• Bicentenary Congress
• Development of Physics in Australia
• Innovation and Australia’s Future
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PO Box 160
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Telephone (049) 60 1681
Fax (049) 69 6981

Editor-in-Chief
Lionel Wisbey BSc, BA

Executive Editor
Paul Hewitt BSc, PhD

Editorial Assistant
Dawn McMillan

Advertising Manager
Susanne Butterworth

Editorial Address
Australian Physicist
PO Box 160
Jesmond NSW 2299

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Front Cover An aerial photograph of the University of NSW, host to the Bicentenary Congress of Physics. Photograph courtesy of the University's Public Affairs Unit.
The long-awaited, long-planned-for Australian Bicentenary Congress of Physicists is over, leaving me with happy memories of a very successful week of physics. The bare statistics are impressive: over 950 registrants; ten participating societies running ten semi-independent conferences with up to 13 parallel sessions linked each morning by a wide-ranging program of plenary lectures, 705 papers; daylight- to-dusk activity with special lunch-hour popular lectures and an evening lecture/symposium program. When one adds to this a spectacular accompanying program of events on Sydney Harbour during the Bicentennial week, all held in superb weather, one has the ingredients for a remarkable occasion.

The Congress was opened by the Hon. Barry O. Jones, Minister for Science, Customs and Small Business, with a typically forthright address urging scientists to rise and fight for their share of the GNP.

The scientific scene was set by a masterly opening plenary lecture by Prof. Klaus von Klitzing (Stuttgart). The 1985 Nobel Laureate in Physics presented a formidable topic 'The Quantum Hall Effect' with a light and amusing touch that captivated his large audience. Here was a man whose elegant experiments and deceptively simple equation have led to a highly accurate realisation of the fundamental ratio h/e^2 (or of the fine structure constant, if you prefer). He was capable in one sentence of showing unashamed pride in his achievement and in the next of completely deflating himself with a wickedly barbed remark. It was great theatre — but at the same time the audience were given a clear overview of the importance of two-dimensional systems.

Reminiscences must inevitably be personal. I enjoyed a throaty aside by the ebullient BOJ at the completion of the review by Prof. Alan Astbury (British Columbia) of the esoteric world of fundamental particle physics, with its exotic inhabitants and highly- coloured jargon — a world entered via tera-electron-volt accelerators and colliders at a cost of tens and hundred of giga-dollars — "Thank God there is no one here from the Department of Finance. They would have freaked out!"

I was fascinated by the skilful unfolding of a detective story by Prof. Louis Frank (Iowa). Using a combination of theory, logical argument and sophisticated reduction of noisy day-glow signals, he produced from a maze of computer-generated images of satellite observations a group of almost indistinguishable tilted tracks. These Frank attributed to a flux of small, wet comets bringing, over geological time, vast quantities of water into our atmosphere from outer space — is this the origin of the oceans?

I also gained much pleasure from reports of two plenary speakers heard remarking that they were enjoying a Congress that gave them the opportunity to hear first-class plenary talks in areas of physics very different from their own.

The quality and diversity of the invited talks were, to my mind, a distinguishing feature of this Congress. They emphasized the great benefits to be gained when ten autonomous groups pool resources to produce a far more valuable week for Australian physics than could be achieved by ten independent conferences.

It was a once-off occasion which we should not necessarily try to emulate on this scale in the immediate future. But, the point has surely been made of the benefits of co-operative action. If future Australian physics conferences contain a significant proportion of joint meetings, a synergistic benefit must flow to Australian physics. Then the hard work of the organisers of this Bicentenary Congress will have been doubly worthwhile.
The Silver Jubilee of the AIP: Two New Awards Announced

The Australian Institute of Physics took the opportunity afforded by the Congress Dinner at the recent Bicentenary Congress of Australian Physicists to mark publicly the occasion of its 25th Anniversary. The Dinner attracted a near-capacity crowd of 420 to the Galaxy Room in the Members’ Stand at the Australian Jockey Club, Randwick Racecourse. Despite strong urging, the AIP resisted the temptation to run a twilight race for 25 year olds for the ‘AIP Cup’ as a backdrop to the Dinner!

In proposing the toast to ‘Australian physics and the Australian Institute of Physics’, the President of The Institute of Physics, Dr Godfrey Stafford, paid tribute to the quality and depth of Australian physics, to the work of the AIP in its evolution from the old Australian Branch of the British body, and to the outstanding contribution made to physics in the United Kingdom by individual Australian physicists.

Dr Stafford (below, right) presented the President of the Australian Institute of Physics, Dr John Collins, with a handsomely boxed wooden and brass gavel for use in controlling unruly or noisy Council meetings. Dr Stafford also referred to the desk and
chair, made of Australian black bean timber, that were presented to the IOP over 20 years ago by the fledgling AIP and which are in use in the members’ lounge at the Institute of Physics headquarters in Belgrave Square, London.

The Harrie Massey Prize

Dr Stafford announced the wish of the Institute of Physics to establish a prize to be awarded biennially to an Australian physicist by the IOP on the advice of the AIP and to honour the name of Sir Harrie Massey (1908-1983). H.S.W. Massey graduated in Natural Philosophy at the University of Melbourne, and in 1929 went to England to continue his studies at the Cavendish Laboratory, Cambridge. He pursued a distinguished research career in the physics of atomic and molecular particles, during a long association with University College, London.

Details of the award will be considered by the respective Councils of the two Institutes, and announced later this year.

The AFA Harper Scholarships

The AIP President — after calling the Dinner to order with the new gavel — thanked Dr Stafford and the IOP for their gift and accepted the generous offer of the Harrie Massey Prize on behalf of the AIP.

Dr Collins then formally welcomed to the Dinner as guests of the AIP, Dr and Mrs Stafford, Dr Louis Cohen (Executive Secretary, Institute of Physics) and Mrs Cohen, and members of the first Council of the Australian Institute of Physics. A particular welcome was given to the foundation President, Sir Leonard Hasley, now a spry 85, and Mr Alan Harper, foundation Honorary Secretary.

The President then announced Council’s decision to mark the Institute’s Jubilee by naming the recently established scholarships for excellence in the study of physics as ‘The AFA Harper Scholarships’. They honour the man, who by his dedicated work for the Australian physics community coupled with his intellectual and organisational skills, played a major role in establishing an independent Australian Institute of Physics, and in ensuring a smooth transition from the parent Institute of Physics and Physical Society. Not the least of Alan Harper’s contributions was the amicable negotiation of a ‘downy’ in the form of the considerable financial assets of the Australian Branch, thus ensuring instant solvency for the new body.

The first AFA Harper Scholarship will be awarded later this year.

A.F.A. Harper (1913-)

Arthur Frederick Alan Harper, AO, MSc, PInstP, Hon FAIP, received his physics education at the University of Sydney. After some years in the late 1930s as a Hospital Physicist attached to the University of Sydney, he was appointed to the research staff of the newly established CSIRO National Standards Laboratory.

Almost immediately Alan Harper and a small group of colleagues set sail in 1939 for the UK. He spent the ‘Blitz’ period in England at the National Physical Laboratory, Teddington, before returning to Australia in December 1940. For the next 30 years he led the Laboratory’s Heat and Temperature Measurement Section within the Division of Physics.

During the period 1940-70, Alan Harper served on national and international standards bodies, including 20 years as the Chairman of the Heat and Temperature Measurement Committee of NATA and periods as Secretary and Chairman of the National Standards Commission.

In the same period he was at various times President of the Royal Society of NSW, President of the CSIRO Officers Association (of which he is an Honorary Life Member), and Foundation Honorary Secretary and later President of the Australian Institute of Physics. He was elected an Honorary Fellow of the Australian Institute of Physics in 1975.

In the late 1960s, Alan Harper began a new phase in his career when he turned to the formidable task of converting Australia to the metric system. He was Technical Consultant to the Senate Select Committee (1967-68) that recommended that Australia should convert to the metric system of weights and measures. From this followed his appointment in 1970 as Executive Member of the Australian Metric Conversion Board. For eleven years his considerable managerial and diplomatic skills and his technical mastery of all aspects of the measurement system, were applied to the task of metricating Australia. In 1981 he was able to retire with the satisfaction of a massive job well done — and with the flow of letters to the papers decrying the metric system reduced to an exponentially decreasing trickle. In 1976 Alan was created an Officer of the Order of Australia for his work for metric conversion.

On its 25th Anniversary, the Institute is proud to honour and perpetuate the name of one of its most eminent founders by establishing this series of annual scholarships for excellence in the study of physics. The areas in which the Scholarships will be awarded will be decided from time to time by Council. The initial awards, worth $500 each, will be made to secondary students selected to represent Australia in the International Physics Olympiads.
Epson Computer Helps Accelerate the Action

"An Epson computer is needed urgently for data taking and analysis. We have no computing facilities of our own at present and rely heavily on equipment belonging to the Australian Nuclear Science and Technology Organisation (ANSTO)."

Those were the sentiments that convinced the judges to award a $3,700 Epson PC-e personal computer system to one of the thousand attendees at the recent Australian Bicentenary Congress of physicists at the University of NSW.

Research teams had to say in 100 words or less why a personal computer was essential to their research project.

The winning entry was submitted by Dr David Cohen from the Australian Institute of Nuclear Science and Engineering (AINSE).

The AINSE Accelerator Group is a small independent facility which provides Australian tertiary institutions and other member organisations, such as CSIRO, with access to the three particle accelerators at the Lucas Heights Research Establishment.

"During 1987 we worked with more than 20 different institutions, on 33 different projects," explained Dr Cohen.

"We will be using the Epson PC for projects as varied as measuring the metabolic rates of desert lizards to profiling the hydrogen content of polymer coatings on steels.

The projects using nuclear techniques span many scientific disciplines and last year involved organising visits to Lucas Heights for over 600 people per day and 300 accelerator running days."

Other entries received ranged from scientists working in Antarctica to a group needing a PC to control a radio telescope.

For further information, contact Lidiya Terzic at Burson-Marsteller on (02) 922 6377 or Mariko Marton, Public Relations Manager, Epson Australia on (02) 452 5222.

Dr David Cohen holding his prize, an Epson Personal Computer. Prof. Tony Klein, AIP Vice President, is on the left.
new products

Superconductivity Measurements with New Magnetometer

The Scientific Instrument Division of EG&G Princeton Applied Research has announced a new vibrating sample magnetometer.

The Model 4500 features improved system sensitivity, lower noise, high stability and absolute accuracy better than 2% of reading.

Measurements may be made over a 1050°C span and a cryogenic version allows sample temperatures to be varied from 1.5 K to 300 K.

A choice of front panel operation or full IEEE control is provided together with comprehensive applications software.

The system which is intended for maximum utility in research, quality assurance and failure analysis will be of particular interest to researchers and engineers involved with superconducting materials.

For further information contact Norman Jones, Quentron Optics on (08) 223 6224.

