealth Heads of Government Regional Meeting in Sydney.

In all its areas of research, CSIRO will have to ensure that it does not duplicate the research activities of other research institutions, undertaken or otherwise supported by the Commonwealth or State Governments.

CSIRO's autonomy in the setting of research project objectives will be maintained. Recognising that CSIRO's activities must accord with the policies of the Government, the Birch Report has recommended ministerial discretion should also be maintained to be used as a last resort. The Government has accepted this recommendation and should ministerial discretion be employed it will be reported in CSIRO's Annual Report.

The Government has accepted the Inquiry's recommendation that, through the application of the revised advisory and consultative machinery, current programs should be terminated where they are judged to be inappropriate. It has also been agreed that CSIRO should present, at appropriate intervals, the main thrusts of its broad policies and more detailed objectives for Government, Parliamentary and community scrutiny.

The Inquiry recommended that specific approval of the Minister should not be required for CSIRO to enter into arrangements for the implementation of research results. The Government has decided that the implementation of research results should continue to be a function of CSIRO subject to a general power of the Minister to provide the Executive with guidelines.

There are numerous further matters dealt with in the Report of the Committee of Inquiry. On many of these, the Government has reached a decision. On others, further examination is required and is currently being undertaken expeditiously. The Minister representing the Minister for Science will outline these matters in a separate statement shortly.

It is the Government's intention to implement as soon as possible the new organisation and Executive structure of CSIRO to facilitate the detailed implementation of the Government's decisions on the Inquiry's Report.

I conclude by placing on record the Government's appreciation of the work done by the Members of the Inquiry, Professor Birch, Sir Cecil Looker and Mr Russell Madigan. Their contribution to the development of Australian science and technology policy in this Inquiry has been an outstanding one, made possible by their wide experience, foresight and judgement.

The Committee of Inquiry could not of course have carried out its work without advice from Commonwealth and State Government Departments, the many private companies and individuals who made submissions to the Inquiry, and of course members of CSIRO at all levels, who, the Committee noted in its Report, assisted the Inquiry with 'courtesy, patience and frankness'.

# Independent Inquiry into CSIRO

*Statement to the Senate by the Minister for Science, Senator the Hon. J. J. Webster, 11 May 1978.*

Mr President,

As the Prime Minister has announced in another place the Government has considered the recommendations of the Independent Inquiry into CSIRO whose report was tabled in Parliament in the latter half of last year. It is to the credit of CSIRO's scientists as well as to its administrators that the CSIRO of today has, under this very critical scrutiny, been found to be equal to the high expectations its founders and subsequent supporters placed in it.

It is clear, Mr President, that CSIRO is a highly mobile scientific task force which gears itself to Australia's day-to-day needs as well as to longer range national aspirations and responsibilities. I am, as Minister responsible for CSIRO, glad to be able to add my thanks to the members of the Inquiry—Professor Arthur Birch, who is Professor of Organic Chemistry at the Australian National University; Sir Cecil Looker, a former president of the Australian Associated Stock Exchanges; and to the Chairman of Hamersley Holdings, Mr Russell Madigan—for the very expert way in which they undertook their investigations.

Because the Prime Minister has announced, in broad terms, the new framework within which CSIRO will go forward into the years ahead as the nation's biggest public-funded scientific and industrial research organisation, I do not intend to go over the same ground again.

However, to put my remarks into context I should like to make just one or two points:

The first is that I believe that the findings of the Independent Inquiry into CSIRO have vindicated this Government's practice of minimising bureaucratic influence on scientific research and providing the proper environment for innovation. The Inquiry recommended and the Government agrees that CSIRO is to continue to operate as a single statutory authority, funded in the main by a specific Government vote and its staff be employed under the Science and Industry Research Act rather than the Public Service Act.

The second point is that industry and community as well as Government interests are to be given more clearly defined ways of advising the CSIRO Executive on the research directions of the Organization. This will be achieved through the revitalised advisory mechanisms to which the Prime Minister has already referred. But at the same time the Government has reaffirmed that it is CSIRO itself which shall determine its research program objectives. It should, however, take note of criteria suggested by the Inquiry.

Mr President, the Inquiry's report conveyed 122 recommendations to the Government for consideration. Many of these are reaffirmations of existing practices and serve, I believe, to strengthen the sense of purpose Australia as a nation derives from the wonderful work CSIRO and its predecessor CSIR have done for the past fifty years.

### Relations with Government/industry

There are however some changes in emphasis, particularly in the reorganisation of the policy formulation mechanisms of CSIRO and to the Organization's relationships with Government instrumentalities and industry and community interest groups as well as universities and colleges of advanced education. These changes will require further investigation before they are implemented.

However, Mr President, I want to reinforce the point that no changes to existing practices, particularly where they are relevant to the wide range of industries, both primary and secondary, that CSIRO serves, will be undertaken without sensitive and full consultation with those concerned.

For instance, the Government has agreed that one role of CSIRO should be continued involvement in the affairs of industrial research associations. However, the question of whether CSIRO should be directly concerned with funding existing research associations other than through contracts is a broader issue and one which I shall explore with my Ministerial colleagues responsible for Productivity, Primary Industry, and Industry and Commerce. On the other hand, the Government believes CSIRO should closely consider how much more of its own engineering and related requirements can be contracted to industry, and I shall be seeking the views of the Executive of CSIRO on this matter.

### Information transfer

As well, CSIRO will be exploring the wider role the Government envisages for it in expanding its activities in interpreting and disseminating information from world science and technology for the benefit of technological innovation in Australia—and for Australian industry to make increased use of this information.

Part of this involves the further consideration of integrating and rationalising CSIRO's own library and information services in relation to a national network. CSIRO will continue to publish journals concerned with original science and dealing with information related to scientific and technical matters, and as well it will continue to contribute to international scientific collaboration, but as at present it will not be the sole agent for Australia for this collaboration. CSIRO will not be obliged to provide policy advice to Government on broad scientific and technological matters but it will provide, as required, factual information to the Government and its science and technology advisory bodies.

### Monitoring of industrial trends

The Government concurs with the Inquiry's recommendation that mechanisms be established in CSIRO to ensure that specialist advice and assistance in monitoring industrial trends and developments are available to research staff and at the same time that industry should have access to CSIRO staff and information services in consulting capacities.

As part of the improved service to industry, Mr President, the Government has directed that CSIRO compile an up-to-date directory of current programs in CSIRO and the people associated with them. This directory is to be presented in terms which are informative to those particularly interested but who may not be technical experts in a particular area. The new Institutes to be formed in CSIRO shortly—and these will be groupings of Divisions with a commonality of research endeavour—will be required, as will the Divisions themselves, to publish regular reports on their activities. And to further improve the communication between CSIRO and industry and the community at large, the Annual Reports of CSIRO as a corporate body will in future outline general policies as well as the practical information they traditionally contain.

Part of the information collection and dissemination process involves ready access to overseas research, and the Government agrees with the Inquiry's report that CSIRO should not be inhibited from establishing overseas posts. Honourable Senators would be aware that at present CSIRO provides the staff for Australia's permanent scientific representation in Washington, London, Tokyo and Moscow.

### Rationalisation of research effort

The Independent Inquiry recommended and the Government concurred that CSIRO should continue to cooperate with other research institutions with a view to ensuring that it does not unnecessarily duplicate their research activities, particularly those undertaken or otherwise supported by the Commonwealth or State Governments. I am confident that this task will be considerably facilitated by the strengthened consultative and planning processes the Prime Minister has already announced.

Some areas where further study needs to be undertaken in relation to rationalising functions have been identified by the Inquiry and the Government has directed, for instance, that CSIRO's work on atmospheric research should be further rationalised with research programs of the Bureau of Meteorology, and as well, that the role of the Australian Numerical Meteorology Research Centre (ANMRC), which currently provides a link between CSIRO and the Bureau of Meteorology should be re-examined next year. Another area the Government agrees requires further examination is the role of CSIRO relative to the Australian National Parks and Wildlife Service, the State Museums, and the Australian Biological Resources Study.

The matter of marine science in Australia is being investigated by the Australian Science and Technology Council and the Government has decided that the results of this Inquiry should be available before the extent of CSIRO's involvement in this very important area of scientific research is finalised.

The question of the proportion of research effort CSIRO expends on the primary and rural sectors of industry compared with the mining and manufacturing sectors was thoroughly explored by the Inquiry. As a result the Government has directed CSIRO to examine the relevance to its role as a national organisation of the composition of its present rural research effort, particularly in relation to the capabilities of other organisations such as State Departments of Agriculture.

Let me assure Honourable Senators this does not mean the rural industries will be neglected in CSIRO's future research programs. CSIRO will continue to compete for Rural Industry Research Funds but in the light of the Inquiry's findings funding from such sources will not be the major component of any broad area research program.

### Liaison with industry and Government

So far as the relevance of CSIRO's work to the nation's manufacturing industry is concerned I shall be consulting with the Ministers for National Development, Industry and Commerce, Finance, and Productivity, on developing methods of undertaking tactical problem-oriented work for this very important sector which employs nearly 20% (19.82% at December 1977—Australian Bureau of Statistics), of Australia's work force.

The Government has directed that consideration be given to extending levies similar to those used to finance the Rural Industry Research Funds to other appropriate industries. This money would be used to support additional research required in those industries.

Another step forward is that the Government has asked CSIRO to consider establishing special liaison mechanisms with industry to promote the implementation of research results. This applies particularly to the manufacturing industries.

In consultation with the relevant Ministers I shall be developing proposals for the implementation of the Government decision to establish more clearly defined high level liaison mechanisms between CSIRO and Commonwealth Government Departments and with industry. This move is to ensure that CSIRO research programs and capabilities are widely comprehended and at the same time are in harmony with Government policies and priorities.

I shall also be following up with my Ministerial colleagues ways of rationalising with the Bureau of Mineral Resources, Geology and Geophysics the strategic mission-oriented work CSIRO does in the mining area which is of immense importance to the national economy. The Government has decided that CSIRO should be encouraged to contract out appropriate work to organisations such as the Australian Mineral Development Laboratories and the Australian Coal Industry Research Laboratories as part of this new impetus to bring CSIRO and industrial implementation expertise closer together.

**Higher education links**

Turning to higher education and research, the Government has agreed that a joint committee of CSIRO and the Australian Vice-Chancellor's Committee will be established to investigate means of collaboration, and I shall be having talks with the Minister for Education on the implementation of this decision. I shall be asking CSIRO itself to report to me on ways of encouraging the development of what are called 'centres of excellence'. These discussions will include the Australian Science and Technology Council and the Tertiary Education Commission.

The Government agrees that CSIRO should in future confine its funding to tertiary institutions to work undertaken in relation to its own research requirements. However, it believes CSIRO should continue to be able to award postdoctoral fellowships and research studentships in universities—if they agree—if the work proposed is for CSIRO's benefit.

As well, the Government has directed CSIRO to give close consideration to siting any new laboratories adjacent to tertiary institutions and it agrees with the Inquiry that secondment of staff between CSIRO and universities should be more actively promoted. The Government believes CSIRO should consider contracting universities and colleges of advanced education to carry out work related to its research programs when these institutions are clearly better constituted for the work involved.

The new Institutes to be formed in CSIRO provide, the Government feels, an opportunity for initiatives to be taken aimed at forging closer links between

CSIRO and tertiary institutions, especially in research, but also in teaching. I shall be actively pursuing this matter.

As well, the Government concurs with the Inquiry recommendation that regional or national centres involving equipment ultimately financed by the Commonwealth Government should be organised for joint use by bodies such as CSIRO, universities and colleges of advanced education, with the possibility of joint financing being closely examined.

There are several more aspects of the Inquiry Report on which I should like briefly to touch. They involve planning, costing, patents, computing services, the National Measurement Laboratory and equally as important, matters affecting the staff of CSIRO itself.

**Planning and Evaluation Advisory Unit**

The Government concurs with the Inquiry's recommendation that a Planning and Evaluation Advisory Unit should be established. This unit will provide advice and assessment related to economic, industrial and social factors, to assist the Executive of CSIRO in its development of strategies and in determining the various priorities when it comes to the allocation of resources.

**Charging for services**

Turning to costing, in future CSIRO will charge on a commercial basis for consulting research services, with the proviso that it can lower these charges to the extent that the work contributes to broader research programs of general benefit. As well, CSIRO's existing program budgeting system is to be further developed, and I shall be conferring with my Ministerial colleagues on the Inquiry's recommendation that CSIRO receive funds direct through the Budget for its building program.

However, lest this be taken to mean that CSIRO is to become primarily a money-making concern, the Government has reaffirmed that CSIRO does not have as a principal aim the generation of revenue, either to support ongoing research or as a direct return for results achieved in research. To do otherwise would defeat the purposes of having a broadly based public-funded national research organisation.

As a general rule, the Government's attitude is that when CSIRO is demonstrably the only body in Australia that can undertake a particular industrial research program, it should sympathetically consider doing it—even if it is not related to its general programs. However, if CSIRO does take on the job it should charge the client full commercial costs, unless some of these can be offset by clear benefits to others in the community.

**Patents and licences**

The patenting of CSIRO inventions and discoveries should, the Government believes, be carried out when possible, not only to ensure a proper level of return to CSIRO, but also to confer proper control of exploitation. As a principle, CSIRO, in granting licences will make some favourable distinction to companies operating and producing in Australia—the overriding consideration being the long-term benefit to the Australian community. Equally, the Government recognises that CSIRO should have the power to select for the development of an invention the partner which will, in its judgement, clearly and justifiably confer the greatest benefit on Australia, even if this appears to confer a particular benefit on that partner.

This same discretionary power of CSIRO to offer preferential treatment to firms should, the Government believes, extend particularly to firms willing to undertake initial development of CSIRO work. The Government is also of the opinion that CSIRO should maximise revenue from the exploitation of its research results outside Australia, consistent with securing the most favourable position for enterprises operating in Australia.

**Computing services**

Turning, Mr President, to CSIRO's computing services, this area was studied by the Inquiry, and in broad terms the Government has decided that these services should be operated on the basis of recouping all costs. CSIRO's computing service network (CSIRONET), will continue to be available to Government Departments and instrumentalities, universities and other approved users, and CSIRONET research efforts should be directly related to user needs, including those of CSIRO.

The Government agrees with the Inquiry recommendation that the provision of individual computers in CSIRO Divisions should be rationalised closely and should not duplicate any service provided by CSIRONET.

At the appropriate time, consideration will also be given to rationalising scientific computing in relation to all Commonwealth Government supported activities including universities and colleges of advanced education, an Inquiry recommendation the Government particularly recommends.

**National standards**

The Government sees an expanded role for CSIRO's National Measurement Laboratory. For instance, branch offices to provide advice and to act as a centre point for despatching equipment to the Laboratory for calibration are to be set up as soon as possible. While the Laboratory should continue to be the custodian of the national standards of measurement, the Government sees real merit in the suggestion that it should extend its standards work to other areas such as safety, pollution and performance standards. In this connection, I should say that while CSIRO will continue its close involvement with the National Association of Testing Authorities (NATA) and the Standards Association of Australia (SAA), those organisations will continue to be financially supported by the Government, but not through CSIRO.

The Government feels consideration should be given to using the new buildings and equipment (at Bradfield Park in Sydney) as a national facility for engineering research. This is yet another matter which I shall be actively exploring with the Executive of CSIRO.

**Staff development**

As the Prime Minister has said, there are some 7000 people employed in CSIRO, and the truism that 'it is people who matter' is never more valid than when innovative scientific and technological research is the goal. The Inquiry identified a number of areas where changes should be implemented. It looked at the promotional criteria adopted in CSIRO and reaffirmed the validity of the personal classification system at present in use. The Government agreed with the Committee of Inquiry that the criteria for assessment of staff so far as promotion is concerned should be clearly defined and made available to staff in printed form. I shall be looking at the question of voluntary retirement of research staff at age 55 in the context of the Government's consideration of redeployment and retirement policies.

The Government has decided that a joint committee of CSIRO and staff associations should be established. This matter is well under way. I am confident Honourable Senators will see merit in the decision that the Executive of CSIRO as part of its human resources development program, is to expand management development and training opportunities for staff and develop uniform staff counselling procedures throughout the Organization.

Finally, Mr President, I should say there are obviously some matters arising from the Independent Inquiry into CSIRO which will require further careful consideration to bring about their implementation and I shall be actively pursuing these.

**Amendments to Act**

There will be amendments to the Science and Industry Research Act under which CSIRO operates and when these are introduced to the Parliament I am sure Honourable Senators will take the opportunity to raise matters of particular interest to them. However, the statement by the Prime Minister in another place and mine here today covers all the decisions of significance made by the Government in relation to the recommendations of the Inquiry.

In conclusion Mr President, let me say that the Inquiry into CSIRO is as thorough and penetrating as any I have encountered. It reflected well on CSIRO's past performances and I believe CSIRO can now get on with the job, confident that its up-dated structure will strengthen its relevance to the nation's needs in the years ahead.

# General

### New Chairman

Dr J. Paul Wild, C.B.E., M.A., Sc.D., F.T.S., F.A.A., F.R.S., has been appointed as the new Chairman of the Executive of CSIRO. The announcement was made by the Minister for Science, Senator J. J. Webster, on 30 June 1978. Dr Wild's seven-year term of office will take effect on 25 September 1978, upon the retirement of the current Chairman, Mr Victor D. Burgmann. Dr Wild, an Associate Member of the Executive since March 1977, is serving as a full-time Member during the period that he is Chairman-designate.

Dr Wild graduated B.A. from the University of Cambridge in 1943, M.A. in 1950 and Sc.D. in 1962 from the same university.

After serving as a Radar Officer with the Royal Navy during the war, Dr Wild joined CSIRO's DIVISION OF RADIOPHYSICS in 1947. With a particular interest in solar radioastronomy, he invented the dynamic radio spectrograph, an instrument for studying disturbances at radio wavelengths in the solar corona, and the radioheliograph, a unique invention for mapping radio emissions over the surface of the Sun. Later, he developed the concept of a microwave landing system for aircraft and led the CSIRO Interscan landing guidance system research team to success, in collaboration with the Department of Transport.

In 1966, Dr Wild was appointed Director of the Division's Solar Radio Observatory at Culgoora, N.S.W., and in 1971 he became Chief of the DIVISION OF RADIOPHYSICS. From 1967 to 1970 he served as President of the Radio Astronomy Commission of the International Astronomical Union. He has served on the Board of the Anglo-Australian Telescope since 1973 and has been its Chairman since 1975. Also in 1973, he became Foreign Secretary of the Australian Academy of Science.

Dr Wild has won a number of awards for scientific achievement. He was awarded the Edgeworth David Medal of the Royal Society of New South Wales in 1958, the Hendryk Arctowski Gold Medal of the National Academy of Science of the United States, and the Balthasar van der Pol Gold Medal of the International Union of Radio Science, both in 1969, the first Herschel Medal of the Royal Astronomical Society in 1974 and the Thomas Ranken Lyle Medal of the Australian Academy of Science in 1975.

In 1961, Dr Wild was elected Honorary Foreign Member of the American Academy of Arts and Sciences, and Foreign Member of the American Philosophical Society the following year. He was elected a Fellow of the Australian Academy of Science in 1962 and Corresponding Member of the Royal Society of Liège in 1969. Dr Wild was elected a Fellow of the Royal Society in

Dr J. P. Wild *Photograph: John Masterson*

1970 and in 1978 was created Commander of the Order of the British Empire. The same year, he was elected a Fellow of the Australian Academy of Technological Sciences.

### Executive changes

In February 1978, Mr V. D. Burgmann and Dr N. K. Boardman agreed to their terms of appointment to the Executive being extended to 24 September 1978.

In November 1977, Dr K. A. Ferguson was reappointed as an Associate Member of the Executive for a further year.

In November 1977 Dr R. J. Millington completed his term of office as an Associate Member of the Executive and resumed the position of Chief of the Division of Land Use Research.

Sir William Vines resigned his position as a part-time Member of the Executive in May 1978. Sir William, who is Chairman of Dalgety Australia Ltd and a Director of Conzinc Riotinto of Australia Ltd, has served as a part-time Member for five years and as a member of the Advisory Council since 1970.

### Senior appointments and retirements

In February 1978, Dr C. H. B. Priestley retired as Chairman of the Environmental Physics Research Laboratories.

In August 1977, Mr D. J. Rochford was appointed Chief of the Division of Fisheries and Oceanography for a period of three years following the retirement of Dr K. Radway-Allen.

In January 1978, Dr W. J. Peacock was appointed Chief of the Division of Plant Industry for a period of six years, following the completion of Dr L. T. Evans' term as Chief.

Dr C. M. Gerrard was appointed Acting Chief of the Division of Applied Geomechanics in October 1977, following the retirement of Mr G. D. Aitchison.

Dr A. L. G. Rees, C.B.E., F.A.A., retired as Chief of the Division of Chemical Physics in May 1978. Dr A. M. Mathieson has been appointed Acting Chief pending the appointment of a new Chief. Drs C. K. Coogan and J. B. Willis have been appointed Assistant Chiefs of the Division for this period.

Following the retirement of Dr R. W. R. Muncey as Chief of the Division of Building Research in May 1978, Dr F. A. Blakey has been appointed Acting Chief.

In February 1978, Dr D. J. Gauntlett was appointed Officer-in-Charge of the Australian Numerical Meteorology Research Centre for a period of seven years following the retirement of Mr R. H. Clarke.

In February 1978, Dr R. H. Wharton was appointed Officer-in-Charge of the Centre for Animal Research and Development, Bogor, Indonesia for a period of three years, following the completion of Mr A. F. Gurnett-Smith's term as Officer-in-Charge.

Dr G. W. Grigg was appointed Officer-in-Charge of the Molecular and Cellular Biology Unit in April 1978. He had been Acting Officer-in-Charge since November 1975 and prior to that was Assistant Chief of the then Division of Animal Genetics.

### Change of name for two Divisions

In February 1978, the DIVISION OF TRIBOPHYSICS was renamed the DIVISION OF MATERIALS SCIENCE. The new name reflects the more broadly-based research program that has been developed by the Division in recent years in order to place greater emphasis on industry-oriented work.

In the same month, the DIVISION OF CHEMICAL ENGINEERING was renamed the DIVISION OF MINERAL ENGINEERING to indicate that the Division's research is directed towards assisting the Australian mineral industry.

### Adelaide laboratory

In September 1977 the South Australian branch of the Materials Research Laboratories of the Department of

Defence was transferred to CSIRO. The new laboratory, which is located at Woodville North, Adelaide, subsequently became the Production Technology Laboratory of the DIVISION OF MATERIALS SCIENCE (formerly the DIVISION OF TRIBOPHYSICS) and Dr C. M. Perrott was appointed Officer-in-Charge. The Laboratory undertakes research on production engineering, including metal cutting, anti-wear and anti-abrasion materials, casting and forging.

At the same time, the NATIONAL MEASUREMENT LABORATORY established a branch in the new Adelaide laboratory with Mr D. Jolly as Officer-in-Charge. The branch provides calibration and standards facilities for South Australian industry.

### Fuel Geoscience Unit

In September 1977, the Executive established the FUEL GEOSCIENCE UNIT as an independent unit within the MINERALS RESEARCH LABORATORIES to undertake research aimed at:

- improving laboratory techniques used in the search for new petroleum and natural gas resources
- assessing the characteristics of Australian coals – particularly in relation to their extraction and use
- assisting in the development of new and improved technologies of fossil fuel utilisation, especially the conversion of coal to oil and other liquid products.

The Unit comprises about 40 scientists and support staff drawn from the DIVISION OF MINERALOGY and located at North Ryde, Sydney, and at the Baas Becking Geobiological Laboratory, Canberra. Dr G. H. Taylor, formerly Assistant Chief at the Division of Mineralogy, has been appointed Officer-in-Charge of the Unit. The DIVISION OF MINERALOGY continues to have a laboratory at North Ryde, staffed by about 30 people and led by Dr R. A. Binns.

### Centre for International Research Cooperation

Towards the end of 1977, the Executive decided to establish a Centre for International Research Cooperation (CIRC) to facilitate the application of the Organization's research and development capabilities to the problems of developing countries.

Mr A. F. Gurnett-Smith, formerly Officer-in-Charge of the ADAB-sponsored Centre for Animal Research and Development in Bogor, Indonesia, has been appointed Officer-in-Charge of CIRC. One of the first priorities of CIRC will be to establish adequate liaison between CSIRO and various national and international bodies concerned with providing assistance to developing countries.

### New Beef Cattle Research Laboratory for Rockhampton

At Rockhampton, Queensland, the DIVISION OF ANIMAL PRODUCTION is studying the breeding of beef cattle better adapted to the tropics and sub-tropics of Australia. The research aims to assess the characters which are important in adaptation (heat tolerance and resistance to disease, ticks, and internal parasites), those factors important to productivity (such as fertility, survival, growth rate, and carcase quality), and to show how they may be measured objectively and used by producers in their breeding program.

At present the Division's research is conducted in sub-standard laboratory accommodation in Rockhampton and at the Australian Meat and Livestock Corporation's 3600 hectare National Cattle Breeding Station, 'Belmont', some 32 km north of the city.

On 2 November 1977, CSIRO gained Parliamentary approval to proceed with the construction of a new Beef Cattle Research Laboratory on a 32 hectare site some 5 km north of Rockhampton, subject to the government making funds available. The Laboratory, expected to be operational by 1981, will replace facilities in Rockhampton which are dispersed, inadequate and difficult to operate with safety.

The estimated cost of the proposed work when referred to the Parliamentary Public Works Committee was $5.44 million at June 1977 prices.

The new Laboratory will allow an intensification of the existing genetics research program of the DIVISION OF ANIMAL PRODUCTION. It will also provide accommodation for officers of the DIVISIONS OF ANIMAL HEALTH, ENTOMOLOGY, COMPUTING RESEARCH, and TROPICAL CROPS AND PASTURES.

### Subject and Divisional reviews

Regular reviews of research programs are conducted at Executive level. These include subject reviews which are concerned with a subject area or discipline as a whole and which frequently span research activities in a number of different Divisions; and Divisional reviews which involve an examination of the extent to which the research programs of an individual Division fulfil a particular need.

The following reviews were undertaken during 1977/78:

*Subject reviews*

The review of the wool industry which was commenced in 1976/77 (see 1976/77 CSIRO Annual Report) has been completed, and steps are now being taken to implement the Review Committee's findings where applicable to CSIRO research programs.

The Energy Review has also been completed and is discussed further under the title 'Energy Review Committee and Energy Priorities Committee'.

A review of recombinant DNA research was initiated during 1977/78. The Review Committee includes two external members, namely Professor A. J. Pittard, University of Melbourne and Dr J. M. Adams, Walter and Eliza Hall Institute.

*Divisional reviews*

During 1977/78, the Executive conducted reviews of the DIVISIONS OF TEXTILE PHYSICS, WILDLIFE RESEARCH, CHEMICAL PHYSICS and PROTEIN CHEMISTRY. In addition to members of the Executive, the Review Committee for the DIVISION OF CHEMICAL PHYSICS included Professor D. P. Craig, Research School of Chemistry, Australian National University, and Dr L. W. Davies, AWA (Aust.) Ltd. The external members of the Committee reviewing the DIVISION OF PROTEIN CHEMISTRY were Dr F. J. Fenner, Centre for Resource and Environmental Studies, Australian National University; Dr S. F. Cox, I.C.I.A.N.Z.; and Professor D. S. Lowther, Monash Univeristy.

### Energy Review Committee and Energy Priorities Committee

The Energy Review Committee established in 1976/77 (see 1976/77 CSIRO Annual Report) has reported its findings to the Executive.

Under its terms of reference, the Committee was asked to identify the problems facing Australia in the energy field both in the immediate and longer terms. Subsequent to a detailed examination of the energy scene, the Committee identified a large number of research areas where increased effort or new initiative would be justified; these were sub-divided into areas of high, medium and low priority.

However, this extensive ordering of research activities required further refinement before it could be integrated with the Organization's research planning process. Accordingly, the Executive established an Energy Priorities Committee comprising three Chiefs, Dr. A. L. G. Rees *(Chairman)* DIVISION OF CHEMICAL PHYSICS, Dr L. T. Evans DIVISION OF PLANT INDUSTRY and Mr M. V. Tracey

DIVISION OF FOOD RESEARCH. The report of the Energy Priorities Committee is currently under consideration by the Executive.

