Institute Affairs ........................................ 129
An Unexpected Find .................................... 131
Resource Physics for the Pacific Islands ............. 132
Glassy Metals ............................................. 135
Light and Lighting in Australia ........................ 139
Membership of the Institute ............................. 141
ANZAAS, 1979 .............................................. 142
Grants for Learned Academies

The learned academies will receive more than $500,000 in grants announced today by the Minister for Science, Senator Webster.

The grants were as follows:

- Academy of Science: $245,000
- Academy of Science exchange program with Academia Sinica: $68,000
- Academy of Social Sciences: $54,800
- Academy of the Humanities: $34,400
- Academy of Technological Sciences: $100,000

The special grant to the Academy of Science for its exchange program with the Academia Sinica of Peking was substantially higher than in 1977-78 as this would be the first full year of the program's operation.

The grant would enable an increase in the number of scientific disciplines represented in exchange groups.

Senator Webster said the Academy of Technological Sciences, established in 1976, would receive a grant for the first time.

Support for the academy reflected the Government's desire to increase the efficiency and competitiveness of Australian industry.

Senator Webster said that in addition to support for the academies, a $14,000 grant would be made to the Australian and New Zealand Association for the Advancement of Science to assist young scientists to attend the ANZAAS Congress in New Zealand next January. [Media Release, Minister for Science]
Institute Affairs

31st COUNCIL MEETING

The 31st meeting of the Council of the Australian Institute of Physics was held in Canberra on 7 and 8 September 1978. Following the practice started in 1977, this is the only meeting to be held in 1978 to review activities during the 1977/78 financial year and to approve plans for the next financial year.

Physics Activities

During the past year the Institute supported a number of conferences and an even broader program has been adopted for the coming year. As a new venture, an Applied Physics Conference is being planned for 1-5 July 1979 at the Capricornia Institute of Advanced Education, Rockhampton. The AIP will contribute $1000 towards the cost of this conference including arrangements for an overseas guest lecturer. It is hoped that this new venture in Conferences will lead to a continuing series of events to focus attention on this important aspect of physics in Australia.

The third in the series of Solid State Physics Conferences is to be held at the Riverina College of Advanced Education from 7-9 February 1979 and a Vacation School is being organised by the NUPP Group, to be held at Katoomba in May 1979. A major International Symposium on Magnetospheric Studies is to be held at La Trobe University from 26 November to 1 December 1979 and this will also receive support from the AIP.

The major Institute event in 1979 will, of course, be the 3rd National AIP Congress to be held in Perth from 15-19 January and this is to be followed by an “Einstein Centenary Summer School on Gravitational Radiation and Collapsed Objects”. A very attractive program is being planned by the Congress organising Committee.

In order to make it possible for students to benefit from the Congress, Council allocated $1000 to assist them in such ways as the Branch Committee think most appropriate.

The activities planned for 1979 cover physics. The Pawsey Memorial Lecture is planned for Hobart and there are other events spread throughout Australia. AIP members should be able to take advantage of one or more of these many events. Meanwhile plans are underway for the 4th National Congress to be held in 1980; for celebrating more significant dates in the history of physics, and to encourage more overseas speakers to visit AIP Branches.

General Activities

The Australian Physicist continues to be the most important general activity of the AIP and the Council meeting expressed its appreciation of the work done by the Editor and Editorial Committee, all of whom contribute a great deal of effort on an honorary basis.

In 1977, a Working Party under the title of "The Growing Edge" was established to investigate the possibility of staging an exhibition to bring something of the excitement of physics to students and the public. The Working Party reported considerable interest from members of the AIP and some progress in planning an exhibition. However, because of the magnitude of this task it has been decided to concentrate on one exhibit for display at the 3rd National Congress. This will provide valuable experience and a definite basis on which to seek support for a larger exhibition. The 31st Council established an Exhibition Committee to continue work on this project.

An even bigger concept was put to Council by the SA Branch - the concept of an AIP Research Fund. Although this would be within the aims of the Institute, as prepared by our founding fathers, Council decided that it was too ambitious to be tackled at this stage.

The AIP has an archive within the Basser library of the Australian Academy of Science and physicists are urged to forward any material which may possibly be worthy of retention but for which no other obvious repository is available. Following a suggestion from the SA Branch, Council decided to investigate the possibility of making analogous arrangements for the preservation of scientific apparatus.

Yet another area of Institute activity is by representation on such committees as:

- The National Committee for Physics
- The Australian National Committee on Illumination
- The Acoustics Standards Committee
- The Australasian Institute of Radiography
- The Australian Journal of Physics
- The National Association of Testing Authorities

Council appreciates the work of AIP members who represent the Institute on these committees. In most cases important contributions are being made to Australian science and technology. But unfortunately one case was brought to the attention of Council where support has been sadly lacking. The Australian Journal of Physics needs additional support and this is a matter for all AIP members rather than just our representative or Council.

A joint review committee (CSIRO/ASS) is considering the future of the Australian journals and the views of members and their support would be appreciated.

Branches

Whilst all these programs on a national scale show a continuing growth in AIP interests, the Branch activities are also expanding. Many new ideas are being considered by Branches and, although an approximately 10% increase in funds is not large, members should see a continuing growth locally as well as nationally.
Committees

Committees have been active through the year on Science Policy, Education and Employment and the outcome to date of this work has been reported separately in The Australian Physicist. The results of the employment survey included with the 1978 subscription notices have been written up and should be published in the near future. A program of activities for the coming year has also been prepared. In the area of science policy, some topics attract an easy consensus of opinion whilst others generate controversy. Every effort is made to use The Australian Physicist to give members opportunity to express their views and arrangements have also been made to obtain direct interaction with Branch members on each topic studied.

Making Ends Meet

Whilst most of the Council meeting was spent in discussions of the activities described above, it was also necessary to consider funding and subscriptions as well as membership matters. Fortunately, the results for the 1977/8 year promise to be very satisfactory. You must have been helping, because for the first time in many years recruitment has been quite significantly high and subscription income will actually exceed budget estimates by a considerable amount. Since we also have been successful in holding costs down, we have the unexpected prospect of a surplus of over $4000.

Council was unanimous that this situation makes it possible to hold subscriptions constant for another year, even though a significantly larger expenditure will be needed to support the many activities. Administrative costs are also increasing again, but plans are being made to change the arrangements for routine work so as to minimize the impact of these increases. Thus, by using some of the 1977/8 surplus as non-recurring grants, it has been possible to draw up a balanced budget for 1978/9. If members will help by keeping the recruitment going, then there could be another pleasant surprise at this time next year.

J. R. Bird (Honorary Secretary)

Safe Disposal of Radioactive Wastes

One of the world's leading geochemists, Professor A. E. Ringwood of the Australian National University, has devised a strategy for safely disposing of radioactive wastes. Professor Ringwood believes his solution to the radwaste disposal problem eliminates one of the major objections to the development of uranium-powered nuclear reactors.

Professor Ringwood's research and consequent new strategy for radioactive waste disposal are set out in a book, Safe Disposal of High Level Nuclear Reactor Wastes: A new strategy, which has gone on sale throughout Australia and overseas. The 72-page book, published by ANU Press, can be understood by those with only limited knowledge of the subject.

Nuclear reactors give rise to high level radioactive wastes -- including such elements as caesium, strontium and plutonium -- that have to be stored for up to one million years before they become harmless. Currently the main method of radwaste disposal is to incorporate waste in borosilicate glass and to bury this underground in deep salt mines.

Many scientists now believe this method has serious drawbacks because long term storage safety cannot be guaranteed. The glass is prone to breakdown over long periods which would permit dangerous radioactive elements to migrate in groundwater and contaminate the biosphere.

Professor Ringwood's new strategy is based on the fact that in nature small amounts of the same elements that occur in radwastes are completely immobilised in the crystal lattices of certain minerals for up to 2000 million years -- much longer than needed for the safe decay of wastes from nuclear reactors.

Professor Ringwood's storage method follows nature. In his laboratory he can produce synthetic minerals -- such as perovskite, zirconia, hollandite, barium felspar, leucite, kalsilite, mica, sphene and fresnoite -- which have the capacity to immobilise radwaste elements in their crystal lattices.

A number of these minerals are mixed together by melting at high temperature and when cooled they crystallise to form a synthetic rock which Professor Ringwood has named SYNROC. Radioactive elements are incorporated in SYNROC at 5-10 percent concentration during cooling and are immobilised in the crystal lattices of the constituent minerals in the rock.