Standardised Data Acquisition and Process Control

CAMAC (Computer Automated Measurement and Control), an internationally accepted interface standard offering you increased system flexibility, reduced hardware and software efforts, and increased system longevity. Fully endorsed by IEEE, ANSI and IEC (ANSI/IEEE-583, IEEE-482/516), CAMAC provides you with a dependable serial or parallel data highway, peripheral interfaces, interrupt capabilities, remote access at high speed, distributed intelligence, and unlimited expansion. Computer independent, CAMAC systems interface to virtually any type of computer, even personal computers such as IBM.

Equally compatible to industry and laboratory, CAMAC continually demonstrates its capability, flexibility and economy in a host of worldwide environments. It is successfully being used to automate everything from machine tools to fusion reactors. In fact, hundreds of CAMAC installations, large and small, successfully operate year after year on a 24 hour a day basis in such applications as rolling aluminum, quality analysis, undersea oil operations, transfer line control, petrochemical processing, and nuclear valve testing.

Kinetic Systems Corporation pioneered the development of computer controlled CAMAC systems for process automation. Step by step, a total system concept, a merger of modularity and standardisation, has evolved. A complete line of field-proven CAMAC systems are process interface modules, fully supported by easy to use software drivers, comprehensive data base packages, and application programming. A line of serial highway (IEEE-595) products permitting standardised distributed data acquisition and control is available.

As more and more companies and research facilities turn to process automation to reduce operating costs and increase profitability, the real question is not whether to automate but how: KSC offers a logical solution with its CAMAC based total system concept.

For further information contact ETP-Oxford's Fred Blake on (02) 858 5122.

Multi-input Pulse Shape Recorder

LeCroy’s Model 2262 is a high-speed plug-in pulse shape digitizer providing a cost-effective solution to large scale waveform recording requirements. The 2262 offers basic digitizer operation designed in a modular standard for ease of system configuration. Several dozen analogue inputs may be accommodated in one standard LeCroy 1544A Rackmount Mainframe. The 2262 is also compatible with GPIB (IEEE-488) operation and IBM/PC compatible software is available for easy, user-oriented waveform display and control. Support and accessory modules are available.

The 2262 is DC-coupled with an analogue bandwidth in excess of 40 MHz and user selectable sampling speeds up to 80 MHz with 10-bit resolution and dynamic range. It is intended for a broad spectrum of applications ranging from destructive and non-destructive testing, ultrasound scanning for industrial and medical research, image chamber detector development in High Energy and Heavy Ion Physics, and basic digital oscilloscope operation.

For further information, contact ETP-Oxford on (02) 858 5122 or (02) 347 0733.

MCS Performance with a Single Plug-in Card

The ACE-MCS plug-in PC card and MCS Emulation Software from EG&G ORTEC convert an IBM Personal Computer or equivalent into a high-performance, easy-to-use multichannel scaler. A single PC can control up to eight ACE-MCS cards.

This powerful yet inexpensive system can now perform multichannel scaling for a wide variety of scientific applications including Mossbauer spectroscopy, time-of-flight measurements, decay analysis, medical uptake studies, mass spectrometer applications, and beam profiling.

The ACE-MCS may be used in conjunction with other EG&G ORTEC instruments including the ACE Mate Amplifier/Bias Supply/SCA/Rate-meter and ACE-MCA cards. A four-page data sheet and quotation are available on request.

Call Quentron Optics for more information on (02) 712 3111.

Germanium Detectors

EG&G ORTEC has recently completed a 30% increase in its germanium detector manufacturing capacity. This increase, which has included major investments in capital equipment, is driven by trends both in the applied and in the scientific segments of the market.

In the applied segment of the market, germanium detectors are increasingly used in monitoring of foodstuffs, especially in Western Europe, where more stringent food monitoring regulations have gone into effect following the Chernobyl accident in April 1986.

In the scientific segment of the market, the spin spectroscopy branch of nuclear physics has, over the past five years, generated a large demand for numerous detectors used in 'crystal ball' arrays. This demand is expected to continue in Western Europe, Canada, and in the US, where plans are now being started for a large facility that will need over 100 large state-of-the-art detectors.

Commenting on this major effort, Mr Bill Hedges, EG&G ORTEC’s president and general manager, stated, "Our parent company, EG&G, Inc., is committed to growth in diversified high-technology commercial markets. Our investment in the germanium detector area reflects an overall trend in the growth strategy of EG&G."
Multi-Channel Optometer

UDT is pleased to announce the arrival of the new model S390 multi-channel optometer: The S390 is equivalent in function to multiple optometers, linked by microprocessor control and housed within a compact, rack-mount package. The package is available with four input channels, or optionally with eight. Each channel may be programmed independently with calibration information.

Operation of the S390 is straightforward and self-explanatory with all functions being controlled via a simple 11-function keyboard.

For further information, contact Paul Wardill at Quentron Optics on (08) 223 6224.

Optical Tables

Do you require the performance and convenience of a vibration-isolated optical table but cannot spare the laboratory space to install one? If so, Oriel Corporation may have the solution to your problem. The new series of 75 cm wide optical tables may be mounted along a laboratory wall and are narrow enough to provide complete access from side. The tables retain the same rigidity, damping and vibration isolation performance of Oriel's conventional table systems while offering considerable savings in space and price.

For further information contact Paul Wardill at Quentron Optics on (08) 223 6224.

NIM Bins

EG&G ORTEC’s Model 4002D 160-W Power Supply for Nuclear Instrumentation Module (NIM) bins is the newest addition to the BLACK MAX™ family of super power supplies. Although economically priced, the 4002D offers higher currents and more power than the traditional NIM power supplies. It can provide any combination of its rated currents from both positive and negative supplies up to a combined maximum power rating of 160 watts at 50°C. For increased reliability, there are no fans or filters to maintain.

A data sheet is available on request. Contact Quentron Optics Pty. Limited, your local EG&G ORTEC representative, for more information on (02) 712 3111.

NIM bin power supply.
Impressions of the Recent NSTAG National Forum

Richard Paying for the AIP Science Policy Committee

NSTAG is the acronym for the National Science and Technology Advisory Group. It comprises representatives from the Australian Academy of Science, the Australian Academy of Technological Sciences and Engineering, the Institution of Engineers (Australia) and FASTS (the Federation of Australian Scientific and Technological Societies).

The second NSTAG National Forum on ‘Science and Technology in the Budget’ was held on November 5 and 6, 1987 at the new Eagle Hawk Hill Complex, outside Canberra. The forum was co-ordinated by FASTS, with Professor Fred Smith as Forum Chair and Dr Ditta Bartels as Chair of the Editorial Committee.

The 1986 NSTAG Report was criticised for concentrating on financial aspects of the Commonwealth Science and Technology (S&T) Budget, and not representing the debate at the 1986 National forum, co-ordinated by the Institution of Engineers. The two activities had seemed too unrelated. For 1987, FASTS was determined that the forum rather than the report would be the major NSTAG activity, that the forum proceedings would form the basis of the 1987 report, and that the forum debate would concentrate on those issues, besides finance, which FASTS saw as crucial in science and technology today. It is a sign of the influence of FASTS that it was able to bring the rest of the NSTAG committee around to this view.

The strength of NSTAG is seen by many to reside in its breadth of representation across the whole of science and technology in Australia. To emphasise this strength, speakers at the forum were chosen for the variety of their backgrounds: from government departments and government-funded research organisations, university academics, high school teachers, and managers and researchers from private industry.

The formal presentations at the forum could be largely divided into four general topics: (i) indicators, trends, and priorities in government S&T support; (ii) government incentives to industry, and the allied topics of pure versus applied research and links between government-funded research and industry; (iii) trends and priorities in the employment/training of scientists and engineers, and (iv) problems in communicating S&T to the Australian public.

It was clear that speakers generally had put a great deal of effort into the preparation of their papers and the enthusiastic, sometimes vehement response from the audience to comments from the speakers showed just how important these topics were seen and felt by the people involved.

One of the most pleasing aspects of the forum was the time given for the audience, of perhaps 100-120 people, to comment on the various issues raised by the speakers. The many impromptu contributions from the audience were often as interesting as the more formal talks and added greatly to the variety of opinions expressed.

Indeed, one overall impression was of the enormous divergence of opinions expressed in the forum. Perhaps NSTAG’s greatest strength — the breadth of its representation — has become its biggest hurdle.

The forum also provided plenty of opportunities for meeting people and for joining in that coffee- or meal-break conversation peculiar to conferences which often affords the most rewarding part of the conference: those moments when you get to hear what is really going on behind the scenes. In stark contrast to this general openness and comradeliness, at the end of a paper on the difficulties of teaching science in today’s high schools, I was staggered to overhear someone say that they were tired of whingeing teachers and that they thought high schools could not really be as bad as they were portrayed.

During the debate on past and projected trends in student numbers in science and engineering, several speakers warned of the coming shortages of technically-trained personnel, especially if Australia is to become more technologically oriented. While the scientists and engineers at the forum, generally, emphasised the coming shortage of scientists and engineers, the industrial managers spoke more of shortages in technical management, sales and production.

One senior engineer suggested Australia already had too many scientists but not enough engineers, and that the excess scientists could be retrained in two years to become ‘useful’ engineers. Still another person argued that the number of engineering graduates simply matched the demand for engineers and if there were not many more engineers graduating now than ten years ago it was because industry showed few signs of needing them.

Several speakers emphasised the imbalance they saw in government-funded R&D — a high commitment to pure or basic research and a relatively low commitment to applied research and development. Figures presented by other speakers during the forum did not necessarily support this position, highlighting the difficulties of interpreting S&T figures, especially those involving international comparisons; still other speakers felt that good basic research was being unfairly blamed for the failures of industry to do its own R&D.

My own paper, a summary of S&T budget trends, given on behalf of the AIP science policy committee, was well received but, then, it was essentially non-controversial. More controversial was the suggestion from the Institution of Engineers that NSTAG should formulate priorities to direct government in specific areas, so that S&T trends more closely represented specific NSTAG policies. FASTS appears to be resisting this strongly, seeing it a danger of focusing too much on short-term solutions, of doing the government’s dirty work for it, or of splitting the S&T community into warring factions.

My own opinion is that if scientists are not prepared to set the political agenda then others will.

For example, in private discussions there were various suggestions (i) that there should be less money for R&D and it should be spent more efficiently, (ii) that academic tenure should be abolished and university researchers kept only if they performed, and (iii) that 150% tax deduction for R&D should not be continued after 1991 because it did not discriminate between good and poor research. NSTAG may have to face many such issues in the future.
The National Teaching Company Scheme

The National Teaching Company Scheme is part of the Federal Government's program to facilitate growth and competitiveness in Australian industry. It forges mutually beneficial links between companies and tertiary education institutions by subsidising the cost to a company of employing a high-calibre graduate to work on a project designed to improve the company's performance. It is not strictly about R&D but rather about boosting the innovativeness and competitiveness of small to medium Australian businesses and making tertiary institutions more industry oriented.