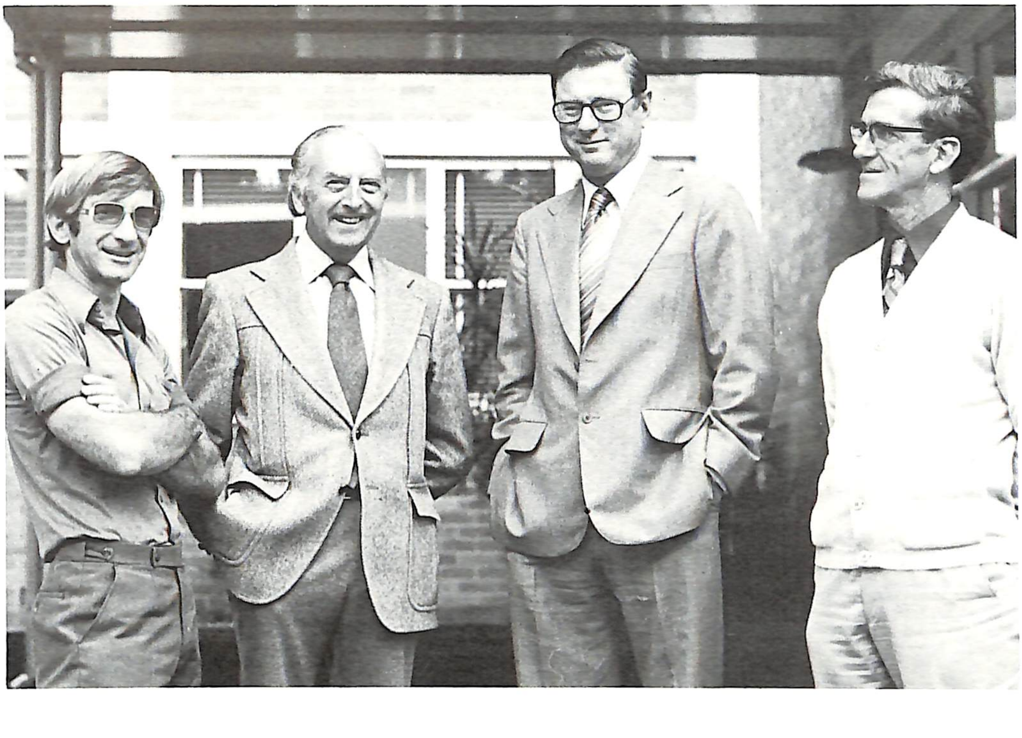
### TRSB/Interscan aircraft landing system

On 19 April 1978, at a meeting of the International Civil Aviation Organization (ICAO) All Weather Operations Division in Montreal, 71 nations voted to choose the aircraft landing system of the future for international standardisation. The ICAO Division chose, by 39 votes to 24 (eight abstentions), the time reference scanning beam (TRSB) system which Australia alone had proposed, under the name of Interscan, at the start of the international contest in 1972. The system was conceived by the CSIRO DIVISION OF RADIOPHYSICS, where it was developed in collaboration with the Department of Transport and Amalgamated Wireless (Australasia) Ltd. The same system was adopted by the United States for its proposal to the ICAO at the end of 1974. The TRSB system has also had the committed support of the USSR since 1976. At the Montreal meeting in 1978, the Federal Republic of Germany abandoned its proposed system in favour of the TRSB system, leaving Britain's Doppler system as the only other contestant in the final ballot.

The new landing system has a much greater capability than the instrument landing system (ILS) in use today. The latter gives accurate guidance only along a single straight glide path, whilst the new system gives accurate guidance throughout an extensive three-dimensional coverage zone within which aircraft, during the last 30 nautical miles of their approach, can make curved approaches at any reasonable descent angle, and enjoy the same operational flexibility in zero visibility conditions as

The principal members of the DIVISION OF RADIOPHYSICS' Interscan team. From left: Dr Dennis Cooper, Mr Harry Minnett, Dr Paul Wild (leader of team) and Mr Brian Cooper.

*Photograph: Henry Armstrong*

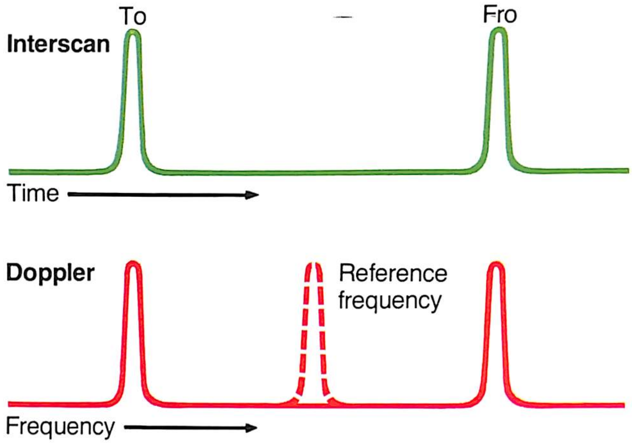


in fine weather. Angle guidance in azimuth and elevation is provided by scanning a beam to and fro (left/right and up/down) respectively across the coverage zone; for either measurement the aircraft thus receives two pulses, one during the 'to' scan and one during the 'fro'. The azimuth or elevation angle is measured simply by the time interval between the two—it is an 'inter-scan' measurement. Thirteen azimuth and 40 elevation to/fro scans are made per second. The two angle measurements combined with conventional distance measuring equipment (DME) in the aircraft permit its position to be accurately located anywhere within the coverage zone.

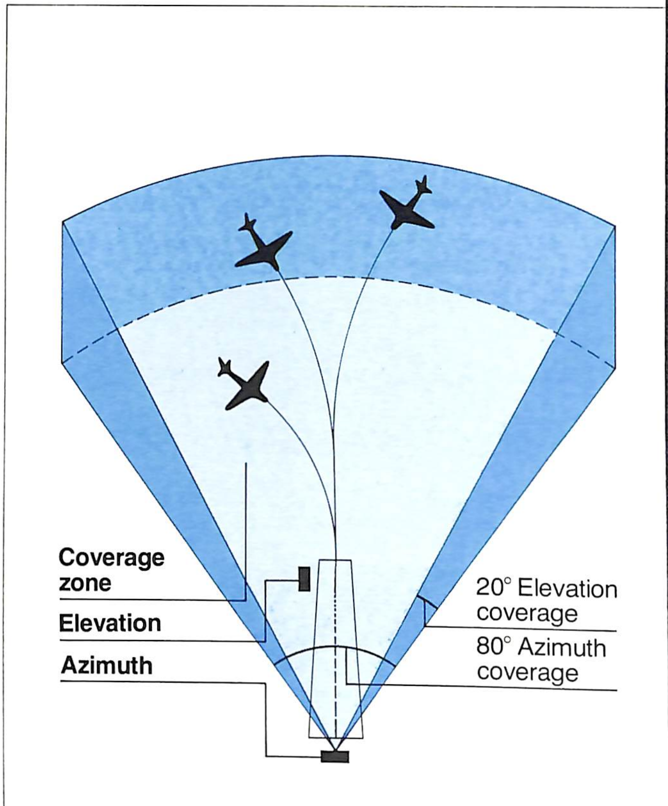
Other sub-systems (not shown in the accompanying figures) are available to provide guidance for aircraft wishing to abort their landings and 'go round again', and to provide a very accurate height measurement during the last 45 metres of descent for blind landings. The system operates in the microwave spectrum at a wavelength of six centimetres in contrast to ILS which operates at wavelengths of one to three metres. The shorter wavelength makes for smaller, more easily installed antennas and minimum site preparation.

The selection of a new landing guidance aid by the ICAO developed into a duel, sometimes fierce, between the rival time reference scanning beam and Doppler systems. From a scientific point of view, this was mitigated by an elegant and fascinating mathematical correspondence between the two systems. Whereas with the Interscan system, the airborne receiver senses two pulses of the same frequency at different times (see upper trace of figure), with an ideal Doppler system the airborne receiver senses two pulses of different frequency at the same time (lower trace). The angle measurement is made by a time difference in the first case and a frequency difference in the second. If antennas of the same size are used, the shapes of the two

1. Comparison of the basic information received in the airborne receiver of a time reference (Interscan) and a Doppler receiver.



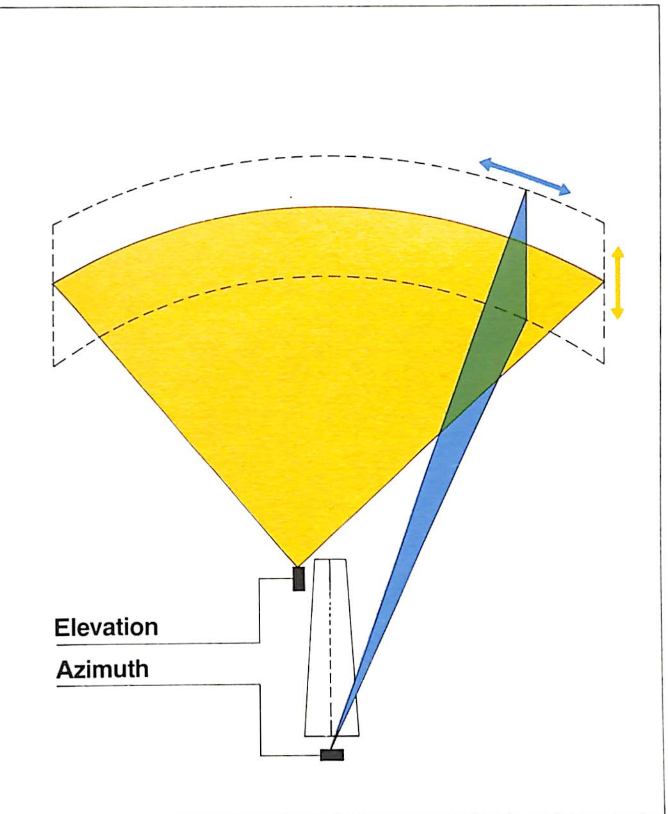

2. Planes are given accurate guidance during the last 30 nautical miles of their approach to the runway within a broad coverage zone inside which a completely flexible range of glide paths can be selected.



traces are exactly comparable and the two systems have identical precision and sensitivity. In practice, however, the designers of the Doppler system found it impracticable to generate the two frequency pulses at the same time and were forced to generate them one after the other so that a simultaneous frequency comparison was not possible. To overcome this problem, they radiate from the ground a second, constant 'reference' signal (broken line in figure) which then allows an accurate frequency comparison to be made.

Thus, the two most basic reasons why the TRSB/Interscan system was adopted in Montreal in 1978 were:

3. Azimuth and elevation guidance angles are conveyed to the aircraft by means of two fan-shaped beams that sweep to and fro. The aircraft determines its position by measuring the time interval between the 'to' and 'fro' transits of each beam.




- on the ground, the Doppler system needs, for each angle measurement, two transmitters (for Doppler and reference signals), resulting in extra cost, lower reliability, and additional errors.

- in the air, the process of measuring an accurate time interval is considerably simpler and cheaper than measuring an accurate frequency difference.

These relative merits had been recognised in Australia from the outset of the program in 1971 and formed the basis of Australia's conviction that an Interscan-type system was superior to the Doppler system.

The Interscan collaborative program of the DIVISION OF RADIOPHYSICS and the Department of Transport leading to the development of ground installations and their extensive flight testing at Melbourne (more recently also at Sydney) airport was described in the 1976/77 CSIRO Annual Report. This program is being continued to ensure that the Department's future requirements for the new landing system are adequately met. Mention was also made in the same Annual Report of a second program coordinated by the Department of Productivity and aimed at the production by Australian industry of a commercial version of Interscan. This program is based on new lens-fed antennas developed by the DIVISION OF RADIOPHYSICS which are more compact and economical than the original antennas designed for the flight-test program.

In May 1978, the Australian Government announced that it would join with industry by investing $8 million in the engineering, development and manufacture of a commercially viable product for the export market. A key role will be played by the Australian Industry Development Corporation which has formed a company, Interscan Australia Pty Ltd, as a vehicle for the industrial consortium which will undertake the development plan. Interscan Australia will also negotiate joint venture arrangements with industry in other countries to ensure penetration of overseas markets, particularly in the United States, where the implementation of the new landing guidance systems will occur first. The United States market represents about half the total world market.

### Relations with ASTEC

To help ensure that it receives as much information and comment as possible on those matters of science and technology on which it advises the Government, ASTEC, the Australian Science and Technology Council, has invited CSIRO and a number of Commonwealth Government Departments and other agencies to have representatives attend Council meetings and contribute to the discussion. Dr N. K. Boardman of the Executive has represented CSIRO at these meetings.

The Executive has welcomed the opportunity to put its views to ASTEC. At the same time it has found the information available to it through ASTEC of value in helping determine the Organization's research priorities.

### Oriental fruit fly

In 1975, an insect suspected of being oriental fruit fly was found on Melville Island, off the coast of the Northern Territory near Darwin. Until then Australia was thought to be free from a pest which is regarded as one of the most damaging fruit fly species in the world.

Surveys by State and Territory authorities have since shown that the insect occurs in the northern part of the Northern Territory and in a small area in the north-east of Western Australia. It has not been found in Queensland or the southern States and there has been no significant change in its recorded distribution in the past year.

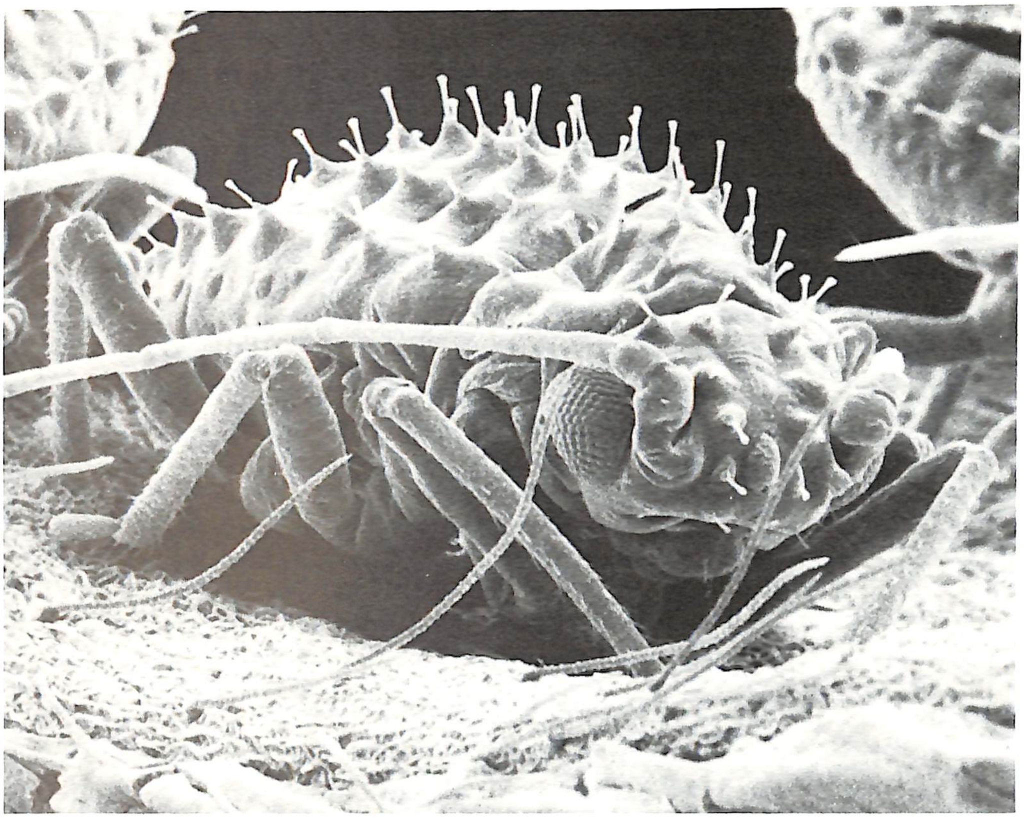
The identity of the insect has been confirmed as a strain of oriental fruit fly. The Queensland Department of Primary Industries is studying whether it is the same as that found overseas in places like Hawaii where it causes serious losses to the fruit-growing industries. Commercial fruit industries in Australia have not been affected; field collections of the fly have been confined to the fruits of two native plants.

In response to the threat posed by the pest, the CSIRO DIVISION OF ENTOMOLOGY established a laboratory in Darwin to study the insect's biology and ecology, a knowledge of which underlies the development of effective control measures. The Department of Health has contributed to the funding. The research has shown that under experimental conditions the fruit fly will attack several cultivated fruits, including papaws, mangoes, bananas, pears and apples, although it is not doing so at present under natural conditions. Other work on the insect's behaviour and life cycle is aimed at ascertaining where the pest might become established permanently in Australia.

### Countering lucerne aphids

During the autumn of 1977 two serious aphid pests of lucerne and other legumes were discovered in Australia: the spotted alfalfa aphid (SAA) and the blue-green aphid (BGA). This discovery was of concern to graziers, farmers and government authorities alike as the potential serious damage to lucerne, annual medics and clovers has long been known. For instance, in the mid-1950s, SAA caused widespread and severe damage to much of the lucerne crop in the United States.

The problem in Australia is accentuated as most of the lucerne crop is based on only one variety, Hunter River, which is very



A scanning electron micrograph of the spotted alfalfa aphid, *Therioaphis trifolii f. maculata*. (Magnification × 76)

*Photograph: Dr Barry Filshie*

susceptible to both aphids. SAA is now present in each of the five mainland States, and BGA is in the five eastern States. Lucerne has been hard hit in many districts in south-eastern Australia; annual medics and sub-clover have also been attacked.

CSIRO and the State Departments of Agriculture responded rapidly to the threat posed by the pests by redeploying staff and facilities to major biological control and legume breeding programs. Close liaison and collaboration between the research groups has been a feature of this work.

The biological control program of the DIVISION OF ENTOMOLOGY comprises three projects: the SAA project, centred in Canberra where introduced parasites are cultured and used in field release trials; research on parasites for control of BGA, at the Division's Sydney laboratory; and work on pathogenic fungi, at the Division's station at Armidale, New South Wales. Field releases of the biological control agents are carried out in collaboration with State agricultural authorities.

Although the introduction of insect parasites of the aphids and the application of a limited insecticidal program, especially on young stands, will be of assistance, the effective re-establishment and future stability of the lucerne industry will depend on the availability of varieties resistant to the two aphid species. The DIVISION OF PLANT INDUSTRY (Canberra) has a major breeding program aimed at providing lucerne varieties resistant to both aphids. These varieties are being developed to replace Hunter River in most of the lucerne growing area of south-eastern Australia. In addition, the DIVISION OF LAND RESOURCES MANAGEMENT (Deniliquin) is selecting for aphid resistance in Falkiner, a new variety for irrigated areas, and the DIVISION OF TROPICAL CROPS AND PASTURES (Brisbane), in collaboration with the Queensland Department of Primary Industry, is working towards a variety suited to the northern extremity of the lucerne-growing area.

# Research

*In a report of this size it is not possible to give a full account of all of CSIRO's current investigations. The items in this section have been chosen, therefore, to show something of the wide range of CSIRO's activities and their relevance to the needs of the Australian community. The items also illustrate that many research programs involve the collaboration of scientists from different disciplines and different Divisions.*

*More comprehensive information on the Organization's current research activities can be obtained from the separate annual reports published by each Division, from a variety of other CSIRO publications listed in 'Serial Publications, Monographs, and Pamphlets Issued by CSIRO', and from 'CSIRO Index' which lists the 200 or so papers produced each month by CSIRO scientists. A brief description of the fields of research engaged in by each Division is given on pages 84–90 of this report.*

## Improving the reproductive efficiency of livestock

*Improvements in the reproductive efficiency of livestock, through improved fertility and increased survival rates of the offspring, offer one of the most direct ways of increasing animal production.*

Reproductive losses in livestock from conception to weaning cause substantial financial losses to Australia's animal industries. In sheep, for instance, the average lambing percentage is about 70 per cent, whereas the genetic potential of the present flocks is 120 per cent. Added to this, some 12 million of the 60 million lambs born annually die at or near birth.

Ways of improving reproductive efficiency are being investigated by the DIVISIONS OF ANIMAL PRODUCTION, ANIMAL HEALTH and PLANT INDUSTRY.

Major losses occur in early pregnancy. In sheep, around one-third of all eggs fertilised are lost in the first three weeks of pregnancy.

The DIVISION OF ANIMAL PRODUCTION, in collaboration with the University of Queensland, has detected the presence of an early pregnancy factor in the blood of sheep and cattle. For this work the rosette inhibition test, which has been used by the University team for studying the presence of this factor in humans and mice, was adapted for sheep and cattle work. Results so far show that the test can detect pregnancy in sheep and cattle on the day after mating and for about the first month of pregnancy. This test is leading to a better understanding of the causes of early embryo mortality.

An important barrier to reproductive efficiency is lack of libido or sex drive of the male. Many strains of ram lack libido at their first mating.

Scientists at the DIVISION OF ANIMAL PRODUCTION have devised a pen test to assess the libido of young rams before they are joined. Field matings have shown that rams which perform well in the pen test sire more lambs than those which perform badly in the pen test, and that rams which have poor libido initially usually continue to be poor performers. Moreover, rams bred from low libido sires generally lack sex drive compared with those bred from rams with high libido.

Research now in progress on the hormonal basis of libido and on methods of modifying the sex drive of rams could lead to the production of high libido rams. This would reduce the cost of sheep breeding and management as fewer sires would be required. Alternatively, if high libido rams could be identified at an early age, a saving could result of several hundred dollars a year for every 1000 ewes joined.

In a combined project, the DIVISIONS OF ANIMAL PRODUCTION and ANIMAL HEALTH are investigating the causes of low fertility in cattle adapted to tropical climates. Assessment of libido in Zebu-crossbred bulls is difficult because they tend to be shy when subjected to the artificial conditions of pen observations as used for testing ram libido. Studies on the male sex hormone, testosterone, are being directed towards developing a hormonal test for detecting bulls of poor performance before they are used for mating.

Anoestrus in cows, particularly following their first calving, is another cause of low fertility, especially in tropical beef breeds. Abnormalities have been observed in the endocrine function in the early stages of the mating period. These, and other physiological observations which have been found to correlate with fertility, may provide more effective methods of selecting animals for a better reproductive performance.

Over a number of years, the DIVISION OF PLANT INDUSTRY has investigated the performance of groups of lactating Aberdeen Angus cows that have run together and shared a common history of management. The results indicated that most of the differences in rates of fertility between the groups were related to liveweight and nutritional status at the time of mating. However, within a group of similar age and history, individual variations in liveweight were not associated with variations in fertility. Thus, improved fertility hinges on improving the liveweight and nutritional status of the group as a whole rather than on supplementing the diet of only the lighter half of the herd.

This conclusion, based on work with cows, does not apply to heifers at their first mating. In Angus/Friesian cross heifers, the probability of conception in the first six weeks of mating is related to liveweight and age. These effects are additive; for example, fertility in 15-month heifers should be satisfactory if the weight is greater than 200 kilograms whereas 12-month heifers would need to weigh at least 240 kilograms to achieve the same rate of conception. These results suggest that it would be more worthwhile to supplement the diets of the younger and lighter heifers in the herd before mating starts if the quantity of feed available will limit the rate of fertility.

Scientists at the Division are now using the results of information gained from this research to develop computer models of beef production systems. With this approach it should be possible to predict more accurately the effects of variable factors such as stocking rates, pasture management, time of calving and supplementation of diet on profitability.

Grazing of pastures containing subterranean clover cultivars of high oestrogenic content is a major cause of infertility in ewes. Although the management practices and agronomic measures now employed have done much to alleviate the problem, about a million ewes still become infertile each year. Half of these losses occur in Western Australia, but parts of New South Wales, South Australia and Victoria are also affected.

The long-term solution probably lies in alternative agronomic practices, especially in substituting non-oestrogenic varieties of clovers. However, this can be both time consuming and costly as a good deal of seed of high oestrogenic varieties will have already accumulated in the soil.

Research by the State Departments of Agriculture and universities as well as by the DIVISION OF ANIMAL PRODUCTION has shown that the oestrogenic substances in the clover have a similar action to the animal's own oestrogenic hormones. However, while the amounts of oestrogens produced by the animals are essential for fertility, the much higher levels produced in clovers impair reproductive function.

The Division is now trying to immunise sheep against 'clover infertility'. Immunisation with plant oestrogens that have been chemically linked to proteins has afforded some protection to ewes by producing antibodies which neutralise much of the effect of the clover without interfering with the animal's own hormones. In the field, protection would need to be maintained over several months each year while the sheep are grazing pastures containing clover. The Division is collaborating with the DIVISION OF APPLIED ORGANIC CHEMISTRY and the Western Australian and South Australian Departments of Agriculture to develop this method for use in the field.

The conversion of plant oestrogens in the animal results in major changes in the biological activity of the hormones. Recognition of these changes is critical in defining the clovers which cause infertility. The DIVISION OF ANIMAL HEALTH is examining the current extent of clover infertility in the sheep industry, and investigating better ways of defining the degree of infertility in flocks under field conditions. The extent of clover-induced problems in cattle has still to be resolved.

Certain diseases also affect the reproductive performance of livestock. The DIVISION OF ANIMAL HEALTH is studying ways of overcoming the effects of two disease organisms, the bacterium *Campylobacter fetus* subsp. *fetus* which causes bovine vibriosis and the protozoan *Tritrichomonas foetus* which produces bovine trichomoniasis. These two venereal diseases cause both infertility and abortion.

Previous research in the Division resulted in the production of vaccines against the two known types of *Campylobacter fetus* subsp. *fetus*. Divisional scientists have now produced a dual vaccine which protects both mature heifers and bulls against infection from either type. Since many herds in Australia are spread over vast areas, vaccination of bulls, which are fewer in number than heifers, offers the most practical way of controlling the disease.

Bovine trichomoniasis is prevalent in beef cattle in the inland of northern Australia. The Division's research is directed towards methods of control for herds where continuous mating is practised and culling of infertile cattle limited. In 1976, the Division began a three-year study to obtain data on the long-term effects of the disease. In this trial, 100 cows are being kept under similar management conditions to those operating in northern Australia. Results from the study should help determine the economic advantages of controlling the disease in the north. Observations so far have shown that infection of the herd has reduced the number of calves born each year by about one-fifth.

Losses of young during the perinatal period—the period around birth—are substantial. For example, about one in five lambs die at or near birth. This 'wastage' is due to a number of causes such as still-births, poor nutrition, predators, desertion, mis-mothering or severe climatic conditions.

In cold and harsh environments such as occur on the tablelands of New South Wales, Victoria and Tasmania, lamb losses due to inclement weather can be particularly high. Consequently, the DIVISION OF ANIMAL PRODUCTION is studying the use of inexpensive shelters for sheep in these areas. Results from experiments with shelters made from plastic mesh were encouraging, but the mesh was expensive and subject to damage.

Later experiments, using hedges of an unpalatable phalaris hybrid grass have shown promise. The system is inexpensive and, as the mature grass is relatively unpalatable to sheep, they are seldom

grazed. Sheep make use of these shelters during adverse weather conditions and during lambing. Flocks which have recently been shorn make particular use of them, resulting in fewer lamb losses from these ewes than from ewes in wool. Results in each of four years indicate that, on average, twice as many lambs survive in the paddocks with the hedges than in paddocks without shelters.

Lamb losses and reduced fertility of ewes as a result of difficult births are of economic importance in Dorset Horns and other meat sheep breeds. In these breeds, more than a third of perinatal deaths have been attributed to lambing difficulties, the occurrence of which is strongly related to the size of the foetus.

Studies by the Division indicate that the incidence of lambing difficulty and hence lamb losses can be considerably reduced by selecting against ewes with small pelvic size.

In southern Australia, a considerable proportion of calves are stillborn, following unassisted deliveries. Since these stillbirths frequently occur at night, the cause of death is generally unknown, but is attributed to oxygen deprivation following prolonged delivery. Current studies at the DIVISION OF ANIMAL HEALTH are directed at discovering the reason for these stillbirths. Results to date indicate that most stillbirths occur when the foetus enters the birth canal rump first. In these cases, deliveries tend to be protracted as the dam becomes exhausted or the foetus becomes impacted. Also, the umbilical cord may rupture before the head is free. Circumstantial evidence suggests that, for reasons that are as yet not fully understood, stillbirths may result from a decreased straining rate of the dam in some normally presented foetuses. In other apparently normal deliveries, death may be due to particularly small foetal membranes which rupture much earlier than usual during labour, reducing the supply of oxygen to the foetus.

The economic success of most sectors of the sheep and cattle industries depends largely on high fertility, with each breeding animal producing one or more offspring each season. In some sections of the sheep industry, particularly in the production of prime lambs, a percentage of twin births is an obvious advantage. In the beef industry, too, a higher return per cow must be achieved to offset the ever-increasing production costs.

The established method of increasing the number of twin births is through selective breeding for high twinning rates. Over the past 20 years, the DIVISION OF ANIMAL PRODUCTION has used selective breeding to build up a flock of high fecundity medium-wool Merino sheep from a small nucleus of highly fecund sheep. The flock, known as 'Booroola'—a medium wool Merino—has a reproduction rate about twice as high as the best commercial Merino flocks. Research is continuing in an attempt to improve fecundity of the flock and to gain an understanding of its reproductive biology.

Booroola rams have been available to the industry for several years now for crossing with local Merino ewes and their impact on the reproductive rate of commercial flocks in Australia and New Zealand is being evaluated. The daughters of these rams have shown an increase in productivity of up to 70 per cent compared with daughters of local sires.

A sheep foetus at 62 days of gestation, representing an early stage in the cycle of life. CSIRO research on reproduction in livestock is aimed at improving reproductive efficiency by overcoming poor fertility in the male or female, and by reducing early losses of the embryo during pregnancy and deaths around the time of birth. *Photograph: Tom Dagg*

In a comparable program, a nucleus of high fertility cattle is now being established.

THE DIVISION OF ANIMAL PRODUCTION is also working on ways of improving control over the fertility and fecundity of sheep and cattle to meet the changing needs of the industry and to provide new management options.

In trials involving small numbers of animals, researchers at the Division have demonstrated that immunising ewes against the hormones androstenedione or oestrone increases their ovulation rate and hence their fertility and fecundity. The potential advantages of the treatment are that the effects can be produced within a few weeks and the procedure can be repeated or not each year, depending on seasonal demands for sheep. Preliminary field tests are now being carried out in Western Australia, in collaboration with the University of Western Australia, and in New South Wales.

Synchronisation of oestrus through the use of prostaglandins—a series of naturally occurring substances—offers another valuable management tool. Use of these compounds for this purpose grew from work in the DIVISION OF ANIMAL PRODUCTION in which it was shown that prostaglandins are normally produced by sheep and cattle in the reproductive cycle and that they play a significant role in controlling the length of the oestrous cycle. If administered to the animal, they can shorten the length of the cycle and be used in artificial breeding programs.