Professor Ringwood says SYNROC provides a host material in which dangerous radioactive elements can be immobilised and locked up safely for millions of years. The radioactive elements will not leach out to contaminate the biosphere even if SYNROC comes in contact with water. Moreover, additional fail-safe barriers can be employed by casing the treated waste in non-corrodeable metal alloy containers and depositing in specially sealed deep drill holes in granite rocks.

Professor Ringwood's basic conclusion is that the problem of immobilising and storing nuclear reactor wastes is solvable.

The University has patented the SYNROC process. Professor Ringwood says the cost of his strategy for safely disposing of nuclear wastes will not exceed a few percent of the total cost of nuclear power and that this method represents a high degree of over-insurance in radwaste safety.

Professor Ringwood, 48, is Director of ANU's Research School of Earth Sciences. A distinguished academic career has given him an international scientific reputation. His many awards and honours include Fellowship of the Royal Society, Foreign Associate of the US National Academy of Sciences and the Bowie Medal of the American Geophysical Union. He was one of the few non-American scientists invited to study moon rocks brought back by the first manned lunar landing in 1969. [ANU Reporter, July 1978]
AN UNEXPECTED FIND

John Jenkin

Readers of The Australian Physicist will have seen Robert Leckey's recent article on Photoelectron Spectroscopy [Leckey, 1978] and may remember my own letter to the Editor regarding old physics books in the March 1977 issue. These two topics have recently combined in a quite unexpected way; briefly the details are as follows:

Maurice le Duc de Broglie was born into this ancient and famous French family in 1875, and, despite the early wishes of his family to the contrary, developed and maintained throughout his long life a devoted interest in the Physical Sciences. Following a period at l'École Navale he subsequently completed a thesis under the direction of Paul Langevin, during which time he began to experiment with X-rays. He rapidly became the leading French authority in this area and, after labouring with the problem of submarine communications during World War I, de Broglie made several most important discoveries in X-ray physics about 1920. In particular, he discovered the third L absorption edge, and he was one of the pioneers in the area now known as X-ray photoelectron spectroscopy (XPS), a technique currently being used in a very much updated form within the Research Centre for Electron Spectroscopy at La Trobe University to study the electronic properties of atoms, molecules and solids. His contribution in this area has recently been reviewed as part of a survey of the history of XPS [Jenkin, et al., 1977].

de Broglie carried out his research work in an unusually well-equipped private laboratory in his own home in the rue Châteaubriand. His young brother, Louis, became interested in Maurice's experiments and was thereby encouraged to make his own career in theoretical physics. Louis de Broglie is now more widely remembered than his older brother, of course, for it was Louis who introduced the concept that material particles have a definite wave character.

Maurice de Broglie died in July, 1960, "perhaps the last representative of a type that has contributed mightily to the advancement of science — the wealthy, independent, experimentalist who could follow what he pleased as far as his energies and ability might carry him." Biographies have been written by Weil-Brunschwig and Heilbron [1970] and by Wilson [1961].

One of Maurice de Broglie's best known published works was "Les Rayons X", which appeared in 1922, and when a copy was recently advertised by an American antiquarian book dealer at a modest price it seemed an opportunity too good to miss. The first part of Chapter VI, for example, is concerned with "Rayons secondaires des rayons X" (that is X-ray photoelectron spectroscopy) and contains a rare photograph of de Broglie's apparatus for these experiments. But no one quite anticipated the depth of interest which the book's arrival at La Trobe would arouse. The half-title page of this particular copy carries the following in de Broglie's own neat hand —

'hommage de l'auteur avec l'expression de ses sentiments dévoués
M. de Broglie

Underneath in pencil is the unmistakable signature —
E. Rutherford

while at the bottom of this page in a bold script one finds —

See note at end of book

Wm. W

and inside the back cover —

This volume was evidently presented by M. de Broglie to Rutherford

Wm. Wilson

Cambridge 10.XII.1943

Rutherford's signature was perhaps done with one of the stubby and blunt pencils he used incessantly and always carried in his waistcoat pockets. William Wilson was one of Rutherford's students at Manchester and wrote the rather inadequate biography of Maurice de Broglie that appeared in 1971 [Wilson 1971].

The volume in question is currently on display in the second-level foyer of the Physics Building at La Trobe University.

REFERENCES:
RESOURCE PHYSICS FOR THE PACIFIC ISLANDS — AN UNDERGRADUATE COURSE

A.D. Weir and J.W. Twidell, School of Natural Resources, University of the South Pacific, Suva, Fiji.

1. INTRODUCTION

The University of the South Pacific serves 11 countries of the South Pacific — Solomon Islands, Fiji, the Gilbert and Ellis Islands, Tuvalu, the New Hebrides, the Cook Islands, Niue, the Tokelau Islands, Western Samoa and Tonga. The total population of these countries is 1.2 million on a total land area of about $68 \times 10^3$ km$^2$ amidst a sea area of about $40 \times 10^6$ km$^2$. Most of the countries are themselves composed of many islands.

We believe that courses in physics at USP should meet the needs of the Region, and in this paper we describe one such course at final year level. Until recently, physics has been a subsidiary discipline to maths, biology, and chemistry, and this, together with the special backgrounds of the students, has shaped the course structure (Lawrence 1973). In particular, there has been a strong interest in ‘Environmental Physics’ (in the sense of Monteith 1970) as applied to meteorology and agriculture. This interest, together with a commitment to electrical physics, formed an excellent base to develop the course structure. We may note that there is no Engineering Faculty at USP.

There is a rising demand for graduates trained in physics in the Region, and we expect the present output to be about 20 to 25 per year. The University planned to meet this demand by developing physics to a major degree interest, coupled (in a 2 major interdisciplinary BSc degree) with one of maths, chemistry or biology.

2. PHYSICS APPROPRIATE FOR THE SOUTH PACIFIC

Here was the opportunity to consider the physics most appropriate to the needs of the South Pacific Region. The geographical constraints of dispersed island communities having relatively small populations are all important. There are close physical and cultural links with the rural and marine environment and there is relatively little industrial development as yet. On the basis of the one manpower survey available (UN 1973), and of our own discussions with a wide range of interested parties, the Physics staff identified the following requirements and constraints for graduates in Physics:

(a) There is a need for a cadre of mature individuals with numerate and technical abilities, to be employed throughout the Region. These graduates could be expected to influence strongly the choice and implementation of technical developments in their societies. Because there are relatively few graduates in the Regional countries, our graduates tend to rise rapidly to positions of responsibility. This is especially so as the countries are rightly pursuing a policy of localisation.

(b) 40% of our graduates are on bonded scholarships to become secondary school teachers, a position of great influence in a young country. Teachers may often have to devise methods of making or adapting their own equipment.

(c) Our graduates must be prepared to meet the forthcoming difficulties of world energy and material supplies. These will be felt acutely in developing countries without indigenous fossil fuel supplies, and will be extreme in dispersed island societies.

(d) Inter-island communication systems and transport are vital in the development of island communities, especially if a dispersed rural base is to be maintained. Already sophisticated telecommunication systems exist, and these must be developed to the highest standards and powered for remote location.

(e) The academic discipline of physics is specifically required for careers in meteorology, environmental and light engineering, electronics, geophysics, communications and medical physics.

(f) A common task needed personnel trained in physics is the application and control of instruments and electronic equipment. In our situation this need is already apparent in agriculture, forestry and marine activities.

We therefore decided to concentrate our final year physics courses into two streams with immediate local application:

(i) telecommunications and instrumentation,

(ii) energy and materials supplies.

The former lies in the mainstream of physics courses worldwide; the latter, which we call resource physics, is the more distinctive, and is the main subject of this article. The full course structure into which they fitted has been described elsewhere (Twidell 1977).

3. OBJECTIVES

The final year single unit courses at USP have the following hours of contact: lectures, 39; laboratories, 65; tutorials, 13. Initially the Resource Physics was a single unit course, but in 1978 it was expanded into two full courses: Energy Supplies and Materials Science. The objectives of the two sections can be listed:

(a) To teach the major aspects of energy supplies in the light of concern about finite reserves of fossil fuels and the debate on nuclear sources. Such interests are not novel (Romer 1976, Clancy 1976), however we feel that the orientation of the USP Course is distinctive.

(b) To emphasize the application of renewable energy supplies using devices associated with intermediate technology (often called appropriate or low-input technology) (Schumacher 1973).