Established in 1984 within the Industry, Technology and Commerce portfolio, the Scheme aims to:

- facilitate the flow of academic know-how to companies to improve manufacturing, marketing and management skills in the creation of new products
- stimulate industry R&D
- give academic staff broad and direct involvement with industry so they are better able to relate their teaching and research to industry's needs
- provide in-service training for existing company and academic staff
- provide graduates with experience to encourage them to take up careers in industry
- open employment doors for graduates in industry
- increase exports through the development of material and products.

How the Scheme Works

First, representatives from a company and a tertiary institution get together to discuss company projects which would benefit from co-operation.

When they have selected a specific project they draw up a timetable with clearly defined steps and goals. The project chosen should require the day-to-day involvement of a graduate with occasional expert advice of an academic who is appointed to supervise the project in collaboration with a company supervisor.

Joint supervision of the project is an essential feature of the Teaching Company Scheme; as the supervisors collaborate on the project, a two-way flow of information and services is established which benefits both company and institution.

Second, a joint application for funding is submitted to the Department of Industry, Technology and Commerce outlining details of the company, its relationship with the institution, a summary of the proposed project and a statement of the benefits the project is expected to give the company, the institution, the graduate and Australia.

Applications can be made at any time but are specifically called for twice annually, usually mid-August and the end of February. When an application is received by the Department, a Departmental officer meets with the applicants to evaluate the project. If a project is suitable, a recommendation is made to an independent selection committee made up of business leaders and academics.

Budgetary constraints mean that only a limited number of projects are supported although State Governments, recognising the value of the Scheme, are now providing funds for some projects in their State which, although suitable, would otherwise miss out. The maximum funding for one project is $45,000 over two years, or pro rata for shorter periods. Of this amount, $15,000 is paid to the institution to cover administrative and staff costs and $30,000 is used to subsidise up to half the salary and salary on-costs of the graduate. Any remainder of the graduate's salary and related costs are paid by the company.

The tertiary institution normally acts as employer of the graduate, handling the recruitment process in consultation with the company and providing progress reports to the Department of Industry, Technology and Commerce. In exceptional circumstances, the company may act as the employer.

The tertiary institution also makes its facilities available for work on the project although it is a condition of the Scheme that most of the graduate's working time be spent on the company's premises. This is because a key objective of the Scheme is to expose graduates to commercial and industrial environments.

Administrative tasks associated with a Teaching Company project are minimal. The Department requires only a simple one-page progress report every three months, a brief financial report on salary and related costs every six months, and a final end-of-project report. A Departmental officer may occasionally seek permission to visit the company to discuss progress. A company's entitlement to the 150 per cent tax concession for expenditure on R&D is not affected by participation in the Teaching Company Scheme, provided the graduate is employed by the institution.

Benefits of the Scheme

Apart from subsidised salary costs, a company taking part in the Teaching Company Scheme receives free consultative services of a senior academic and access to the tertiary education institution's facilities, as well
as being able to enlarge its activities with a view to improving company performance. Another benefit for companies is that they can assess a graduate's performance should an offer of permanent employment be considered.

The tertiary institution involved is able to extend teaching and research activities beyond the classroom and laboratories. Academic staff can gain experience of current industry operations and industry's needs. The development of long-term relationships between the institution and companies provides channels for the interchange of information and ideas and collaborative research.

Graduates are given the challenge of working on demanding tasks which have real commercial and time constraints. They gain valuable industry experience and there is often the opportunity to incorporate the Teaching Company project research into studies for a higher degree.

How to Get Started
The initiative to participate in the Scheme can come from either a company or a tertiary education institution. Having agreed to work together, an application is submitted jointly to the Department of Industry, Technology and Commerce.

Successful applications must meet the following criteria:
- the project is based on a significant company program with planned funding and support
- academic participants can show that they can make a significant contribution
- all participants are strongly committed to the proposal with long-term cooperation to their mutual benefit expected to develop
- the aims of the project have general benefits for Australian industry, training and research.

The Teaching Company project may be part of a larger company project and, in exceptional cases, grants may be awarded for two graduates to work concurrently on one project. However, if it is part of a larger company research or development project, it must have its own clearly defined goals which can be achieved within a maximum of two years.

There is no limit on the type of project funded, or on the discipline required of the graduate. Projects to date have included:
- introduction of computer-integrated manufacturing
- introduction of computer-aided drafting
- development and commercialisation of new products
- development and commercialisation of computer software
- R&D related to manufacturing processes
- product improvement

Preference is given to small to medium size companies that are Australian owned or based; in the case of subsidiary companies, the size of the parent firm is taken into account.

Companies should have an established infrastructure and the ability to support a graduate over the life of the project.

Graduates should:
- have demonstrated high academic ability
- want to apply their training to industry
- be capable of facilitating the achievement of the project's goals
- show the potential to attain a senior management position in the future.

Preference is also given to companies located in close proximity to their cooperating institutions for ease of communication and liaison on the project.

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**RMIT AN EQUAL OPPORTUNITY EMPLOYER**

**SENIOR LECTURER**

**RADIATION PHYSICS/SURFACE ANALYSIS (LIMITED TERM)**

The Department of Applied Physics is seeking a person experienced in some aspects concerning the interaction of radiation with matter including surface analysis. Tertiary teaching experience is essential.

The successful applicant will play a leading role in the activities of either the radiation laboratory or the surface analysis laboratories involving teaching, research and consultancy. This is a limited term position until November 1990.

Further information may be obtained from Dr. H. K. Wagenfeld, Head of Department, on (03) 680 2135.


Phone Personnel Services on (03) 680 2337 for a Position Description. Written applications should be addressed to The Senior Appointments Officer by 22 April 1988.

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**SOUTH AUSTRALIAN INSTITUTE OF TECHNOLOGY**

THE INSTITUTE IS AN EQUAL OPPORTUNITY EMPLOYER

**RESEARCH PROJECT IN HEALTH PHYSICS**

The School of Applied Physics, in collaboration with Roxby Management Services (Olympic Dam Project) offers a full-time research project in health physics applied to mining. The precise topic will be identified in discussions between the student, S.A. Institute of Technology and Roxby Management Services. The general area of interest is the control of radiation exposures from the mining and concentration of uranium ores. The student will be required to enrol for a Masters' Degree (Research) in the School of Applied Physics and to attend such courses as prescribed.

The student will be required to work at both the S.A. Institute of Technology and at Olympic Dam as the needs of the project dictate. Meals and accommodation will be provided at Olympic Dam at no cost to the student.

A stipend of $9,000 is available for a maximum of two years. For further information, contact David Paix, Senior Lecturer (08) 343 3040.

Applications with full academic transcript should be addressed to Ms. Victoria J. Thomas, Appointments Officer, S.A. Institute of Technology, GPO Box 2471, Adelaide, SA 5000 by 18th March, 1988.

Selection will be based on the S.A. Institute of Technology's Policy on Equal Opportunity and made on merit.
Introduction
Over recent years I have participated in — and contributed to — several conferences on the role of research and development, mostly with particular reference to information technology. As a result, I have been able to focus on a number of controversial questions, some of which are still unresolved as far as I am concerned (though I have my preferred answers). I would like to share some of these matters with you.

Definition
The words creation, invention, discovery and innovation are sometimes used interchangeably. One definition which differentiates between them is that creation is the process of carrying an idea through to implementation, discovery consists of finding existing entities (e.g. the discovery of Australia or of the electrical nature of lighting), invention consists of the conception of new devices or processes, and innovation is the introduction of new ideas into practical use, including their commercial exploitation. With these definitions, research, in the context of science and technology, is usually equated to discovery, and development to creation. The connotation of research in the context of law and the humanities — that of carrying out a literature search — is not relevant to this conference. Invention — the combination of known principles to produce new devices and processes — may lead to innovation if it results in a new product in the market place, as may creation — and it may not. It is with the process of innovation that the conference is primarily concerned.

A number of recent discussions concerning R&D have referred to R&D — research, design and development. It is difficult to differentiate between the design process carried out by an engineer and the early steps of the development process, particularly when the physical principles used are well established. However, the term design is often used to connote styling — essentially part of the marketing strategy.

The Australian Position
Successful innovation demands both technology push and demand pull. There is no doubt about the present demand pull in Australia — nearly 90% of our imports are manufactured goods and the fall in the value of the dollar, resulting mainly from reduced export income from our primary products (which provide about three quarters of our export income), gives every encouragement to activities such as increasing the local processing of our mineral ores and the replacement of manufactured imports by local products.

However, there is a problem with expanding our manufacturing industry. Our local market is a small one, and, for many manufacturing ventures to be commercially viable, developing an export market is essential. With manufacturing exports at only about a fifth of the present total, clearly considerable effort is necessary if these exports are to be expanded even to the extent of balancing the fall of income from our primary industries.

If this expansion to be effective, then we shall have to concentrate on niche markets in which manufacturers can create an element of technology push by demonstrating that their products have and edge on competitors, and it is in this context that R&D in the private sector is important. Moreover, particularly because of our high labour costs, it is often more appropriate to concentrate on the use of high technology production methods for medium and low technology products to achieve increases in exports rather than on new high technology products.

Some International Comparisons
Comparison with Sweden provides a convenient benchmark by which to judge our present R&D position as Sweden is a small country (the population is about half of ours) and has shown that it can survive mainly because of the exports of manufactured products (Forsberg, 1987). Although Sweden is closer to the European market, we have an even larger Asian market on our doorstep. Travel time is hardly a relevant factor, and trade attaches and local agents minimise language problems.

Heavy engineering and other manufactured goods from its mechanical engineering industry are 60% of Sweden’s exports. R&D expenditure in the Swedish private sector (which includes such familiar names as Volvo, Electrolux, Ericsson, SAAB, ASEA, and SKF) is eight times that in the public sector, whereas the corresponding Australian figure is half.

And yet this country has a good research record. Measured in terms of published papers per head, the Australian figure is 1.7 times the average of 25 OECD countries. However, when it comes to putting ideas to work, we do not show up so well. For every 10 publications, we have only 1.5 world patents to our credit. The Swedish figure is 7.1, the Swiss figure is 14.8. A tradition from our colonial heritage of leaving manufacture and associated R&D to the mother (or foster mother) country may provide a partial explanation for this poor performance, an explanation which receives some support from the fact that the performance of Canada (a country with a similar history) is worse — the Canadian number of world patents per 10 publications is only 1.0.

The rate of penetration of new techniques into our industry may be gauged by the extent to which robots are used. The Australian usage is six robots per 10,000 industrial workers. The Swedish figure is 36, as is the Japanese.

How good is our export performance? Overall, its rate of growth is low — only a tenth of the average rate of growth for OECD countries. The rate of growth of exports in manufactured goods is 30 percent of the OECD rate of growth — a higher rate which probably reflects the small base from which it started. Less than 4% of our exports are R&D intensive, the figure for the Netherlands being 12%, and for the UK 25%.