The DIVISION OF ANIMAL PRODUCTION has coordinated extensive experimental evaluations and field trials of prostaglandins and prostaglandin analogues. In tests involving thousands of cattle, scientists, producers, State Departments of Agriculture and ICI Australia Ltd joined forces to evaluate alternative treatments and the subsequent fertility of the synchronised cattle. Administration of prostaglandin by subcutaneous injection between days six and 16 of the cycle was found to bring about early oestrus. Two injections, spaced 11 days apart, will bring all of a treated group of cows into oestrus together.

Similar trials conducted concurrently in Europe, the USA and New Zealand over three years have resulted in a wealth of data on the conditions under which prostaglandins should be used.

The trials have highlighted the management advantages offered by synchronisation of oestrus, particularly when applied to artificial insemination programs in cattle. The period required for insemination is reduced from the normal three weeks of the oestrous cycle to about four days and supplementary feeding prior to insemination is reduced likewise. Since calving occurs over about two weeks instead of about 10, farmers are able to channel all their resources at that time to calving. Culling of calves on growth rate is also facilitated as age is known fairly accurately. An additional advantage is the increased saleability of batches of young animals due to the even age range within batches.

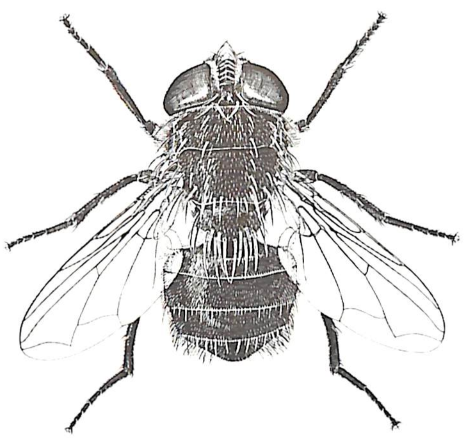
In general, when animals of normal fertility are treated with prostaglandins, and provided nutrition and management are good, fertility after synchronisation can be as high as with normal artificial insemination procedures. However, prostaglandins are not 'fertility drugs' and are only applicable to normally cycling animals.

A good deal of research on reproductive processes involves measuring hormones in blood. For this, specialised and standardised antisera for radioimmuno-assays have been produced in the DIVISION OF ANIMAL PRODUCTION. In addition to use within CSIRO, these antisera have also been made available in the past two years to over 30 laboratories in Australia and overseas, for experimental work in animal science and in human clinical studies.

## Arming Australia against screw-worm flies

*Methods of detecting and countering an invasion of screw-worm flies into northern Australia are being developed.*

The Old World screw-worm fly, *Chrysomya bezziana,* is a parasite of warm-blooded animals in many areas to the north of Australia, including Papua New Guinea. If the screw-worm fly were to become established in northern Australia, the effects on the livestock industry in the north could be devastating and, in addition, severe seasonal outbreaks would be likely to occur in New South Wales and Victoria. The female lays its eggs near any type of open wound or area affected by discharge. Larvae hatching from the eggs invade the affected area and feed on the living tissues, burrowing deeply as they go.



The Old World screw-worm fly, *Chrysomya bezziana.*

Livestock of European origin and small mammals frequently die if the infestation remains untreated. Alternatively, the animals may be so maimed in the genital region that further reproduction becomes impossible.

Studies by the DIVISION OF ENTOMOLOGY in Papua New Guinea indicate that the fly has considerable powers of flight. Torres Strait is less than 160 kilometres wide and the distance between islands is considerably less. In the past, the comparatively low numbers of feral and domestic animals, especially livestock, throughout the Cape York Peninsula and the top end of Australia, the Torres Strait and adjacent areas of Papua New Guinea, greatly reduced the chances of invasion of Australia. With the numbers of susceptible hosts rising in these areas, the threat of invasion is now far higher. The Division is therefore engaged in research aimed at monitoring the dispersion of screw-worm flies and developing strategies to deal with any outbreaks that may occur.

Recent studies in Torres Strait using radar to follow insect dispersion have shown a considerable inter-island movement of large insects. The Division is now assembling millimetre-wavelength equipment to track the movement of smaller insects ranging in size from screw-worm flies down to aphids or even smaller. In addition, scientists at the Division have recently begun using radiotracer and other methods of marking screw-worm flies to aid studies of how they disperse.

A method known as the Sterile Insect Release Method (SIRM) has largely eradicated the New World screw-worm fly, *C. hominivorax,* from the United States of America. In this method, large numbers of the pests are reared in the laboratory, then sterilised by irradiation and released. Although male screw-worm flies may mate many times, females mate only once during their lifetime. Thus if a wild female mates with a sterile male only infertile eggs are laid and her opportunity to reproduce is lost. Release of sufficient numbers of sterile males into the wild population will thus reduce pest numbers. The Division is currently studying the applicability of SIRM to controlling the Old World screw-worm fly. The development of improved lures and traps is already aiding the Division's ecological studies of the insect and could also help in assessing the likely effectiveness of SIRM under Australian conditions.

The Division is also examining the feasibility of various control methods that might be used should an outbreak occur. These include:

- treating individual livestock to ensure destruction of all maggots and to prevent reinfestation
- controlling the movement of all livestock and other animals in or near the area of an outbreak
- destroying all feral animals in the region
- initiating a program of preventive treatment through the use of insecticides
- trapping or poison-baiting the flies.

## Improved testing for brucellosis in cattle

*A new improved test for brucellosis in cattle could facilitate eradication of the disease.*

Brucellosis is a highly contagious bacterial disease that causes abortion and loss of milk production in infected cows. It can also cause undulant fever in farmers, veterinarians, abattoir workers and others whose occupation exposes them to infection. Eradication depends on vaccination to reduce the incidence of infection to a very low level—about two per cent—at which stage it becomes economically feasible to eliminate the remaining infected cattle by a test and slaughter program. It is not possible to eradicate by vaccination alone since the best existing vaccines protect only about 90 per cent of the animals.

The Bureau of Animal Health and the State Departments of Agriculture are conducting a national campaign to eradicate brucellosis from Australia's 30 million cattle. The test system used to detect infected cattle is cumbersome and the campaign involves an estimated 100 million tests. Samples of blood serum are first submitted to a rapid screening test. Although this seldom fails to detect antibodies in the serum of an infected animal, it also gives false positive results with many serum samples from uninfected cattle. All positive samples must therefore be tested again using the more accurate, but more time-consuming and costly, complement fixation test (CFT). Unfortunately this sometimes gives false negative results when sera from infected animals are tested at high concentrations. Sera must therefore be tested at a series of dilutions.

Research at the DIVISION OF ANIMAL HEALTH showed that the infected sera which gave false negative results to the CFT test at certain dilutions contained high levels of a subclass of antibody which blocked the response to the test. The Division then devised an alternative test, the indirect haemolysis test (IHLT) which is not subject to the blocking effect and requires only one serum dilution. The new test could be used to replace both the rapid screening test and the CFT, resulting in significant savings of both cost and time.

Another major advantage of the new test is that it is largely free from interference by antibodies induced by vaccination with S19, the most widely used vaccine against brucellosis. Antibodies induced by vaccination with S19 cause serious interference with the standard tests—a problem that has complicated brucellosis control and eradication programs for half a century. Because of this, use of the vaccine has had to be restricted to heifers between three and six months of age, and use of diagnostic tests limited to animals over 20 months old, the time lag allowing antibodies to the vaccine to dissipate. Since IHLT differentiates better between antibodies induced by vaccination and those resulting from infection, its use would allow vaccination of older animals. This would help contain outbreaks among susceptible cattle populations during the later stages of an eradication campaign.

The Division is collaborating with the Victorian Department of Agriculture in evaluating the IHLT under field conditions. The results obtained so far show that apart from being simpler, the test is at least as effective as the CFT as an aid to eradication.

### Defence against disease

*There are many major livestock diseases exotic to Australia which, if introduced, could have devastating consequences for our livestock industries and for the economy in general. Australia's preparedness against the dangers of such an introduction is vitally dependent on the knowledge and experience being gained through research.*

Australia is fortunate in being free from many of the diseases that plague livestock in other countries. The first livestock were introduced by the early British settlers, and the long voyage from Europe to Australia ensured that most major diseases that were prevalent at the time of embarkation had run their course before arrival in Australia. As a result, chronic diseases and those with low mortality rates were, but for a few isolated exceptions, the only ones to enter the country. However, Australia can no longer rely to the same extent on its physical isolation to help keep out exotic diseases. Faster methods of transport and freer movement of people between all parts of the world have increased the danger of transferring acute and economically devasting diseases from country to country.

The quarantine service operated by the Australian Department of Health has been a major barrier to the accidental introduction of exotic diseases, but no quarantine service, however efficient, can hope to provide an absolute guarantee against their entry.

The rapid detection and diagnosis of an exotic disease that has penetrated our quarantine barrier can be the most vital factor in its successful control and eradication. Moreover, the diagnosis should identify not only the organism responsible for the disease, but also the particular strain of that organism. For example, throughout the world 20 different types of bluetongue virus have been identified so far and seven types of foot and mouth disease virus. The picture is further complicated by the fact that the seven foot and mouth disease virus types can be subdivided into at least 60 different subtypes. A knowledge of the correct strain is essential if an effective vaccine is to be developed.

Once a disease is suspected in the field, it must be confirmed in the laboratory. Australian laboratories currently hold diagnostic reagents for a very limited number of exotic diseases, including Newcastle disease and swine fever. In most cases, however, confirmation of a field diagnosis cannot be made within Australia.

It was a growing awareness of Australia's complete dependence on overseas laboratories for diagnosis of most exotic diseases, and the uncertainties and delays associated with such a dependence that led in 1964 to the Department of Health inviting an expert from the Food and Agriculture Organization (FAO) of the United Nations to investigate and report on Australia's preparedness to cope with an outbreak of exotic disease in her livestock population. His report recommended that Australia should establish its own high security laboratory to provide the support needed for diagnosing and controlling exotic diseases.

Subsequently, after careful consideration by the various State and Commonwealth authorities concerned with matters of animal health, the

Australian Agricultural Council agreed that such a facility was necessary. A comprehensive study involving examination of high security facilities overseas was undertaken to evaluate the feasibility of constructing a laboratory to meet Australia's needs. The report of the evaluation group contained detailed designs on which the preparation of working drawings could be based. A proposal was then submitted to the Commonwealth Government and approved in 1974.

It was agreed that the laboratory, to be known as the Australian National Animal Health Laboratory (ANAHL), should be located at Geelong, Victoria. Following a further period of investigation and detailed design, construction of ANAHL commenced in March 1978.

ANAHL will be administered and operated on behalf of the Commonwealth Government by CSIRO. When completed in several years time, it will provide a much-needed facility for the diagnosis and control of any exotic diseases of livestock that penetrate our quarantine barriers, and will enable research on exotic diseases of livestock to be carried out in Australia in complete safety.

Australia's preparedness to cope with exotic diseases depends, however, not only on facilities but also on trained scientists with a knowledge of the diseases concerned. Since its establishment in 1931, the DIVISION OF ANIMAL HEALTH has added considerably to this knowledge and has helped ensure that Australia has had skilled specialists and advanced techniques during times of emergency.

The decision made by the Division in 1958 to establish a virology unit at its Parkville laboratory in Melbourne was a particularly important one, since most of the serious exotic diseases are caused by viruses. Over the last 20 years Divisional virologists have identified a number of virus diseases not previously known to exist in Australia and demonstrated their spread over the whole country. They have done valuable research on a number of virus diseases including ephemeral fever, Akabane disease, infectious bovine rhinotracheitis, bovine mucosal disease and swine fever, and have worked in overseas laboratories on important diseases such as foot and mouth disease and bluetongue.

It was the expertise in virology developed within the Division that enabled CSIRO to make a significant contribution to the design and planning of ANAHL.

The isolation of an unidentified virus by the DIVISION OF ANIMAL HEALTH from a group of biting midges collected in the Northern Territory between 1974 and 1976, and its subsequent identification in 1977 as a new strain of bluetongue virus, gave further emphasis to Australia's vulnerability to exotic diseases in the absence of a high security facility. It also highlighted the importance of research on virus diseases to Australia's preparedness to cope with outbreaks of exotic disease.

Bluetongue can be a serious disease of sheep; cattle can be carriers of the virus but are not seriously affected. It is caused by an arbovirus—that is, a virus which multiplies in and is transmitted by biting insects. Other arbovirus diseases include African horse sickness, and equine viral encephalitis, a disease which affects man as well as horses.

In 1957, a severe outbreak of bluetongue in sheep in Portugal served as a grim warning of the severe economic losses that could be expected if the disease ever found its way into Australia's sheep population. It was also a reminder of how little was known about insects which could transmit diseases to sheep in Australia.

In 1961, therefore, the DIVISION OF ANIMAL HEALTH established a specialised group to examine such insects, particularly the biting midges (*Culicoides* species), one of which was known to be a transmitter or vector of bluetongue in South Africa. Over the years the group has assembled an invaluable catalogue of Australian biting insects, their breeding sites and seasonal occurrence in different environments, and the hosts on which they feed.

A later stage in this program involved isolating and identifying viruses from the captured insects. This work, which was done in collaboration with the Queensland Institute of Medical Research has led to the isolation of a surprisingly large number of different viruses, some of which are responsible for disease in man. These surveys also provided, for the first time, a broad picture of the distribution of several virus diseases of cattle.

To obtain information about virus diseases as they occur in the field, the Division established a sentinel herd scheme in 1969 in which herds of cattle, each containing 20 animals, were strategically placed around Australia and New Guinea. There are now more than 50 of these herds. Testing of blood samples from each herd for antibodies to a wide range of viruses enabled the virus infection status of each herd to be established. Subsequent sampling and testing on a regular basis is enabling the Division to monitor the spread of virus diseases over a period of time. By 1971 it was clear that insect-borne viruses were far more prevalent and more important in Australia than had been suspected. To enable work to be done on these viruses without endangering local livestock populations, a special insect-proof building was constructed at the Division's Long Pocket Laboratories in Brisbane to house experimental animals such as cattle and sheep. This facility was completed in 1977.

Between 1974 and 1976, the Division undertook an intensive study in collaboration with the Northern Territory Administration at Beatrice Hills, south-east of Darwin. The broad objectives of this study were to determine the seasonal distribution and abundance of insect species biting cattle, to monitor the activity of arboviruses in livestock by serological means and to screen insect collections for arboviruses. Over a period of 83 weeks 235 000 insects collected at Beatrice Hills were processed for virus isolation. A total of 91 viruses were isolated from these, including an unidentified virus isolated from a pool of 214 *Culicoides* insects. This isolate was sent to the Arbovirus Research Unit at Yale in the United States. On 24 October 1977, the Yale unit reported that the virus was indistinguishable from bluetongue. A diagnostic kit prepared at the Bluetongue World Reference Centre at Ondersterpoort in South Africa and held in bond at the Division's Parkville Laboratory, Melbourne, was immediately released from bond and used to confirm the finding of the Yale unit. Subsequently, the Bluetongue World Reference Centre showed that it was a type of bluetongue virus distinct from any previously known type. The virus is now known as bluetongue virus type 20.

Following the report from Yale, the DIVISION OF ANIMAL HEALTH redeployed 13 of its staff to work on the problem, while a futher four staff were made available on a temporary basis. Some $300 000 was diverted from other programs to help finance the work.

The need for secure insect-proof accommodation, foreshadowed in 1971, was fully justified at this point. The newly commissioned building at the Long Pocket Laboratories was put to immediate use in transmission studies. Without these facilities Australia would have been completely dependent on overseas assistance, with consequent inordinate delays. It has been shown that this virus produces mild symptoms when inoculated into sheep in the laboratory. However, its full disease-producing potential will not be known until further studies, including insect transmission, have been carried out. These studies are now in progress and will continue for some time.

In addition to the work on transmission, a nation-wide serological survey was conducted in association with State authorities to determine quickly the past distribution of the virus.

The whole bluetongue incident highlights the extreme danger of Australia being dependent upon other institutes and countries for final diagnostic studies.

### Breeding better sunflowers

*Factors affecting yield in sunflowers are being studied so that more productive varieties can be bred.*

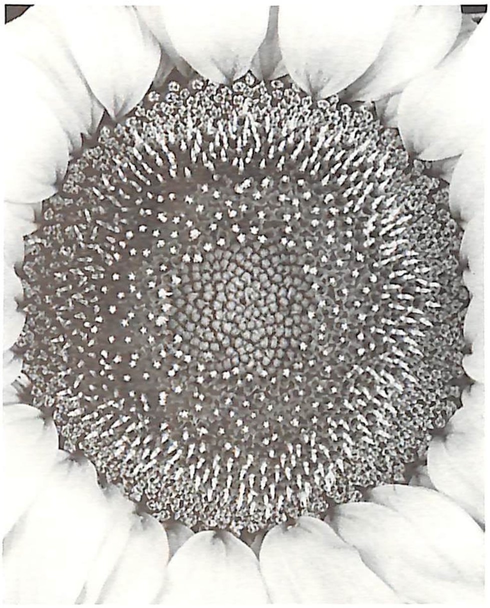
Sunflowers are Australia's main oil-seed crop. They produce oil for cooking and for margarine. The oil-cake left after the oil has been extracted from the seed is used as a stock feed. The leaves and the flower bud of the sunflower plant move during the day to follow the path of the Sun. The leaf movements help the sunflower to achieve a high rate of photosynthesis, but in spite of this seed yields are often poor.

Research at the DIVISION OF IRRIGATION RESEARCH has identified low bee populations as the factor responsible for poor seed set. Experiments have shown that, in the absence of bees, even under otherwise ideal growing conditions, seed set in both self-fertile hybrids and open-pollinated cultivars ranges from 80 per cent down to 10 per cent. Only one non-commercial cultivar has been found to set more than 80 per cent seed in the absence of pollination by bees. The Division is aiming to breed new self-fertile cultivars of sunflower, all of which will set 80 per cent or more seed, as well as being rust resistant and having a high yield of polyunsaturated oil per hectare.

The Division has found that when temperatures exceed 30°C, the pollen deteriorates rapidly and loses its ability to fertilise. High temperatures can also burn whole sections of the flower head. Nature has endowed the plants with a trait that minimises the risk of burning—once flowering commences, the head no longer follows the Sun but remains in a fixed position facing east. This suggests the possibility of reducing the loss of yield through scorching by breeding plants whose flower heads permanently face away from the Sun. In hot areas, sowing in late season to avoid mid-summer flowering would also help reduce scorching and help maintain the viability of the pollen for longer periods.

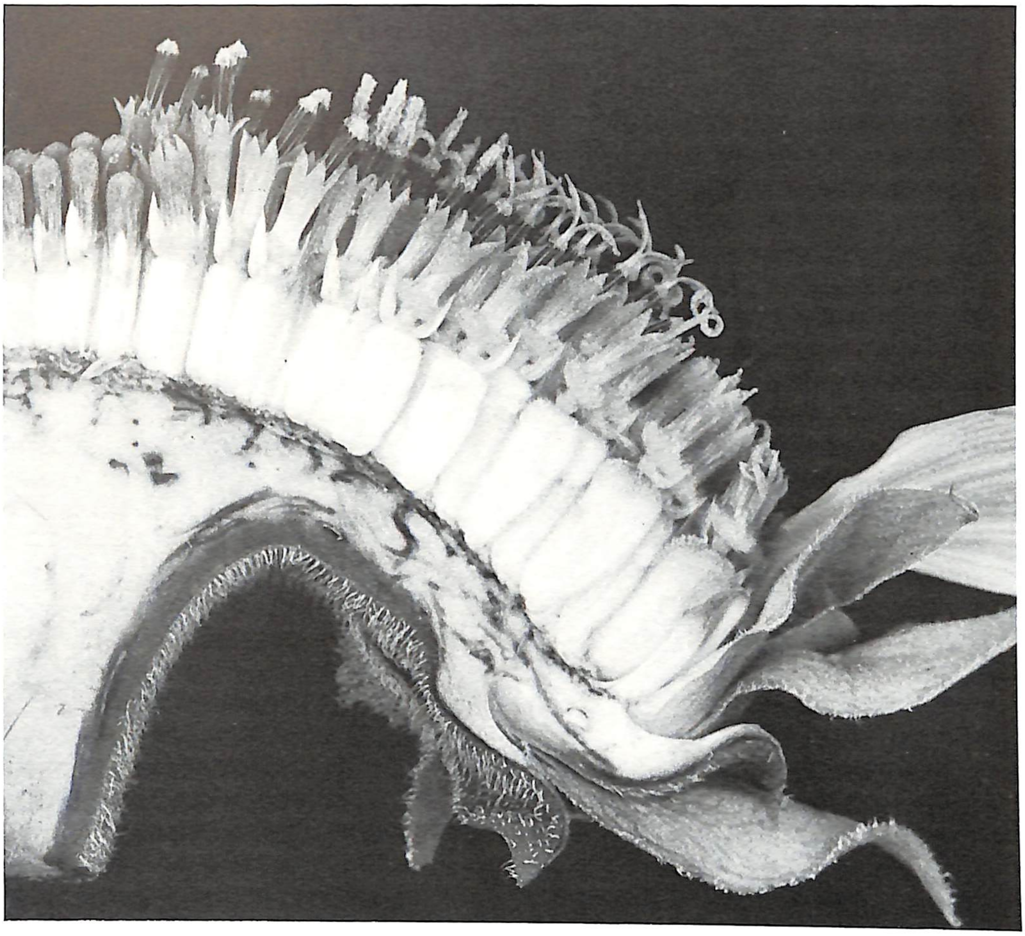
It may also be possible to grow sunflowers commercially in cooler, more temperate climates where the heat hazard is less than it is in the tropical and sub-tropical areas of Queensland and the warmer regions of New South Wales where most commercial plantings are situated. Yields from crops grown experimentally in the temperate climate of the Division's headquarters at Griffith, NSW, have been enouraging.

Another factor which contributes to poor or variable yields in cross-pollinated types is the difficulty of securing bee pollination of the flowers. Sunflowers are not particularly attractive to bees as the nectar and sucrose content are low. This sometimes causes granulation of the honey in the comb, and since granulated honey is hard to extract from the comb, many beekeepers are reluctant to place their hives in sunflower fields. The Division is searching for new genetic material to introduce into their breeding program in order to raise both the sucrose content and the overall concentration of sugar in the nectar. The Division also hopes to increase the protein content of the pollen to above 20 per cent, since the percentage protein is critical to increasing the brood in the hive. If these aims can be achieved, pollination of sunflowers will be improved, and beekeepers will be able to harvest honey from sunflowers in commercial quantities.



Sunflower heads viewed from above and in cross-section. Four floral stages occur on the head of a sunflower at one time and portray the reproductive process. In the centre of the head the florets are young and not yet open. Next to these are young open flowers with only the staminal columns visible above the reduced petals. In the third stage the styles, bearing the pollen-receptive stigmas, are seen to have grown through the staminal columns. The florets may be cross-pollinated or in self-fertile cultivars, if cross-pollination does not occur, self-pollination takes place by the stigmas bending back and touching the styles on which pollen has been deposited from the staminal columns. In the outermost ring of florets fertilisation has occurred and the stamens, styles and stigmas have shrivelled away. The whole sequence takes 10 days.

*Photographs: Len Gallagher*



## Dietary fibre and human health

*The influence of dietary fibre on human health is being investigated.*

Dietary fibre is the indigestible fraction which is present in most foodstuffs—particularly those derived from plants. It has been suggested that insufficient fibre in the diet might predispose people to many diseases of the circulatory and digestive systems prevalent in Western society.

Several research groups overseas have shown that a diet containing a high proportion of fibre can lower blood cholesterol levels in both man and experimental animals. High blood cholesterol levels can cause atherosclerosis—fatty deposits in the arteries—which may lead to coronary heart disease, a major cause of premature death of Australians. Cholesterol is used by the liver to produce bile acids, which in turn are used to help digest fat as food passes through the small intestine. Most of the bile acids are re-absorbed from the gut and return to the liver, but a portion becomes adsorbed onto fibre and is excreted in the faeces. This loss has to be made good by increasing the production of bile acids from cholesterol. Thus increased bile acid excretion indirectly increases the loss of cholesterol from the body.

Collaborative research by the DIVISIONS OF FOOD RESEARCH and HUMAN NUTRITION has shown that plant fibre alone does not adsorb bile salts. Adsorption occurs when saponins are present in the fibre. Saponins are present in most of those food plants which have been shown to lower blood cholesterol levels in man or experimental animals, whereas wheat bran, which is free of saponins, has no effect. The source of fibre is therefore important if its consumption is to reduce the risk of heart disease. Saponins are present in relatively few food plants—the most common being soya beans, peanuts, spinach, aubergines and chick peas.

Current studies with rats at the DIVISION OF HUMAN NUTRITION have shown that saponins may reduce plasma cholesterol as a result of increased excretion of bile acids and neutral sterols in the faeces. Studies are now being initiated on pigs and human volunteers to see whether there is a similar lowering of plasma cholesterol. As a normal constituent of food plants, saponins may provide a better means of lowering plasma cholesterol than those methods which rely on drugs.

## Looking for oil

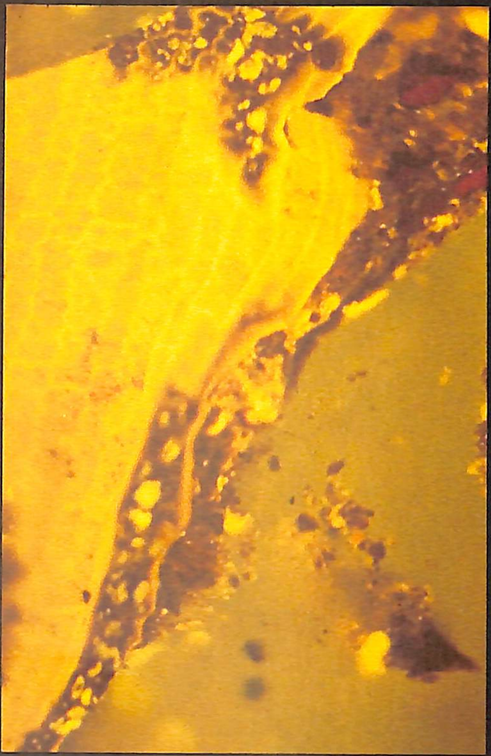
*New and improved techniques are being developed to help in the search for oil.*

Companies searching for naturally occurring oil and gas need to know which types of rock are capable of yielding hydrocarbons; whether these rocks are present in specific areas; whether the rocks have reached or passed the degree of maturity necessary for them to release their yield of oil and gas; and whether the geology of a particular sedimentary basin

Fluorescence microscope photographs of the polished surface of rocks recovered from oil-drilling operations in Bass Strait. The material which appears yellow is solid organic material with a high hydrogen content. The hydrogen content of the organic material is a guide to the oil-generating potential of the rocks.

1. Waxy leaf cuticle with cell structure visible
2. Oval resin bodies
3. Algal body (largest yellow area) and smaller compressed pollen grains
4. Unusually rich concentrations of strongly fluorescing material including cuticle resin and pollen.

(Magnification × 25) *Photographs Dr Michio Shibaoka*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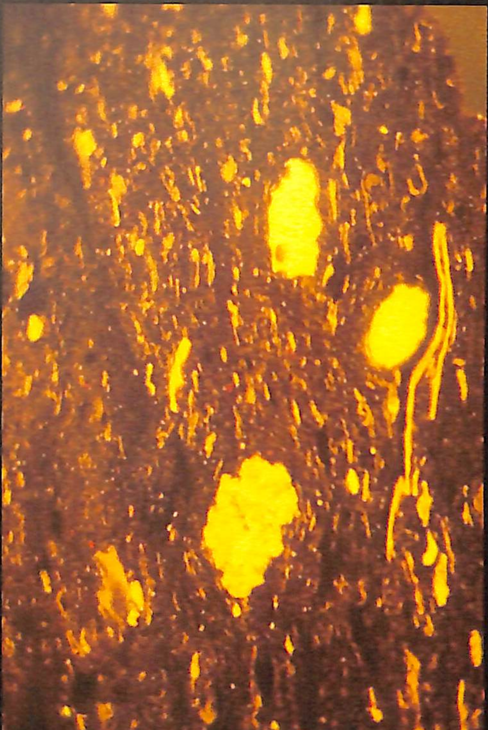
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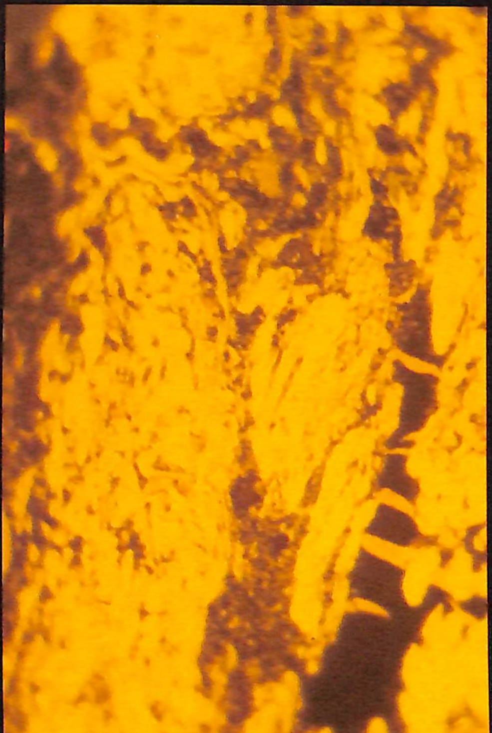
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is conducive to trapping any hydrocarbons released.