(c) To make our students aware of the potentialities and properties of locally available materials, and to give them the opportunity of open-ended project work in association with workshop training. It is important for teachers in a developing country to learn that good science can be done with simple locally made equipment.
(d) To use the applied objectives of the course as motivation for the analytical understanding of basic phenomena in physics. Thus it is most important to relate the materials properties to solid state physics; and the energy debate to nuclear physics.

4. ASPECTS OF THE CURRICULUM

Teaching on materials makes a sustained attempt to relate macroscopic properties to the microscopic. As in the course at WAIIT (Price and Terry 1972), there is more emphasis on mechanical properties than is usual in a straight physics course. The approach of the materials courses in the Open University’s Technology Degree is useful, as are the books of Gordon (1968, 1977). The macroscopic view of materials relates well to the teaching in Industrial Arts already well established in our secondary schools, and it is also important for our workshop course and laboratory project work. The syllabus covers the conventional ground of interatomic forces and crystal structure and progresses to defects and dislocations, crack propagation, composites, and alloys. Some of this work is reinforced by the teaching from the chemistry area that all our students receive.

The properties of composites in general, and biological materials in particular, are given more emphasis than usual, as physicists have often neglected the unique properties of timber (Cokley 1977).

One of the greatest assets of the Islands is the availability of renewable energy sources, such as solar, wind, hydro, wave, biogas, and even geothermal sources of energy, so our teaching, and especially the laboratory work, concentrates on these. Our students learn about the energy, material and momentum flows in the natural environment in an earlier course on Environmental Physics. We find that many of the instruments used in the practical work on agricultural micrometeorology (radiometers, anemometers, thermometers, data recording, etc.) are essential in the practical work on renewable energy devices. However the synthesis of all these techniques and properties into the construction and operation of a device such as a solar water heater or a wind-powered generator is extremely demanding. We emphasize the importance of good design, construction, and maintenance in the practical work which is of extreme importance if local materials and skills are to be used as we stress. In practice the urgent desire of governments and villages to obtain renewable energy resources in the light of high fossil fuel costs make the motivation and application of these topics obvious.

As our graduates will make decisions on national energy policy, it is important to consider the full range of energy sources that may become available in the Islands, from ocean thermal gradients to nuclear reactors. We go into moderate detail of the physics of nuclear reactors including waste problems – this being the students’ only exposure to nuclear physics. We also treat closely related topics that are essential to a numerate analysis of energy supplies, e.g. world and local population structure, economic aspirations, world fuel reserves, projected energy demands and costs, and energy use in agriculture, marine activities and industry.

Text books on general materials properties are quite readily available: we used Anderson & Leaver (1975). There are several books now available on the general energy problem, but very few are suitable for the analytical study of renewable energy devices. We used the reprints edited by Ruedisili and Firebaugh (1975), and dealt individually with each device using journal reprints, appropriate technology literature such as the “Energy Primer” (1973) and our own handouts. A recent book by Cook (1976) should prove useful.

Assessment is on the basis of course work (essays, tests, tutorial assignments, project talks), and a final written examination. Each component counts 50% of the total mark.

5. TEACHING MODE

The course includes lectures, analytical assignments, laboratory set-piece work and open-ended projects. A number of lecturers and project supervisors visit from outside and participate in the teaching as guests. We find that this adds relevance to the course. Mechanical or electrical workshops training is included in all physics courses and we encourage a close working relationship between technicians and students. Equipment, funds, and workshop facilities are limited at USP despite foreign aid, which gives the students practice in applying their science and technology within the constraints of a developing country. The relevance of the courses has been such that a number of local organisations have been pleased to give or loan equipment for practical work and make their facilities available for visits.

6. LABORATORY PROJECTS

The Laboratory took the form of materials testing and open-ended projects (cf. Morgan et al 1976). With our limited resources, the projects naturally emphasised appropriate technology. Many of the projects are linked to staff consultancy and research and an example of this is:

Biogas digester. An anaerobic digester for pig and poultry waste was made from reinforced rubber sheet. The loaded bag weighed ~ 3 tonnes, and the project included design for the materials properties of the bag and housing. Such digesters are now being installed on local pig farms. An inflated bag can be seen in Fig. 1, behind the student, who is working on a related project, measuring the optimum conditions for biogas production.

Solar sea-water distillation. A still was designed with condensation taking place on a cool metal back plate.

Figure 1. Student measuring biogas yields.
The main frame of the still was formed manually in ferrocement — a material of great potential in the region — using semi-skilled (student) labour (Fig. 2). The full analysis of the operation of the still is an extremely demanding task in heat transfer, fluid mechanics, and careful use of instruments.

Solar voltaic cells. One project was to test and evaluate a prototype system for the Fiji Marine Department. This consisted of a 12V 1A maximum array of silicon cells used to charge a battery. The power was to be used for lights on a remote unattended reef. The project required understanding of the solid state physics of the cells, and had to contend with fluctuations in solar energy input. The results showed that the efficiency of the light bulb was a severely limiting factor.

Figure 2. Students making a solar still.

Wind power. We were able to borrow a wind driven water pumping unit and a large (36V, 200W, 3m diameter) wind generator. Student work on these systems is seriously constrained by safety requirements. However students have managed to measure the efficiency of the overall system and several of its component parts (blades, generator, battery).

Hydropower: We were able to test and develop a 3kW Pelton wheel system linked to a 240V a.c. generator through a novel electronic controller. The controller automatically switches power from the useful supply (eg. light) to a standby load (eg. water heater). Thus the wheel is presented with a controlled load to stabilize the frequency or voltage.

7. STUDENT AND PUBLIC RESPONSE

We had major difficulties developing the laboratory and equipment at the same time as teaching the course. Not surprisingly, the first batch of 13 students were confused about the direction of the course, but this should be corrected during the second presentation. At a personal level, the objectives of the course were met in that initiative, creativity and commitment were developed in the students and they became aware of practical applications of their science.

Public interest was indeed great. A documentary film was made by the Fiji Ministry of Information highlighting the renewable energy devices of the laboratory. This was shown to cinema audiences throughout the country, which, in the absence of television are large. Immediately following the initial course, a 3-week United Nations sponsored International Workshop on "Rural Energy Sources" was held at the university. All of the student project devices were demonstrated as part of the Workshop. An Open Day for local schools attracted over a thousand visitors. The hydro-power project was taken over by the Fiji Government Public Works Department, and the system was installed with local voluntary labour in a remote village. Power was ceremonially switched on by the Deputy Prime Minister in February 1978.

8. ACKNOWLEDGEMENTS

A feature of the course has been the widespread cooperation and participation of colleagues in the University, and of outside friends. We must especially thank the Principal, Dr Swami, of the Derrick Technical Institute; Mr P. Johnston of the Central Planning Office of the Fiji Government; the Director, Mr Alston, of the Timber Utilization Bureau; Dr C. Sapsford and Dr D. Hutton on leave of absence from the University of New South Wales and Monash University respectively; Miss H. Wyper, a ‘VSO’ volunteer with the Public Works Department; and Mr F. Griffiths of the USP Industrial Arts section. Readers’ suggestions for improvements in the course will be gratefully received.

REFERENCES


Energy Primer (1973) (San Francisco: Portola Institute).


GLASSY METALS
A NEW CLASS OF MATERIAL

A.M. Stewart, School of Physics, University of New South Wales.

This article is based upon an invited talk given at the AIP Solid State Physics Meeting at Wagga Wagga, NSW in February, 1978.

Introduction
In the past five years or so a new type of solid material – amorphous or glassy metals – has engaged the attention of an increasing number of solid state physicists. There are two reasons for this interest. First, the new class of material is likely to have industrial applications of great importance, and second, consideration of the physical properties of these materials brings to light many fundamental problems in solid state physics. These seem likely to give workers in this subject a new field of research that should keep them occupied for many years to come.

In this article I shall first discuss the structural properties and methods of preparation of metallic glasses, then I shall mention some of their possible applications. Finally, in order to illustrate the existence of some as yet unsolved problems in this subject I shall describe a particular phenomenon, the resistance minimum, which occurs almost universally in these potentially useful materials, but which is so poorly understood that even the physical interaction responsible for the effect is not agreed upon.