Transnational Corporations
One aspect of international trade which is particularly relevant in considering long term trends is the role of the transnational corporations (TNCs). Half of the world’s trade is between TNCs and their subsidiaries, and TNCs can be expected to operate...
in such a way that they optimise overall profit in their country of origin. This optimisation (including long-term investment and transfer pricing decisions) will take into account company taxes, import duties and property taxes. As multinationals can be expected to show a preference for carrying out R&D in their country of origin, most of their subsidiaries will be concerned primarily with distribution and servicing. And TNCs are large operations: a few years ago, a combined ranking of countries and TNCs in terms of their annual product placed nine TNCs in the top 50, with the largest (General Motors, with two thirds of Australia's annual product) in the position 23, just ahead of Switzerland (Sexton, 1977).

So, clearly, conflicts between the demands of national sovereignty and the interests of TNCs are bound to arise. An international policy which aims to build up local technology will strike a balance between requiring TNCs to build up local operations (including R&D) if they are to be allowed to tap the market, and not making the cost of doing so too high. The withdrawal of IBM from India a few years ago was an instance of the latter situation.

There is a long term hidden benefit in encouraging local manufacture by TNCs which may not be immediately obvious — that of technology transfer to an infrastructure of engineers who can later use their acquired skills to make new products with either the same company or another. New technology skills are associated with people, not companies.

This long term benefit is best illustrated by Japan's entry into world computer market starting 1961, at which time a number of the zaibatsu undertook to make US computers under licence for sale in Japan only. With the skills their engineers acquired in this way, they are now the world's number two manufacturer of computers, and expect to be number one within the next five years.

Government Assistance
What can governments do to help? Our own offset, MIC, GIRD, NIES and tax rebate policies are clearly moves in the right direction, and are now bearing fruit (Button, 1987). Registrations under the 150% tax concession scheme to encourage R&D total $1.2 billion dollars in 1986/7 so that private sectors R&D is now 0.4% of GDP — twice the 1981/2 proportion but still well below the OECD average of 1.6%. The Management and Investment Company (MIC) scheme has in 1985/6 invested about $113 million in 112 businesses — these businesses generated total sales of $150 million last year, one third of which was for exports. And the offsets scheme resulted in $650 million being committed to Australian industry last year.

There are other ways in which governments can help. As a qualified buyer of complex technological systems, their critical comments can do much to improve the quality of products available for export as it is easier to fix design faults in a sympathetic customer's equipment close to base. And government customers provide an answer to the question which potential foreign buyers are likely to ask: "If your system is so good why is your government not using it?".

R&D in the public sector, through appropriate in some cases, has one major disadvantage in that it usually results in less cross fertilisation of ideas than would be the case if the same activity were carried out in industry. In this regard, our own defence research, carried out almost entirely in the public sector, is in marked contrast with Sweden, where all defence research is carried out in the private sector.

The total venture capital market has grown from about $5 million in 1982/3 to $240 million in 1985/6. A frequent US pattern in this high risk field is for a preference for equity over debt, and for a three stage process — first the establishment of a private company, then the going public stage, and finally a takeover by a large company as a way of providing a comparatively painless entry into a new technological development. It is profit from this last stage which can yield the main attraction for the venture capital backer.

Technological Graduation Rates
Perhaps the most important way in which government support can help build up the country's technological capability in the long term is by ensuring an adequate supply of engineers and scientists — with emphasis on the first of these two categories. And in this regard the Australian record is not good.

Although it has improved considerably in recent years, the current retention rate (that is, the proportion of students finishing high school) of 50% is still low. The corresponding US rate is 74% the Japanese rate is 95%. The percentage of workforce entrants with some tertiary qualification in 1980 was 7, in Japan 39. Our graduation rate for engineers is 146 per million, that of Japan 629. And whereas Australia graduates three scientists per engineer, the Japanese figure is five engineers per scientist. Another comparison is that in Sweden the total number of engineers — 70,000 — is 2% of the workforce. The corresponding Australia figure is about half this.

The current funding arrangements for Australian universities and CAEs are primarily Commonwealth — though CTEC — and are implemented in such a way that funds are not earmarked for particular purposes: it is left to individual institutions to decide their own priorities. In the period of financial stringency which we are told lies ahead of us, it is to be expected that funding to universities and CAEs will not increase significantly. And so, unless earmarking of funds is resorted to, it is unlikely that there will be any great changes in the present pattern of graduate supply.

There is a school of thought (to which I do not belong) that increasing the intake of our university engineering schools is bad because it may result in a lowering of standards, and that increases in throughput should be a matter for CAEs and Institutes. The present position is that less than half (45% in 1985) of professional engineers qualifying in Australia come from CAEs and Institutes.

Incidentally, a similar figure applies for computer specialists — an important category in short supply.

The division between the two types of tertiary institutions is unlikely to remain relevant in the case of leading institutes, as more can be expected to follow the precedent set by Curtin University in the next few years, and to apply for university status.

Interfacing Research to Industry
Apart from the help universities and CAEs can give by providing technological graduates, access to expertise and ongoing research is one aspect of the resources of these bodies which has been underutilised. The formal step which had been taken by a number of these institutions to remedy this defect is to set up organisations such as Technsearch and Unisearch to provide an interface with academic research activity. An alternative approach is that adopted by the
University of Sydney, where 30 Foundations have been set up, each covering a specialist field and supported mainly by Australian industry.

These interface bodies are doing much to provide a bridge between research groups in tertiary institutions and industry, which in the past appears to have been a little reluctant to tap their resources. However, for such a mechanism to be fruitful, it is important that academic research groups be adequately funded as regards equipment, support staff and research students. Research students are perhaps the most important in the long term, as they will provide industry with its R&D workers for the future.

Basic Research

There is a view, recently propounded by the Canadian Dr Suzuki on the 11 July Science Show, that innovation should proceed from basic research through development to commercial exploitation, that scientific discovery, being a process without predictable fallout, should be funded on faith. As in mediaeval days a tithe would be paid to the church in the hope of a more comfortable life hereafter, so basic research should be supported with similar expectations. Perhaps the strongest argument for adopting this approach to solving our export problem in some instances is that it could provide an environment for brighter students to work with outstanding scientists. So, even if no breakthroughs which are achieved do not have an immediate practical fallout, the payoff will be experience gained by them as research students, which will be available for use in other contexts.

However, most innovation is incremental rather than revolutionary. And, as an investment for the future, it would be most unwise for a small country like Australia to rely solely on such centres of excellence to provide the feed stock of technical ideas which will lead to a trade balance in the future.

Recent US and UK Experience

Recent US experience may be useful in this context. Industry contribution to university research has increased three times in the last seven years: however, it is now only 1.25% of the expenditure of the top 850-odd US companies on R & D at their own and commercial laboratories. Moreover, 70 cents in every US research dollar is for military research — and so not acceptable to some academics.

So, as federal funding decreases, academics have been actively seeking help from business — and engineering schools have been particularly successful in this regard. The National Science Foundation has decided to capitalise on this trend and has set up a number of Engineering Research Centres (ERCs). Six were set up in 1985, another five this year and there are another 14 in prospect. These ERCs also receive industry contracts to develop specific products and industry support for staff and students or in the form of equipment donations. The name of the game is to make money, an approach not always acceptable to academics. However, in at least one case, the approach has paid off. A group of companies was spending one in five of its research dollars on biotechnology research at universities. Per dollar invested, academic laboratories provided four times as many patent applications as the group’s own laboratories. And over forty percent of the biotechnology firms involved have derived at least one trade secret from their academic partners (Joyce, 1987).

Over the last four years, the UK government has spent 350 million pounds on information technology R&D (the Alvey programme). The aim is to encourage joint academic — industrial ‘precompetitive’ research projects and virtually every university in the country (and 12 polytechnics) are involved in about 200 projects, of which 90 have already produced demonstrable products (Oakley, 1987).

References

Button, J.N. (1987), Keynote address, Eleventh annual symposium, Australian Academy of Technological Sciences and Engineering, Brisbane.


Correction

On page 8 of Volume 25 of the Australian Physicist the word ‘pensioner’ should be replaced by ‘physicist’, and on page 9 the interest shown for SA should have been $986, not $9.

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Australian Physicist Vol 25 No 2 March 1988
The Development of Physics in Australia: I

H.C. Bolton
Department of Physics, Monash University, Clayton, Victoria 3168

This article was written to accompany the lecture under the same title given at the Congress of the Australian Institute of Physics in January 1988 in Sydney. This part covers the period 1770-1918.

Introduction

I have chosen the work ‘development’ in the title rather than ‘history’ as I wanted to give a personal view of my subject, writing as a practitioner and not having been brought up in the tradition of professional historians. Although the story is brought up to the post-World-War-II period I feel that it is nearly an impossible, even invidious, task to survey the many major strands of work now being done in Australia. An attempt is made, therefore, to review the major influences that have helped to shape the physics profession here with a few discussions of the physics actually performed.

In the last twenty years, there has been much work written on the history of science in Australia. The Bicentennial this year has intensified this work and the Australian Academy of Science, together with Cambridge University Press, are publishing a volume of essays called Australian Science in the Making (Home, 1988). This valuable and comprehensive set of essays surveys in broad outline many movements in science in Australia since the landing of the First Fleet, starting with Aboriginal conceptions of the working of nature. The year 1988 is also the centenary of the founding of the Australasian Association for the Advancement of Science; its successor ANZAAS has commissioned a book of essays on the various sciences (ANZAAS, 1988). In this latter book the essay on physics is by Professor R.W. Home of the Department of History and Philosophy of Science at the University of Melbourne, and if in many items the theme of the present article overlaps those in Home’s essay, I am pleased to acknowledge my indebtedness to his judgements and understanding. As an example of the recent activity in the field of history of science it can be noted that the Records of the Australian Academy of Science started in 1966 with one annual issue and became the Historical Records of Australian Science in 1980 and in 1987 became biannual. There is also in existence a valuable resource for historical work in physics in Australia because R.W. Home has a comprehensive list of all research articles in physics published from Australia up to 1945. Each entry is that of a person; there is a brief biography and bibliography of books and articles with a photocopy of each article. At the lecture were displayed several books, articles and photocopies that had special significance in the development of physics in Australia; a list is given in the Appendix following Part II.

Exploration

We ought to start by recalling that among the original and overt reason for Captain James Cook’s first voyage of exploration (1768-71) was the need to observe the transit of Venus in the Pacific Ocean. The measurement of the transit of the planet Venus across the sun’s disc allowed the radius of the earth’s orbit about the sun to be found by parallax and thus the size of the planetary solar system was established. The results were expressed in terms of the solar parallax which is the angle subtended by the earth’s radius at the centre of the sun; it is about 9 seconds of arc. The first observation of the transit of Venus was by Horrocks in 1639 (Proctor, 1874) and in 1766, Edmund Halley proposed a definite plan to determine accurately the solar parallax. Halley died in 1742 and the next transit, in 1761, was probably the first international scientific investigation with 120 observers, most of them French, at 62 sites. Because the accuracy of the observations was much below what had been expected and desired, the next transit of 1769 assumed a special significance. At least two sites on the earth’s surface were needed and calculations suggested a position in the middle of the Pacific Ocean, then called the South Seas. Cook and his astronomer Charles Green each had a reflecting telescope made by James Short, the successful telescope maker of the time. The visual observation is very difficult; there were several extra sources of possible error in the solar astronomy of that time compared to stellar astronomy. The analysis of the results of the early transits was given by Proctor (1874). Cook and Green at the time thought that their results differed significantly and were disappointed. But the errors were indeed large and a recent review by Bray (1980) has shown that the observations were as good as the technology available and indicates, if there were a need, the abilities of Cook and Green as observational scientists. Bray’s article contains a reproduction of Cook’s journal showing sketches of some of the famous ‘contacts’ on the solar disc. After the transit observations, Cook opened his famous ‘Sealed Packet’ and proceeded to his explorations and cartography of the South Seas.