Over the past 10 years, research in various sections of the MINERALS RESEARCH LABORATORIES has helped advance the knowledge of the way in which petroleum is formed. With the prospect of a much reduced supply of oil over the next decade from existing Australian fields, the MINERALS RESEARCH LABORATORIES, particularly the newly-formed FUEL GEOSCIENCE UNIT, are stepping up their research in this area. Emphasis is being placed on the way in which oil and gas are generated from source rocks, on how oil and gas subsequently migrate into natural rock traps, and on improving exploration techniques.

Earlier research by the Laboratories indicated that the petroleum in Bass Strait was formed from the remains of land plants. More recent research indicates that most of the hydrocarbon deposits in Australia were also derived from this source. The plant remains were deposited with minerals, especially clays, and formed rocks such as carbonaceous shales which in later geological times were potential source rocks for petroleum.

Together with other research groups working in this field, the FUEL GEOSCIENCE UNIT has found that the origin of the organic material has a direct bearing on the kinds of hydrocarbon formed and is a major factor in determining whether oil or gas or both occur in a particular field. Since petroleum is a hydrogen-rich material, it is hardly surprising that the generation of oil is favoured when the organic remains have a comparatively high content of hydrogen. Such hydrogen-rich organic matter includes the remains of algae, some resins, the waxy protective coating of leaves, and the envelopes of pollen grains and spores.

It is becoming increasingly evident that the organic contents of petroleum source rocks, oil shales, and coals are closely related. All are derived from plant material and all have undergone similar changes during the maturing process. Similarly, gas occurring in coal seams and gas found in association with petroleum have comparable organic origins and similar histories of liberation from the organic matter.

In order to establish which rocks have a potential for generating hydrocarbons, the Unit, in collaboration with the Bureau of Mineral Resources, has been systematically assessing possible source rocks encountered during drilling operations in many parts of Australia. The quantity of carbonaceous matter has been determined, the state of maturity assessed, and any hydrocarbons isolated and analysed. By June 1978 some 300 samples had been analysed and the results made public.

Where hydrocarbons have already been found in an area, an opportunity exists for establishing a direct relationship between the hydrocarbons and source rocks, and in some cases it has been possible to do this. The data from these studies, together with information provided directly by exploration companies, constitute a strong basis for both theoretical and experimental work within the Unit.

As the stage at which hydrocarbons are released from their source rocks depends largely on the degree of maturity of the rocks, the Unit is developing and improving methods of assessing maturity. Scientists in the Unit have developed a chemical method for separating the carbonaceous matter from the inorganic portion of the rock. The carbonaceous matter can then be examined microscopically and analysed chemically. The method is time-consuming and cannot be applied on a bulk scale, but it allows highly detailed studies which provide a base-line of information against which a faster, less refined technique can be used effectively. This second method involves separating the carbonaceous material by physical methods and then measuring the proportion of light that it reflects. The technique has proved very suitable for assessing maturity.

By correlating the reflectivity data with the history of deposition of the source rocks and the younger rocks above them, it is possible to deduce the stage of maturity at which the sedimentary basin released its hydrocarbons. This work has enabled three basic patterns of maturation to be recognised: the Gippsland Basin type where hydrocarbons are being generated vigorously at present; the Cooper Basin type, where generation is almost complete; and the Sydney Basin type, much of which is over-mature for the generation of oil and where large volumes of sedimentary rocks have been lost by erosion.

It has been generally assumed that hydrocarbons, trapped in reservoirs well below the earth's surface where temperatures were below 100°C, remained unchanged almost indefinitely. Recent research, however, has revealed evidence that bacteria have degraded the hydrocarbons in a number of wells. Since calcite or other carbonates could result from the bacterial degradation of hydrocarbons, a search has begun for these substances.

Such carbonates have already been found in rocks from the upper of two oil-bearing horizons at Barrow Island, Western Australia. Not only do the carbonates themselves differ in their chemical structure from normal carbonates, but the oil with which they are associated is itself of an unusual composition, containing almost no simple chain-like hydrocarbons. On the other hand, the deeper oil has a normal composition. This evidence suggests that both oils may originally have been of the same type and perhaps even from the same source. The significance of this finding is that the same situation could recur elsewhere in the basin, warranting deeper drilling to locate a possible second oil-bearing horizon.

An application of this discovery which is currently being explored by the Baas Becking Laboratory, a research laboratory financed jointly by CSIRO, the Australian mining industry and the Bureau of Mineral Resources, is the possibility of increasing the yield of oil from known reservoirs by introducing bacteria into them. In some reservoirs, less than half the oil can be recovered by conventional techniques. By introducing certain bacteria it might be possible to modify the oil or the rock in which it occurs so that additional oil can be recovered.

Experimental work and theoretical calculations in the FUEL GEOSCIENCE UNIT consistently indicate far greater quantities of oil and gas than are actually found in reservoirs. The discrepancy can be partly accounted for since some of the oil never escapes from the rock in which it was generated while larger hydrocarbon molecules which do not migrate eventually break down into gas or solid carbonaceous matter. However, it seems that the main reason why the calculations do not tally with the amounts found is that most natural traps tend to leak and reservoirs are therefore in a dynamic state. Where the rate at which oil is added to the reservoir exceeds the rate of leakage, the reservoirs will be full. Ultimately, most of the oil that leaks out reaches the surface. If, of course, the trap is full, any further oil will be forced to the surface.

The conclusion that hydrocarbons escape to the surface in many oilfields has important implications for exploration. Some attempts have been made in various parts of the world to use such seeps as pointers to the presence of hydrocarbons at depth. 'Sniffing' devices are used to sample and analyse trace amounts of hydrocarbons and associated chemicals at or near the surface. The Unit is now engaged in a study to find the most suitable techniques for various Australian environments, both onshore and offshore.

Onshore, these techniques will include sampling gases in and above soils. Offshore, it is hoped to sample water just above the sea floor as well as at the surface.

The escape of hydrocarbons to the surface also lends itself to the possibility of using remote sensing devices to detect them, especially offshore. The Unit, in collaboration with the DIVISION OF MINERAL PHYSICS, is investigating the use of LANDSAT satellite imagery for this purpose.

In locating seeps, it is essential to be able to distinguish between hydrocarbons escaping from reservoirs and those resulting from human activities. Usually detailed chemical analyses can provide a means of discriminating between say, an oil spill from a ship and an offshore seep.

### SIROTEM—an aid to mineral exploration

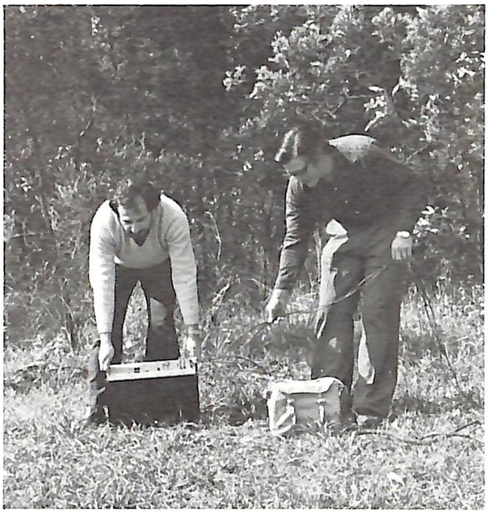
*A portable instrument for detecting ore bodies beneath the earth's surface has been developed for Australian conditions.*

Scientists in the DIVISION OF MINERAL PHYSICS have developed an instrument to help mineral exploration and geological mapping in Australia. The instrument is named SIROTEM, standing for CSIRO Transient ElectroMagnetics.

The principle of TEM depends on the good electrical conducting properties of mineral ore bodies compared with the lesser conductivity of surrounding rocks and soil. Measurements are made in promising areas by placing a large loop of wire on the ground. This loop, called the transmitter loop, can be up to 100 metres or more across. An electric current is passed through the loop, creating a magnetic field that extends into the ground beneath. When the current is switched off, the magnetic field collapses and in so doing, induces eddy currents of electricity in the ground which last for a fraction of a second.

These eddy currents produce short-lived—or transient—magnetic fields of their own which can be detected and measured by a second loop of wire, the receiver loop. The strength and rate of decay of the transient magnetic signals

*Photographs: Geoff Lane*



Sirotem, a portable instrument for detecting ore bodies beneath the earth's surface. The canvas bag to the right of the instrument in the upper photograph contains the battery pack.

depend on the conducting properties of the ground beneath—an ore body signal can last up to about a tenth of a second while a plain rock signal lasts only a few thousandths of a second.

The technique of transient electromagnetics was first used for exploration in the United States in 1947. However, the early instruments were large and did not perform well and their use was soon discontinued. A few years later, scientists in the Soviet Union produced a much improved instrument which was smaller and lighter and worked well in temperate and cold climates. Consequently, mining companies bought the Russian instruments, which performed particularly well in Europe, to detect mineral deposits buried beneath the earth's surface.

Five instruments were imported into Australia, but they experienced a serious impediment as a result of the nature of Australia's surface geology. Many parts of the continent are covered by thick salty soils and oxidised rocks. This salty top layer of soil produces a signal of its own which can last up to a hundredth of a second and which can be mistaken for, or mask, an ore body signal. The top layer can also obliterate the first hundredth of a second of the signal from the ore body. As a result, TEM was not being used to its full potential in Australia.

In view of the major importance to the Australian mining industry of overcoming the problem, the DIVISION OF MINERAL PHYSICS commenced a program of research in 1973 that involved field trials throughout Australia. Scientists at the Division decided to take advantage of the fact that the ore body signal lasts longer than that from the salty top layer. They designed an instrument that would measure more reliably the longer signal from the ore body. Since the signal is usually extremely weak, the new instrument had to be very sensitive so that the electrical noise would not swamp the transient signals.

They solved this by using a scientific equivalent of a technique often resorted to on a noisy telephone line; that is, to repeat the message several times. They decided to make the ore body send back not one, but thousands of identical signals, one after another, and built an instrument that would average all these signals. While the ore body signals, which are received at regular time intervals, reinforce one another in the averaging process, spurious signals cancel out. The spurious signals come from a variety of sources such as electrical machinery operating nearby, lightning, or the wire of the receiver loop swaying back and forth in the wind.

The first experiments in 1973 showed that these modifications were a great improvement on the Russian system. However, the 20 kg computer that was needed to process the complex signals would not have been sufficiently portable for practical use. Luckily, the first reliable microprocessors were released on the Australian market at that time. The 20 kg computer was replaced by a 200 gram printed circuit card, reducing the total weight of the CSIRO instrument to 8 kg, or 16 kg with batteries.

The microprocessor in SIROTEM averages the transient signals and sends the result to a small digital printer. The strength of the ore body signal above that of the background noise is at least 50 times greater than that achieved in the Russian TEM instruments. Whilst developing this sensitivity, the scientists had to overcome several noise problems. Interference signals from thunderstorms occurring as far away as South Africa and man-made signals sometimes a million times greater than those from the ore body were being picked up. These interferences were carefully studied and within two years, a method had been developed for screening these out so that the present SIROTEM instrument can be used confidently near mines and other areas of power-generating activity, or in the tropics during the monsoon season.

The mining industry in Australia provided invaluable assistance throughout the development stages. Many exploration managers explained their practical needs and five companies, through the Australian Mineral Industries Research Association, provided financial assistance to build a SIROTEM prototype. They also provided practical advice and test areas in which to evaluate the instrument.

In 1977, SIROTEM was field tested in Russia and a prototype caused great interest at a Canadian exhibition. An Australian firm, Geoex Pty Ltd, has been granted a licence to manufacture the instruments commercially and the first commercial instrument was handed over by Geoex to BHP in March 1978.

## Solar heat for industry

*A program is under way to develop and demonstrate the use of solar heating in a variety of industrial processes.*

Manufacturing industry consumes about one-third of all oil used in Australia, mostly to provide heat at moderate temperatures. Much of this heat could be provided by solar heating systems.

A major objective of the SOLAR ENERGY STUDIES UNIT is to develop solar heat generating systems suited to specific industrial processes and to demonstrate their viability on a commercial scale. In collaboration with industry, the Unit has begun a program of developing and demonstrating the use of solar heating in industrial applications.

The first industrial development and demonstration installation of the program has been operating in a soft drink factory at Queanbeyan, New South Wales, since January 1977. A second is being installed in a brewery in Adelaide. The purpose of these installations is to:

- demonstrate in a factory environment, a solar process heating system which has been developed to the stage where it can operate without special supervision
- identify and, if possible, solve any problems that arise
- measure the performance of the system under operating conditions and determine its cost effectiveness in the light of both present and future energy costs
- encourage an interchange between research workers and industry.

The Queanbeyan installation supplies heat directly to the factory's can-warming machine which operates between 50 and 60°C and forms one of the final stages of the production line. It runs in parallel with the existing heat input from an oil-fired boiler which delivers water at 80°C to the can-warming machine. When the input from the solar heat generating system is high enough, the heat input from the boiler is automatically cut off, but when necessary, the boiler takes over some or all of the load. The installation will be operated as an experiment until 1979, to obtain data on the performance of such a system in a factory environment.

Already the installation has proved to be operationally satisfactory, and experience with it has led to the development of an improved type of industrial solar collector for use in process heating and air conditioning. The early prototype collectors installed at Queanbeyan did not use low-iron glass covers or the chrome-black solar-absorbing surfaces developed by the DIVISION OF MINERAL CHEMISTRY. These innovations have been incorporated in the Adelaide installation and will be included in future installations. The new collectors were developed by the SOLAR ENERGY STUDIES UNIT and Beasley Industries, who have applied for a joint patent. The collectors are suitable for absorption cooling systems in air conditioning and for industrial processes where the temperature of water entering the collector does not exceed 85°C.

The Queanbeyan installation is providing valuable information on the cost effectiveness of solar heat generating systems in industry, as capital outlay, running costs and annual heat generation are reported. The break-down of capital costs for the installation was: collectors 41 per cent, insulated thermal store 12 per cent, and energy transfer loops (for circulation of water to and from the collectors and the can warmer) and controls 47 per cent. This break-down emphasises the need to simplify and reduce the cost of the transfer loops and controls. It also shows the value of improving the efficiency of the collectors, even if this means an increase in cost. Since the collectors represent less than half the total cost an improvement which adds, say, 20 per cent to their cost but only 10 per cent to their efficiency, would still result in an increase in cost effectiveness of the system.

A measure of cost effectiveness is the annual heat energy utilised per dollar invested, a convenient unit being the number of gigajoules (1 gigajoule equals 1000 million joules) of energy used annually for each $1000 invested in solar equipment. After 12 month's operation, the Queanbeyan installation, with 77 square metres of collectors, had an annual utilisation effectiveness of 4·5 gigajoules per $1000 invested. The collector area has now been increased to 94 square metres, using units with low-iron glass and chrome black selective surfaces. This has increased the figure to five gigajoules annually per $1000 invested.

It is estimated that the Adelaide installation will be able to produce six gigajoules annually per $1000 invested. Hopefully, operational experience on the industrial installations will lead to further improvements in performance.

## Measuring the curvature of contact lenses

*A method has been developed for measuring the curvature of soft contact lenses.*

Contact lenses not only have cosmetic advantages over spectacles but, more significantly, are the only means of correcting certain visual defects. The soft contact lenses now available are more comfortable than the earlier hard plastic lenses and can be tolerated by more people. A difficulty encountered in measuring the curvature of soft lenses—a measurement needed to ensure comfortable fit and proper optical correction—results from the nature of the material used. The material owes its softness to its ability to absorb a large amount of water. However, the lenses must be manufactured in a hard, dry state, then hydrated before use by saturating with water. As the material becomes hydrated, the dimensions of the lens change. Thus the manufacturer must measure the curvature with the lens in its hydrated form and immersed in a saline solution.

The curvature of all lenses is best measured optically. This is particularly the case with soft lenses as mechanical methods are inaccurate and may damage the lens. However, no satisfactory optical method has been available for soft lenses. In response to the problem, the NATIONAL MEASUREMENT LABORATORY has adapted the radiuscope, the instrument generally used for measuring the curvature of hard lenses, for use with soft lenses.

The radiuscope consists of a microscope incorporating an illuminated target and is arranged so that it can be focused on reflected images of this target. The distance the microscope must be moved between focusing on a reflected image of the target first at the lens surface and then at the centre of curvature is equal to the radius of curvature. If the standard radiuscope is used, very little light is reflected from a lens immersed in water and it is completely swamped by light reflected from the dry lenses that are a component part of the radiuscope itself.

In the adapted version, scientists at the Laboratory have used polarised light to illuminate the target in the radiuscope. A second polariser, near the eyepiece of the radiuscope, is rotated until it crosses the first, thus eliminating all reflected light. To ensure that the reflections from the contact lens are not also eliminated, a thin plate of quartz or mica is placed between the contact lens and the radiuscope to alter the polarisation of this light. In this way, the faint reflections from the lens reach the eyepiece without competition from other reflections, enabling accurate measurements to be made.

Firms in Australia and the United States have now been licensed to modify existing radiuscopes and manufacture new radiuscopes incorporating the novel features.

### Coming clean with wool

*A new process has been developed which removes the pollutants from wool scour effluents.*

Raw wool contains impurities—grease, suint (water soluble sweat salts) and soil particles— that must be removed by scouring. The waste scour waters are the most polluted of all textile wastes. As well as the dirt and grease washed from the wool, they contain the detergent and soda used for scouring. As environmental protection legislation has come into force, both in Australia and overseas, wool scourers have been faced with massive increases in waste-disposal costs. Charges are normally levied, not on volume, but on the weight of impurities in the waste water. Thus, the only way of reducing costs appreciably is to remove the impurities from the waste water and dispose of them separately.

Lo-flo scouring unit at the laboratories of the DIVISION OF TEXTILE INDUSTRY, Geelong, Vic.

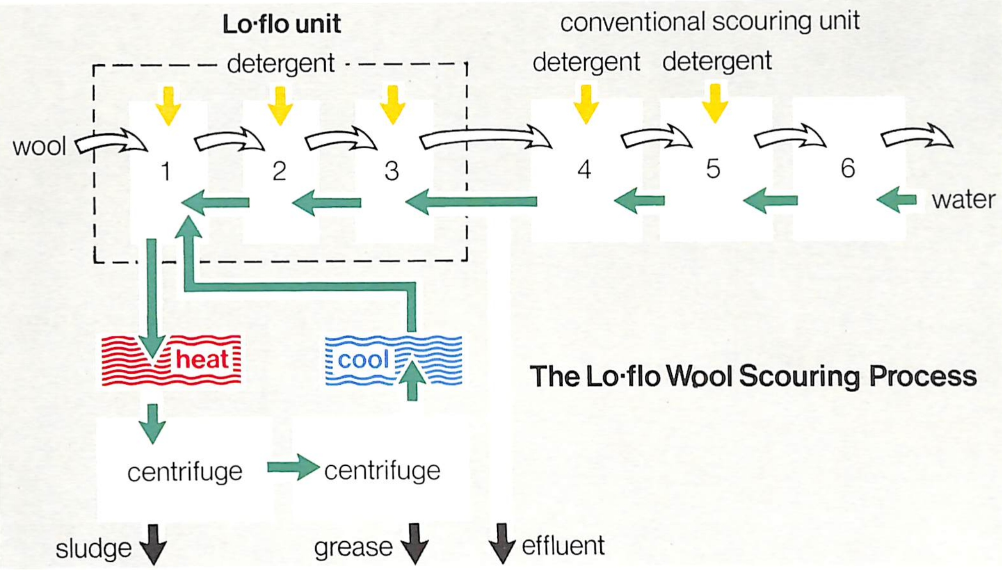
Economic removal of the contaminants is not easy as the dirt and grease form a stable suspension in the scour liquors. Because of this stability, less than half the grease can be removed by centrifuging. Chemicals can be added to destabilise the suspension and aid the separation of grease and dirt, but this is seldom economical.

Several years ago, scientists in the DIVISION OF TEXTILE INDUSTRY discovered that high concentrations of detergent, soda and suint in the scour waters aided destabilisation. In normal scouring, the detergent chemicals and suint are not present in sufficient concentration for destabilisation to occur. The search for a method of scouring in which sufficiently high concentrations could be achieved without the addition of further chemicals and without affecting the quality of the wool, led to the development of a new scouring process known as Lo-flo.

In traditional scouring, the raw wool is passed through a series of four or five bowls, the first few containing hot detergent or soap and soda solutions and the last one or two containing only water for rinsing. The wool moves in a direction opposite to the water, so that the dirtiest water is used in the initial bowl while the cleanest water is used in the final rinsing bowl.

In Lo-flo, the high concentrations of the chemicals and suint are attained by reducing the volume of water used in the first stages of scouring. This is done by replacing the first bowl in a conventional scouring machine with a specially-designed Lo-flo unit. The unit consists of three small scour bowls containing

Photograph: John Card
Artwork: David Marshall




The Lo·flo Wool Scouring Process

inclined, perforated plates. As the wool slides down the plates, it is washed by jets of scouring water then squeezed between rollers.

The water from the first bowl in the Lo-flo unit—the dirtiest water—is fed into a centrifuge where the dirt is removed as a sludge containing small amounts of water and grease. The water is then fed into another centrifuge where the rest of the grease is removed, and the water is then returned to the first bowl. The water in the first bowl is continually circulated through the two centrifuges and then back to the bowl, the water input to the unit being reduced to about a tenth the normal amount. After the wool leaves the last bowl of the Lo-flo unit, washing is completed in the conventional bowls of the scouring machine.

The grease and sludge removed by the Lo-flo unit account for about 95 per cent of the contaminants that were on the wool. The sludge can be either burnt or dumped. The grease is generally refined to lanolin for use in pharmaceuticals and cosmetics and the Division is undertaking further research to develop an on-line refining system. The water from the conventional part of the scouring machine is relatively innocuous, containing only five per cent of the original contaminants plus some biodegradable detergent, and can be discharged to the sewer.

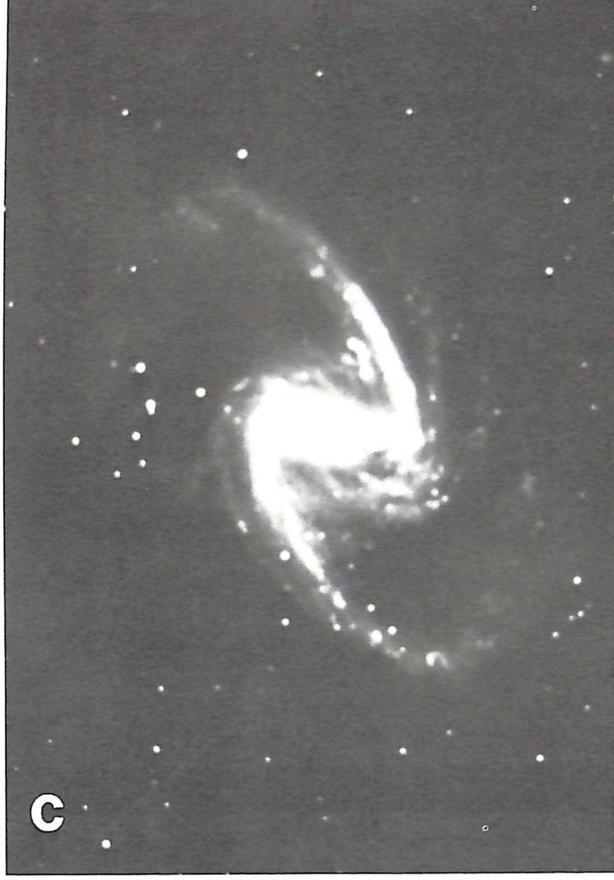
Three commercial Lo-flo units are presently under construction and the Division is carrying out trials for a number of wool scourers on its own equipment. The system is considerably cheaper than disposing of the untreated waste waters to the sewer and, as a bonus, about twice as much grease is recovered compared with conventional techniques.


*Original photograph: Anglo-Australian Telescope Board*

## Radio astronomy and technical innovation

*The urge of mankind to understand the cosmos provides the stimulus for the development of new and improved instruments for radio astronomy observations. This in turn can lead to applications in other fields, such as radio communications and navigation.*

It is from radio astronomy that man has learned of quasars, the greatest sources of energy in the universe; of pulsars, the collapsed stars whose radio beams sweep past the Earth as the stars spin at the incredible rate of several revolutions per second; of charged particles ejected from the Sun at nearly the speed of light; and of relatively dense clouds between the stars that contain many complex molecules related to the origins of life. Radio astronomy tests the fundamental theories of physics such as relativity and gravitation, it provides a means of studying matter in states of density and temperature



which are impossible to achieve on the Earth, and by investigating the acceleration of particles in plasmas it adds to the understanding man needs before he can achieve controlled thermo-nuclear fusion on the Earth. Radio astronomy gives warnings of likely interference to terrestrial radio circuits following solar explosions, and the techniques it has developed are widely used in communications and navigational systems.

Research in radio astronomy by the DIVISION OF RADIOPHYSICS began immediately after World War II in an attempt to understand two types of radio 'noise'. One form was found before the war by an American engineer investigating interference to trans-Atlantic radio telephones: he discovered radio noise coming from our Galaxy, the Milky Way. The second was discovered during the war when intense radio noise from the Sun jammed radar sets in Britain.

In studying these radio signals, the key to success has been the continuous development of new instruments. Initially the Division applied the expertise in radar technology which it had acquired during the war. Since then there has been a continuing cycle in which the Division has developed new technology to achieve the aims of basic research, and then gone on to find applications for the new technology and the new principles involved in it in areas quite removed from radio astronomy. The most recent example of this has been the successful development by the Division

The southern barred-spiral galaxy NGC 1365,
(a) as photographed with the Anglo-Australian 3.9 metre optical telescope,
(b) as it would appear with the resolution of the Parkes 64 metre radio telescope operating at a wavelength of 6 cm, and
(c) as it would appear with the resolution of the proposed Australian Synthesis Telescope operating at the same wavelength.

of the Interscan microwave landing system for aircraft which has now been selected for international adoption. (See article on p. 25.)

From the start, radio astronomy has been faced with twin problems—the natural signals received from the cosmos are incredibly weak and also, because of the relatively long wavelengths of radio waves it is difficult to distinguish or resolve the detailed structure of the emitting region. The development of instruments capable of overcoming these difficulties has been followed by a series of spectacular advances in our knowledge of the Universe. The problem of weak signals has been overcome by a steady increase in the size of radio telescopes and by the development of new receivers of ever greater sensitivity. The increased size of radio telescopes also increases the resolution of fine details of the emitting regions. But, as explained below, much greater improvements in resolution have followed fundamental developments in aerial design and signal processing. As a result the radio astronomer can now produce a map or television-type picture of the sky, revealing fineness of detail comparable with that obtainable with optical telescopes.

The Division's well-known 64 metre diameter telescope at Parkes, New South Wales, for many years the world's finest fully steerable radio telescope, was designed to be an extremely versatile instrument. To collect as much signal as possible, the designers made the telescope as large as they could, consistent with maintaining the accuracy of the reflector surface as the telescope is tipped to face different parts of the sky. In addition, it is equipped with radio receivers having the highest possible sensitivity. All receivers generate internal radio noise and to detect the very weak signals from space this noise must be kept to a minimum. Scientists have therefore developed new types of radio receiver, including the maser (the microwave forerunner of the laser) and the parametric amplifier. To reduce this internal radio noise still further, the Parkes telescope receivers are refrigerated to temperatures as low as -269°C (four degrees above absolute zero).

The ability of a telescope to resolve the details of the source of radio signals depends on both the wavelength of the radio waves being received and on the size of the aerial systems. The resolution increases for shorter waves and for larger aerial systems. Originally the Parkes 64 metre telescope was designed to operate at wavelengths down to 10cm. Because of careful initial design, however, it has been possible to make a series of modifications which have resulted in a reflector surface that is smooth enough to operate efficiently at much lower wavelengths. The whole 64 metre diameter surface can now be used for wavelengths as short as 25 millimetres, while a central 17 metre section can be used down to wavelengths of 3 millimetres. Because of the large size of these surface dimensions relative to the wavelengths studied, the telescope is able to map radio-emitting objects in the sky with an angular blurring of only about 1 minute of arc.

The Parkes 64 metre telescope has been used to study quasars and pulsars, to map the radio emission from hot gas clouds condensing to form new stars, and to map the cold dense clouds which surround the hot regions and have an unexpected abundance of organic molecules. It has studied objects ranging in distance from the Moon and planets to the far fringes of the Universe. But perhaps the discovery of organic molecules in the gas between the stars has stirred the imagination more than most other discoveries. The unexpected presence of these relatively complex molecules—building blocks of the proteins—in the vastness of interstellar space touches on the very basis of man's origins. It is for this reason that the Division recently acquired a new telescope at its headquarters at Epping, Sydney. This telescope, although only 4 metres in diameter, can operate at wavelengths as short as 1 millimetre (compared with 3 millimetres for the Parkes telescope) and therefore has the potential to detect a much greater range of molecules in space.

Although the Parkes telescope is extraordinarily versatile over a range of wavelengths from 3 millimetres to 3 metres, it is only at the shortest wavelengths that it achieves a resolution approaching 1 minute of arc. In maps made at a wavelength of 3 metres, for example, the angular blurring is several degrees. To achieve higher resolution than is possible with a single, fully steerable telescope, radio astronomers have devised many ingenious aerial systems. When resolution is more important than sensitivity, it is possible to collect signals with arrays of aerials occupying only a portion of the potential aperture area. Distorted images would normally be produced by such a system but this problem can be overcome by special signal processing. This technique permits the construction of the extremely large apertures needed to achieve very high resolution. The Mills Cross, originally developed by the Division, was one of the first aerials of this type. Its two long narrow collectors—the arms of the cross—can be much longer than the diameter of a steerable dish. So, for the long wavelengths at which the cross was designed to operate, the resolution is much higher. In a later development—the Christiansen Cross—each of the long arms of the Mills Cross was replaced by a row of fully steerable dishes allowing the device to be pointed anywhere in the sky.