Amorphous Solids
An amorphous or glassy solid is defined as a solid that does not possess the property of crystallinity. That is, its atoms do not lie on a periodic space lattice that extends over many atomic spacings. Because of this, the elegant mathematical methods that are so powerful in the theory of periodic solids, such as group theory and the theory of Brillouin zones, are not applicable to amorphous materials. Consequently the theory of amorphous solids is far less advanced than the theory of crystalline ones, and a great deal of theoretical work needs to be done to clarify the basic structural and electronic features of these materials.

Furthermore, the lack of symmetry and intrinsic disorder of amorphous materials means that their physical properties will always have some sort of randomness associated with them. Therefore the theory of the amorphous state is much concerned with averaging procedures, and the experimental results on amorphous solids show that most of the sharp features associated with crystalline materials, such as X-ray diffraction peaks and resonance absorption lines, are smeared out into broad distributions. The situation is very similar to that in liquids, and indeed an amorphous solid may be thought of as a frozen liquid.

However, an important concept that is unique to amorphous solids was developed by P.W. Anderson and others in the nineteen fifties and is now known as Anderson Localisation. This theorem describes the conditions under which the electronic wavefunctions of an amorphous material will be bandstates, i.e. extended throughout the solid, or else localised in space, as for example are the states in the forbidden gap of a semiconductor. Anderson's criterion states that the wavefunctions will be localised if the energy that is characteristic of the disorder, for example the width of the distribution of atomic energy levels, is greater than the hopping energy that causes electrons to tunnel from one atom to another. In amorphous semiconductors the relevant electron states are most often localised, and many of the unusual properties of these materials follow from this. However in amorphous metals, which are our concern in this article, the valence electrons of the metallic atoms overlap strongly, the hopping of electrons from one atom to another is rapid, and the electronic conduction is by the usual band mechanism. The electronic mean free paths through, are very short, of the order of one atomic spacing, and this gives rise to a high electrical resistivity.

Preparation
There are two basic methods that have been used to prepare metallic glasses. The first is to quench them very swiftly from the melt, and the second is to deposit the constituent atoms randomly onto a substrate by evaporation, sputtering, or electrodeposition.

Three types of metallic glass have been studied extensively since work first began on the metallurgy of these materials over fifteen years ago.

The first are elemental metals prepared by evaporation onto cold substrates.

Since the amorphous state of a solid is, at best, a metastable state, and the lowest energy state always appears in practice to be crystalline (although any theoretical proof that this is the case has yet to be produced) it follows that if the temperature of an amorphous solid is raised sufficiently the atoms in the solid will possess enough energy to move to the lower energy positions of the perfect lattice and the material will "crystallise". The recrystallisation temperatures of elemental metallic glasses tend to be lower than those of more complicated substances, such as silica glass SiO₂. This is because the metallic bond is non-directional and metallic atoms can therefore slip past each other into energetically favourable configurations more easily than can more complicated structural units. Elemental metallic glasses tend to have recrystallisation temperatures below room temperature, and because of this they have no technological applications, although their physical properties are important to study in order to obtain an understanding of the nature of the amorphous state itself.

The second group of metallic glass materials to have been studied in detail are those that contain rare earth atoms together with transition metals like iron or cobalt. These materials are prepared by evaporation, and their constituent atoms are magnetic. A great deal has been learnt about magnetism in the amorphous state by comparing the magnetic properties of these materials to those of their crystalline counterparts, such as intermetallic compounds like TbFe₂, but these materials do not appear to have any widespread applications at present.

The third class of glassy metal consists of combinations of transition metals T, such as iron, nickel or palladium with metalloids M, such as silicon, phosphorus or boron, in the approximate ratio TₐM, as in P₈B₉S₁₂ for example. These glasses are prepared most easily around the eutectic composition TₐM, and compositions away from this need faster quenching rates. The ease of glass preparation is increased by incorporating several different types of atom, for example various proportions of Fe,Co,Ni for T and P,As,Si for M. The reason for this is simply that it is harder for glasses of more complicated compositions to crystallise as the atoms find more difficulty in pairing up with their appropriate crystalline partners.

Since this type of metallic glass has
many favourable physical properties including recrystallisation temperatures of the order of 300°C, well above room temperature, that give promise of many practical applications, I shall discuss only this type of glass from now on.

These glasses are prepared by rapid cooling from the melt at rates of $10^5 - 10^6$ K/sec. The first method that was used for quenching samples at such high rates was splat cooling, in which drops of the molten specimen are suddenly compressed between cold copper plates. The principles of a continuous casting process, known as ribbon spinning, that is used to produce ribbons of metallic glass on an industrial scale is illustrated in Fig. 1. A rotating copper disc is dipped into the surface of the melt, which solidifies rapidly on the edge of the disc and is carried upwards and thrown off in the form of a continuous ribbon of unlimited length1. The ribbon is of the order of 0.005 cm thick and can be up to a few inches in width. The thickness needs to be small in order to attain the required cooling rate, but there seems to be no fundamental limitation on the width and it is likely that future technological developments will allow much wider ribbons to be produced.

Another important way of producing glassy metals is by the method of laser glazing. In this process a high power laser beam is scanned across the surface of a metallic workpiece. The laser energy melts the surface layer of the workpiece which, because it is in contact with the cold substrate, freezes rapidly, producing a surface layer of metallic glass. As this layer may have physical properties that are superior to those of the crystalline substrate the method of laser glazing promises to have wide scale applications in metal processing.

Structure

The fundamental difference between a crystalline and an amorphous solid lies, of course, in the structure. The structures of the various states of matter are illustrated in Fig. 2. In Fig. 2(a) the structure of a periodic crystalline solid is shown together with the pair distribution function $g(r)$, which measures the probability of finding an atom at a distance $r$ from another atom. For a crystal, $g(r)$ is a series of very narrow peaks. For a gas, shown in Fig. 2(b) $g(r)$ is constant away from the hard core. The pair correlation functions of a liquid and an amorphous solid, in Fig. 2(c) and 2(d) are very similar, reflecting the similarity in structure.

The pair correlation functions, whose Fourier transforms are related to the X-ray scattering factors, of these substances can be seen to be intermediate between those of a gas and of a crystalline solid. This shows that a considerable amount of short range order, or correlation between the positions of neighbouring atoms is retained in liquids and in amorphous solids, but that the long range order is lost. The pair correlation function of an amorphous solid shows slightly more structure than that of the liquid because in the latter the atomic motions perform an averaging effect.

The theoretical understanding of the structure of metallic glasses is at present in a very rudimentary state. The most popular theory is known as the Dense Random Packing of Hard Spheres model. In this, the atoms are represented by hard spheres of appropriate size, and are randomly placed together by a computer to form the amorphous solid. The computer then calculates structural data, such as the pair correlation function, from the atomic positions. The agreement with experiment is usually good, but it is not clear that any understanding of the nature of the amorphous state at a fundamental level is gained from such calculations.

Properties

The potential usefulness of the $T_2M$ metallic glasses does not, in general, arise because they have any particular properties that surpass those of crystalline materials. It arises because they possess combinations of properties, for example mechanical hardness and magnetic softness together with a very low cost, that are not to be found in any one crystalline material.

The Yield Strengths of metallic glasses can be as high as those of good crystalline materials, but the plastic strain before fracture can be as much as 50%. The resulting ability to absorb a large amount of energy before fracture is a highly desirable mechanical property.

Some of the glasses, particularly those that contain silicon, prove to be strongly resistant to corrosion. It is not clear whether this is due to the formation of corrosion resistant $SiO_2$ on the surface of the material or to the lack of grain boundaries that in a crystalline material would be attacked preferentially.

Amorphous materials, by their very nature, are likely to be resistant to radiation damage, because if an atom in an amorphous substance is displaced by radiation the resulting material will still be amorphous. On the other hand, radiation falling on a crystalline material may destroy its crystallinity and radically alter its physical properties.
Many of the $T_{2}M$ glasses that contain large amounts of iron or cobalt are ferromagnetic at room temperature. That is, the magnetic moments of some of the electrons are lined up in one direction by cooperative interactions within the material. These glasses become magnets. However what is remarkable about them is that they are very easily magnetised and demagnetised and have very low magnetic power losses. This is probably due to the fact that in an amorphous material there are no crystal grain boundaries to impede the motion of magnetic domain walls.

However the most significant property of metallic glasses is their low cost. It is much cheaper to manufacture them than to prepare a crystalline material in the form of wires. This is because the continuous casting process for metallic glasses is so simple, whereas the hot and cold forming processes which would be necessary to convert a crystalline ingot into a ribbon of similar shape would be very expensive in terms of time and energy.