If we are strict purists we might take exception and say that astronomy is not physics but I think that it would be too severe a judgement and we would be churlish physicists not to have pleasure in recognising the work of Cook and Green in terms of the observational science of their age. We will return to astronomy and radio astronomy later in this article.

The Start of the Profession

If we define the practice of physics to need laboratories, workshops and supplies of technical equipment then it is a fair question to ask when we can recognise its beginning in Australia. In fact physics needs more than laboratories; it needs laboratories, libraries and above all, leisure in a professional society, at least for some in the community. Since Australia was a pioneer colonial country for several generations after 1788 it is no surprise that physics did not get going until well into the nineteenth century. There are strong similarities between Australia and the United States of America in their early scientific
development (Reingold, 1966). Reingold's comment about the early scientific views in the USA can well apply here in Australia; "The United States was a natural historian's delight with its many species of plants and animals undescribed and unclassified." Both countries were influenced strongly by links to the United Kingdom and in both, the professions had to find how to stand on their own feet. In the USA the War of Independence meant that the break with the UK was sudden but in Australia the links to the UK were close. In physics, the influence of the Cavendish Laboratory in Cambridge has been strong right up to recent generations since World War II. The merits or demerits of this influence of Cambridge will not be argued here beyond asking if any other source of physical ideas could reasonably have been available. Nor will we debate the place of pure versus applied research. A case has been made for thinking that the influence of Cambridge with its emphasis on pure rather than applied research has not been altogether in the best long-term interests of Australian physics, and in general of science and technology in Australia (Jenkins, 1983). It was not until after World War II that this link with Cambridge was converted into wider links with a worldwide range of laboratories, but that was probably due to a spread of science in general and not something special to Australia.

Astronomical and surveying observatories were established in the 1880s in Melbourne, Sydney and Adelaide (ANZAAS, 1968). In addition to original astronomical work, a local time service was provided for each colony. At Williamstown, Melbourne the one o'clock time ball that used to give the local time for the sailing ships in Port Phillip Bay is being renovated by engineering students of Monash University and in 1988 should join the few remaining working time balls scattered over the earth's surface. The observatories also calibrated navigational and surveying instruments and maintained the colonial weights and measures. Astronomical work was perhaps more important at Melbourne, where the 48 inch reflector, the Great Melbourne Telescope, was the largest in the world at its installation in 1866. Meteorological observations were organised from the observatories and the telegraph allowed observations to be correlated. The problem of Colonial 'times' was important when the railways began to link the various colonial centres and the co-ordination of train arrivals and departures became necessary (Davison, 1987). The capital city of each colony has its own local time determined by its observatory. Some of the times were 12.00 Sydney, 12.07 Brisbane, 11.44 Hobart and 11.35 in Melbourne. With the telegraph, time signals could be sent to post and telegraph offices and in Melbourne there was an automatic adjustment by hourly time signals. Time was not so precisely kept beyond the capital cities. A central large clock at the Town Hall or Post Office may have had a bell or chimes. Bowen in Queensland would have liked a public clock but instead had a one o'clock cannon each Saturday. Each colonial railway kept to the time of its capital city and thus at the end of its railway system time could be quite different from local (sun) time. Queensland however was an exception and each separate railway system kept the local time of its coastal terminals. The extension of the railway system was a strong incentive for the use of capital city time, except in Queensland where the railways were not connected. Broken Hill had three times; railway (that of Adelaide), the Post Office (Sydney) and the mines (local time). The question must have been put; should the public houses close by Sydney or by local time? There could only be one answer — not to close at all. After the Intercolonial Postal Conferences of 1891 and 1893 the zone system as we now know it was introduced in 1895 with Eastern, Central and Western Standard Time.

The Overland Telegraph from Adelaide to Darwin by Charles Todd (the Governor Astronomer, Superintendent of Telegraphs and later Postmaster General of the Colony of South Australia) was a major step forward in the reduction of the 'tyranny of distance', not only the distance between the centres of science in Australia but also between them and Europe and the USA. Todd conceived the idea of the Overland Telegraph in 1859; it was begun in 1870 and completed in 1872. Todd's work on this and earlier lines was based on several of his own horseback expeditions and on that of Burke and Wills (1860-1) (Moyal, 1984). Todd's wife was Alice Gillam after whom Alice Springs is named and Todd's daughter was the wife of W.H. Bragg.
Co-operation and Community

As the nineteenth century progressed, the small growing number of scientists in Australia and New Zealand felt a great need to meet to discuss their current work and the first meeting of the Australasian Association for the Advancement of Science took place in 1888 in Sydney (ANZAAS, 1888). The new professor of physics at the University of Sydney, Richard Threlfall, read one paper describing his new laboratory and he gave a guided tour. He read two others on his work on electrical research. But more important than any individual lecture was the very existence of the Association. There were 820 people registered. For many generations the AAAS and its successor ANZAAS acted as a focus not only for public lectures on science to the general public but also for scientific discussions amongst the professionals. Together with the growing political awareness of the need for Australia to have a unified political vision, there were clearly strong forces in society aiming to break down the internal tyranny of distance.

We might pause here and ask the question, was there a physicist whom we might identify as the 'first' in Australia? If we accept that a physicist must have a laboratory, a library and leisure then undoubtedly Richard Threlfall fitted. He was Professor of Physics from 1886 to 1898 at the University of Sydney and the case for him being the first has been well argued (Home, 1987). Threlfall had indeed a good laboratory and the photographs of its buildings and its workshop are ample evidence (Branagan & Holland, 1985, reproduced in Home, 1987). Threlfall was a big man in many ways. He had been a student of J.J. Thomson at the Cavendish Laboratory and was given J.J.'s high praise; Threlfall was 'one of the best experimenters I ever met' (Thomson, 1936). As an undergraduate in 1882 he had developed the first automatic microtome for cutting thin biological specimens. His main research interest was in electrical measurements on which he wrote a number of research articles. He was also active in what is now called applied research especially in the physics of explosives and explosions. He followed C.V. Boys in working with fine quartz threads. He interacted well with the Royal Navy, made friends with politicians (on both sides) and was an industrial consultant to several manufacturers. After resigning from Sydney he became Director of Research of Albright & Wilson, the phosphorus manufacturer in the UK.

There are many stories about Threlfall. As a student he was a member of the Cambridge University Rugby Football Team as well as being a member of the University Shooting Eight. In 1885 the proposal came before the Cambridge Union Society to grant Blues for Rugby Football and it was Threlfall's speech and no doubt formidable presence that prevailed over what seems to have been considerable opposition (Threlfall, 1951, Chapter 10). J.J. Thomson was a keen follower of Rugby and was to be seen often on the touchline with his ancient and famous umbrella. When the Sydney University Senate first met Threlfall he informed them that he had ordered scientific equipment for his new laboratory and workshop without getting Senate's approval. Rutherford visited Threlfall and had no doubt his laboratory when on his way from New Zealand to Cambridge with an 1851 Scholarship, strengthening the 'Cambridge connection'. Threlfall was a friend of Robert Louis Stevenson who stayed with him in Sydney. R.L.S. was originally a student of electrical engineering at Edinburgh under H.C.F. Jenkin, a collaborator of Lord Kelvin on electrical experiments on cables.

Threlfall's skills in experimentation in classical physics are revealed nowhere better than in his book On Laboratory Arts (Threlfall, 1898). Every chapter is written so that readers can learn how to perform the technique for themselves. It might be considered that the Arts was the first book of physics written in Australia but that honour
must go to that by Horace Lamb, Professor of
Mathematics at the University of Adelaide 1875-85 (Lamb,
1879). It is a treatise on the mathematical theory of the
motion of fluids and based on his very successful work
on hydrodynamics in Adelaide. A modern physicist may
be tempted to say that Lamb's approach was that of an
applied mathematician, but at the time the distinction
between applied mathematics and physics (perhaps
theoretical physics) would not be so clear. Classical
physicists in general asked for continuous functions to
represent continuous variables and although the concepts
of atomicity were certainly present in physics towards the
end of the nineteenth century it was not until concepts
such as the electron, quantum theory, and Perrin's
experiments on counting atoms were available that physics
achieved its present structure with atomicity holding a
paramount place.

Threlfall's laboratory made a deep impression on the
young W.H. Bragg who occupied the chair of mathe-
ematics and physics at the University of Adelaide from 1886
to 1909, and by the early 1900s Bragg also had his
laboratory. Bragg's development as a physicist in Adelaide
has been well charted in recent years (Tomlin, 1975; Caroe,
1978; Home, 1981; Jenkin, 1986). We now know that W.H.
Bragg had trained himself in the ways of physical research
before getting attracted into the new field of radioactivity
and was able to make his reputation with his studies of the
ranges of alpha particles (Bragg, 1904). About the
same time, T.R. Lyle at the University of Melbourne had
established a reputation for electrical measurements and
developed the representation of electric currents by
complex numbers independently of Steinmetz (Lyle, 1986).
We can see that there were the three main laboratories of
Sydney, Adelaide and Melbourne doing work of
international importance at the turn of the century, and
it is worth emphasising again the credit due to the AAAS
for bringing these and other laboratories together on a
regular basis and for providing stimulation for much of
the work.