A different arrangement of steerable dishes is used in the Division's radio-heliograph (literally, 'radio sun mapper') located at Culgoora, near Narrabri in northern New South Wales. Here 96 dishes, each 13 metres in diameter, are arranged on the circumference of a circle 3 kilometres across. This large overall dimension ensures that the resolution of the telescope at the wavelengths used (between 1 and 7 metres) provides reasonably detailed maps of the radio emission over the surface of the Sun. The signals from the 96 dishes are processed in such a way that the instrument simultaneously records the radio signals coming from 48 different positions along a line on the Sun. In half a second these beams are swept across the Sun so as to form a television-type picture of the radio emission from the Sun: in successive half-second intervals pictures may be made at four different wavelengths and in two polarisations.

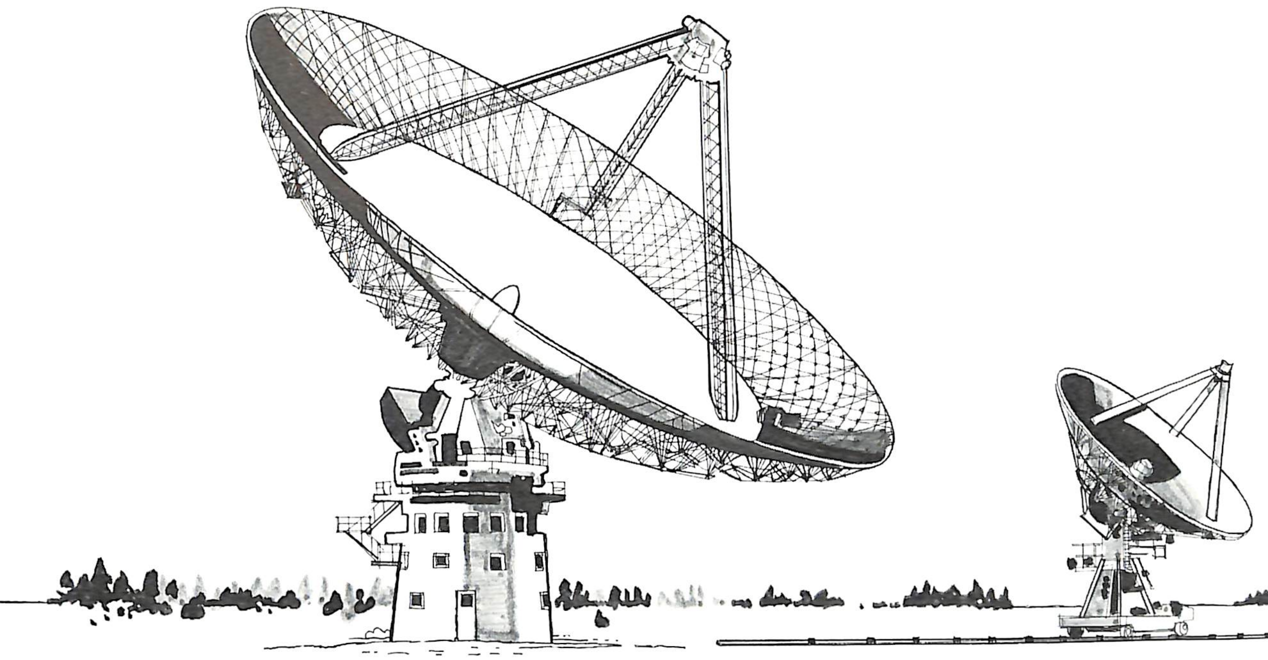
The maps from this unique instrument show the violent activity taking place in the normally invisible outer parts of the Sun's atmosphere and the ejection of clouds of charged particles, some of which later hit the Earth's upper atmosphere. Because of the importance of these studies, the Division is currently converting the Culgoora instrument from a scanning telescope to one which will record the entire map of the Sun simultaneously. This will allow the study of still more rapidly varying phenomena. In another development, the outward transport of energy at lower levels in the Sun's atmosphere will be studied by mapping the millimetre wavelength radio waves from the Sun using the new 4 metre telescope at Epping working as an interferometer with a smaller dish.

It is not only in the development of new forms of aerial that the DIVISION OF RADIOPHYSICS has shown the way in instrumental developments for radio astronomy. Important advances have also been made in signal processing. One powerful method of analysing radio signals is to separate them into channels according to their wavelengths. By analogy with optics, the devices which achieve this are called radio spectrographs. Many of the early clues to understanding the explosions on the Sun, including the ejection of clouds of electrons at nearly the speed of light, came from the solar radio spectrograph which was pioneered in the Division. In this device, a single filter was automatically tuned across the wavelength range every half second.

Radio spectrographs used at Parkes to identify the chemicals present in the clouds between the stars and to measure the speeds of these clouds were also constructed in the Division. Some of these consist of banks of filters spanning a whole range of wavelengths simultaneously. Another is a special-purpose high-speed computer (digital correlator) which analyses the signal into a thousand different wavelength ranges simultaneously. The latest radio spectrograph developed in the Division—the acousto-optic spectrograph—can also provide a thousand simultaneous channels spanning an even wider range of wavelengths than the digital correlator. In this device the radio signal, converted into a supersonic wave in a transparent crystal, deflects a laser beam across an array of solid-state photo-diodes which in turn convert the laser light into electrical signals.

The urge of mankind to understand the cosmos provides the driving force for the development of instruments for radio astronomy, but the instruments and the principles they embody may then find applications in other fields and particularly in modern communications. The resemblance between a satellite communciation ground station and the Parkes radio telescope is not coincidental. Also, the performance of communication systems can now be checked by making measurements of the cosmic radio sources discovered by radio astronomers. Receivers with very low noise were developed by radio astronomers to meet their research needs and have since found wider application in communication systems. Telecom Australia needs inexpensive low-noise amplifiers so the DIVISION OF RADIOPHYSICS and Telecom are engaged in a joint project to develop refrigerated receivers employing field-effect transistors.

The spin-offs from radio astronomy are not always in the form of instruments. Observations with the Culgoora radioheliograph, for example, are used to study the methods of predicting the



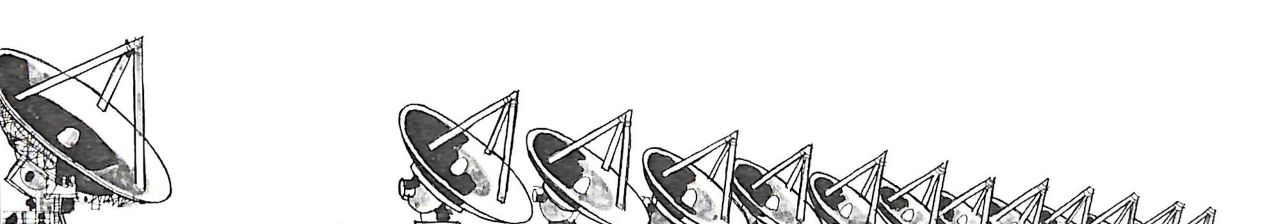
disturbances to communications on the Earth as well as dangers to high-flying aircraft and manned spacecraft. However, the greatest spin-off is undoubtedly the deep understanding that has been obtained of the physics of both the radio sources in the sky and of the instruments themselves. It was the familiarity with the physics of aerials and radio waves coming from research in radio astronomy that enabled the Division to achieve such success in the design of an aircraft landing guidance system. The international adoption of the Interscan system developed by the Division not only ensures that aviation will have a navigational aid of the highest order, but also offers considerable commercial opportunities for the Australian electronics industry.

Progress in the study of the Universe around us depends on the continued development of new instruments. Currently there is a great need for an instrument capable of mapping the radio emission of the southern skies with less blurring than occurs with present telescopes. Recognising this need, Australian astronomers have combined to propose the building of such an instrument—a synthesis telescope—as a joint project of the Australian National University, the University of Sydney, the University of Tasmania, Monash University and the DIVISION OF RADIOPHYSICS.

The proposed Australian Synthesis Telescope will use an array of smaller dishes in conjunction with the Parkes 64 metre telescope to produce maps by 'Earth rotation synthesis'. This process combines observations of a celestial object made throughout a 12-hour period. As the source moves across the sky due to the rotation of the Earth, the projection of the aerial baseline seen from the source changes and, in effect, fills the gaps between the dishes so as to synthesise an almost complete aperture.

The angular resolution of a synthesis telescope is still determined by the overall extent of the aerial system. With the proposed telescope operating at its shortest wavelength of 13 millimetres, the maps will have detail down to 1 second of arc, or 100 times better than with the Parkes 64 metre

Artist's impression of the array of antennas of the proposed Australian Synthesis Telescope. The array incorporates the Parkes 64 metre telescope, shown here at left.



telescope alone. This detail is comparable with that in optical sky photographs. Studies with the proposed Australian Synthesis Telescope will complement those being made with optical telescopes such as the new Anglo-Australian Telescope and the UK Science Research Council's Schmidt Camera on Siding Spring Mountain near Coonabarabran, New South Wales.

The design of the Australian Synthesis Telescope is being optimised for studies of gas clouds in our Galaxy and nearby galaxies since the centre of our Galaxy passes overhead in Australia and the nearest external galaxies—the Clouds of Magellan—are observable only from the southern hemisphere. However, it will be a versatile instrument and in addition will be used to study the physical processes in quasars, radio galaxies, neutron stars, black holes and other mysterious objects in the Universe where complementary observations in the radio, optical and X-ray regions of the electromagnetic spectrum are required.

Design studies of the new telescope are under way as a collaborative project between the sponsoring institutions. Many of the novel features will be tested in a two-stage joint project of the DIVISION OF RADIOPHYSICS and the Australian National University. In the first stage, the existing 64 metre and 18 metre telescopes at Parkes are being linked to form a basic operating module of the proposed synthesis telescope. In the second stage, a prototype of the antennas for the proposed synthesis instrument will be designed and constructed.

The construction of a national synthesis telescope would not only enable Australia's astronomers to contribute their share to man's understanding of the cosmos, but would also uphold our reputation for technical innovation in radio astronomy. From past experience, moreover, the project could be expected to yield additional dividends in those many earthly applications which share the same underlying physics and techniques.

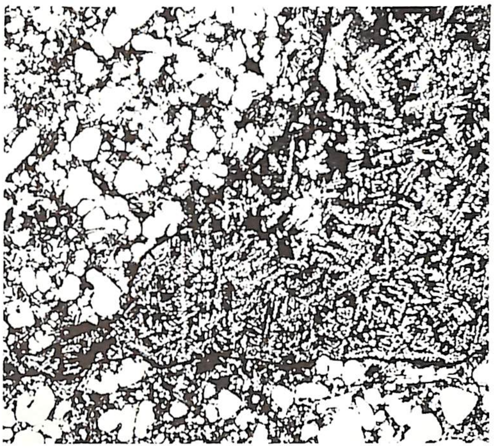
### Better diecastings

*Studies of high pressure diecasting have cut production costs, improved the quality of castings and stimulated the export of refined metals.*

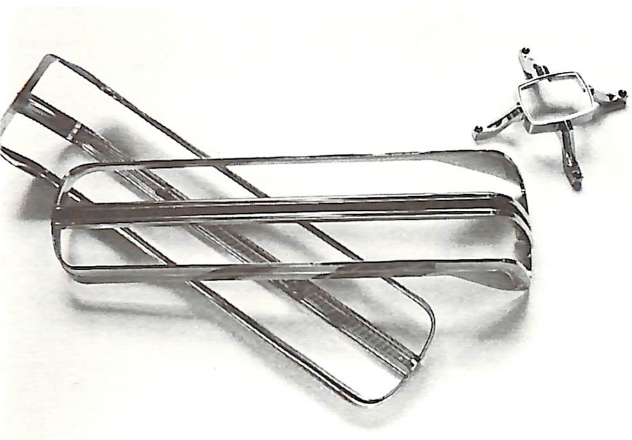
High pressure diecasting is a direct and potentially economical method of producing many of the components needed by manufacturing industry. Essentially, it consists of injecting molten metal into a cavity between two steel die-blocks at high speed and under high pressure.

In Australia, the diecasting industry is made up mostly of small and medium-sized, Australian-owned companies. It relies for its raw materials on metals that are mined and refined locally; the refined metals also have a large export market. The problems besetting the industry over the last few years have arisen mainly from the need to produce parts economically in a small and highly diverse market in competition with alternative processes and imported components. However, diecasting lends itself to a high degree of automation and sophistication even while retaining the small production units characteristic of the Australian industry.

In order to enable diecasting to realise its full economic potential and to stimulate the export of the refined metals, the DIVISION OF MATERIALS SCIENCE, the diecasting industry, major mining companies and industry development associations have undertaken, over the past six years, a joint program of research and development. The program has been aimed at upgrading the technical efficiency of the process and also at developing the industry into a model for the overseas users of Australian raw



Fine tree-like dendrites of aluminium formed by premature solidification of a molten metal stream at the entry to a die cavity. Significant improvements in the design and operation of the system through which molten metal is fed into the die cavity in the casting tool have resulted in the elimination of casting defects associated with this type of blockage of the high speed metal stream. *Photograph: Dr Peter Robinson*



Improvements in high pressure diecasting technology have led to the production of tough, thin-walled diecastings for a variety of applications, such as these car tail-light bezels.
*Photograph: Australian Zinc Development Association*

materials. The Division's contribution of research staff and facilities has been matched with the supply by industry of plant, engineers and production staff. The funding of the program has been aided by a significant contribution from the International Lead Zinc Research Organization.

Scientists at the DIVISION OF MATERIALS SCIENCE have made a meticulous study of the basic physics, engineering and metallurgy involved in diecasting and have developed or adapted a number of tests and techniques in order to understand and hence improve the process. For example, techniques for studying engineering design problems have ranged from computer modelling to methods for gathering and storing information on process variables that fluctuate in fractions of a second. Techniques for evaluating the reliability and performance of the products have included scanning electron microscopy and fracture toughness testing. Projects have varied from laboratory experiments to full plant trials using production tooling and machines.

Major aims have been to reduce the cost of developing the dies in which components are cast and the machines which carry the dies and inject the molten metal. Another objective has been to improve the metallurgical quality of the casting.

Significant improvements have been made to the design of the system through which molten metal is fed into the die cavity in the casting tool. These improvements have been based on an understanding of the flow of liquid metals at high pressures and velocities. In the currently evolving technology, metal enters the die cavity at speeds of up to 50 metres per second, filling the casting cavity in times as short as a hundredth of a second. During this time, the distribution of the metal into the cavity is controlled so as to minimise defects in the casting. As a result of this research, the design of casting dies is now based on scientific principles and assessment of performance rather than on experience alone.

Another important area open to improvement has been the design of casting machines, all of which are imported into Australia. The Division has collaborated with overseas manufacturers and in some cases it has been possible to incorporate changes during manufacture. In other instances, improvements have been made after importation. Improved process control—that is the control of variables while the process is actually running—has been made possible by the methods developed by the Division for high speed processing of information and analysis of data. The combination of these special methods with the new design criteria has led to substantial improvements in the quality and reliability of the product, together with higher production rates. Finishing costs have been reduced by about 30 per cent as the surface finish of the castings is suitable for direct electroplating or other surface coating operations, without the need, as previously, for prior polishing and buffing.

The Division's research into the engineering and metallurigcal aspects of high pressure diecasting has led to considerable improvements in the design of diecast components. As a result, a range of cast products is being manufactured which are setting new standards of technical achievement. Tough, light-weight castings with wall thicknesses of less than one millimetre are being produced for a variety of applications. The reduction in weight and consequent savings in the cost of raw materials is of prime importance in many applications, for instance in castings used in cars and domestic appliances.

The methods of transferring technology to industry and of translating technology into practical use have revolved around the high degree of collaboration established between research and industry staff from the outset of the project. Research workers have been in constant contact with a network of personnel at various levels of management and production from a number of firms. The degree of collaboration has enabled research and development in the Division to proceed simultaneously with innovation on the shop floor in an industry dominated by small production units.

The success of the program can be measured in terms of the high degree of technical excellence achieved and the associated savings in production times and costs. Equally important, the technological innovations introduced have made Australia a focal point for world-wide interest in this precision engineering technique.

## Fire hazard standards for textile products

*CSIRO is making an important contribution to the development of realistic Australian and international standards that define the extent to which various textiles and products incorporating textiles present a fire hazard.*

Textiles—whether used in clothing, curtains, carpets, furniture or mattresses—are flammable. However, the degree of flammability and the fire hazard that various textiles present differs considerably depending on the textile itself, the product it is used in, the design of the product, the size and type of ignition source, the time for which the ignition source is applied, and so on. Standards are written to quantify these hazards and may include the results of fire test procedures, design specifications and use limitations.

A recent survey by the International Organization for Standardization (ISO) revealed that ninety different flammability test methods were employed in the nineteen responding countries. While it is not possible to have only one test method, because textiles used in different applications (for example, clothing and carpets) obviously require different tests, it is important both for the promotion of fire safety and for international trade that common flammability standards be adopted for each particular end-use. It is equally important that the small-scale test methods selected are relevant to the real fire situation.

Flammability research by the DIVISIONS OF BUILDING RESEARCH, PROTEIN CHEMISTRY and TEXTILE PHYSICS is making a significant contribution to the development of realistic Australian and international standards.

In October 1977, an ISO sub-committee concerned with the burning behaviour of textiles and textile products met, together with its five Working Groups, in Washington. Three CSIRO officers (two from the DIVISION OF PROTEIN CHEMISTRY and one from the DIVISION OF TEXTILE PHYSICS) attended the Working Group meetings as individual experts and the plenary meeting as members of the Australian delegation. The proposals for international standards drafted at the meeting were in accord with and were influenced by the results of Australian research.

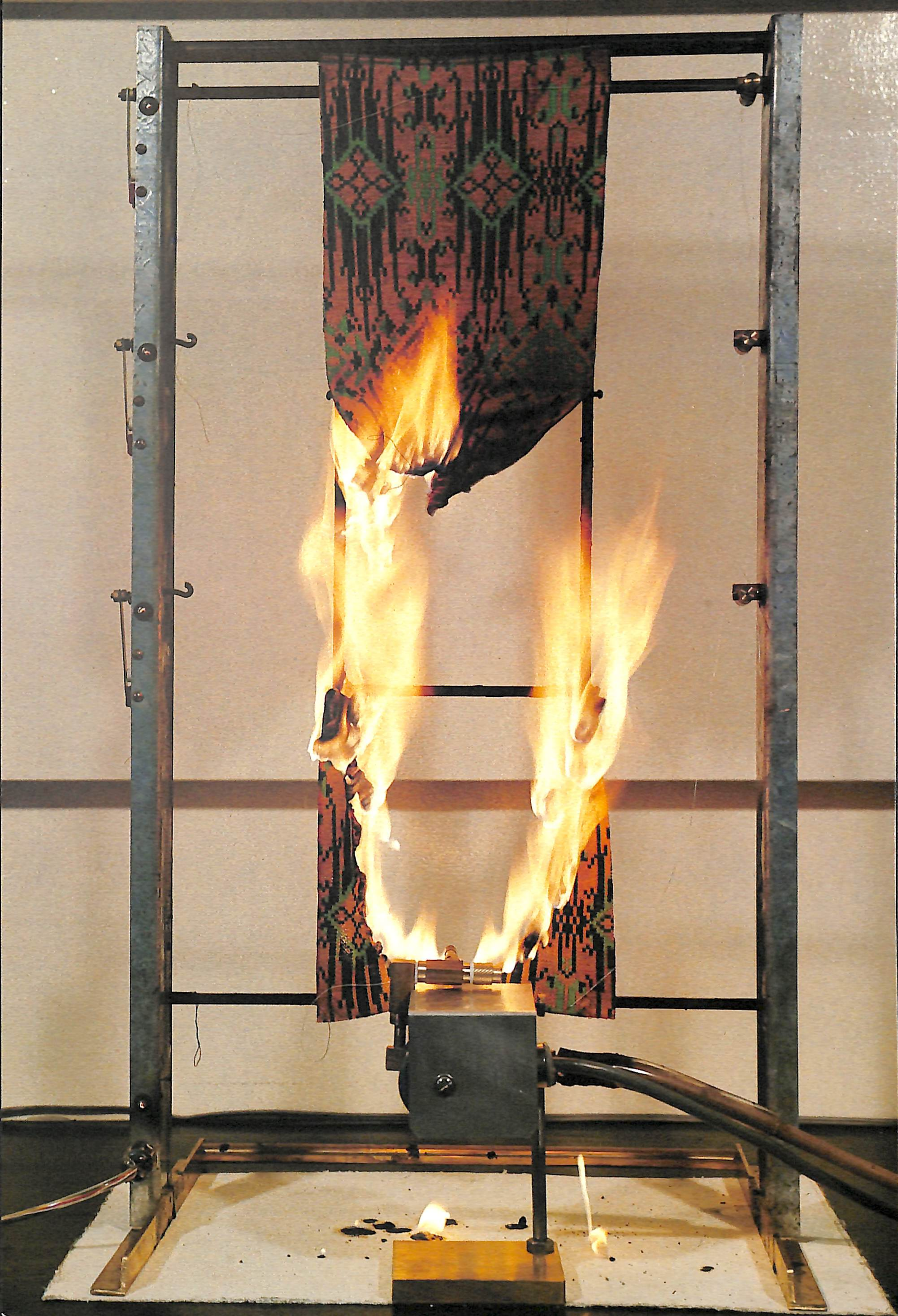
Before the Washington meeting, international interlaboratory trials were conducted to compare small-scale tests with fabric rankings obtained in full-scale tests in order to establish which aspects of the small-scale tests were important and which were not. The DIVISION OF PROTEIN CHEMISTRY participated in the trial on apparel fabrics, and analysed the results of the whole trial. The best correlation with full-scale burning experiments on manikins was obtained with a test method wherein the specimen was loosely constrained on a frame, ignited on the surface of the fabric, and an adequate length of specimen used.

The DIVISION OF TEXTILE PHYSICS participated in an international interlaboratory trial on curtain flammability. Small-scale methods investigated by the Division included two Australian Standard methods of test (one initially developed for apparel textiles, the other for textiles or thin sheet pliable building materials), a German method previously proposed for consideration as an ISO standard, and a 'semi-restrained' test based on an American proposal.

The most significant feature to emerge from the trial was the importance of the specimen holder. It was demonstrated that tests in which the specimen was loosely constrained (by pins or chains) gave results consistent with full-scale experiments, whereas specimens clamped tightly in a U-shaped metal frame—as is the case with the German method—behaved differently.

Both Australian test methods feature loose restraint and gave results which correlated well with each other and with full-scale tests conducted by the Department of Construction at its Experimental Building Station at North Ryde. Neither method exhibited marked superiority over the other, so rationalisation of methods will be deferred until an ISO method is adopted.

The DIVISION OF BUILDING RESEARCH is investigating the fire behaviour of carpets,



mattresses and furniture which incorporates textiles, and is represented on the relevant committees of the Standards Association of Australia which are concerned with the fire hazard of these items.

In the case of carpets, the main ignition situations are a small flaming source such as a lighted match, a small smouldering source such as a cigarette, and a large source with accompanying high levels of radiant energy such as a burning piece of furniture or even a whole room and contents involved in a fire. An interlaboratory trial of test procedures which assess flame propagation when the source of ignition is a small flaming or smouldering object, has been conducted amongst various Melbourne laboratories and a draft Australian Fire Hazard Standard has been written on the basis of the results obtained. The Division is at present assessing test procedures applicable to the high radiant energy conditions of ignition and intends to develop a procedure which will determine both flame propagation and smoke release characteristics of carpets.

The factors which determine the fire hazards of mattresses are complex, because mattresses are used in combination with bedding items such as sheets, blankets and quilts. The DIVISION OF BUILDING RESEARCH has carried out experiments with various bedding assemblies to examine their ignitability with small ignition sources such as lighted cigarettes and matches. It is also trying to assess the associated hazards in terms of flame propagation, release of heat, smoke, and toxic gases once the mattress has been ignited. Because of the complexity of the situation, further work is needed before definite conclusions can be drawn and recommendations made to the relevant SAA committee.

The Division is also concerned with the fire behaviour of various items of furniture. For example, it has been studying the behaviour of bean bags covered with polyvinylchloride coated fabric when subjected to ignition sources such as lighted cigarettes, matches, newspapers and portable electric radiators. The bean bags examined could not be ignited with lighted cigarettes, and although the cover was ignited by a lighted match the bag filling was not involved. However, when burning newspaper or an electric radiator were used the bean bags ignited and burned to completion. The effect of introducing fire retardant chemicals into the filling material—expanded polystyrene beads—was also assessed, but no significant difference in behaviour was observed between bags containing beads with retardant and those containing beads without retardant. Simulation experiments have also been carried out for Australian railway authorities on prototype railway carriage seats using burning newspaper as an ignition source.

Despite the achievements of the three Divisions to date, much more research remains to be done, not only in the areas relevant to fire hazard standards, but also in fundamental work on such matters as how flame retardant treatments for textile materials actually work and the nature of the toxic gases produced when textiles burn.

A synthetic material being tested on the apparatus proposed for an international test method for measuring the rate of flame spread on vertical textile specimens. Time is measured from application of the gas flame igniter until each of three cotton marker threads is severed by the flame. Loose constraint simulates the effects of a real fire situation as it allows the fabric to shrink away from the igniting flame.

## Better hearing aids

*A hearing aid has been developed which offers people with impaired hearing a new dimension in communication.*

A conventional hearing aid helps its users by amplifying sounds so that they can be heard. Unfortunately, a person with defective hearing has difficulty in dealing with a mixture of sounds, for example, when listening to speech in a noisy environment. His hearing aid simply amplifies all the incoming sounds, leaving the voice obscured by noise.

The problem of noisy environments can be overcome by using the hearing aid in conjunction with a second microphone that a speaker can wear or hold near his lips. In this way his voice is amplified relative to the background noise and is much more easily discerned. Although the principle has long been recognised, the practicalities of sending a signal from a remote microphone to a hearing aid have prevented its general adoption. Wire connections are awkward, even in a comparatively simple situation such as a school classroom. Here, radio transmission can be used to advantage, provided each class has its own frequency channel to prevent interference between transmissions in nearby classrooms. In everyday situations, however, the widespread use of radio transmission by hearing aid users would result in excessive interference.

In collaboration with the National Acoustic Laboratories of the Department of Health, the NATIONAL MEASUREMENT LABORATORY has developed a short range wireless system that avoids interference between transmissions on the same frequency. Instead of using radio waves, the new development uses a magnetic induction field which decays rapidly with distance from the transmitter. Transmissions can generally be made on the one frequency, since each receiver responds to the strongest signal and simply picks up the transmission nearest to it. Even within a single room, several transmissions can proceed simultaneously on the same frequency. No tuning-in is needed to select the required transmission; the listener simply remains within normal conversational range of the speaker. In schools for deaf children it would be necessary to avoid using the same frequency in adjacent classrooms and several frequencies would be required.

The National Acoustic Laboratories have embarked on a program to supply their younger patients with aids of this type for use at home, at school and anywhere else where they will need help. The localised nature of the transmission removes any need to restrict usage. In November 1977, the Commonwealth Government let an $874 000 contract to Plessey Australia Pty Ltd for the miniaturisation of transmitters and receivers for this program. It is anticipated that the aids will become available to the general public in due course.

Because the operation of the system depends on the use of frequencies within a particular and limited range, it is desirable that these frequencies be set aside for this purpose to prevent interference from strong radio signals. Several channels have been assigned in Australia, and it is hoped that, despite the present intense competition for frequencies, the 1979 World Administrative Radio Conference will provide a suitable world-wide frequency allocation.

The NATIONAL MEASUREMENT LABORATORY is investigating the application of the same system of wireless transmission to permit person-to-person communication in noisy situations such as in a factory.

## Creating clean vacuums

*A new, oil-free mechanical vacuum pump enables clean, ultra-high vacuums to be attained.*

Many scientific and industrial operations can only be performed in a vacuum. Large numbers of vacuum pumps of various kinds are manufactured, the main type being the oil-sealed, rotary-vane backing pump. These pumps have been the mainstay of the vacuum industry ever since they were introduced by Gaede in Germany some 70 years ago. At present, well over $100 000 000 worth of Gaede pumps are produced in Europe and North America each year.

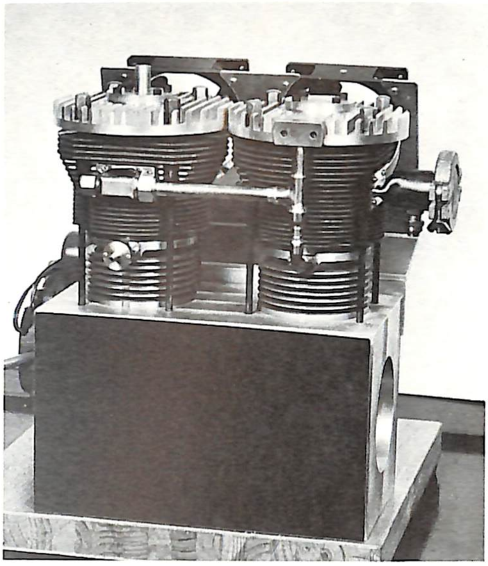
Pumps of the Gaede type are capable of reducing the amount of air in a vessel by about a million times, so that the total pressure of nitrogen and oxygen falls from 101 000 pascals (atmospheric pressure) to about 0.1 pascal. Unfortunately, the oil which is used to lubricate and seal Gaede-type pumps rapidly degrades with use, and as the oil molecules break into fragments, the vacuum becomes contaminated with an oily vapour which frequently raises the pressure in the evacuated vessel to about 0.5 pascal.