Applications
The largest scale applications of metallic glass ribbons are likely to make use of their mechanical properties of strength and flexibility by incorporating the ribbons as reinforcing fillers in tubing, car tyres, flexible belts or in the reinforcement of rigid materials like plastics. Their corrosion resistance will clearly be an advantage here. Since the materials are hard and can be sharpened one can imagine the construction of knives or razors with continuously replaceable blades.

The magnetic properties of metallic glasses are likely to be used in manufacturing relay and low loss transformer cores. The fact that the materials are produced already in laminated form is an extra advantage. Sheets of the materials could be used for magnetic shielding. The materials also have square B-H loops, and could be used to make non-volatile magnetic memories with small switching energies.

The surface hardening of crystalline metals by laser glasing is another possibility for large scale industrial processes.

Finally, the use of metallic glasses in all these applications may be more favourable in a radiation environment. Metallic glasses may find much use in nuclear reactor technology.

The Puzzle of the Resistance Minimum
In the last part of this article I shall try to illustrate the existence of fundamental unsolved problems in the field of amorphous metals by discussing a particular one of them, the resistance minimum.

How does one expect the resistivity of an amorphous metal to vary with temperature? The electrical resistivity of a perfectly periodic metal is zero according to the famous theorem of Bloch, and the reason why the resistivities of crystalline metals increase with temperature is that thermal vibrations displace the atoms from their equilibrium positions and destroy the periodicity. Therefore an amorphous metal would be expected to have a high resistivity which increases only slightly with temperature, because the material is highly disordered to begin with and thermal vibrations create only a small additional contribution to this disorder. This expectation is generally born out by experiment. Amorphous metals have resistivities of the order of 100-200$\mu\Omega$cm that vary only by a few percent between room temperature and absolute zero. This resistivity corresponds to electronic mean free paths of about one atomic spacing.

However, when high resolution resistivity measurements are made on amorphous metals it is found in very many cases that a minimum in the resistivity exists between about 10$K$ and room temperature. An example of this is shown in Fig. 3 in which the resistivities of four metallic glass alloys are seen to decrease by an amount of 1% or less from zero temperature to 20$K$. The resistivity then passes through a minimum and increases by a few percent up to room temperature. The increase in resistivity above the minimum is not shown in the figure.

The phenomenon of the small resistance minimum has caused a great deal of interest among solid state physicists in the last few years. The basic reason for this interest is that another resistance minimum effect in metals, called the Kondo effect after the Japanese theoretical physicist J. Kondo who explained it in 1964, had produced a flood of experimental and theoretical work in the decade between 1965 and 1975. This resistance minimum occurs when magnetic atoms are dissolved in a non-magnetic metal, for example iron or copper. The minimum is produced by spin-flip scattering of conduction electrons by the magnetic atoms, and the discovery of a similar effect in amorphous metals led people to wonder if the cause could be the same. However the Kondo effect explanation is not entirely satisfactory, as I shall explain, and several quite different explanations have been proposed. At the present time it is not known which, if any, is the correct one.

The Kondo effect explanation was quickly put forward when the resistance minimum in metallic glasses was first discovered, but it was soon criticised on the following grounds. The spin-flip scattering mechanism will only be able to act effectively in a small magnetic field, because as a magnetic atom flips its spin from one direction to another it gains or loses energy, and this is difficult to do at the low temperatures we are concerned with. Now many of the glassy metals in which the resistance minimum occurs are ferromagnetically ordered. Therefore the magnetic interactions within the material should provide an internal "molecular" magnetic field which ought to quench the spin flip scattering process and so eliminate the resistance minimum. A number of ways have been suggested of getting round this obstacle, but none are entirely satisfactory. Two such ways

![Fig. 3. The resistivities $\rho$ of four metallic glasses from 0.3K to 20K. Unpublished measurements of A. M. Stewart and W. A. Phillips.](image-url)
invoke the randomness of the material and suggest that the internal magnetic field will also be random in magnitude, so that a few magnetic atoms will sit in zero internal field and scatter effectively. Alternatively the magnetic excitations will have a finite energy width and there will be an adequate number of them with the low energies required for spin-flip scattering.

The second explanation for the resistance minimum arose from the observation that resistance minima can occur (although this is debatable) in metallic glasses in which no magnetic atoms are present. Physicists at McGill University in Montreal suggested that a type of scattering similar to that in the Kondo effect could be produced by the scattering of conduction electrons by tunneling states. The concept of the tunneling state as a fundamental excitation in amorphous solids was introduced by W. A. Phillips, P. W. Anderson, B. I. Halperin and C. M. Varma in 1972. A tunneling state is an atom or group of atoms that can tunnel quantum mechanically from one position or configuration in the solid to another one of nearby energy. Alternative configurations of similar energy must exist in the amorphous state because the configuration that the material solidifies into is arbitrary, and not unique as it is for a crystalline solid. These tunneling states are claimed to make an important contribution to the specific heats of amorphous insulators, and the McGill workers suggest that they may produce the resistivity minimum in amorphous metals, although the details of the theory have yet to be worked out satisfactorily.

However, the most simple and elegant explanation for the resistance minimum has been put forward by F. J. Okhawa and K. Yosida. They argue that it is caused by non-linear forces between the atoms in the amorphous solid. To understand this, let us consider three atoms situated colinearly in the amorphous metal.

![Diagram](image)

Fig. 4. Illustration of non-linear forces between atoms in an amorphous solid. The solid curve shows the anharmonic potential energy of the central atom under the influence of the two outer atoms. The dotted curve shows a harmonic potential.

(Fig. 4). Since the substance is amorphous, the central atom will not, in general, lie exactly in the middle of the line joining the two outer atoms, but will lie rather nearer to one than to the other. Consider now what happens when thermal energy is supplied and the atoms start vibrating. The central atom will find it preferable to move away from its nearer neighbour towards the centre point. This is because the repulsive forces between atoms become very strong as the atoms get close together.

The net result of this is that the middle atom moves towards the centre point as the temperature increases and therefore the solid becomes more symmetrical and periodic. Okhawa and Yosida argue that the resistivity decrease is the result of the solid becoming more periodic with rising temperature because, as mentioned before, the resistivity of a perfectly periodic metal is zero.

These three very different explanations of the resistance minimum in amorphous metals are not the only ones to have been proposed. The writer knows of at least two others at present awaiting publication. It is not clear that any of these theories has yet provided the correct explanation for the resistance minimum that appears in so many amorphous metals.

Conclusion
Glassy metals form a new class of material that may have important engineering applications in the future. For solid state physicists and materials scientists they offer a new field for research. I expect research on amorphous metals to take two forms. First, there will be systematic studies of how mechanical, electrical and magnetic properties vary with composition and method of preparation. Second, there will be investigations of such effects as the resistance minimum that seem to be caused by the unique nature of the amorphous state, in order to develop an understanding of the fundamental differences between ordered and disordered states of solid matter.

References
2. For a more detailed description of the preparation and properties of metallic glasses see the article by F. J. Gilman. 1975, Phys. Rev. Lett. 46, 676.
7. Recent work discussing magnetic applications of metallic glasses is published in The Journal of Applied Physics 1978 49, No. 3.

138 The Australian Physicist, October 1978
LIGHT AND LIGHTING IN AUSTRALIA

A.J.D. Farmer, AIP Representative on the Australian National Committee on Illumination

LIGHT is a commodity that has been around for a long time; so long in fact that many people, physicists included, might consider the subject to be well studied and understood by all and therefore not important nor particularly interesting. This short article is an attempt to show that the subject of light and lighting is alive and well. Certainly the field has been extensively studied but there are many areas in which our knowledge of basic optical phenomena or our understanding of a particular lighting application leaves much to be desired. Far from being unimportant and uninteresting it is not too difficult to find numerous aspects of our life and work which involve us in some extent with light, usually in an almost essential capacity. Consider, for example, the many ways in which light is involved in the every day (or night) driving of a motor vehicle.

The subject of light and lighting encompasses a wide variety of disciplines and professions and, if the interaction of these is to be fruitful, it is desirable that they have some common ground or starting point for discussion. For this reason, the Australian National Committee on Illumination (ANCI) was formed in 1949 with two broad objectives. Firstly, it was to be a means of drawing together organizations and persons in Australia interested in light and lighting. Secondly, by becoming a member of the international lighting body, the International Commission on Illumination (CIE), ANCI would provide a link between Australia and the rest of the world lighting community.