The Turn of the Century and the New Passions
If fact the new University laboratories were ready for the
first of the "passions" and "fashions" that are now so
familiar to the profession of physics. In 1897 when this
article was written, physicists were living through the
excitement of the discovery of ceramic superconductors
with their critical temperatures in the range of liquid
nitrogen temperatures. Such a revelation of new properties
has been, to many, unexpected and exciting and the
number of studies made has given rise to backlogs in their
publication. Perhaps the first such passion was the
discovery of Roentgen's rays late in 1895. It is now only
faintly apparent to us what the discovery of a new
radiation must have seemed like to its contemporary
physicists. Australian laboratories were ready to catch this
exciting idea. The three laboratories of Sydney, Adelaide
and Melbourne were all equipped for classical
experiments. In essence, to do the experiment all that was
needed was a Winshurst machine, a discharge tube and
a photographic plate or fluorescent screen, standard items
in a classical laboratory, especially for those in the
Cambridge tradition with researches on discharges in
gases. The excitement is well described in Trainor (1946)
and the radiology explored in Hamersley (1982). The first
person to succeed in Australia seems to have been Lyle
of Melbourne who announced his result on the 3rd March
1896 issue of the Australasian and in the issue of 14th
March appeared the photograph probably of the foot of
D.O. Masson, Professor of Chemistry at the University
of Melbourne. The Melbourne Argus reported the success
on 4th March, 1896. Lyle had to make a new discharge
tube. He gave a demonstration of the value of the new
radiation in surgery at Melbourne Hospital on 12th June
1896. The equipment needed was well within the capacities
of an amateur to buy or to make and G.W. Selby in
Melbourne was just such an amateur. He had already been
the first to make a wireless communication in Australia.
But for an illness, he could have been the first to see the
effects of the Roentgen rays. Later he sold an 'X-ray set'
to F.J. Cledinnen, the medical doctor in Melbourne who
was the first medical radiologist in Australia and who was
an amateur experimenter in science. W.H. Bragg gave a
demonstration in Adelaide to the press on 28th May 1896.
One of the first Adelaide patients for the new science of
radiology was his son W.L. Bragg who at five years of
age had a broken elbow from a fall from his bicycle.
Threlfall was in the hunt in Sydney and to his credit had
by May 1896 written a full account "on the preparation
of vacuum tubes for the production of Professor
Roentgen's radiation". This appeared in his book as an
appendix to his chapter on Glass Blowing (Threlfall,
1898). This appendix gives full instructions how to make

APPENDIX TO CHAPTER I

ON THE PREPARATION OF VACUUM TUBES FOR THE
PRODUCTION OF PROFESSOR RÖNTGEN'S RADIATION

When Professor Röntgen's discovery was first announced
at the end of 1895 much difficulty was experienced in
obtaining radiation of the requisite intensity for the
repetition of his experiments. The following notes on the

production of vacuum tubes of the required quality may
therefore be of use to those who desire to prepare their
own apparatus

It appears that flint glass is much more opaque to
Röntgen's radiation than soda glass, and consequently the

Written in May 1896.

Figure 3: A page from Threlfall's book on which he describes his experiments
on the design of X-ray tubes.
The tubes and shows that Threlfall had personally explored the problems in depth. This gave him an advantage because he was able to publish in December 1896 an article with J.A. Pollock, his successor in the Chair of Physics at Sydney, describing experiments to explore the nature of the radiation (Threlfall & Pollock, 1896). One of their five possible 'explanations' was that the new radiation was electromagnetic which they said was similar to another radiation which they called 'aether waves', giving a small hint that the aether was not so universal as it had been thought for so long in the nineteenth century. The experiments of Threlfall and Pollock used Michelson's interferometer as a sensitive detector to test if the new radiation were associated with 'aether movements' but of course none were found.

The new research field of radioactivity and ionising radiations was taken up by W.H. Bragg in Adelaide. His experiments on the range of alpha particles were so successful that he was elected to the Royal Society whilst he was in Adelaide. In a series of articles, some with J.P.V. Madsen he explored the problem of the nature of Roentgen's radiation and gamma rays (Home, 1981). Bragg gave a summary of his work at the Brisbane AAAS Congress in 1909, just before leaving Australia for a chair in physics at the University of Leeds. We can understand Bragg's decision, when he found himself one of the leaders in the work on new radiations, that he should wish to be closer to the action in Europe.

One of the long traditions in science is that of a devoted amateur and it is a pleasure to find the tradition maintained in Australia. At the turn of the century there was such a person in Melbourne, William Sutherland, working in Melbourne. To call him an amateur must not be interpreted as doing any lesser work than the paid professionals of the time, but rather that he did not have a regular professional position and took occasional teaching and examining posts (Osborne, 1920). To show his abilities, between 1885 and 1911 Sutherland published 69 articles. His third article, in 1886, was 'The law of attraction amongst the molecules of a gas' and this subject was one of the main themes of his work. It had been stimulated by the success of the 1873 thesis and equation of J.H. van der Waals. Sutherland is remembered for the constant which appears in his formula of 1893 for the temperature variation of gas viscosity. He discussed the structure of liquid water in terms of clusters of water molecules. A case has been made that he is Australia's first physical chemist (Spurling, 1974) and a counter-claim that he is rather Australia's first chemical physicist! This latter claim rests on Sutherland's preoccupation with atoms and molecules and their specific atomic properties (Stuart, 1982). In the Festschrift for Boltzmann's 60th birthday, of the 116 authors five only were from outside Europe and Sutherland was one of these five (Boltzmann, 1904). His article in the Festschrift on 'dynamical similarity' is close to what we now call the Virial Theorem. Sutherland must now be remembered for his focussing attention on intermolecular forces and we may regret that he did not have a professional position and the chance of having colleagues and students to succeed him.

Also in the amateur tradition and also in Melbourne, the microscope rulings and ruled diffraction gratings of H.J. Crayson gained him an international reputation just before WWI. His ruling engine was second in the world to that of Rowland (Jarrell, 1960). He started making the rulings as an amateur microscopist but in a short time he was appointed by the University of Melbourne and with T.R. Lyle's support joined the Natural Philosophy Department (McNeill, 1972; Bolton, 1987). His diffraction gratings were used and appreciated in laboratories round the world. After his death in 1918 his ruling engine was maintained and operated at the University of Melbourne until the 1930s and his gratings were used by T.H. Laby in his work on soft X rays in the 1930s to which we will refer later.

In 1914 the British Association for the Advancement of Science held its 84th meeting in Australia from July 28 to August 31 (British Association, 1915; Robertson, 1980). The President of Section A, F.J. Trouton referred to the recent death of W. Sutherland. P. Barrachi, the Director of the Melbourne Observatory spoke of the establishment in 1910 of Mt. Stromlo Observatory and its early difficulties. Rutherford (still Sir Ernest at that date) in a joint meeting with the Chemistry Section B initiated a discussion of the structure of atoms and molecules and referred to C.T.R. Wilson's photographs of alpha particle tracks. H.G.J. Moseley talked about his recent classification of the elements by their X-ray spectra. JW. Nicholson discussed the Bohr atom and commented on
the difficulties that it contained when applied to the helium atom with its two electrons. However he made the compelling and correct statement about the work of Bohr and himself; "without the introduction of some new universal constant such as \( \hbar \) (Planck's constant) no atom has anything in its nature which compels a definite size, and definite unchanging properties".

W.J. Pope, President of the Chemistry Section B discussed crystal structure and defined the problem "... what the units are which become homogeneously arranged in the crystal, why they become so arranged, and in what way a connection can be established between chemical constitution and crystal structure". Pope referred to the recent work of W.H. and W.L. Bragg which would yield "the actual arrangements of the constituent atoms in crystal structure". A discussion on wireless telegraphy was opened by Sir Oliver Lodge and H.G.J. Moseley read a paper on 'High-frequency spectra'. A.S. Eddington gave lectures and the visiting astronomers visited the State observatories of Perth, Adelaide, Melbourne and Sydney and the private observatory of Mr Tebbutt at Windsor, NSW.

This galaxy of lecturers and lectures was part of a well-planned organisation taking some 300 overseas visitors to all the capital cities. During the meeting, World War I started. This did not upset the planned itinerary but after Brisbane many visitors took the opportunity of boarding a ship for the UK; 30 visitors extended their study into Tasmania. The whole meeting was subsidised by the very considerable sum of 15,000 pounds Sterling from the Australian Government. The scientific impact and the influences of the BA meeting must have been smaller than could have been wished because of the war of 1914-18.
Adventures in Overhead Projection I: Transparencies

E.W. Dearden
Department of Physics, University of Queensland

Introduction

How many of us have faced this problem: students suddenly start complaining that they cannot read our overhead projection (OHP) transparencies. The reason becomes evident — the class size has increased. Students are now sitting at large distances and at extreme angles to the screen. For those of us whose mucous membranes can no longer tolerate the insult of chalk dust, and who in consequence have a vast investment in prepared transparencies, what does one do? The first solution is:

WRITE LARGER!

The second is:

FIX THE PROJECTION SYSTEM!

The problem with overhead projection systems in a university is that to the physicist the operation of these devices is so obvious that they are not worthy of any attention at all, while the rest of the teaching staff don't understand them.

This particular article discusses criteria for controlling and standardising the legibility of transparencies and OHP systems. A following article will discuss techniques for coercing OHPs into operation at high magnification in restricted spaces, and will conclude on aspects of projection screens. These articles report on, and are part of, an ongoing program directed towards the enhancement of OHP systems.

Transparencies

If the image of the projection table of side-to-side (or equal top-to-bottom) dimension T just fills the screen of height H, then the height P of a projected symbol on the screen is given by $P = \frac{HS}{T}$, where $S$ is the height of the symbol on the transparency (i.e. the body of the symbol, excluding risers and descenders). The angle $a$ that the projected symbol subtends at the eye of the student sitting at the greatest distance $X$ from the screen is given by $a = \frac{P}{X}$. Consequently

$$S = a \frac{TX}{H}.$$  

TerLouw (1965) of Eastman Kodak states that experiments have shown that the smallest symbol to be discriminated must subtend 2.6 mrad, while Eastman Kodak (1983) and DAVS (1979) implicitly use a figure of $a$ greater than or equal to 2.5 mrad. For example, for a lecture theatre with an $H = 2440$ mm screen and a $T = 254$ mm projector, and with the most disadvantaged student sitting at $X = 19$ m, the minimum symbol height is 5 mm.

In comparison, the Snellen criterion used by optometrists for 6-6 vision is that persons with normal vision should be just able to resolve specially proportioned and illuminated symbols subtending 1.5 mrad at the eye. Another criterion is used by publishers who do not allow the height of text intended for normal reading to fall below 1.5 mm, i.e. 6.0 mrad at the normal 250 mm reading distance. For footnotes and less important text, a minimum height of 1.0 mm, i.e. 4.0 mrad at normal reading distance, is permitted.

The legibility of diagrams and other textual information on transparencies may be checked without leaving the office by simply viewing the transparencies at a distance of $TX/H$ (for the above example, 2.0 m). The diagrams and text will then be at the same scale as viewed by the student most distant from the screen. Additionally, the effect of any obliquity between the screen and disadvantaged viewers may be simulated. Further, if it is assumed that the Snellen criterion can be applied to the direct viewing of transparencies, then these should be just totally comprehensible when viewed directly by eye at a distance equal to five-thirds of $TX/H$ (for the example quoted this is 3.3 m). Although simple and obvious, these criteria for in-office checks are commonly overlooked.

In preparing transparencies to a criterion of $a$ greater than or equal to 2.5 mrad it needs to be kept in mind that this figure is much nearer to the Snellen threshold than to that used for normal printed text. Thus it is particularly important to ensure that sub/superscripts are not allowed to drop below the value of S as determined above. A style something like typewriter mathematics, with sub/superscripts pretty much the same size as other symbols, may be conveniently used.