In some kinds of scientific instruments the presence of this oily vapour is extremely troublesome. This is the case with modern electron microscopes, which can produce images of details which are about a thousandfold smaller than those that can be seen with the best light microscopes. However, the presence of the oily vapour in an electron microscope leads to the deposition of a carbonaceous contaminating layer of material on the specimen and on various surfaces exposed to the electrons. This contaminating material obscures the finer details of specimens and, in addition, becomes electrically charged so that it causes the electron beam to be deflected, resulting in a deterioration of the optical performance of the microscope. The presence of oil vapour and the resulting carbonaceous deposits also seriously affect the performance of other types of instrument such as various kinds of mass spectrometer and electron diffraction camera.

The manufacture of transistors, metal-coated plastic goods, anti-reflecting camera lenses and many other familiar articles involves the deposition in vacuum of thin layers of metals, insulating materials and transparent and light-absorbing substances. These deposition processes and the properties of the deposited layers are particularly sensitive to the presence of oil vapour which can seriously affect the quality of the product.

Obviously, the problems presented by oil vapour could best be avoided by using oil-free backing pumps and a number of manufacturers have attempted to produce a suitable design. At present, oil-free backing pumps of the rubber diaphragm, metal bellows, carbon-vane and piston types, all capable of continuous operation, are in production. However, none of those marketed at present is able to produce pressures much lower than 1000 pascals, so their usefulness is limited.

In response to the pressing need for a high performance oil-free mechanical vacuum pump, the DIVISION OF CHEMICAL PHYSICS has developed a twin cylinder reciprocating piston pump which is oil-free. This pump is fitted with piston rings made from polytetrafluoroethylene (Teflon) polymer, a self-lubricating material, filled with finely divided materials which render the polymer sufficiently wear-resistant. This composite material has a very high coefficient of expansion and a low thermal conductivity, so the heat generated in the piston rings during operation could cause them to expand and seize in the cylinder bores. To overcome this problem, the Division evolved a special piston ring design which prevents the rings from exerting large forces on the cylinder walls when their



A parallel twin-cylinder model of the oil-free vacuum pump developed by the DIVISION OF CHEMICAL PHYSICS. From atmospheric pressure down to 80 pascals, the pumping speed is 75 litres per minute. The pump can achieve pressures of less than 0.5 pascal. *Photograph: Roger Lamb*

temperature rises. In addition, the design adopted ensures that, even without oil as a sealant and lubricant, the rate of leakage of air past the rings is very low.

The capabilities of the oil-free mechanical vacuum pump far exceed those of any comparable pump. The most recent laboratory model is able to reduce the total pressure of atmospheric gases such as nitrogen and oxygen to better than 0.5 pascal, which is about 1000 times better than has been achieved with currently marketed oil-free mechanical pumps. The lifetime of the piston rings is quite adequate: a pump which has operated continuously for 3500 hours shows no evidence of serious wear. The new pump achieves a pumping speed about equal to that of oil-sealed pumps of similar size.

In order to reach extremely low pressures, it has always been standard vacuum practice to use a second pump, of a type specially designed for the purpose, in series with a mechanical backing pump. In 1958, titanium ion pumps were invented to perform this function and they are now widely used to produce ultra-high vacuums. Pumps of this type contain no organic material so they cannot give rise to contaminating vapours; however, they must be evacuated to pressures below one pascal before they can be operated without overheating. Experiments have proved that the Division's oil-free pumps are eminently suitable for pre-pumping titanium ion pumps to pressures at which they can be switched on safely. In this way, perfectly clean vacuums can be produced and suitable systems can be pumped down rapidly and conveniently from atmospheric pressure to less than $10^{-8}$ (one hundred millionth) of a pascal.

The design of the oil-free mechanical pump has aroused considerable interest overseas. A licence to manufacture the pumps has now been issued to the Australian-owned firm Repco Research Pty Ltd. Repco has undertaken to manufacture the pumps in Australia and market them throughout the world.

Tarrango, a new wine grape bred specifically for Australian conditions by the DIVISION OF HORTICULTURAL RESEARCH. The wine is a light red, suitable for drinking within a year of vintage.

So far, the Division has bred three other new varieties of grape—Carina, for the production of currants, and Goyura and Tullilah for wine.
*Photograph: Ted Lawton*


CSIRO
DIVISION OF
HORTICULTURAL RESEARCH
1977
TARRANGO
WINE GRAPE QUALITY LABORATORY,
MERBEIN, VICTORIA.

## Carbon dioxide in the atmosphere

*Increasing levels of carbon dioxide in the atmosphere may bring about significant changes in our climate.*

Carbon dioxide makes up only about 0.03 per cent of gases in the atmosphere, yet it has a significant effect on climate. Carbon dioxide absorbs part of the heat radiated from the earth that would otherwise be lost to space and so helps to warm the lower atmosphere. Studies have shown that the level of carbon dioxide in the atmosphere is increasing.

If levels continue to rise at the present rate, the concentration of carbon dioxide could double by the middle of the next century and produce a rise in average air temperature of about 2–3°C. This would have far reaching implications for our climate and for those activities such as agriculture which are climate-dependent. In polar areas, temperature increases could be even higher with the attendant danger of significant melting of the ice caps and consequent increases in ocean levels. The AUSTRALIAN NUMERICAL METEOROLOGY RESEARCH CENTRE has been examining the way in which changing carbon dioxide levels could alter current patterns of climate by changing the heat budget of the troposphere or lower atmosphere.

Independently of man's activities, carbon dioxide is cycled continuously between land and sea via the atmosphere. In the oceans, it is stored largely as carbonates and bicarbonates, while on land it is incorporated in plant matter. Land and sea surfaces act as both sources and sinks of carbon dioxide, depending on circumstances. Broadly speaking, the oceans absorb carbon dioxide when the surface temperature falls and release it when the temperature rises. On land, plants take up carbon dioxide from the air during photosynthesis and convert it into carbohydrates. This carbon dioxide is returned to the atmosphere during respiration and when the plants decay.

The DIVISION OF ENVIRONMENTAL MECHANICS has investigated whether the rate at which plants remove carbon dioxide from the air is large enough to have a significant effect on regional atmospheric carbon dioxide concentrations. Measurements made in wheat fields near Wagga Wagga and Bungendore, NSW, show that the air near the crop contains up to 15 per cent less carbon dioxide than the free atmosphere, but large day to day variations occur, which appear to be associated with the distance the air has travelled over vegetation. The changes are large enough to account for daily variations in the rate of plant photosynthesis of about 20 per cent for moderately productive regions. These results underline the necessity for assessing carbon dioxide concentrations from samples of maritime air or other air which has not passed over growing plants.

About six years ago, the DIVISION OF ATMOSPHERIC PHYSICS began studying levels of carbon dioxide in the atmosphere. Sampling regions are carefully selected to ensure that carbon dioxide levels are not affected by local effects, for example, industrial activity or plant growth. Air samples are collected using aircraft fitted with special equipment designed and built at the Division. Pressure-activated switches allow the equipment to operate automatically, drawing in samples of outside air at pre-determined altitudes. Results have shown that above a relatively shallow surface layer, carbon dioxide is distributed fairly evenly, both horizontally and vertically through the atmosphere, at least up to the base of the stratosphere or upper atmosphere.

Data obtained from aircraft have now been supplemented by data from a newly established 'baseline' station at Cape Grim in north-western Tasmania, where concentrations of carbon dioxide, as well as other atmospheric components, are monitored continuously. Responsibility for the station is shared by the Department of Science and the Department of Environment, Housing and Community Development; the DIVISIONS OF ATMOSPHERIC PHYSICS and CLOUD PHYSICS provide scientific guidance for the monitoring programs and their interpretation.

Results to date confirm findings made by research workers in the United States and Sweden, that the concentration of the gas is rising slowly but steadily. Whether the increase is due to the burning of fossil fuels on a massive scale, the clearing and burning of trees to provide timber and agricultural land, some long-term natural cycle of events, or a combination of these factors is not yet known. The DIVISION OF ATMOSPHERIC PHYSICS is now trying to trace the cause of the increase.

The measured increases in atmospheric carbon dioxide have usually been interpreted as meaning that between one third and one half of the man-made carbon dioxide remains in the atmosphere while the remainder is absorbed by the oceans and the biosphere. Overseas investigations into the penetration of the naturally-occurring radioactive carbon isotope $^{14}C$ into the surface layers of the ocean, indicate that only about 40 per cent of the missing two thirds is taken up by the ocean. By implication, the other 60 per cent should be taken up by the net growth of the biosphere. Yet, studies of the biosphere suggest that deforestation and agricultural practices have reduced its size. Thus the oceans are probably acting as much larger sinks than is apparent from the radiocarbon studies. Perhaps, too, the remaining biosphere is able to store more of the excess carbon dioxide than has been previously recognised.

Studies of other naturally-occurring isotopes of carbon ($^{13}C$ and $^{12}C$) may shed some light on the problem. Measurements by the DIVISION OF ATMOSPHERIC PHYSICS have shown that the relative amounts of $^{13}C$ and $^{12}C$ found in vegetation differ from the ratio found in the oceans by other research workers. Thus it may be possible to assess the extent to which the oceans and the biosphere are contributing to the carbon dioxide in the atmosphere.

The ratio of $^{13}C$ to $^{12}C$ laid down in annual growth rings of trees could provide a way of estimating the composition of the atmosphere before industrial activity altered the balance. Throughout their life, trees lay down carbon taken from the atmosphere and the $^{13}C$ to $^{12}C$ ratio present in the wood probably reflects the ratio existing in the atmosphere at the time of growth. The Division is burning dated growth rings from carefully selected Tasmanian trees, and analysing the resulting carbon dioxide for its isotopic composition. Some of the trees have been affected by local influences, and work now under way is aimed at using only those trees which are truly representative of the free atmosphere. Parts of Tasmania provide good sites from which to select trees which have been exposed to the prevailing unpolluted westerlies.

Since the temperature of the air over the oceans is closely related to the sea surface temperature, which in turn controls the release of carbon dioxide from the oceans, the information gained from the tree-ring investigations may also be a guide to past climates.

The exchange of carbon dioxide between the atmosphere and the biosphere is complicated by the large scale clearing and burning of trees to provide timber and agricultural land. While burning increases the amount of carbon dioxide, reduction of vegetation decreases the overall capacity of the biosphere to absorb the extra carbon dioxide.

In order to gain some insight into changing atmospheric concentrations on plant growth, the DIVISION OF PLANT INDUSTRY has been studying the effect of increased carbon dioxide levels on wheat yields. Experiments have shown that although rising carbon dioxide levels stimulate growth, the effect is modified by other factors such as the level of water, nutrients, temperature and light. The relative increase in growth rate of plants following carbon dioxide enrichment was found to be more marked when the plants were receiving less than optimum levels of light and water than when they were well lit and well watered. Previously it had been assumed that plant growth would be relatively insensitive to carbon dioxide enrichment if light and water levels were restricted. The role of the biosphere in absorbing excess atmospheric carbon dioxide will therefore have to be reassessed.

The agricultural implications of these research findings are particularly interesting for crops grown in areas such as Australia's wheat-belt where water supply limits yield. In an experiment where wheat was grown under conditions of severely limited water supply, yield was doubled by raising the concentration of carbon dioxide in the air around the crop by 60 per cent. Under agricultural conditions, this favourable result might be offset if temperatures rose or rainfall decreased as a result of the rise in atmospheric carbon dioxide.

**Better use of phosphorus fertilisers**

*Extensive research in a number of Divisions is increasing the efficiency of producing and using phosphorus fertilisers.*

In their native state, nearly all Australian soils are deficient in phosphorus. It is therefore not surprising that soon after it was first used here in the 1880s, superphosphate became the nation's most important and widely used fertiliser. It retains that position today, but two important problems now facing Australia are the rising costs of producing phosphate fertilisers and the diminishing reserves of high-grade phosphate rock on the oceanic islands from which supplies are currently obtained.

Superphosphate is made by treating finely ground phosphate rock with sulphuric acid. The rock contains calcium phosphate in an insoluble form. Superphosphate contains soluble calcium phosphates and calcium sulphate and is a valuable source of both the phosphorus and sulphur needed for plant growth. For superphosphate production to be economical, the phosphate rock should contain a high percentage of phosphorus and relatively low percentages of iron, aluminium and silica.

The oceanic island reserves of high grade rock could provide Australia's requirements for about 10 years, but in the longer term the much larger oceanic deposits of lower grade ore will have to be considered. These deposits, together with the very large phosphorite deposits in Queensland comprise our future domestic resources. The efficient utilisation of their phosphate content requires an understanding of their physical and chemical behaviour.

The DIVISION OF MINERAL CHEMISTRY is examining the behaviour of lower grade phosphate ores under chemical treatment. The aim is the use of such ores in the manufacture of superphosphate or alternative fertilisers. Particular attention is being paid to removing or rendering inert unwanted iron and aluminium. Several possible chemical reaction paths have been tested on low grade phosphate ore from Christmas Island. While these are technically viable, they are not as yet economic.

The effects of impurities on the crystallisation of the byproduct calcium sulphate during phosphoric acid manufacture are being studied with a view to utilising lower grades of ore.

In another approach to the problem, the DIVISION OF SOILS has evaluated a method for treating lower grade rock from Christmas Island. Finely ground rock is roasted (calcined) at high temperatures, then granulated for use as a fertiliser. The fertiliser is called Citraphos, because it contains phosphorus that is soluble in weak acids like citric acid. Trials show it to be a good phosphorus fertiliser for pastures in the wetter parts of southern Australia.

The DIVISION OF SOILS has also developed a fertiliser, Biosuper, made by mixing ground phosphate rock with elemental sulphur in a granule inoculated with sulphur oxidising bacteria. On contacting moist soil, the granule absorbs water and the bacteria multiply and turn the sulphur into sulphuric acid which reacts with the finely ground phosphate rock to produce superphosphate. Biosuper is being tested in trials throughout Australia but seems to be most suitable for pastures in high rainfall tropical areas.

When it is first applied to soil, most of the phosphorus in superphosphate is soluble, but it soon reacts chemically with the soil and much of it is converted into forms that are less available to plants. Consequently plants are unable to utilise all the fertiliser phosphorus during the growing season. The portion not taken up by plants—the residual phosphorus—remains in the soil but at a lower level of availability than when first applied. Many soil components including calcium, iron and aluminium compounds are involved in these reactions. Research at the DIVISION OF SOILS to determine the fate of phosphorus after it is applied to soils suggests that iron oxides hold phosphorus more strongly than aluminium oxides. Even though residual phosphorus is less available, it will still be of some value for plant nutrition, but the problem is to determine just how effective it is.

Recent research at the DIVISION OF LAND RESOURCES MANAGEMENT suggests that phosphorus is transformed into less available forms in two steps. Soluble phosphate becomes adsorbed or attached to soil particles in a relatively fast reaction and the adsorbed material is then slowly converted into a more firmly held form. The research showed that this slow reaction could be accelerated by warming or incubating soil that is in contact with applied phosphate. This technique was used to prepare soils to examine how the availability of phosphate changed after different periods of contact. It now seems certain that availability drops off quickly at first and then slows down with prolonged contact. By the time the relative effectiveness of phosphate has fallen to about a fifth of that of the freshly applied material, the decline has become very slow. Most of the soils studied behaved in a similar way—the differences between them did not seem to be related to any single soil property. Current research is aimed at studying ways in which the firmly-held phosphate can be released and thus made available to plants.

Farmers are constantly seeking aids to improve their decisions concerning applications of fertiliser. With rising fertiliser prices and falling returns for farm products, such decisions are now more critical than ever before. However, the optimum rate of applying superphosphate depends on many factors including the type of soil, its phosphorus status, the plant species, climatic environment and the type of farming enterprise.

A property of soils that markedly affects their responsiveness to applications of phosphorus is phosphate buffering capacity. This is the ability of a soil to resist changes in the concentration of dissolved phosphate as phosphorus is added or removed. Several years ago the DIVISION OF LAND RESOURCES MANAGEMENT developed a test for phosphate buffering capacity that could be used as an aid in predicting superphosphate requirements for Western Australian soils.

From the results of their studies into the reactions of phosphorus in soils, coupled with the use of phosphate buffering capacity to determine phosphorus requirements, scientists at the DIVISION OF LAND RESOURCES MANAGEMENT developed a mathematical model to help farmers decide how much superphosphate to use. The model, called 'Decide', was field-tested and refined in collaboration with the Western Australian Department of Agriculture. It is now widely used in Western Australia to determine how much superphosphate farmers should apply. Attempts are now being made to adapt 'Decide' for use in other parts of Australia and overseas.

The DIVISION OF SOILS has been collaborating with State Departments of Agriculture and fertiliser companies in the National Soil Fertility Survey. Data generated as a result of the survey are being analysed and a report is being prepared. The survey was intended to define the nutrient requirements of crops and pastures in southern Australia and to calibrate tests suitable for evaluating soil fertility.

Various methods are used in different States. Their reliability depends on local factors such as soil type and rainfall. Some tests are more suitable for particular soils than others and all tests must be calibrated against the responses of specific crops in field situations.

It has been estimated that less than 20 per cent of the phosphorus fertiliser applied annually in Australia is recovered in plant products. Research by the DIVISIONS OF LAND RESOURCES MANAGEMENT, PLANT INDUSTRY and TROPICAL CROPS AND PASTURES indicate that different crop and pasture species differ in their phosphate requirements. Reasons for the differences are being sought. Some plants appear to take up less phosphorus than others simply because they need less, while other plants appear to differ in their ability to utilise phosphorus from soil. If plants could be found that utilise firmly bound phosphate from soils, the efficiency with which phosphorus fertilisers is used would be greatly increased.

Research at the DIVISION OF PLANT INDUSTRY suggests that plants which use phosphorus more efficiently have a greater root volume and more root hairs. The increased area of absorption may, therefore, be a reason for improved uptake of phosphorus. Other factors that may also play a part in increased uptake include the ability of roots to render the soil acidic and the presence in plants of enzymes called phosphatases which assist in the uptake of phosphorus. In the DIVISIONS OF PLANT INDUSTRY and TROPICAL CROPS AND PASTURES attempts are being made to use the presence of these enzymes as an index of the phosphorus status of soils and plants.

In another approach to the problem of improving the recovery of phosphorus from soil, scientists at the DIVISIONS OF LAND RESOURCES MANAGEMENT, SOILS and TROPICAL CROPS AND PASTURES are examining vesicular arbuscular mycorrhizal fungi. These fungi infect the roots of most herbaceous plants and shrubs. The fungi act as an extension of the roots and increase the volume of soil explored, thereby enhancing the ability of the plants to recover nutrients including phosphorus. Some have the ability to infect roots at an early age and naturally help the plants to grow faster. Various strains are being examined with a view to selecting the best. The DIVISION OF IRRIGATION RESEARCH is examining the effects of both long-term and short-term water logging on these fungi.

Phosphorus, together with nitrogen, is necessary for the successful growth of pine plantations. Experiments at the DIVISION OF FOREST RESEARCH have shown that over the 30 years or so of a pine crop's life both rock phosphate and superphosphate can be effective sources of phosphorus. The rock phosphate must be finely ground high grade material to produce a result equal to that of superphosphate. Recent research has shown that for maximum benefit the fertiliser must be applied immediately after planting and that responses obtained by the time of canopy closure are permanent. Because of this, superphosphate, which provides a readily available source of phosphorus, is favoured for application at planting, and the use of rock phosphate in forestry has declined to almost nil.

The use of superphosphate in forestry is likely to increase as it is cheaper to produce more wood on existing plantations than to establish new ones. The Division is, therefore, examining phosphorus cycling and utilisation in forests.

The DIVISION OF TROPICAL CROPS AND PASTURES, in cooperation with the Malaysian Agricultural Research and Development Institute (MARDI), has found that Christmas Island rock phosphate is a suitable source of phosphorus in the wet tropics of Peninsular Malaysia, particularly for maintenance applications.

In the rice-growing areas of south-eastern Australia, farmers have experienced difficulties in producing high-yielding summer crops when they were sown soon after a rice crop. Research by the DIVISIONS OF IRRIGATION RESEARCH and SOILS has shown that these crops are frequently deficient in phosphorus despite the application of high rates of phosphorus fertilisers. Further investigations have demonstrated that flooding the soil for several months during the growth of rice increases the phosphate buffering capacity of the soil. This increase is associated with changes in the form of iron oxides in the soil. Consequently, higher rates of phosphorus fertilisers are required for crops sown after rice than for crops sown in non-rice soils. Further research has shown that the problem can be overcome by applying the phosphorus fertiliser during sowing in bands close to the seed.

Phosphorus has long been recognised as essential for animal production. However, little attention has been devoted to examining the efficiency with which it is used by animals. Increasing efforts are now being devoted to finding more profitable ways of using phosphorus for animal production. The DIVISIONS OF LAND RESOURCES MANAGEMENT, ANIMAL PRODUCTION, PLANT INDUSTRY and TROPICAL CROPS AND PASTURES are participating in this research.

Several years ago, experiments in Western Australia showed that sheep select feed with a high phosphorus content. Since the phosphorus content of pasture falls during the dry Western Australian summer, the ability to select feed that is high in phosphorus could be an advantage. Pen trials confirmed that sheep eating these feeds gain weight faster than those eating similar feeds which are low in phosphorus. Field trials to extend the research to a practical level suggest that grazing management and applications of fertiliser could be altered to take advantage of this knowledge. Rather than applying phosphorus uniformly over the whole property it might be better to concentrate dressings in individual paddocks on a rotational basis over three years. Young sheep that are growing fastest could then be grazed on freshly top-dressed pastures where they would gain most from the higher concentration of phosphorus.

Although basic information about fertilisers can be gained from simple experiments, it is often difficult to incorporate the knowledge acquired into complex farm systems without affecting other components. For this reason computer models are being used by a number of Divisions to simulate farm systems.

A research program of the DIVISION OF PLANT INDUSTRY in Canberra is aimed at examining major problems of animal production systems including that of costly fertiliser inputs. Results suggest that where fertiliser has been applied regularly over a number of years, considerable savings could be made by reducing superphosphate applications without loss of production. The area where the experiments are being carried out is typical of many sites on the Southern Tablelands of New South Wales. In these areas, with their long history of superphosphate applications, most soils are in a 'maintenance' phase as far as phosphorus status is concerned. In the 'maintenance' phase, soils frequently require a smaller annual input of superphosphate to maintain their productivity. Determining whether or not a response to fertiliser will be obtained on such soils is difficult. Soil tests have proved unreliable and the 'Decide' model, although satisfactory in Western Australia, needs modification for soils in this area. Test strips have so far proved to be the most reliable guide to fertiliser response in these experiments. Fertiliser is applied at increasing rates in a series of strips and the responses are compared with unfertilised areas. The test strips are simple and cheap to lay out and are now being assessed in terms of animal production.

In northern Australia the DIVISION OF TROPICAL CROPS AND PASTURES is investigating methods of evaluating the maintenance phosphorus requirements of tropical pastures and crops. Methods being used include chemical analyses of soils and plants, and comparisons of fertilised and unfertilised strips and enclosures in paddocks.

At Armidale on the Northern Tablelands of New South Wales the use of remote sensing techniques to detect differences in the fertility status of grazed pastures is being investigated by the DIVISION OF ANIMAL PRODUCTION. The 'Decide' model is being further developed for use on perennial pastures in collaboration with the New South Wales Department of Agriculture. Models are designed to simulate the effects of rates of stocking and applications of superphosphate on the productivity of grazed plants and their utilisation by grazing animals.

Tracer techniques are being used to follow the uptake of different types of fertiliser and the recycling of phosphorus and sulphur from organic matter and excreta. Information from the research should enable fertiliser applications and grazing routines to be managed more effectively from the point of view of animal production.

A great deal of effort has gone into investigating the recycling of phosphorus and sulphur through animals, plants, soils and microorganisms. Recycling is an important component of the continuing value of previously applied fertiliser. Most of the phosphorus in feed eaten by animals is returned to the pasture in faeces. Sheep tend to congregate and rest on high spots or sheltered places within paddocks. High levels of phosphorus and other elements excreted by the sheep accumulate in these camps. The characteristics of camps and the effect of stocking density are being examined in an attempt to devise methods of avoiding this wasteful concentration.

Research on phosphorus in soil organic matter has continued over a number of years in the DIVISIONS OF PLANT INDUSTRY, ANIMAL PRODUCTION and LAND RESOURCES MANAGEMENT. This phosphorus is not readily available to plants, yet it forms a significant proportion of the total phosphorus present in some soils. Organic phosphorus becomes available slowly as microorganisms break down the organic matter and convert the phosphorus into more readily available forms. Ways of stimulating the growth of soil microorganisms would help to increase the turnover of the organic matter together with the phosphorus that it contains. At Armidale the effects of various treatments on the buildup and breakdown of soil organic matter are being examined. The application of small quantities of lime to stimulate the buildup of organisms that break down soil organic matter is being tested.

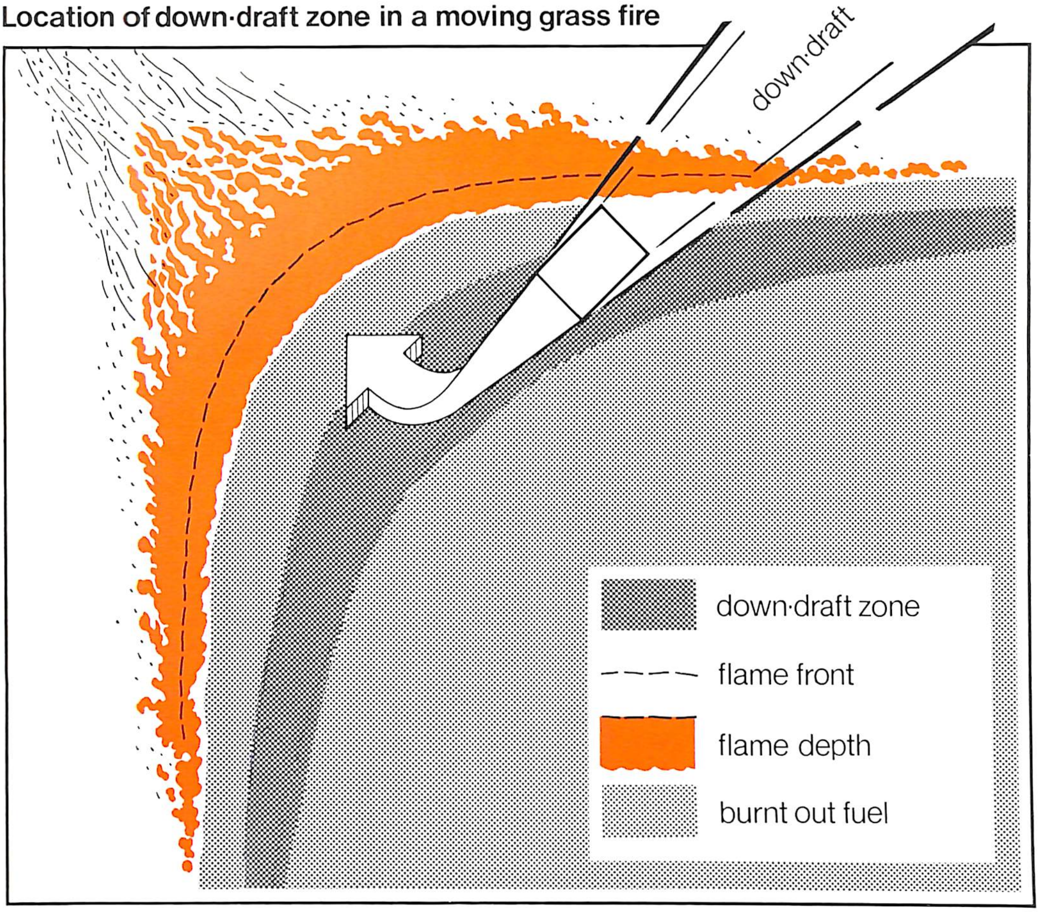
## Measuring winds in bushfires

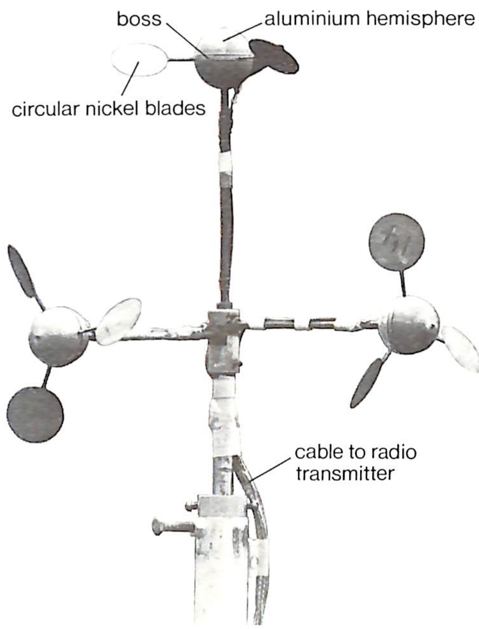
*A new anemometer measures windspeeds in and around moving fires.*

A knowledge of how fires behave under different conditions helps firefighters to predict their behaviour and marshal the resources needed to bring them under control. The same information is needed for safe prescribed burning. Windspeed is the dominant factor in determining the rate at which fires spread. The DIVISION OF FOREST RESEARCH has designed and constructed an anemometer which can withstand intense heat and measure windspeeds in and around moving fires. The anemometers are robust enough for field use, are portable and can be erected

*Artwork: David Marshall*

**Location of down·draft zone in a moving grass fire**






A cluster of three of the anemometers developed by the DIVISION OF FOREST RESEARCH provides information on windspeed and direction.
*Photograph: Alan Edward*

quickly. They can withstand immersion in flames for up to two minutes which is sufficient time for the passage of most fires, and they are able to measure windspeeds ranging from 0·5 to 15 metres a second.