The stated aims of the CIE are:

(a) to provide an international forum for all matters relating to the science and art of lighting.
(b) to promote by all appropriate means the study of such matters.
(c) to provide for the interchange of lighting information between different countries.
(d) to prepare and publish international agreements in the field of lighting.

Member countries of the CIE participate in the executive decisions of that body and also nominate representatives to sit on its working committees - the CIE Technical Committees. It is through these Technical Committees that the CIE works towards its objectives and it is here that Australia contributes to the benefits from the international knowledge of lighting matters. A list of the current CIE Technical Committees is given in Table I and it can be readily seen that the range of topics covered by them is quite considerable. Australia is represented on each of these committees and is at present responsible for the running of two of them: TC-3.4 "Discomfort Glare" (Chairman: Mr K. Poulton of the Commonwealth Department of Productivity) and TC-4.6 "Road Lighting" (Chairman: Dr A. J. Fisher of the University of New South Wales Department of Transport and Traffic).

1. Genesis 1, 3

<table>
<thead>
<tr>
<th>TABLE I – CIE TECHNICAL COMMITTEES</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC 1.1 Terminology</td>
</tr>
<tr>
<td>TC 1.2 Photometry and Radiometry</td>
</tr>
<tr>
<td>TC 1.3 Colorimetry</td>
</tr>
<tr>
<td>TC 1.4 Vision</td>
</tr>
<tr>
<td>TC 1.5 Lighting Calculations</td>
</tr>
<tr>
<td>TC 1.6 Visual Signalling</td>
</tr>
<tr>
<td>TC 1.7 Actinic Effects of Optical Radiation</td>
</tr>
<tr>
<td>TC 2.1 Sources</td>
</tr>
<tr>
<td>TC 2.2 Detectors</td>
</tr>
<tr>
<td>TC 2.3 Materials</td>
</tr>
<tr>
<td>TC 2.4 Luminaires</td>
</tr>
<tr>
<td>TC 3.1 Visual Performance</td>
</tr>
<tr>
<td>TC 3.2 Colour Rendering</td>
</tr>
<tr>
<td>TC 3.3 Physical Environment</td>
</tr>
<tr>
<td>TC 3.4 Discomfort Glare</td>
</tr>
<tr>
<td>TC 3.5 Visual Environment</td>
</tr>
<tr>
<td>TC 3.6 Lighting and Architecture</td>
</tr>
<tr>
<td>TC 4.1 Interior Lighting</td>
</tr>
<tr>
<td>TC 4.2 Daylighting</td>
</tr>
<tr>
<td>TC 4.4 Sports Lighting</td>
</tr>
<tr>
<td>TC 4.5 Exterior Lighting</td>
</tr>
<tr>
<td>TC 4.6 Road Lighting</td>
</tr>
<tr>
<td>TC 4.7 Automobile Lighting</td>
</tr>
<tr>
<td>TC 4.8 Aircraft Lighting and Signals</td>
</tr>
<tr>
<td>TC 4.9 Lighting Economics</td>
</tr>
<tr>
<td>TC 4.10 Mine Lighting</td>
</tr>
<tr>
<td>Study Group F Photochemistry and Agriculture</td>
</tr>
<tr>
<td>Study Group G Global Radiation</td>
</tr>
<tr>
<td>Study Group H Lighting for Theatre, Television and Film</td>
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The working programs of most of the Technical Committees follow the same general pattern. They include collecting and assessing the available information and data in a particular area of lighting research, development or application; organizing for additional data to be obtained if required; reaching an agreement on the problem being studied and publishing the results of their investigations. Part of the working program of TC-2.2 "Detectors" is for example:

1. Organization of an international intercomparison of measurements of the spectral sensitivity and linearity of silicon cells.

The wide range of topics being studied by the CIE means that information is needed from an equally wide range of professional disciplines. This is reflected in the CIE and ANCI membership which includes architects, chemists, engineers, ophthalmologists, psychologists, members of the medical profession and of course physicists. The important role of the physicist in many aspects of lighting is well recognized by the AIP which was a foundation member of ANCI and has retained its membership to the present time. One subject to which physicists have made significant contributions is that of Technical Committee TC-1.3 "Colorimetry". This committee has been responsible for recommending and obtaining international recognition for objective systems.
of colorimetry. These enable the use of accurate physical methods for measuring colour and colour differences rather than the earlier visual methods. The objective measurement of colour and its associated studies has considerable bearing on many fields. Some obvious examples would be the textile and paint industries, colour specification and control in manufacturing industry and the design, manufacture and use of television cameras and receivers, while perhaps an unexpected use is in archaeology for identifying pigments in pottery etc. Several systems for specifying and measuring colour have been progressively developed within this committee, each satisfying particular requirements of the end user. These developments are continuing and are basically aimed at producing a more uniform colour solid. Considerable effort has also been directed towards specifying standard sources for colour measurement, recommending geometries for reflectance measurements and studying various aspects of whiteness, metamerism and chromatic adaptation.

In addition to its involvement with CIE Technical Committees, CIE quadrennial sessions and other CIE affairs, ANCI holds two one-day meetings each year. The morning sessions are usually devoted to the business of running ANCI and its international involvement but the afternoons are set aside for technical meetings on some aspects of current work in lighting. To involve as many interested people as possible, these meetings are held alternately in Melbourne and Sydney and the technical meetings are open to anyone wishing to attend. The next meeting is on October 30, 1978, and will be held at the CSIRO National Measurement Laboratory in Sydney.

Full membership of ANCI is available to any Australian organization of a national character interested in light or lighting and there is also a grade of Associate Membership for organizations who do not meet the requirements of full membership. A list of full members of ANCI is given in Table II.

Further information on ANCI and CIE activities may be obtained from the author.

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TABLE II - MEMBERSHIP OF ANCI

| Australian Broadcasting Commission |
| Australian Electrical Manufacturers' Association |
| Australian Institute of Physics |
| Australian Medical Association |
| Australian Optometrical Association |
| Australian Psychological Society |
| Australian Road Research Board |
| Commonwealth Experimental Building Station |
| Commonwealth Scientific & Industrial Research Organization |
| Department of Construction |
| Department of Productivity |
| Department of Transport |
| Electricity Supply Association of Australia |
| Federation of Australian Commercial Television Stations |
| Illuminating Engineering Societies of Australia |
| Materials Research Laboratories |
| National Association of Testing Authorities |
| Royal Australian Institute of Architects |
| Standards Association of Australia |
| The Institution of Engineers, Australia |
| The Society of Dyers & Colourists of Australia & New Zealand |

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UNIVERSITY OF MELBOURNE

LECTURESHIP

in the

SCHOOL OF PHYSICS

Applications are invited for a continuing Lectureship position in the School of Physics. The current research interests of the School are high energy physics, diffraction physics, low energy nuclear physics and theoretical physics.

The successful applicant will be required to teach at an undergraduate level by lecturing or supervising laboratory classes, to supervise research students and to conduct research in one of the above areas of physics.

QUALIFICATIONS: PhD with postdoctoral experience.

SALARY: $15,179 to $19,940 per annum.

The position can be taken up on 16th January, 1979 or as soon as possible thereafter.

Further information, including details of application procedure and conditions of appointment, is available from the Registrar, University of Melbourne, Parkville, Victoria, Australia, 3052. Applications referring to Position Number 640 039 should be addressed to the Registrar and close 31st October, 1978.

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140 The Australian Physicist, October 1978
The number of applications being received from students and postgraduate students for incorrect grades of membership of the Institute suggests that some applicants and their proposers are confusing the generic title “student” with the Institute grade of “Student”. The current employment situation for recent graduates has also raised problems in relation to gaining professional experience as a physicist subsequent to graduation.

The Committee uses the following guidelines, based on the requirements set down in the Articles of Association and the By-laws:

- For admission as a Student a candidate must at the time of application be proceeding towards the attainment of the qualifications for Graduateship, i.e. be studying for a first tertiary qualification in physics in one of the courses listed below:
- A postgraduate student with a pass B.Sc. but less than one year of postgraduate experience is eligible for Graduateship (and subsequent upgrading to Graduateship after one year of postgraduate experience in physics);
- A postgraduate student with a B.Sc. (Hons) is eligible for Graduateship, the honours year being regarded as appropriate experience;
- A postgraduate student with a pass B.Sc. and one year of postgraduate experience is eligible for Graduateship;
- A postgraduate student who is already a Student of the Institute is permitted to remain as a Student until eligible for Graduateship, i.e. during the honours year or the first year of postgraduate study after the pass B.Sc.