‘Permanent’ OHP pens are probably the best. Choose a pen that produces a dense line of a thickness that gives the highest legibility for the particular lettering size that is needed. The thickness of the pen’s tip may be altered with fine emery paper. Alterations to transparencies are simply made with metholated spirits. This may be kept on the desk in one of the small (10 to 15 ml) plastic squeeze bottles normally used for eyedrops. With care, and a little practice, transparencies with undersized sub/superscripts can be salvaged. Use a tissue folded to a metho-moistened point in one hand, and if necessary blot with a tissue pad in the other. Cotton buds are also useful.

Standardisation of OHP Legibility

There has been a consistent attempt by manufacturers and others to standardise the resolution of OHP systems by promoting the criterion that the screen should have a minimum height equal to a definite fraction of the distance to the most distant student. Again this assumes that the image of the projection table just fills the screen. The fraction proposed is usually one-sixth, but ranges
from one-fifth to one-eighth. Thus if lecture-theatre screens were all built to the \( H = X/6 \) criterion, all transparencies should have lettering height of at least 3.8 mm for \( T = 254 \) mm projectors and 4.3 mm for \( T = 285 \) mm projectors. Unfortunately, many lecture theatres do not satisfy this criterion and larger symbols must be used.

Many projectors now have 285 mm tables compared with 254 mm tables on older projectors. This has the advantage that A4 transparencies (of height 297 mm) fit the table with just small overlap at top and bottom, with a high probability that all information is projected. It is also useful to be able to project the whole transparency sideways. While these are convenient additional features, it must be remembered that as far as readability goes, there is no advantage unless the screens are correspondingly larger! If the above \( H = X/6 \) criterion is intended to apply for theatres using \( T = 254 \) mm projectors, then we should use \( H = X/5.3 \) for theatres using projectors with 285 mm tables. As argued in the following section there is considerable value in maximising the amount of information that can be presented simultaneously. Thus lower values of \( X/H \) (5 or 6) ought to be favoured.

While lecturers in their home institutions can easily collect the necessary information to ensure legibility, it ought to be the responsibility of conference organisers to supply the information for their particular venue. Irrespective of the elementary theory given here, it is clear that many of us should have conducted, and should conduct in the future, simple practical on-location legibility trials, before attempting to inflict our transparencies on our students and colleagues.

**Magnification**

Many lecture theatres are equipped with elaborate multiple chalk-board systems. An experienced chalk-board user will commonly employ a script size adequate for the rear viewer, but no larger, and, proceeding systematically, will put up a summary covering perhaps almost the whole of a 50-minute lecture. Both students and lecturer make use of this information, referring back at intervals throughout the lecture. Thus it is perceived that considerable educational value is placed on the total amount of information that can be developed and presented simultaneously.

In comparison, an OHP user is at a disadvantage. Clearly, once the basic criterion of legibility is reasonably met, there is no virtue in further increases in symbol height. Provided the material is arranged and presented so that it can be properly understood, then the total area of a transparency is a valuable resource which should be carefully shepherded.

If a rear viewer at a fixed distance from the screen is always provided with images of lettering at a reasonable, agreed, minimum standard of legibility, then the total amount of information presented simultaneously will obviously be proportional to the screen area, which, for an OHP of given table dimension \( T \), will be proportional to the square of the magnification. Thus, depending on the particular circumstances, there may be an incentive to increase the magnification of an OHP system to the physical limit, consistent with existing firmly established environmental dimensions. This pursuit will be the subject of the second article.

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letters to the editor

Peter Mason and Physics at Macquarie

Dear Editor,

Recent correspondence appears to castigate Arthur Pryor's perspective on the contributions Peter Mason made to physics at Macquarie University (Powe, 1987).

As a physics graduate from Macquarie who has had experience with other tertiary institutions (both in Australia and the US) I must admit that the level and quality of instruction given at Macquarie is one of the finest I have seen. In this regard, I refer specifically to the mid-to-late seventies when physics at Macquarie was identified with people like John C. Ward, R.E.B. Makinson, Ron Aitchison, Elmer Laik, and others. Thus, Macquarie's physics students were introduced to a program based on quantum physics, electromagnetism, solid-state physics, electronics, and one of the best courses in experimental physics anywhere. Sadly, Peter Mason was somewhat removed from this scheme. His contribution consisted in teaching sections of courses of a more applied nature such as biophysics and materials science.

I have no doubt that a man of the intellect and stature of Peter could have been an integral part of the hardcore physics program of the school. However, it appears that at the time he was already deeply committed to his books and to a philosophy of interdisciplinary education.

It was perhaps due to the latter reason that Peter Mason decided for a position of neutrality when the BS issue surfaced at Macquarie, in the late seventies. On this academic and philosophical matter he opted for a view which was clearly divergent from the concensus prevalent in the sciences, and in physics in particular (those unfamiliar with the BS debate may refer to the Sydney Morning Herald: 1979; and the Bulletin, 1980).

There is no doubt that Peter Mason made significant contributions to Macquarie University and society as a whole. However, his influence on physics at Macquarie was less prevalent.

In this context, the perspective offered by Arthur Pryor was quite fair and reasonable.

References


Sydney Morning Herald (1979), September 13.

Frank Duarte
Eastman Kodak Company
Rochester, NY 14630

Sing Along

Dear Editor,

The highlight of the recent 8th AIP Conference was the conference dinner, in particular the following song, which was composed especially for the occasion.

It was a 'hit' and I've had several requests for it to be printed in the *Australian Physicist*. The lyrics are by David Vance of the University Singers.

Stephen Colloccot
CSIRO Division of Applied Physics
Lindfield 2070

1. Heavenly stars do it
   Venus, Jupiter and Mars do it
   Let's do it, Let's fall in love

2. Quasars and quarks do it
   Little lasers with a spark do it
   Let's do it, Let's fall in love

3. Old Galileo, we know, did it,
   Though it angered the Pope
   Archimedes in his bath did it,
   But he had to use soap!

4. Astronomers, late at night, do it
   Einstein at the speed of light could do it
   (relatively speaking)
   Let's do it, Let's fall in love

5. Max Planck and Bohr did it
   Both the Curies, we are sure, did it
   Let's do it, Let's fall in love

6. And ever'amp, ohm and watt does it
   Even Stephen Colloccot does it
   Let's do it, Let's fall in love

7. Magnetic fields, north and south, do it
   And it cannot be stopped,
   Newton would gravitate to it
   Once the apple had dropped.

8. Few physicists, we surmise, ignore it,
   Some have won the Nobel prize for it
   Let's encore it, Let's fall in love.

David Vance 25/1/88

Quantum Statistics of Charged Particle Systems

W.D. Kraeft, D. Krenz, W. Ebeling & G. Röpke


This book is a reasonable text book on Green's Function techniques for studying the quantum statistics of charged particle systems. It seems to me that it introduces Green's functions, develops them for Coulomb systems and then applies them to equilibrium and transport properties with a chapter on optical properties, all in a perfectly workmanlike way. Nonetheless at US$49.50 one would expect a decent translation from German (surely not too arcane a language), a reasonably low rate of typographical errors, and especially attention to such pedagogical details as defining notation as it is introduced. The question of notation was extremely vexing, especially in the introductory chapters. Lack of definition of symbols made these chapters very hard to read and one got tired of working out finally what a symbol meant, only to find its definition three or four pages later. For a good review of the techniques, it's a good book, but not an easy one to learn them from for the first time.

Another major defect in the book is its handling of the major advances in the general theory of distribution functions in plasmas (by Gruber, Martin and co-workers) in rigorous formulations (by Lieb and co-workers) that have occurred in the last ten years. It seems to me that there would be a ready market for a book which incorporated these advances into the main part of the text, however this book isn't the one. It does have an introductory chapter on these developments, but it appears to be a late skin graft only.

E.R. Smith
Department of Mathematics
La Trobe University

Atomic Physics of Lasers

D. Eastham


The importance of the laser as a light source for a wide range of physical and technical applications is well known. Features such as (a) high intensity, (b) high directionality, (c) monochromaticity, (d) coherence and (e) ultra short pulses have been extensively exploited. As a physical
system the laser is important in terms of (a) producing a light field that comes close to resembling the familiar classical electromagnetic wave, (b) providing an example of an open nonequilibrium system in which macroscopic order can appear when certain threshold conditions are satisfied, and also in which chaotic behavior can occur under other conditions.

A large range of different types of laser devices have been produced, and the present book provides a useful introduction to the practical question of understanding how these operate with reference to the energy level schemes of the various laser media involved and to the properties of optical cavities, etc. Introductory chapters on atomic/molecular structure and the interaction of electromagnetic radiation with atoms are also provided. Laser theory is discussed in terms of the simple rate equation approach based on energy level populations, which at least enables the threshold condition to be understood. However, the semiclassical theory of lasers (atoms treated quantum mechanically, light treated classically) and the fully quantum theory (both light and atoms treated as quantum systems) which are needed to understand phenomena such as frequency shifting and coherence, are both beyond the scope of the book.

B.J. Dalton
Department of Physics
University of Queensland

Waves in Focal Regions
J.J. Stannes
Adam Hilger Ltd., Bristol, 1986
xxiii + 360pp., £19.50

We have no easy answer to the apparently simple question: what pattern is created when a plane wave impinges on a circular aperture in a plane? Understanding this problem and its elaborations is the subject matter of Stannes' book along with some applications. Perhaps Born and Wolfe was once all that was needed to be consulted on optical theory, but now we are seeing books like the present one giving in-depth modern treatment of particular topics.

The diffraction and focusing of waves, is an old topic (Airy's 1835 paper is quoted), but certainly not a closed one, with physical questions such as the symmetry of the field around a focus and the validity of various approximations still spawning papers in the 1980s. The arrival of computer power has placed an emphasis on numerical methods and allowed us to check approximations and present graphs helping us to readily assimilate results. This book abounds in beautiful diagrams and excellent careful comparisons. The computer has greatly enhanced the applicability of the wave theory of optical systems, so that designers will more and more go beyond geometrical optics methods and that is one major motivation behind this book.

This large book - 600 pages - treats the physics, the mathematical analysis and the practical implementation of diffraction theory in great detail. The book is very carefully organized and each of the seven parts has a short introductory overview, which I found extremely useful. Parts of the book can appear somewhat maze-like and the sectioning gets to the 12.5.2(a) level. Part I is a qualitative and historical introduction, but Part II launches us into the full theory of Diffraction of Scalar Waves. The basic problem is formulated in the modern way using Fourier theory and then the Rayleigh-Sommerfeld and Kirchhoff theories are extended and compared both mathematically and numerically as far as their treatment of the field in and near to the aperture. The care with which the reader is lead through the many formulations and their relationships is for me a high-point of the book. This Part also discusses rays and Huygens' Principle and has a chapter on numerical techniques. Part III presents Asymptotic Theories and the method of stationary phase is presented in detail for one and two-dimensional integrals. The complete expansions are presented right from the start; no compromises here and perhaps no place for the faint-hearted! So it is with the whole book.