Each anemometer consists of three circular nickel blades, mounted on a flat boss whose axle rotates both clockwise and anticlockwise on small, stainless steel ballbearings. The boss is inserted within the two aluminium hemispheres that comprise the body of the instrument.

When the nickel blades catch the wind, they rotate, driving a set of magnets in the boss. The turning magnets close two dry reed switches, each closure triggering a pulse in an electronic encoder. The pulses are transmitted by an HF radio link to a field receiving station. The number of closures over a given time indicates the rate of rotation while the sequence in which the two reed switches close gives the direction of rotation of the blades.

Three separate anemometers can be arranged in a cluster so as to detect north/south, east/west and vertical winds. In field experiments, clusters of three anemometers are placed two metres above the ground at each of six positions along the paths of experimental fires and up to 800 metres from the origin of the fires. The electronic encoder and radio transmitter are buried nearby. The anemometers measure the changes in the wind velocity as the fire approaches and passes through each position. The information is telemetered to a data logger located outside the fire area and is recorded on punched tape.

In experiments in the Northern Territory, scientists from the Division measured the winds around high intensity fires in open tropical woodland. An important factor which emerged from these experiments was the presence of a relatively strong down-draft zone behind the flame front. This down-draft appears to supply the bulk of the oxygen that supports most of the flaming combustion. It was consistently located 15–30 metres behind the flame front at the head of the fire in both low and high intensity fires. It was usually 8–10 metres wide, and seemed to occur in an arc, roughly parallel to the flame front, but closer to the front at the flanks where the fire spreads more slowly. In fast-moving fires, the down-draft sometimes occurred immediately over the trailing edge of the flaming zone and lasted for only a few seconds at any one point.

## Managing to cut building costs

*A variety of improved management systems are being developed to help the building and construction industries reduce costs.*

The building industry is one of the largest sectors of the Australian economy, with buildings constructed to the value of \$6500 million in 1976/1977.

In the public sector, most building work is managed by specialist departments such as the Commonwealth Department of Construction, the various State Public Works Departments and the public housing authorities, each of which handles many projects at any given time. The number, size and variety of projects, limitations of finance and other resources, and political priorities, place severe constraints on management. Under-spending or over-spending the cash budget can therefore have severe effects on the total construction program of a department.

To help departments cope more effectively with these management problems, the DIVISION OF BUILDING RESEARCH has developed two computerised systems for use in the critical areas of forward planning and operational control. The first of these systems, FINPLAN, provides automatically and from a minimal input of data, tabulations for five years ahead showing target dates for completing the design and construction phases of projects, and the anticipated monthly cash flows from various sources. Once a project begins, FINPLAN provides a progress control system which enables the actual progress to be monitored and compared with the estimated progress. Should there be any significant discrepancy between the estimated and actual progress, new cash flow requirements and target dates are readily available through an automatic updating system.

The other system, EZWORKS, is a highly efficient program for network planning—a technique for scheduling projects. EZWORKS incorporates a new concept of establishing small libraries of information on standard work patterns to overcome the problem of excessive data handling by any one organisation.

Between them, FINPLAN and EZWORKS indicate how the maximum amount of construction can be achieved at the right time and with the most efficient use of available funds. Each is already in use in the Public Works Departments of at least two States.

In the private housing sector, a wide range of construction methods, materials, labour skills and other conditions need to be matched with appropriate management systems. Research by the Division using video recording techniques is revealing the strengths and weaknesses of alternative housing construction techniques, and measures which could be taken to reduce housing costs. It is also providing base-line data against which variations and innovations in cost productivity can be measured.

In the commercial area, the Division has found that buildings used for similar purposes can vary widely in cost effectiveness because of differences in design. Scientists at the Division have developed a computerised model of the design process to compare the cost effectiveness of alternative preliminary designs taking account of the location and dimensions of the site and the associated building regulations. The rapid results obtained by using this model can improve the cost effectiveness of buildings by enabling many more design alternatives to be explored than would otherwise be feasible.

Management systems used in the transfer of information also have a bearing on building costs. Of the three main areas of communication—the conditions of contract, the plans and the specification—the contract conditions and drawing practices have been largely standardised. This is not true, however, for the drawing up of specifications. In collaboration with Government departments and private industry, the Division is attempting to identify the most appropriate formats and contents for the more commonly used items, and to standardise, where possible, the terminology. A reasonable degree of standardisation should help to streamline management procedures and reduce costly errors in construction, as well as decrease the costs of preparing and analysing specifications.

Both the Division and the industry have been particularly concerned with the management practices relating to cost escalation. Frequently these have been unable to cope adequately with the sharply rising wages and prices experienced since 1972. Consequently, many firms in the building and construction industries have run into financial difficulties. The Division has analysed the cost structures involved in a wide range of projects and was able, in 1976, to recommend improved practices to the industry. These recommendations identify projects of different magnitude, distinguish the important elements in the cost structure for each of these, and provide a means of indexing each of these cost elements in a manner that is equitable to both the builder and the client.

### A matter of survival

*Statistical methods for evaluating survival are being developed for a wide range of applications.*

One of the most active areas of current statistical research is concerned with the analysis of what mathematicians call 'survival data'. For instance, in the manufacturing industry it is important to know the likely life of a mechanical component such as a drill bit, the load required to break a certain material, or the time interval between successive breakdowns of a machine. In recent years, medical research has provided a further stimulus to analysis of survival data, for example, in relation to the survival time of patients who have undergone transplant operations. Survival time can also be the latent period before the manifestation of symptoms or the time of remission from a disease.

Until recently, methods for analysing survival time had limited application. However, more generally applicable methods have now been developed for dealing with survival data. The DIVISION OF MATHEMATICS AND STATISTICS has adapted these because of their potential usefulness in a diverse range of research projects and industrial situations, especially in studies of industrial reliability.

The Division has been actively involved in developing methods for analysing sets of data which previously could not be dealt with satisfactorily or were totally unmanageable. They have made a special contribution in developing methods for treating large sets of data where multiple observations have the same basic variables. In the past, analysis of survival data posed substantial computer storage problems since the type of data involved was often awkward to handle and the whole data matrix needed to be stored. A medical study, for example, could reasonably contain records on 5000 or more patients.

The new methodology has been used to handle data in a relatively large experiment conducted by the DIVISION OF BUILDING RESEARCH. The experiment was aimed at evaluating the resistance of wood treated with various preservatives to fungal and termite attack. In 1964, 275 small specimens of timber, consisting of five replicates of 55 treatments, plus 10 untreated controls, were treated with various preservatives and placed in the ground. The specimens were then inspected every two to three years for a total of five inspections. The data collected consisted of the numbers that had failed to resist attack, had survived or had been 'censored', that is, eliminated through circumstances outside the experimental conditions. The capability of handling large data sets and censored data was particularly important in this case and will offer the possibility of planning more meaningful experiments in the future.

The mathematical model developed for the wood preservative trial has since been used by the DIVISION OF LAND RESOURCES MANAGEMENT to analyse data concerning the survival of shoots on sand dune plants. The DIVISION OF APPLIED GEOMECHANICS has also used the model to assess the stability of slopes in open-cut mines.

# Organisation

CSIRO has a total staff of about 6950 people located in more than 100 laboratories and field stations throughout Australia. Some one-third of the staff are scientists.

At present the Science and Industry Research Act 1949 provides for CSIRO to be governed by an Executive comprising a full-time Chairman, four other full-time members and four part-time members. In addition, the Executive has adopted the practice of inviting senior members of its scientific staff to serve as associate members for a limited period to fulfil special needs.

CSIRO has 37 research Divisions, each led by a Chief who is responsible to the Executive for the work of that Division. There are also six smaller research Units. A number of Divisions have been linked together in what are known as Group Laboratories.

The Executive is assisted in the implementation, administration and development of its policies by a Secretariat with headquarters in Canberra. Some central administrative functions are undertaken at regional offices in Brisbane, Canberra, Melbourne, Perth and Sydney.

The chart opposite shows the organisational structure of CSIRO as at 1 July 1978.

**HEAD OFFICE**

| | |
|---|---|
| *Secretary* | L.G. Wilson |
| Administrative Branch<br>*First Assistant Secretary (Administration)* | H.C. Crozier |
| Central Communication Unit<br>*Manager* | G.R. Williams |
| Central Information, Library and Editorial Section<br>*Officer-in-Charge* | P.J. Judge |
| Science Branch<br>*Secretary (Research)* | S. Lattimore |
| *Assistant to Chairman* | J. Coombe |

**Overseas Offices**

| | |
|---|---|
| *Minister (Scientific), London* | Dr R.M. Moore |
| *Counsellor (Scientific), Moscow* | J.G. Downes |
| *Counsellor (Scientific), Tokyo and Seoul* | Dr C.A. Anderson |
| *Counsellor (Scientific), Washington* | J.H. Whittem |

## EXECUTIVE

*Chairman*
V.D. Burgmann
*Members*
Dr N.K. Boardman
Professor M.E. Holman (*part-time*)
V.E. Jennings (*part-time*)
Dr A.E. Pierce
Dr J.P. Wild
Sir Frederick Wiltshire (*part-time*)
Professor Emeritus H.W. Worner
*Associate Member*
Dr K.A. Ferguson

## DIVISIONS AND CHIEFS

### ANIMAL RESEARCH LABORATORIES

| | |
|---|---|
| *Chairman, ARL Committee* | Dr K.A. Ferguson |
| Animal Health | Dr A.K. Lascelles |
| Animal Production | Dr T.W. Scott |

*The Animal Research Laboratories also include the Centre for Animal Research and Development, and the Molecular and Cellular Biology Unit. See entries under Units.*

### APPLIED CHEMISTRY LABORATORIES

| | |
|---|---|
| *Chairman, ACL Committee* | Dr S.D. Hamann |
| Applied Organic Chemistry | Dr D.H. Solomon |
| Chemical Technology | Dr D.E. Weiss |

### LAND RESOURCES LABORATORIES

| | |
|---|---|
| *Chairman, LRL Committee* | Dr E.G. Hallsworth |
| Land Resources Management | R.A. Perry |
| Land Use Research | Dr R.J. Millington |
| Soils | Dr A.E. Martin |

### MINERALS RESEARCH LABORATORIES

| | |
|---|---|
| *Director* | I.E. Newnham |
| Mineral Chemistry | Dr D.F.A. Koch |
| Mineral Engineering | Dr D.F. Kelsall |
| Mineral Physics | Dr K.G. McCracken |
| Mineralogy | A.J. Gaskin |
| Process Technology | A.V. Bradshaw |

*The Minerals Research Laboratories also include the Fuel Geoscience Unit. See entry under Units.*

### WOOL RESEARCH LABORATORIES

| | |
|---|---|
| *Chairman, WRL Committee* | Dr D.S. Taylor |
| Protein Chemistry | Dr W.G. Crewther |
| Textile Industry | Dr D.S. Taylor |
| Textile Physics | Dr A.R. Haly |

| | |
|---|---|
| Applied Geomechanics | Dr C.M. Gerrard (*Acting*) |
| Atmospheric Physics | Dr G.B. Tucker |
| Building Research | Dr F.A. Blakey (*Acting*) |
| Chemical Physics | Dr A.McL. Mathieson (*Acting*) |
| Cloud Physics | J. Warner |
| Computing Research | Dr P.J. Claringbold |
| Entomology | Dr D.F. Waterhouse |
| Environmental Mechanics | Dr J.R. Philip |
| Fisheries and Oceanography | D.J. Rochford |
| Food Research | M.V. Tracey |
| Forest Research | Dr M.F.C. Day |
| Horticultural Research | Dr J.V. Possingham |
| Human Nutrition | Dr B.S. Hetzel |
| Irrigation Research | Dr H.D. Barrs (*Acting*) |
| Materials Science | Dr J.R. Anderson |
| Mathematics and Statistics | Dr J.M. Gani |
| Mechanical Engineering | Dr B. Rawlings |
| Plant Industry | Dr W.J. Peacock |
| Radiophysics | H.C. Minnett (*Acting*) |
| Tropical Crops and Pastures | Dr E.F. Henzell |
| Wildlife Research | Dr H.J. Frith |

| | |
|---|---|
| National Measurement Laboratory | F.J. Lehany *Director* |

## UNITS AND OFFICERS-IN-CHARGE

| | |
|---|---|
| Australian Numerical Meteorology Research Centre | Dr D.J. Gauntlett |
| Centre for Animal Research and Development | Dr R.H. Wharton |
| Fuel Geoscience | Dr G.H. Taylor |
| Molecular and Cellular Biology | Dr G.W. Grigg |
| Solar Energy Studies | R.N. Morse *Director* |
| Wheat Research | E.E. Bond |

The various CSIRO Divisions, their fields of research, and the location of their laboratories and field stations are shown below. A more detailed account of the Organization's research programs can be found in the publication 'CSIRO Research Program Objectives, 1977/78.'

ANIMAL HEALTH

Diseases of livestock and poultry caused by bacteria, viruses, mycoplasmas, protozoa and plant poisons; external parasites—cattle tick, lice and biting insects—as potential transmitters of disease; worm parasites of sheep and cattle; immunology.

*Melbourne, with laboratories in Sydney and Brisbane, with units at Armidale, N.S.W., Rockhampton and Townsville, Qld, and Perth. Field stations at Maribyrnong, Seymour and Werribee, Vic., Badgery's Creek, N.S.W., and Jimboomba, Qld.*

ANIMAL PRODUCTION

Physiology, endocrinology, nutrition and ecology of sheep and cattle in relation to reproductive performance and improved efficiency of wool and meat production; development of practices which combine high levels of animal production with efficient fertiliser use; control of metabolic disorders in grazing ruminants; use of chemical methods for defleecing sheep; identifying causative factors that lead to losses from fleece rot and fly strike. Genetics and its application to Australian animal industries; genetics and the improvement of beef cattle, dairy cattle, sheep and poultry through breeding and selection.

*Sydney, with the Genetics Research Laboratories at North Ryde, N.S.W., the Pastoral Research Laboratory at Armidale, N.S.W., the Bloat Research Unit at Melbourne, the Tropical Cattle Research Centre and National Cattle Breeding Station, 'Belmont', at Rockhampton, Qld, the Trace Element Research Unit at Perth, research stations at Armidale and Badgery's Creek, N.S.W., and a field investigation unit at Wollongbar, N.S.W.*

APPLIED GEOMECHANICS

Properties and behaviour of soils and rocks in relation to the design of civil and mining engineering structures such as building foundations, earthen embankments, road pavements, surface excavations and underground openings.

*Melbourne, with a laboratory in Adelaide and a field station at Cobar, N.S.W.*

APPLIED ORGANIC CHEMISTRY

Application of chemistry to problems of national and industrial importance, with particular interest in biological organic chemistry, polymer science and energy and environmental studies. Investigations into oil from coal; chemical storage of solar energy; chemical shearing of sheep; immunisation against clover infertility disease; chemical control of insects and ticks; water pollution by heavy metals and organic chemicals; development of specialised polymers; toxic products from burning polymers.

*Melbourne.*

ATMOSPHERIC PHYSICS

Physical and chemical atmospheric processes that underlie and control the weather and climate and are responsible for the distribution of airborne material including gases. This covers research into those aspects of the oceans that affect the atmosphere. Methods include field work, laboratory and numerical models, and analyses of globally derived data.

*Melbourne.*

BUILDING RESEARCH

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

*Melbourne.*

CHEMICAL PHYSICS

Advancement of understanding of chemicophysical phenomena and exploitation of the results of this research in the solution of scientific and technological problems and for the promotion of technological innovation, particularly in the area of scientific instruments and techniques. Research is centred on the following fields—atomic absorption and resonance spectroscopy; molecular spectroscopy; specialised optics, including optical diffraction gratings; mass spectroscopy; magnetic resonance spectroscopy; X-ray structure analysis; electron diffraction; electron microscopy; solid state investigations; low-temperature studies; theoretical chemistry; development of scientific instruments and techniques.

*Melbourne.*

CHEMICAL TECHNOLOGY

Application of chemical technology and particularly polymer technology to developing ways whereby Australia's renewable and recycling resources can be more effectively utilised and protected. Investigations include fractionation of plants to produce fibre in conjunction with protein and other marketable products; studies of pulp and paper and the use of cellulose materials in packaging, writing, printing and building products; assessment of the technological potential of forest resources; technology of purifying and recycling water; energy storage; and recycling and bioenergetics.

*Melbourne, with the Agroindustrial Systems Program at Canberra, officers stationed at Townsville, Qld, and an experiment station at Lower Plenty, Vic.*

CLOUD PHYSICS

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

*Sydney.*

COMPUTING RESEARCH

The Division provides advanced scientific and technical computing services for CSIRO Divisions, Government departments, and some universities, through the CSIRONET computing network, which links the central computer in Canberra with smaller computers in all State capitals and certain other cities in various parts of Australia. To improve the standard of service available, the Division conducts continuing research programs which are concerned with the development and application of advanced computer-operating systems, picture processing and graphics, simulation languages and simulation techniques, and data-base management systems.

*Canberra, with branch offices in Adelaide, Brisbane, Hobart, Melbourne, Perth, Sydney, and at Armidale and Griffith, N.S.W., and Rockhampton and Townsville, Qld.*

ENTOMOLOGY

Taxonomy, ecology, population dynamics, genetics, behaviour, physiology and biochemistry of insects, particularly in relation to the development of methods of control that reduce or eliminate the disadvantages commonly associated with the use of pesticides. Biological control of insect pests and weeds by introduction of specific natural enemies into Australia.

*Canberra, with laboratories in Brisbane, Perth and Sydney, and field stations at Armidale, Trangie, Warrawee and Wilton, N.S.W., Rockhampton and Amberley, Qld, Hobart, and Port Moresby, Papua New Guinea. The Division also has biological control units at Curitiba, Brazil, Montpellier, France, and Pretoria, South Africa.*

ENVIRONMENTAL MECHANICS

Physical investigations of energy exchange and of the movement of natural and introduced substances (e.g. water, carbon dioxide, salts, fertilisers) in the environment, with special reference to plants, soils and the lower layers of the atmosphere; application of results of this research to problems in agriculture, ecology, hydrology, meteorology, and industrial processes, mathematical aspects of ecology.

*Canberra.*

FISHERIES AND OCEANOGRAPHY

Investigation of the ecology of marine populations and the application of such knowledge to the strategy of management of harvestable resources such as lobsters, prawns and fish. Biological, chemical and physical oceanography of coastal and oceanic waters to provide an understanding of their dynamical behaviour, productivity, pollutant sensitivity and general ecology with special application to problems of national and international interest.

*Sydney, with regional laboratories in Brisbane and Perth, and a field laboratory at Karumba, Qld.*

FOOD RESEARCH

Properties, preservation, processing, packaging, storage and transport of foods in relation to quality at the consumer level; properties of bacterial spores; membrane structure and biochemistry; identification and evaluation of flavours; plant physiology; polyunsaturated meat and dairy products; new protein and dairy foods; treatment and utilisation of processing wastes.

*Sydney, with the Meat Research Laboratory, Brisbane; Dairy Research Laboratory, Melbourne; Tasmanian Food Research Unit, Hobart.*

FOREST RESEARCH

Long-term use of Australia's forests, both native and exotic, for wood, water catchment, recreation and as a wildlife habitat. Research areas include resources assessment; harvesting; genetics and tree breeding; taxonomy; ecology; physiology; soils and nutrition; hydrology; insect pests and diseases; fire.

*Canberra, with laboratories in Hobart, Perth, Darwin, Atherton, Qld, Traralgon, Vic., and Mt Gambier, S.A.*

HORTICULTURAL RESEARCH

Introduction and adaptation of fruit crops to Australian environments; breeding of wine and drying grapes; management of fruit trees and grapevines including effects of nematodes, viruses and salinity; processing of dried grapes; physiology and biochemistry of horticultural plants; domestication of Australian native plants.

*Adelaide, with a laboratory and field station at Merbein, Vic., and officers stationed at Darwin and Hobart.*

HUMAN NUTRITION

Nutritional processes in humans, including biochemical aspects of nutrition in relation to growth and development.

*Adelaide.*

IRRIGATION RESEARCH

Crop growth, management and quality of irrigated crops, especially vegetables and oilseed crops; water quality and management in irrigation; environmental plant physiology and biochemistry; and engineering aspects of intensive crop production.

*Griffith.*

LAND RESOURCES MANAGEMENT

The Division is primarily concerned with the management of land resources for efficient productivity consistent with their conservation. Research includes environmental and societal implications of land use in pastoral, agricultural, forested, mined and near-urban areas and development of methods for collecting, processing,appraising and communicating information to assist land use decision-making.

*Perth, with laboratories at Deniliquin, N.S.W., Alice Springs, N.T., and field stations at Baker's Hill, W.A., and Deniliquin, N.S.W.*

LAND USE RESEARCH

Inventory of land and water resources and assessment of their current and potential uses; development of methods for relating these natural and socio-economic resources in developing balanced land use planning techniques; ecology and conservation of woodlands.

*Canberra, with a laboratory at Lawes, Qld.*

MATERIALS SCIENCE

Properties, behaviour and utilisation of important metals, alloys and ceramics; relation between surface and bulk properties of these materials and material structure; physical and chemical processes at surfaces; development of catalysts and catalytic processes for gaseous and liquid fuel interconversions.

*Melbourne, with the Production Technology Laboratory, Adelaide.*

MATHEMATICS AND STATISTICS

Mathematical modelling and statistical analysis of scientific problems arising in agriculture, biology, the physical and environmental sciences and industry. The Division also provides advice and consultation services to other Divisions and outside bodies on statistical matters.

*Canberra, with officers stationed in Adelaide, Brisbane, Hobart, Melbourne, Perth and Sydney, and at Armidale, N.S.W., and Townsville, Qld.*

MECHANICAL ENGINEERING

Human environment engineering; energy use in the built environment and in transportation; utilisation of solar energy; industrial fluid dynamics and noise control; agricultural engineering; forestry engineering.

*Melbourne.*

MINERAL CHEMISTRY
For research activities, see Minerals Research Laboratories.

*Melbourne.*

MINERAL ENGINEERING
For research activities, see Minerals Research Laboratories.

*Melbourne.*

MINERAL PHYSICS
For research activities, see Minerals Research Laboratories

*Sydney, with a laboratory in Melbourne.*

MINERALOGY
For research activities, see Minerals Research Laboratories.

*Perth, with laboratories in Canberra and Sydney.*

MINERALS RESEARCH LABORATORIES
Field and laboratory work to help indicate where useful mineral deposits might occur in Australia; development of search and localisation techniques designed to provide direct evidence for the existence of oil and mineral deposits; the exploitation of properties of minerals to improve the efficiency of their mining, concentration and handling; the adaptation, improvement and control of methods for processing and treating mineral and other resources; the reduction and possible utilisation of solid, liquid and gaseous wastes from recovery and use of minerals; the study and control of atmospheric pollutants in urban and industrial environments, and heavy metals in water near industrial operations; the assessment and utilisation of fossil fuels in Australia, including the conversion of coal into solid, liquid and gaseous fuels; the improvement of solar energy absorbers and assessment of new materials for small-scale solar electricity generation; examination of electric battery systems for traction; the development of alternative processes for treatment of minerals and other materials designed to reduce the demand on scarce energy resources.

*The Minerals Research Laboratories comprise the Divisions of Mineral Chemistry, Mineral Engineering, Mineral Physics, Mineralogy, Process Technology and the Fuel Geoscience Unit. For locations see separate entries.*

NATIONAL MEASUREMENT LABORATORY
Maintenance of the Australian standards of measurement of physical quantities and the means for relating measurements throughout the Australian community to these standards; development of improved standards and methods of measurement in collaboration with national laboratories overseas and with the International Bureau of Weights and Measures; calibration of standards and instruments, especially for verifying authorities designated by the National Standards Commission and for laboratories of the National Association of Testing Authorities; research on the properties of materials; solar physics and air glow.

*Sydney, with a laboratory in Adelaide and the optical facility of the CSIRO Solar Observatory, Culgoora, N.S.W.*

PLANT INDUSTRY
Research in the plant sciences as a basis for the development and utilisation of crops and pastures better adapted to Australian conditions; taxonomy and ecology of Australian vegetation.

*Canberra, with a Cotton Research Unit at Narrabri, N.S.W., ecology units at Brisbane, and*

*Waste Point, N.S.W., and experiment stations at Canberra and Burren Junction, N.S.W.*

PROCESS TECHNOLOGY

For research activities, see Minerals Research Laboratories.

*Sydney.*

PROTEIN CHEMISTRY

Structure and chemistry of wool as a basis for understanding the physical and textile properties of the fibre and for developing new and improved wool manufacturing processes; the flammability of textiles; the binding of polymers to wool and leather; photostabilisation of dyes and proteins; tanning and leather manufacture; meat proteins; plant proteins; improvements in paramedical products.

*Melbourne.*

RADIOPHYSICS

Observation of radio emissions from the Sun, planets, stars and interstellar matter in our own Milky Way Galaxy and from more distant objects in the Universe such as other galaxies and quasars; interpretation of these observations to understand the astrophysical processes involved and to contribute to knowledge of the Universe; innovation and development of improved observing instruments and techniques embodying advanced antennas, sensitive receivers and digital devices for the acquisition, processing and display of data; application of expertise in radiophysics to problems in radio navigation and communication.

*Sydney, with the Australian National Radio Astronomy Observatory at Parkes, N.S.W., and the radio facility of the CSIRO Solar Observatory, Culgoora, N.S.W.*

SOILS

Physics, chemistry, mineralogy and biology of soils in relation to growth and health of plants, animals and man; soils in relation to forestry, water supplies and land use problems in urban and rural areas.

*Adelaide, with laboratories in Brisbane, Canberra, Hobart, and Townsville, Qld.*

TEXTILE INDUSTRY

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

*Geelong.*

TEXTILE PHYSICS

Development of methods of testing wool as an aid to marketing and manufacturing; physical properties and behaviour of wool and wool products; processing studies; surface properties of materials; reactive minerals; environmental contamination from mining and fossil fuels.

*Sydney.*

TROPICAL CROPS AND PASTURES

Principles controlling crop and pasture production in northern Australia (excluding arid zones); studies on plant nutrition, genetics, physiology, biochemistry, nutritive value, and on legume bacteriology; agronomic research integrated with work on introduction, selection and breeding of new pasture and crop varieties.

*Brisbane, with laboratories at Townsville and Lawes, Qld, and field stations at Beerwah, Mundubberra, Samford and Woodstock, Qld, Katherine, N.T., and Kununurra, W.A.*

WILDLIFE RESEARCH

Biology of birds and mammals, both native and introduced, in relation to pest control and conservation. Species investigated include those which are clearly pests, such as the rabbit, those which are exploited, such as the water fowl and quail, and those which need to be conserved.

*Canberra, with laboratories in Perth and Darwin, and staff located at North Ryde and Prospect, N.S.W.*

In addition to the Divisions, CSIRO has six smaller research units. They are:

AUSTRALIAN NUMERICAL METEOROLOGY RESEARCH CENTRE

Development of numerical models which simulate atmospheric behaviour, and application of these models to improve both the accuracy and time-range of weather predictions and the understanding with a view to later prediction of variations of climate on the earth.

*Melbourne. The Centre is jointly sponsored by CSIRO and the Department of Science.*

CENTRE FOR ANIMAL RESEARCH AND DEVELOPMENT

Nutrition, genetics, reproduction, heat tolerance, and resistance to disease of poultry, cattle, buffalo, goats and pigs. The research is aimed at helping improve the efficiency of livestock production in Indonesia.

*Bogor, West Java, Indonesia. The Centre is a joint CSIRO / Indonesian Government Laboratory financed by the Australian Development Assistance Bureau under the Colombo Plan.*

FUEL GEOSCIENCE UNIT

For research activities, see Minerals Research Laboratories.

*Sydney.*

MOLECULAR AND CELLULAR BIOLOGY UNIT

Molecular evolution of influenza virus; DNA breakage and repair and its application to the development of new antibiotic systems; mechanisms of differentiation and the properties of differentiation factors.

*Sydney.*

SOLAR ENERGY STUDIES UNIT

Feasibility studies; analysis and provision of data; contact with research workers in Australia and overseas.

*Melbourne.*

WHEAT RESEARCH UNIT

Structure and biochemistry of the wheat grain and relationship to flour quality; investigations into rapid methods of grain sampling and testing, including protein determination and wheat variety identification.

*Sydney.*

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# Finance and buildings

## General

While CSIRO's total expenditure for 1977/78 represented an increase of 9% over the 1976/77 level, in real terms there was a significant reduction in the Organization's level of funding and staffing compared with 1976/77. The staffing level of the Organization decreased as a result of a 1.3% reduction in the level of its staff ceiling for Appropriation funded activities and a slight decrease in positions supported from other fund sources.

The table below summarises the sources of CSIRO funds for 1977/78 and the categories of expenditure.