As a result of the current shortage of professional positions for qualified physicists, a number of recent graduates have taken employment at sub-professional level as Technical Officer, Technician, Laboratory Assistant, etc. and have requested the Institute to recognise this work as constituting the one year of experience in the practice of physics or its applications which is required for Graduateship. In the absence of detailed statements from the candidate or his/her proposer about the actual nature of the work, the Membership Committee faces a difficulty in assessing the extent to which the position allows the exercise of professional skills and the knowledge of physics at a standard satisfactory to the Institute. In some recent cases, where the Committee has had doubts about the level of experience being gained in a nominally sub-professional position, a “weighting factor” has been applied and the candidate has been requested to defer an application for Graduateship for a specified period of time. In cases where evidence has been presented that the occupant of a nominally sub-professional position is actually carrying out the work of a professional physicist, full credit is given for “experience” when assessing eligibility for Graduateship.

Qualifications Recognized for Graduateship

a. A pass degree in physics from any Australian or New Zealand university;

b. A degree in physics from any university recognised by The Institute of Physics (London);

c. Any of the following degrees or diplomas with physics as a major subject:
   - The Ballarat College of Advanced Education: B.App.Sc. (double major in Physics); Diploma in Applied Physics;
   - Canberra College of Advanced Education: B.App.Sc. (with special requirements as to physics content.);
   - The Capricornia Institute of Advanced Education: B.App.Sc. (Physics);
   - Caulfield Institute of Technology: B.App.Sc. (Multidisciplinary), provided either unit PA 25 or PA 26 is taken;
   - Darling Downs Institute of Advance Education: B.App.Sc. (Physics);
   - Gordon Institute of Technology: Diploma of Applied Physics: B.App.Sc. (Multistream);
   - The New South Wales Institute of Technology: Diploma in Technology with major in Physics;
   - Queensland Institute of Technology: B.App.Sc. (Physics);
   - Royal Melbourne Institute of Technology: B.App.Sc. (Physics); Fellowship Diploma in Applied Physics or Applied Physics (Meteorology);
   - South Australian Institute of Technology: B.App.Sc. in Applied Physics;
   - Sydney Technical College: The ASTC Diploma in Physics, provided it was obtained prior to 1964;
   - The University of Adelaide: B.Tech., in Industrial Physics; B.App.Sc. in Applied Physics on work done at the South Australian Institute of Technology;
   - University of Melbourne: B.App.Sc., provided it includes Physics at the third level, Electronics and Mathematics;
   - The University of New South Wales: B.Sc. in Textile Physics;
   - Western Australia Institute of Technology: B.App.Sc. (with special requirements as to physics content).

d. Other overseas qualifications in physics that are assessed by the Institute as equivalent to the above.
Enquiries and registrations for the 49th Congress of the Australian and New Zealand Association for the Advancement of Science, to be held at the University of Auckland from January 22 to 26, 1979, are flowing in steadily.

At least 3,000 delegates, from Australia and New Zealand, as well as from Britain, Europe and North America, are expected to attend. Such a figure would make it one of the biggest, as well as the most varied, conferences ever to be staged in Auckland.

Congresses are held every fifteen to eighteen months in the principal cities of Australia and New Zealand, with this country being asked to act as host every twelve years or so. Auckland has been the venue only once before, in 1937.

A deduction of $7.50 from the general Congress member's fee of $47.50 will be granted anyone registering before October 31. Full-time students are also entitled to a reduction of $7.50, which would make their fee $10, providing they too register before the end of October.

Brochures with attached registration forms are currently being distributed but can also be obtained by writing to the organising secretary, 49th ANZAAS Congress, University of Auckland, Private Bag, Auckland. Australians can obtain brochures from Trans-Australia Airlines. Most of the programmes for the 32 sections of the Congress have been completed and are included in a pre-Congress circular at present being printed. This will be distributed to all those who have registered and to those requesting a copy.

The President of the Congress will be a distinguished Australian scientist and administrator, Dr. K. L. Sutherland, O.B.E., D.S.c., Ph.D., a founding member and past President of the Australian Industrial Research Group. He has been the Director of Research of C.S.R. Ltd. and managing director of C.S.R. Research Pty. Ltd.

Four new sections will feature at the Auckland Congress. They are Sports Science, Oenology (wine science), Musicology, and Trace Metals Research.

The various sections, which range across the physical and natural sciences, medical sciences, and the social sciences also include economics, industrial relations, history and many more.

In addition to presenting the latest findings of specialists, ANZAAS attempts to disseminate the discoveries of science and its other member disciplines as widely as possible among the general public.

A series of symposia, all expressing the central Congress theme, "Directions for the Future", will aim at a broad base of participation. These will be presented in collaboration with national bodies such as the New Zealand Planning Council, the New Zealand Energy Research and Development Committee, the New Zealand Council for Educational Research, the DSIR and the Department of Trade and Industry.

Speakers will be drawn from political parties, Government departments, statutory authorities, various professions, trade unions and other appropriate organisations.

Experts of world standing from Europe and North America are expected to feature among the 27 or so keynote speakers.

The topics will be: Directions for the Future; the World Scene and the place of New Zealand in it; Economic and Social Planning; Oil — Australian and New Zealand Response to Dwindling Resources; New Zealand's Language Future; Future of Primary Industries in Australia and New Zealand; Development of Technology in the Future Pattern of Industries; Social Responsibility in Science; Conservation in the Southern Oceans and Australasia; Human Resources in Health Care; Is Medicine an Art, a Science or a Business?; Children in Society; Application of Scientific and Technical Knowledge in Asia; Problems and Prospects; Survival and Solvency in the South Pacific; New Zealand and Australian Official Aid; Can Science be Administered?; Modern Drug Treatment: Benefit, Risks and Costs; and Application of Scientific Analysis to Problems of Art Administration.

It is hoped to ensure comprehensive coverage of the symposia and many of the specialist papers through the news media. A publicity committee is planning extensive facilities at the Congress for media representatives, who will include leading science journalists from Australia.

Consideration is also being given to newspaper supplements and special television and radio programmes on the Congress. Scientific and trade exhibitions will be held on the University campus.

"Student ANZAAS" will focus on issues of particular interest to youth, such as genetic engineering, the effects of drugs on the nervous system, stellar evolution, the search for extra-terrestrial intelligence, the application of nuclear physics and the development of indigenous energy resources.

The organising committee, in a recent report, stated that a body which "interprets science so widely, and which reflects in its members and Congress delegates such a range of professional and influential Australians and New Zealanders, is ideally suited to give a lead to both countries at this juncture." The report added: "The organising committee therefore hopes for a wide participation by political and local leaders, members of the public and, particularly, members of the scientific community."

Most delegates will come from Australia and New Zealand. Many will bring wives/husbands and families, with the intention of touring the country either before or after the Congress. The event will, therefore, earn considerable overseas exchange.

The time of the Congress, coinciding as it will with the summer holidays, presents certain travel and accommodation problems, which are being dealt with by Air New Zealand, Trans-Australia Airlines and the New Zealand Government Tourist Bureau.

Apart from the business sessions of the 49th Congress, there will be an extensive social programme for members and their families. This will include visits to historic homes, city shops, gardens, beaches, the Waitakere Ranges, the Museum of Transport and Technology, the
New Zealand Steel Works, the Naval Dockyard, the viticultural research station at Te Kauwhata and the John Waititi Marae.

A programme of musical and other cultural events is planned throughout the week too, including orchestral and choral concerts and opera and ballet workshops. The organising committee will hold a reception for overseas guests in the Maori Hall at the Auckland War Memorial Museum.

Diversity will be the keynote for the social get-together of the Congress, the “grand finale” in Old Government House. European and indigenous cultural themes will permeate an evening of singing and dancing, craft displays, a display by the trained rams of Rotorua’s Agrodome, fireworks and a musical masque specially written for the occasion.

The Programme Circular will be available in September. Those wishing to obtain detailed information about Section programmes before this should write to the appropriate Section organiser listed in an earlier Newsletter or to the Honorary Secretary.