The applications begin in Part IV with the Focusing of Scalar Waves and various aperture shapes and incident fields are considered using the whole range of methods. Again I must pay a tribute to the way the author weaves together and balances the importance of the physical basis and mathematical approximations in the various methods, which are illustrated and compared using computational and experimental results.

Parts V-VII cover electromagnetic, sound and water waves and non-linear waves make an appearance. A short chapter on 'Zone-plate Lens for Focusing of Ocean Swells' testifies to the diversity of the book.

This is not an easy book to review. It is packed with information and the approach may seem detailed, technical and forbidding, but I believe it will be an enormously useful reference book for those who wish to ascertain the 'real story' in all its glory.

C. Pass
Department of Mathematics
Australian Defence Force Academy, ACT

Coherence, Co-operation and Fluctuations
F. Haake, L.M. Narducci & D. Walls (Eds.)
Cambridge Univ. Press, Cambridge, 1986, viii + 456pp., $125.00

This volume contains the proceedings of a 1985 symposium held in honour of R.J. Glauber for his contributions in nuclear and high energy physics (optical model), statistical physics (kinetic Ising model) and quantum optics (coherent states of the quantum electromagnetic field). A wide range of recent work in these areas is included, although papers in quantum optics make up the major part. Several of Glauber's most important papers are also reprinted. These include the classical series in which both coherent states of the quantum electromagnetic field (states which must closely resemble the classical electromagnetic wave and which are generated by lasers operating well above threshold) and also quantum correlation functions (which express the results of n-photon detection measurements) are defined.

In a short review it would be impossible to refer to more than a few articles and these will tend to reflect the interest of the reviewer. However among the most notable was that by Filipowicz et al. discussing how laser light is coherent due to averaging the coherent atom-light interaction over incoherent fluctuations and losses, and which suggests how lasers could be modified to generate a much wider range of fields than the usual coherent state - including even the elusive n photon number state. Elegant articles by Caves on the measurement of amplitude and phase in quantum optics, by Loudon on balanced homodyne detection, and by Walls on measurement theory are also included. For those working on particular quantum optics the discussions on optical pulse propagation by Ackerhalt et al., on quantum beat lasers by Pedrotti et al. will be of interest, as will the review by Arecchi on order and chaos in quantum optics.

In the statistical physics area there are articles by Kadonoff on fractal singularities and by Titulaer on kinetic boundary layers (which are an example of a small scale system far from thermal equilibrium). In the nuclear and high energy physics section, treatments of electron-nucleus scattering by Franco and of medium energy hadron propagation through nuclei by Bleszyński et al. involve the extension of basic work by Glauber.

Overall the book is a worthwhile addition to any physics library and would be of special interest to institutions doing quantum optics research.

B.J. Dalton
Department of Physics
University of Queensland

Frontiers in Quantum Optics
E.R. Pike & S. Sarkar (Eds.)
Adam Hilger/IOP Publishing, Bristol, 1986. xii + 577pp., $78.00.

It is somewhat paradoxical that many of the phenomena studied in the field of quantum optics can be described via semi-classical approaches, where although the atomic systems with which the radiation field interacts are treated quantum mechanically, the radiation itself is described as a classical field. However, in recent years a number of phenomena have been recognised as requiring a full quantum (non-classical) model for the radiation also, and the symposium held at Malvern in 1985 (out of which the above Proceedings arose), involved this major theme.

Squeezed states of light are an example of a non-classical phenomenon, and are characterised by the fluctuation in one of the quadrature components of the field being less than for the case of a coherent state (such as is produced by a laser operating well above threshold). The book contains excellent articles on recent experiments, theory and possible applications of squeezed states by Slusher et al., Loudon, Walls et al. and Leuchs et al.

The collapse and revivals of populations in two-level Rydberg atoms in microwave cavities are associated with radiation field situations where the numbers of photons are small and where again a field quantisation is necessary. Articles by Knight, Barnett et al. give clear reviews of this work.

Spontaneous parametric down conversion (in which an incident pump photon interacts with a non-linear dielectric and fissions into two lower frequency photons) also produces a non-classical light field which may come close to realising localised one-photon states. This subject is dealt with by L. Mandel, and by Pike et al.

A stimulating article by Kimble analyses situations where a quantum treatment of the dynamics in quantum optics is vital. Excellent articles on the quantum theory of lasers by Haken, on quantum effects in optical bistability by Ligato et al., Carmichael, P. Mandel, and Satchell et al., on sub-Poissionian photon-electron statistics by Jakeman and on the quantum theory of measurement by Glauber are also included.

This book is an essential item in the library of any institution involved in quantum optics research and many researchers will also wish to have their own private copy.

B.J. Dalton
Department of Physics
University of Queensland

Wafer Scale Integration
C. Jesshope & W. Moore (Eds.)
Adam Hilger Ltd., Bristol, 1986 xii + 274pp., $72.50.

Wafer scale integration has been the probable cause of one US computer company's recent collapse, and other companies seem to be doing little in this promising though difficult field.

The basic concept of wafer scale integration requires the electronic system designer to put all of the devices required onto a single wafer of silicon crystal, and instead of using a printed circuit board to wire them together, to form all of the inter-chip wiring on the wafer surface. Of course multiple copies of devices must be made since not all will be functional, and to date the most successful approaches to high-density wiring have simply bonded good chips onto a ceramic or silicon wafer 'printed circuit board' which has been patterned very finely with many conductor layers.

This book reports the proceedings of a workshop held in Southampton in 1985. The contributions are mainly from academic rather than industrial viewpoints; only very rudimentary examples of working wafer-scale structures are mentioned. The book contains an excellent review of the potential and the problems of WSI. The articles which follow mainly consider optimal chip shape and size, and strategies for providing efficient (though of necessity long) interconnections across the wafer surface. Physicists with a practical inclination will find one article on the use of lasers to both form and break connections interesting.

Overall, this book will be of interest to those studying the behaviour and construction of large randomly-connected systems.

C.M. Horowitz
School of Electrical Engineering
& Computer Science
University of New South Wales

Dynamical Phenomena at Surfaces, Interfaces and Superlattices
F. Nizzoli, K.H. Rieder & R.F. Willis (Eds.)
Springer-Verlag, Berlin, 1985, xii + 329pp., DM89.

The book is compiled from lectures presented at the 1984 International Summer School on the subject, resulting in an overall tutorial style, rather than being a disjoint collection of articles. At the same time the book is rather unusual as it covers an enormous range of surface phenomena and probing techniques, necessarily briefly, but at a reasonably sophisticated level. As a result the utility of the book must be carefully considered. It is likely that topics familiar to the reader will be covered in insufficient depth to be useful as reference material, while unfamiliar areas of interest are often presented without adequate introduction, reducing the value of the material for tutorial or general review purposes. The book excels as an overview of the field, however, and the individual contributions at least indicate to the reader some requirements for further study, plus many useful references.

Of the 36 contributed articles 4 are noteworthy as useful review articles. These are: Structural Determination of Surfaces and Overlayers with Diffraction Methods (11 pp., 49 refs); Advances in Semiconductor Superlattices, Quantum Wells and Heterostructures (7 pp., 104 refs); Surface Reconstruction Phase Transformations (19 pp, 81 refs); and, Magnetism at Interfaces and Surfaces, as Probed by Neutron Scattering (9 pp., 24 refs).

A useful text for surface physicists as a 'directory' of the field.

G.J. Grifiths
CSIRO Division of Radiophysics
Epping, NSW
conferences & meetings — 1988

Apr 4-8  International Workshop on Radiological Protection in Mining, Darwin.  
Dr J. Kvasnicka, Dept. of Mines & Energy, GPO Box 2901, Darwin, NT 5794.

Apr 5-8  International Non-Ionizing Radiation Workshop, Melbourne.  
T. Boat, PO Box 4057, Melbourne, VIC, 3001.

Apr 6-9  8th General Conference of the Condensed Matter Division of EPS, Budapest.  
N. Kroo, Central Research Institute for Physics, POB 49, H-1525, Budapest, Hungary.

Apr 10-17  7th International Congress on Radiation Protection Practice, Sydney.  

Apr 10-19  International Symposium and Workshop on Fusion Nuclear Technology, Tokyo.  
K. Miya, Nuclear Engineering Research Labs., The Univ. of Tokyo, Tokai-mura, Ibaraki Prefecture, 319-11, Japan.

Apr 25-May 20  Radioisotope Course for Graduates No. 34., Lucas Heights.  
The Principal, Australian School of Nuclear Technology, Lock Mail Bag No. 1, Menai, NSW 2234.

May  Int. Conference on Physics of Transition Metals, Kiev.  
Inst. of Metal Physics, Ukrainian Academy of Sciences, Vernadsky Str. 36, SU-252680, Kiev-142, USSR.

May 2-6  8th International Conference on Plasma Surface Interactions in Controlled Fusion Devices, West Germany.  
Ms M. Spittler-Wilden, KFA Juliach, POB 1913, D-5170 Juliach, West Germany.

May 16-20  ANZAS 1988 Centenary Congress, Sydney.  
B. O'Rourke, Organising Sec, 1988 ANZAS Centenary Cong., 118 Darlington Rd, Univ. of Sydney, NSW 2006.

May 19-21  5th International Conference on Computer Security, Gold Coast.  
IFIP Secretariat, 16 Place Longemalle CH-1204, Geneva, Switzerland.

June 20-24  Third Asia Pacific Physics Conference, Hong Kong.  
K. Young, 3rd Asia Pacific Phys. Conf., Dept. of Physics, The Chinese Univ. of Hong Kong, Shatin, Hong Kong.

July 12-14  4th National Space Engineering Symposium, Adelaide.  

July 24-30  17th International Conference on the Physics of Electronic and Atomic Collisions (ICPEAC), Brisbane.  
Dr W. Newell, Dept of Physics, Uni. College of London, Gower Street, London WC1E 6BT UK.

Aug 8-12  5th Marcel Grossmann Meeting, Perth.  
Dr D. Blair, Physics Dept, The University of Western Australia, Perth, WA 6009.

J. Watson, AXAA-88, PO Box 479, Claremont, WA 6010.

Aug 14-19  10th International Congress on Rheology, Sydney.  
Prof. R. Tanner, University of Sydney.

Aug 21-26  10th International Congress on Rheology, Sydney.  
Prof. R. Tanner, University of Sydney.

IE(Aust.), II National Circuit, Barton, ACT 2600.

Aug 29-Sept 1  3rd Australian Archaeometry Conference, Adelaide  
Prof. John Prescott, University of Adelaide, SA 5001.

Oct 3-8  9th International Symposium on Exoelectron Emission, Related Phenomena and Applications, University of Wroclaw, Poland.  
Prof. J.A. Ramsey, Physics Dept, University of Newcastle, 2308.

Nov 6-10  International Symposium on Industrial Robots, Sydney.  
International Federation of Robotics Sveriges Mekanforbund, Box 5506 S-11485, Stockholm, Sweden.

For details of other conferences please contact the Executive Editor.
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