The Organization's expenditure of $138.6m from Appropriation and Revenue represents an increase of $15m over the Organization's expenditure of $123.6m from the same source in 1976/77. However, a significant proportion of this increase ($5.7m) resulted from changed funding arrangements in regard to the

| Source of funds | Salaries and general running expenses ($) | Contributions to Research Associations and other contributions ($) | Capital works and services and major items of equipment ($) | Total ($) |
|---|---|---|---|---|
| Appropriation including revenue | 131,724,428 | 4,101,869 | 2,750,770 | 138,577,067 |
| Wool Research Trust Fund | 8,878,127 | – | 435,298 | 9,313,425 |
| Meat Research Trust Account | 2,751,461 | – | 8,472 | 2,759,933 |
| Tobacco Industry Trust Account | 500 | – | – | 500 |
| Dairy Produce Research Trust Account | 327,267 | – | – | 327,267 |
| Wheat Research Trust Account | 342,296 | – | 86 | 342,382 |
| Fishing Industry Research Trust Account | 136,603 | – | – | 136,603 |
| Dried Fruits Research Trust Account | 54,240 | – | – | 54,240 |
| Chicken Meat Research Trust Account | – | – | 32,296 | 32,296 |
| Pig Industry Research Trust Account | 20,760 | – | 701 | 21,461 |
| Poultry Research Trust Account | – | – | 9,500 | 9,500 |
| Other Contributors | 5,897,802 | – | 2,547,860 | 8,445,662 |
| Total | 150,133,484 | 4,101,869 | 5,784,983 | 160,020,336 |

Organization's sheep and wool research programs, the operation of the Kimberley Research Station and the transfer of the Department of Defence's Materials Research Laboratory in Adelaide to CSIRO.

After allowing for reductions in the Organization's staff ceilings, a further $6.6m of the increase was absorbed by inescapable salary adjustments. All but $1m of the remainder of the increase was absorbed in costs associated with the occupation of new premises, including occupation of the new National Measurement Laboratory at Bradfield Park, and inescapable increases associated with the payment of grants and the provision of computing, microanalytical and SDI services.

While it was not possible for the Government to provide additional staff for the expansion of research in important areas such as energy and biological control, it was possible for the Organization to continue to redeploy some staff resources into selected areas of research and to obtain a modest expansion of activities in some important programs by allocating for this purpose $1m of the additional funds provided in the Appropriation.

No provision was made in the Organization's 1977/78 Appropriation Funds to offset inflationary increases in operating costs, and it was necessary for the Organization to seek out economies wherever possible in order to maintain its existing level of research activities.

The changed arrangements for the funding of the Organization's sheep and wool research programs took effect from 1 January 1978, with the Government appropriating direct to CSIRO $4.4m for the support of 60% of the research previously funded from the Wool Research Trust Fund.

The responsibility for the funding of the Kimberley Research Station was transferred from the Department of National Resources to CSIRO from 1 January 1977, and an increase of $600 000 provided in the Organization's Budget to continue at the same level, the research being undertaken at that Station.

From 1 September 1978, CSIRO took over the responsibility for operating the Materials Research Laboratory in Adelaide, previously operated by the Department of Defence, and an increase of $745 000 was provided in CSIRO's Budget to continue the activities of that Laboratory.

In respect of those research activities supported by Rural Industry Trust Funds, inflationary pressures on salaries and operating costs continued to make it difficult to maintain existing levels of research activities.

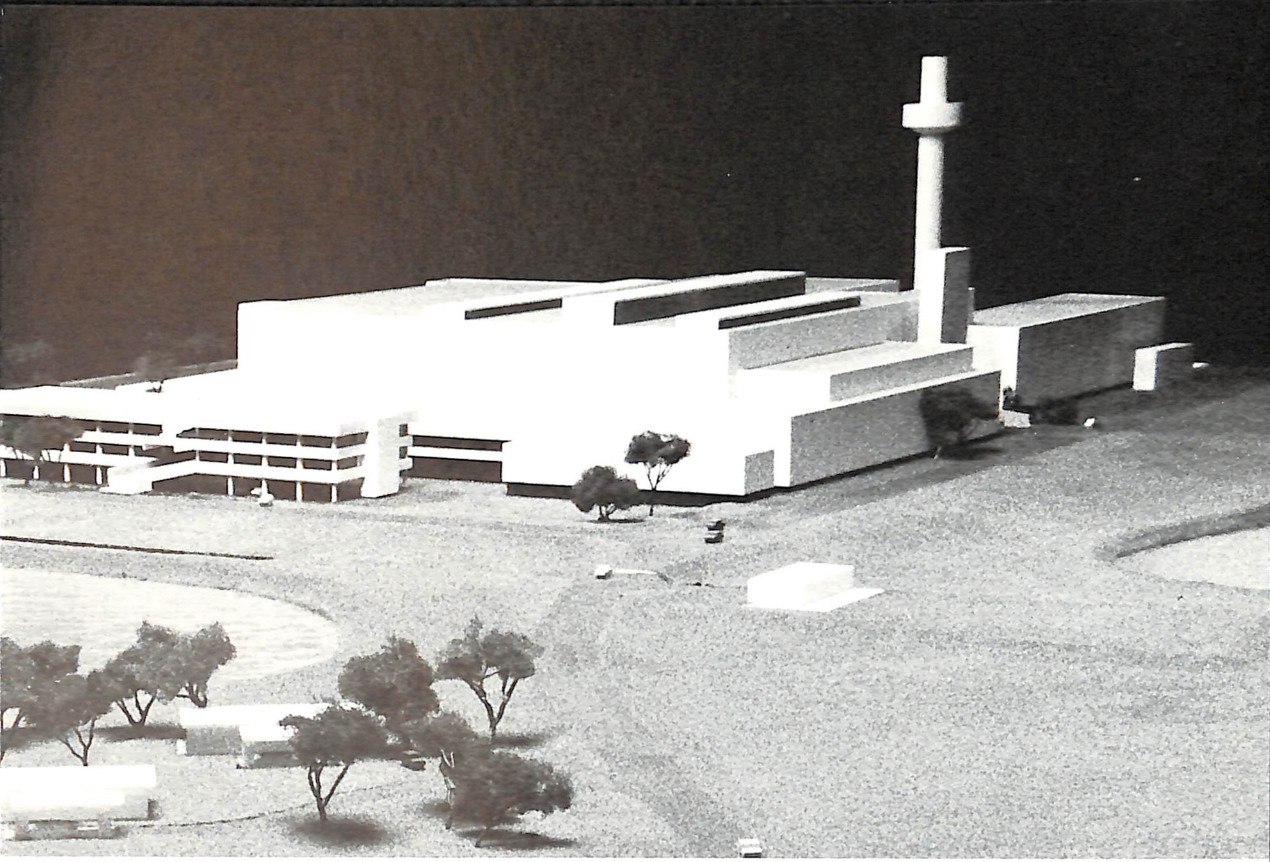
In addition to the money that CSIRO received from the Government, industry and other contributors, some $11.2m was spent by the Department of Construction and the Department of Administrative Services on buildings and other works for CSIRO, and on the acquisition of land.

Some 87% of CSIRO's income was provided directly by the Commonwealth Government and by Appropriation—derived General Revenue. Of the remaining 13%, some two-thirds was contributed from trust funds concerned with primary industries. Most of these funds are derived from a statutory levy on produce with a supporting contribution from the Commonwealth Government.

### Buildings

Although the continuing Government policy of financial restraint has caused some slowing down in the civil works program, tenders were let by the end of the financial year for all but one of the building projects included in the 1977/78 civil works program.

The National Measurement Laboratory at Bradfield Park, Sydney, was completed and occupied during the year. The Laboratory, which cost approximately $27



Scale model of ANAHL—the Australian National Animal Health laboratory—to be built at Geelong, Vic. Construction work on the project began in March 1978.

*Photograph: Department of Construction*

million, is the largest single construction project yet undertaken for CSIRO.

Construction has begun on the Australian National Animal Health Laboratory at Geelong. This project is expected to take six years to complete.

Work on the Centre for Animal Research and Development (the P4 Project financed by ADAB) at Ciawi, near Bogor in West Java continued satisfactorily and it is expected that the main complex will be completed during 1978.

Projects costing $100 000 or more which were completed during 1977/78 are listed below:

NATIONAL MEASUREMENT LABORATORY—Bradfield Park, Sydney—$27 104 000

FISHERIES AND OCEANOGRAPHY—Fisheries Research Laboratories, Cleveland Point, Brisbane—$1 907 000

ANIMAL HEALTH—Animal Room prototype, Maribyrnong, Melbourne—$783 000

CLOUD PHYSICS—Laboratory Extension, Epping, Sydney—$426 000

FISHERIES AND OCEANOGRAPHY—Fish Biology Laboratory, Cronulla, Sydney—$324 000

MINERAL CHEMISTRY—Conversion of Buildings, Garden City, Melbourne—$260 000

LAND USE RESEARCH—Divisional Store, Black Mountain, Canberra—$160 000

PLANT INDUSTRY—Glasshouse to provide Quarantine Facilities, Black Mountain, Canberra—$131 000

WILDLIFE RESEARCH—Field Laboratory, Stage 1, Kapalga, N.T.—$110 000

Projects costing more than $100 000 which were commenced during 1977/78 include:

AUSTRALIAN NATIONAL ANIMAL HEALTH LABORATORY—High Security Diseases Establishment, Geelong, Vic.—$83 000 000

COMPUTING RESEARCH—New computer laboratory and modifications of existing building services, Black Mountain, Canberra—$840 000

MINERALS RESEARCH LABORATORIES—Expansion and upgrading of Building 24 to house test rigs for Energy Program, North Ryde, Sydney—$700 000

SITE SERVICES—Site Boiler House, Black Mountain, Canberra—$545 000; site development, including major entrance roadway, Black Mountain—$110 000

TEXTILE INDUSTRY—Extensions to existing laboratory and library, Geelong, Vic.—$500 000

FISHERIES AND OCEANOGRAPHY—Fencing, dredging, dock, boat ramp and gear shed, Cleveland, Brisbane—$315 000

MINERAL ENGINEERING—Extension to light technical laboratories, Clayton, Melbourne—$275 000

ANIMAL PRODUCTION—Modifications to animal house and canteen, Prospect, Sydney—$245 000

ANIMAL PRODUCTION—Animal House, Floreat Park, Perth—$189 000

APPLIED ORGANIC CHEMISTRY—Upgrading and refurbishing of laboratories, Fishermen's Bend, Melbourne—$188 000

MINERAL CHEMISTRY—Upgrading Building 1, and associated services, Garden City, Melbourne—$177 000

HORTICULTURAL RESEARCH—Workshop and associated facilities, Merbein, Vic.—$170 000

FOREST RESEARCH—Construction of Herbarium, Atherton, Qld.—$152 000

FOOD RESEARCH—Modifications to workshop and microbiology laboratory, Highett, Melbourne—$150 000

WILDLIFE RESEARCH—Field Laboratory, Stage 2, Kapalga, N.T.—$150 000

ANIMAL HEALTH—Small Animals House, Badgery's Creek, N.S.W.—$133 000

RADIOPHYSICS—Extension to water supply at Solar Observatory, Culgoora, N.S.W.—$128 000

MINERALOGY—Hydro thermal laboratory, Floreat Park, Perth—$120 000.

## Annual Expenditure

The following summary gives details of expenditure by CSIRO Divisions and Units on other than capital items from 1 July 1977 to 30 June 1978.

| Division or Unit | Appropriation 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, Tokyo and Moscow and general office expenditure | 9,376,726 | 30,205 | 9,406,931 |
| **Research Programs** | | | |
| **Agricultural Research – Animal Industry** | | | |
| Animal Health | 5,072,348 | 866,023 | 5,938,371 |
| Animal Production | 4,619,809 | 2,754,779 | 7,374,588 |
| Centre for Animal Research and Development Indonesia | – | 2,306,025 | 2,306,025 |
| **Agricultural Research – Plant Industry** | | | |
| Plant Industry | 7,087,907 | 416,788 | 7,504,695 |
| Horticultural Research | 1,468,407 | 82,668 | 1,551,075 |
| Irrigation Research | 1,157,498 | 78,691 | 1,236,189 |
| Tropical Crops and Pastures | 5,189,875 | 601,744 | 5,791,619 |
| **Agricultural Research – Entomology** | 5,395,860 | 1,656,080 | 7,051,940 |
| **Agricultural Research – Processing of Agricultural Products** | | | |
| Wheat Research | 176,827 | 177,582 | 354,409 |
| Textile Industry | 1,010,097 | 2,775,409 | 3,785,506 |
| Textile Physics | 1,178,895 | 1,469,402 | 2,648,297 |
| Protein Chemistry | 1,826,704 | 891,126 | 2,717,830 |
| **Land Resources Studies** | | | |
| Wildlife Research | 2,332,799 | 331,552 | 2,664,351 |
| Soils | 4,006,256 | 67,309 | 4,073,565 |
| Land Use Research | 2,638,820 | 408,820 | 3,047,640 |
| Land Resources Management | 3,410,996 | 360,558 | 3,771,554 |
| Forest Research | 4,127,300 | 19,022 | 4,146,322 |
| **Fisheries and Oceanography** | 5,458,296 | 106,204 | 5,564,500 |
| **Food and Human Nutrition** | | | |
| Molecular and Cellular Biology Unit | 965,998 | – | 965,998 |
| Human Nutrition | 1,672,796 | – | 1,672,796 |
| Food Research | 5,251,379 | 1,162,009 | 6,413,388 |
| **Manufacturing Industry – General** | | | |
| Chemical Technology | 2,457,307 | 199,231 | 2,656,538 |
| Building Research | 5,003,752 | 114,370 | 5,118,122 |
| Materials Science* | 2,826,196 | 61,820 | 2,888,016 |
| Mechanical Engineering | 1,769,699 | 158,731 | 1,928,430 |

| Division or Unit | Appropriation Funds ($) | Contributory Funds ($) | Total ($) |
|---|---|---|---|
| **Manufacturing Industry – Chemical Support** | | | |
| Applied Organic Chemistry (including Microanalytical Laboratory) | 2,538,746 | 162,873 | 2,701,619 |
| **Manufacturing Industry – Physical Support** | | | |
| Chemical Physics | 2,341,287 | – | 2,341,287 |
| National Measurement Laboratory | 8,120,656 | – | 8,120,656 |
| **Mining, Minerals and Energy** | | | |
| Minerals Research Laboratory – Clayton | 1,823,800 | 47,203 | 1,871,003 |
| Minerals Research Laboratory – Port Melbourne | 2,920,199 | 150,782 | 3,070,981 |
| Minerals Research Laboratory – Floreat Park | 1,122,799 | 32,994 | 1,155,793 |
| Minerals Research Laboratory – North Ryde | 4,624,734 | 201,470 | 4,826,204 |
| Baas Becking Geobiological Group | 15,000 | 93,179 | 108,179 |
| Applied Geomechanics | 1,671,394 | 307,600 | 1,978,994 |
| Solar Energy Unit | 211,660 | – | 211,660 |
| **Atmospheric Science** | | | |
| Atmospheric Physics | 2,092,998 | 2,919 | 2,095,917 |
| Cloud Physics | 1,045,592 | 3,553 | 1,049,145 |
| Environmental Mechanics | 589,620 | 6,900 | 596,520 |
| Australian Numerical Meteorology Research Centre | 385,831 | – | 385,831 |
| **Astronomy** | | | |
| Radiophysics | 3,827,597 | 222,817 | 4,050,414 |
| **Research Support** | | | |
| Computing Research | 3,147,186 | – | 3,147,186 |
| Mathematics and Statistics | 2,352,795 | – | 2,352,795 |
| Contract Research | 141,742 | – | 141,742 |
| Extra-Mural Grants | 287,913 | – | 287,913 |
| Developmental Projects | 295,538 | – | 295,538 |
| **Information Services** | | | |
| Central Information, Library and Editorial Section | 3,523,769 | 253 | 3,524,022 |
| Central Communication Unit | 611,493 | – | 611,493 |
| **Miscellaneous** | 2,549,532 | 80,365 | 2,629,897 |
| **Contributions** | | | |
| Research Associations | 976,072 | – | 976,072 |
| Other Contributions | 3,125,797 | – | 3,125,797 |
| **Total Expenditure** | **135,826,297** | **18,409,056** | **154,235,353** |

* Formerly known as the Division of Tribophysics.

## 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 $25,000 each.

| Division or Unit | Appropriation Funds ($) | Contributory Funds ($) | Total ($) |
|---|---|---|---|
| **Head Office** | 18,051 | – | 18,051 |
| **Agricultural Research – Animal Industry** | | | |
| Animal Health | 90,215 | 103,812 | 194,027 |
| Animal Production | 85,163 | 164,607 | 249,770 |
| Centre for Animal Research and Development, Indonesia | – | 2,462,014 | 2,462,014 |
| **Agricultural Research – Plant Industry** | | | |
| Plant Industry | 107,482 | 2,221 | 109,703 |
| Horticultural Research | 12,880 | 10,723 | 23,603 |
| Irrigation Research | 48,343 | – | 48,343 |
| Tropical Crops and Pastures | 37,800 | 8,315 | 46,115 |
| **Agricultural Research – Entomology** | 189,028 | 6,500 | 195,528 |
| **Agricultural Research – Processing of Agricultural Products** | | | |
| Textile Industry | 155,487 | 176,763 | 332,250 |
| Textile Physics | – | 66,436 | 66,436 |
| Protein Chemistry | 105,742 | 24,976 | 130,718 |
| **Land Resources Studies** | | | |
| Wildlife Research | 12,994 | – | 12,994 |
| Soils | 186,287 | – | 186,287 |
| Land Use Research | 7,384 | – | 7,384 |
| Land Resources Management | 30,006 | 7,760 | 37,766 |
| Forest Research | 1,367 | – | 1,367 |
| **Fisheries and Oceanography** | 171,991 | – | 171,991 |
| **Food and Human Nutrition** | | | |
| Human Nutrition | 75,330 | – | 75,330 |
| Food Research | 13,879 | – | 13,879 |
| **Manufacturing Industry – General** | | | |
| Chemical Technology | 8,366 | – | 8,366 |
| Building Research | 114,343 | – | 114,343 |
| Materials Science* | 197,783 | – | 197,783 |
| Mechanical Engineering | 67,249 | 86 | 67,335 |
| **Manufacturing Industry – Chemical Support** | | | |
| Applied Organic Chemistry | 34,072 | – | 34,072 |
| **Manufacturing Industry – Physical Support** | | | |
| National Measurement Laboratory | 113,973 | – | 113,973 |
| **Mining, Minerals and Energy** | | | |
| Minerals Research Laboratory – Clayton | 1,706 | – | 1,706 |
| Minerals Research Laboratory – Port Melbourne | 35,476 | – | 35,476 |
| Minerals Research Laboratory – Floreat Park | 642 | – | 642 |
| Minerals Research Laboratory – North Ryde | 309,250 | – | 309,250 |
| Applied Geomechanics | 95,995 | – | 95,995 |

| Division or Unit | Appropriation Funds ($) | Contributory Funds ($) | Total ($) |
|---|---|---|---|
| **Atmospheric Science** | | | |
| Atmospheric Physics | 34,274 | – | 34,274 |
| Cloud Physics | 335,745 | – | 335,745 |
| Environmental Mechanics | 189 | – | 189 |
| **Research Support** | | | |
| Computing Research | 1,242 | – | 1,242 |
| Mathematics and Statistics | 15,191 | – | 15,191 |
| **Information Services** | | | |
| Central Information, Library and Editorial Section | 35,845 | – | 35,845 |
| **Total Capital Expenditure** | **2,750,770** | **3,034,213** | **5,784,983** |

* Formerly known as the Division of Tribophysics.

AUDITOR-GENERAL'S OFFICE
Canberra House, Marcus Clarke St.,
Canberra City, A.C.T. 2601
29 August 1978

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

Dear Sir,

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

In compliance with section 30(2) of the Science and Industry Research Act 1949, financial statements of the Commonwealth Scientific and Industrial Research Organization for the year ended 30 June 1978 have been submitted for my report. These comprise—

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

One set of the statements, in the form approved by the Minister for Finance, 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, to the extent these are reflected in statements prepared on a cash rather than an accrual basis, show fairly the financial operations of the Organization; and
(c) the receipt, expenditure and investment of moneys, and the acquisition and disposal of other property, by the Organization during the year have been in accordance with the Act.

Yours faithfully,

(Sgd) D. R. STEELE CRAIK

(D. R. STEELE CRAIK)
AUDITOR-GENERAL

## Summary of Receipts and Payments

| | Funds held 1 July 1977 ($) | Receipts ($) | Total funds available ($) | Payments ($) | Funds held 30 June 1978 ($) |
|---|---|---|---|---|---|
| Special Account | 336,515 | 138,719,845* | 139,056,360 | 138,577,067 | 479,293 |
| | (455,442)** | (123,467,074) | (123,922,516) | (123,586,001) | (336,515) |
| Specific Research Account | 2,874,307 | 21,931,577 | 24,805,884 | 21,443,269 | 3,362,615[+] |
| | (3,005,923) | (24,020,165) | (27,026,088) | (24,151,781) | (2,874,307) |
| Other Trust Moneys[‡] | 431,583 | 1,313,022 | 1,744,605 | 1,427,088 | 317,517 |
| | (267,426) | (1,686,060) | (1,953,486) | (1,521,903) | (431,583) |
| **Total** | **3,642,405** | **161,964,444** | **165,606,849** | **161,447,424** | **4,159,425** |
| | **(3,728,791)**[§] | (149,173,299) | (152,902,090) | (149,259,685) | (3,642,405) |

| | $ | $ |
|---|---|---|
| *Comprises: | | |
| Appropriations—Consolidated Revenue Fund | | |
| Operational | 132,651,000 | |
| Capital | 2,800,000 | |
| | | 135,451,000 |
| Revenue and Other Receipts | | |
| Sale of Publications | 228,606 | |
| Receipts in respect of expenditure of former years | 325,667 | |
| Sale of produce, including livestock | 232,818 | |
| Royalties from patents | 35,816 | |
| Fees for tests and other services | 189,191 | |
| Computing service charges | 2,134,796 | |
| Miscellaneous receipts | 121,951 | |
| | | 3,268,845 |
| | | 138,719,845 |

** Figures in brackets refer to 1976/77 financial year.
[+] Includes investments totalling $165,700.
[‡] Moneys held temporarily on behalf of other organisations and individuals.
[§] 1976/77 figures adjusted to delete Cafeteria Account which was closed during 1976/77

V. D. Burgmann *(Chairman)* I. C. Bogg *(Acting Senior Assistant Secretary, Finance and Properties)*

## Consolidated Statement of Payments

| 1976/77 ($) | | 1977/78 ($) |
|---|---|---|
| | **Head Office** (including Regional Administrative Offices) | |
| 6,492,265 | Salaries and allowances | 6,723,502 |
| 299,284 | Travelling and Subsistence | 333,929 |
| 574,670 | Postage, telegrams and telephone | 455,798 |
| 1,534,534 | Incidental and other expenditure | 1,893,702 |
| 8,900,753 | | 9,406,931 |
| | **Research Programs** | |
| | Agricultural Research | |
| 13,857,737 | Animal Industry | 15,618,984 |
| 15,095,096 | Plant Industry | 16,083,578 |
| 6,405,533 | Entomology | 7,051,940 |
| 8,384,488 | Processing of Agricultural Products | 9,506,042 |
| 16,337,523 | Land Resources Studies | 17,703,432 |
| 5,564,332 | Fisheries and Oceanography | 5,564,500 |
| 8,573,543 | Food and Human Nutrition | 9,052,182 |
| | Manufacturing Industry | |
| 11,173,476 | General | 12,591,106 |
| 2,708,723 | Chemical Support | 2,701,619 |
| 9,047,564 | Physical Support | 10,461,943 |
| 12,706,828 | Mining, Minerals and Energy | 13,222,814 |
| 3,869,454 | Atmospheric Science | 4,127,413 |
| 4,071,501 | Astronomy | 4,050,414 |
| 5,308,041 | Research Support | 6,225,174 |
| 3,286,454 | Information Services | 4,135,515 |
| 2,316,482 | Miscellaneous | 2,629,897 |
| 128,706,775 | | 140,726,553 |
| | **Contributions** | |
| 843,821 | Research Associations | 976,072 |
| 2,795,256 | Other Contributions | 3,125,797 |
| 3,639,077 | | 4,101,869 |
| | **Capital Works and Services** | |
| 4,398,327 | Buildings, works, plant and development expenditure | 3,369,467 |
| 2,092,850 | Major items of laboratory equipment | 2,415,516 |
| 6,491,177 | | 5,784,983 |

| 1976/77 ($) | | 1977/78 ($) |
|---|---|---|
| | **Other Trust Moneys** | |
| | Remittance of revenue from investigations financed from | |
| 607,501 | Industry Trust Accounts | 610,452 |
| 914,402 | Other miscellaneous remittances | 816,636 |
| 1,521,903 | | 1,427,088 |
| **149,259,685*†** | **Total Expenditure** | **161,447,424** |

* 1976/77 figures adjusted to delete Cafeteria Account which was closed during 1976/77.

† Dissection details of 1976/77 expenditure have been adjusted, where necessary, to allow comparison with 1977/78 figures.

V. D. Burgmann *(Chairman)*  I. C. Bogg *(Acting Senior Assistant Secretary, Finance and Properties)*

## Statement of Payments—Special Account*

| 1976/77 ($) | | 1977/78 ($) |
|---|---|---|
| | **Head Office** (including Regional Administrative Offices) | |
| 6,475,954 | Salaries and allowances | 6,706,994 |
| 299,206 | Travelling and Subsistence | 333,929 |
| 574,670 | Postage, telegrams and telephone | 455,798 |
| 1,514,366 | Incidental and other expenditure | 1,880,005 |
| 8,864,196 | | 9,376,726 |
| | **Research Programs** | |
| | Agricultural Research | |
| 8,166,383 | Animal Industry | 9,692,157 |
| 13,358,602 | Plant Industry | 14,903,687 |
| 4,880,998 | Entomology | 5,395,860 |
| 1,819,601 | Processing of Agricultural Products | 4,192,523 |
| 14,896,383 | Land Resources Studies | 16,516,171 |
| 5,453,236 | Fisheries and Oceanography | 5,458,296 |
| 7,421,442 | Food and Human Nutrition | 7,890,173 |
| | Manufacturing Industry | |
| 10,759,652 | General | 12,056,954 |
| 2,454,281 | Chemical Support | 2,538,746 |
| 9,047,564 | Physical Support | 10,461,943 |
| 11,954,527 | Mining, Minerals and Energy | 12,389,586 |
| 3,839,190 | Atmospheric Science | 4,114,041 |
| 3,753,816 | Astronomy | 3,827,597 |
| 5,307,774 | Research Support | 6,225,174 |
| 3,286,454 | Information Services | 4,135,262 |
| 2,182,829 | Miscellaneous | 2,549,532 |
| 108,582,732 | | 122,347,702 |
| | **Contributions** | |
| 843,821 | Research Associations | 976,072 |
| 2,795,256 | Other Contributions | 3,125,797 |
| 3,639,077 | | 4,101,869 |
| | **Capital Works and Services** | |
| 699,997 | Buildings, works, plant and developmental expenditure | 757,440 |
| 1,799,999 | Major items of laboratory equipment | 1,993,330 |
| 2,499,996 | | 2,750,770 |
| **123,586,001†** | **Total Expenditure** | **138,577,067** |

* 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.

† Dissection details of 1976/77 expenditure have been adjusted, where necessary, to allow comparison with 1977/78 figures.

V. D. Burgmann *(Chairman)* I. C. Bogg *(Acting Senior Assistant Secretary, Finance and Properties)*

## Statement of Payments—Specific Research Account

| 1976/77 ($) | | 1977/78 ($) |
|---|---|---|
| | **Head Office** (including Regional Administrative Offices) | |
| 16,311 | Salaries and allowances | 16,508 |
| 78 | Travelling and subsistence | — |
| 20,168 | Incidental and other expenditure | 13,697 |
| 36,557 | | 30,205 |
| | **Research Programs** | |
| | Agricultural Research | |
| 5,691,354 | Animal Industry | 5,926,827 |
| 1,736,494 | Plant Industry | 1,179,891 |
| 1,524,535 | Entomology | 1,656,080 |
| 6,564,887 | Processing of Agricultural Products | 5,313,519 |
| 1,441,140 | Land Resources Studies | 1,187,261 |
| 111,096 | Fisheries and Oceanography | 106,204 |
| 1,152,101 | Food and Human Nutrition | 1,162,009 |
| | Manufacturing Industry | |
| 413,824 | General | 534,152 |
| 254,442 | Chemical Support | 162,873 |
| 752,301 | Mining, Minerals and Energy | 833,228 |
| 30,264 | Atmospheric Science | 13,372 |
| 317,685 | Astronomy | 222,817 |
| 267 | Research Support | — |
| — | Information Services | 253 |
| 133,653 | Miscellaneous | 80,365 |
| 20,124,043 | | 18,378,851 |
| | **Capital Works and Services** | |
| 3,698,330 | Buildings, works, plant and development expenditure | 2,612,027 |
| 292,851 | Major items of laboratory equipment | 422,186 |
| 3,991,181 | | 3,034,213 |
| **24,151,781†** | **Total Expenditure** | **21,443,269** |

† Dissection details of 1976/77 expenditure have been adjusted, where necessary, to allow comparison with 1977/78 figures.

V. D. Burgmann *(Chairman)* I. C. Bogg *(Acting Senior Assistant Secretary, Finance and Properties)*

# CSIRO Thirtieth Annual Report 1977/78