SECTIONAL PROGRAMME: PHYSICS, SECTION I

Symposia:

Laser Physics: Photo Spectroscopy; Time Resolved Spectroscopy; Photon Correlation Spectroscopy; Quantum Beat Spectroscopy; Electron Raman Spectroscopy; Ultra-high Resolution Spectroscopy; Multi-photon Processes in Gases, Liquids, Solids and Plasmas.

Laser Developments and Applications: New Laser Systems; Excitation Mechanisms Leading to Population Inversion; Lasers in Industry; Holography; Length Standards; Laser Anemometry; Isotope Separation.

Ionospheric Physics: Properties of the Ionosphere: The High Latitude Ionosphere (absorption, noise, auroral radar and structure); Irregularities and Gravity Waves measurements, properties and generation).

VLF and Radio Propagation: Whistlers and VLF Propagation (methods and results); General Ionospheric Radio Propagation Studies (transsequatorial paths, ray tracing ionogram analysis).

Medical Science: Monitoring and Diagnostic Techniques: Non-Invasive Diagnostics; Electronic Monitoring of the Human Foetus; Software in Medicine; Measurement of the External Urine Flow; Modern X-ray and Isotope Techniques.

Therapeutic Techniques: Physical and Chemical Treatments; Radiotherapy (radiation therapy; cancer management; radiation and the environment); Chemotherapy.

THEORETICAL PHYSICS WORKSHOP

AT MELBOURNE UNIVERSITY

H.C. Bolton, Professor of Physics, Monash University.

Dr Dick ter Haar from the Department of Theoretical Physics, Oxford, has been visiting Australia based jointly in the Mathematics Department, Monash University, and the Physics Department, Melbourne University. Many people have enjoyed his presence with us. In addition to the lectures on Plasma Astrophysics and Solitons which he has been giving, a Theoretical Physics Workshop was arranged jointly by Andrew Prentice, Monash, and Norm Frankel, Melbourne. Several theoretical physicists were invited to give a one hour lecture on their own current work; the Workshop extended over three days. The atmosphere was relaxed and expansive and the discussions arising from the lectures were extensive. Many people commented on this and said how pleasant a change it was from the conference with many short papers in which discussion never seems to get off the ground. Altogether it was a successful occasion and one that could be repeated, given a visitor like Dick ter Haar with a wide range of interests. Theoretical physicists come together at the speciality sessions of the Mathematical Society Summer Research Institutes and at the annual Conference on Statistical Mechanics run by Colin Thompson at Melbourne but it is possible that this was the first time that so many theoretical physicists have come together in Australia to talk about a whole range of current topics.

The workshop was funded by the Department of Physics and Mathematics at Melbourne; the Departments of Physics and Mathematics at Monash, and by Physics at La Trobe. Andrew and Norm are to be congratulated on a very happy idea.

The lectures were as follows:

D. ter Haar  “Ergodicity, Solitons, etc.”
C. A. Hurst  “Statistical Mechanics of Nerve Membranes”
C. J. Thompson  “Solitary Spin Waves”
M. J. Buckingham  “Fundamental Problems of Very Weak Signal Detection”
H. C. Bolton  “Series Expansion Analysis of Critical Temperature Shifts of Finite Ising Lattices”
K. D. Cole  “The Magnetosphere”
M. L. Glasser  “Electron Gas in a Magnetic Field”
G. Derrick  “Doubly Periodic Diffraction Gratings with Applications to Solar Energy”
B. W. Ninham  “Langmuir (USA) vs. DLVO (USSR + Netherlands) — Round 10: Langmuir by a Knockout”
R. G. Giovanelli  “Outer Layers of the Sun”
A. J. R. Prentice  “Aggregation of the Planets”

The Australian Physicist, October 1978 143
Reviewed by K. H. Lloyd, Aerospace Division, Weapons Research Establishment, Salisbury, South Australia.

Reviewing this book is like writing a review of a revised translation of the Bible. The Clergy know all about it anyway; the laity are unlikely to be interested. Nevertheless ... 

To the uninitiated: whether you are a student, or a researcher wishing to learn about positional astronomy, do not be put off by the old fashioned format and type set. Smart also has many old fashioned virtues; he is lucid, rigorous and instructive. He will take you systematically and authoritatively through it all — starting with the basic formulae of spherical trigonometry, proceeding with computations on the celestial sphere and ending with astronomical photometry. In the mean time, this generally dry but essential material will have been leavened by discussion of such phenomena as eclipses and binary star motion. You will also benefit by a good index, and examples at the end of each chapter. My advice is that if you are looking for a text which will instruct rather than amuse, buy this book.

To the cognoscenti: fear not, there are no major changes in the style or content of this latest edition of Smar's definitive text. The revisor, R. M. Green, has updated the terminology to make it consistent with the current usage in the Astronomical Ephemeris and other almanacs; this applies particularly to the distinction between Universal and Ephemeris time. You will also find added comments which relate the subject matter to the new developments in modern astronomy; however, these additions are at the expense of material on the same page, thereby minimising the expense of reblocking. The changes are not sufficient to justify buying this edition, but it might be worth your while getting hold of it, and annotating your present copy.

Reviewed by R. Beevers, School of Biological Sciences, STC., TAFE.

The study of mesomorphic phases (liquid crystals) has developed rapidly in recent years largely as a result of technical interest in liquid crystals as display systems for a variety of electronic applications. Several books are now available [see, The Australian Physicist 13, 170 (1976)] but these have been concerned with technical aspects and especially the relationship between chemical structure and mesomorphism. The book under review is most timely and is the first physics book on this subject. The author has produced an extremely well-written and balanced treatment and the diverse and complex experimental data are fitted into the physical analysis very deftly. Parts of the treatment are far from elementary and the book is primarily an advanced textbook for the specialist or those becoming involved with liquid crystals. The author has undoubtedly benefited from working at the Raman Research Institute with its long period of interest in the optical properties of materials.

Following a short introduction the book is divided into four long chapters: Statistical theories of nematic order; Continuum theory of the nematics; The reviewer’s liquid crystals and Smectic liquid crystals. The text is accompanied by many well drawn and informative diagrams. A few plates are included which have good tonal balance. In the treatment of the optical properties of the cholesteric structures the author has replaced the usual account based on the Poincaré sphere with a fresh treatment using the Jones calculus. Clearly a great deal of effort has been taken to give a unity to the subject and this book will be invaluable for the future development of this area.

Although this is a book on a specialised topic and so may be disregarded by the majority of physicists two points are worth making. Firstly, the study of liquid crystals, like that of philosophy, is an educational experience. Secondly, liquid crystals can provide striking visual displays for the teaching of physics. The reviewer’s first contact with liquid crystals was as a student when they were used to give a dramatic demonstration of optical rotation.

SPACE AND TIME IN THE MODERN UNIVERSE
Reviewed by J. R. Shepanski, Department of Theoretical Physics, School of Physics, The University of New South Wales, Kensington, NSW, Australia.

The author is well known to any reader of Nature for his very clear and penetrating review-type articles in that journal, especially those concerning developments in Relativity and Cosmology. In this book he follows the same tradition and its style is exceptionally accessible for just about anyone interested.

The range of topics covered by this modest tome (222pp of actual text) is quite extensive. There is an introductory chapter on general characteristics of space and time, another attempting to explain (mainly) the kinematics of Special Relativity and one concerning questions of time asymmetry and associated thermodynamical concepts. There then follows a relatively long (55pp) chapter discussing the ideas of General Theory of Gravitation including a very lucid exposition of the concept of "black holes" (both static and rotating). The following two chapters attempt to give an outline of modern cosmological ideas, certainly giving a good guide to them for anyone not too directly involved in the subject. The book closes with a somewhat philosophical view on the effects that the knowledge of the Universe might have on the idea — formation in man.

What the author undertook in this book he does very well indeed. The book is certainly well worth reading by any person who wants to gain an over-all view of what modern cosmology is about. It is not a book for an expert but is a suitable source for, eg., those undergraduate courses in which development of concepts is stressed.

Except for several annoying misspellings (such as Michelson instead of Michelson everywhere except in the index), the book is remarkably free of errors. It also has a valuable 10-page Index. As the book is written with a layman in mind, a number of more original and more expressive diagrams would have been helpful.
Note from Prof. T. M. Sabine, President, AIP

"I acknowledge receipt of an anonymous letter addressed to the President of the Institute and dated August 30, 1978.

Could the sender telephone me at the NSW Institute of Technology to discuss the subject matter of the letter".