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PRESIDENT'S COLUMN

Australian Participation in Major International Research Facilities

Background
Late last year, the Australian Science and Technology Council (ASTEC) was commissioned by the Federal Government to consider and report on the merits of Australian access to a range of international research facilities which, because of their high cost, are generally not available in Australia. In a newspaper advertisement calling for submissions they said that:

"A number of proposals had recently been raised with the Government including Australian participation in CERN, and a report to the Academy of Science which identifies Australian needs in relation to overseas synchrotron radiation sources and intense neutron beams. These and other associated high cost experimental and analytical research facilities were to be the focus of the ASTEC study.

Terms of Reference
ASTEC will report and make recommendations on:

1. Australian responsibilities and needs in relation to international research facilities;
2. the major international research facilities and organisations in which Australia should seek to participate;
3. the nature of the participation which Australia should seek in each case;
4. mechanisms for funding and for evaluating the benefits of membership."

Submission:
Written submissions on the above terms of reference were invited, with a deadline of 19 January 1990. There was obviously no time for any consultation with Branches of the AIP nor with the membership at large. However, your President, being a card-carrying member of the "suitcase-physicists" brigade, put in the following submission:

Secretary
Working Party on Australian Participation in Major International Research Facilities
3 - 5 National Circuit
BARTON ACT 2600
5th January, 1990

Dear Sir/Madam,

I am responding to your call for submissions in my capacity as President of the Australian Institute of Physics. However, I must point out that I am expressing my personal views which may differ from those of sections of the membership. In particular, I will refer, throughout, to

27th ANNUAL GENERAL MEETING

Notice is hereby given that the 27th Annual General Meeting of the Australian Institute of Physics will be held on Thursday, 19th April 1990 at 8.00pm in the Hercules Lecture Theatre, School of Physics, University of Melbourne.

Agenda
1. Apologies and declaration of proxies
2. Minutes of the 26th AGM
3. Business arising from the minutes
4. Presentation of the financial statements
5. Confirmation of filling the casual vacancy on the Executive created by the resignation of Dr Terry Freeman with Dr Robert Fleming.
6. Appointments of Auditors
7. Other Business

John Riley
Honorary Secretary
PRESIDENT'S COLUMN

basic research only, i.e. work for which no immediate, short-term commercial or industrial application is envisaged. For this kind of work there is widespread international cooperation and open access.

Research at various major international facilities has been carried out by Australian physicists for several decades. On the basis of the accumulated experience, I would give the following brief summary comments on your several Terms of Reference:

1. Australian responsibilities are threefold: First, to make significant contributions to international science. Second, to make tangible contributions, whenever possible, to the apparatus, infrastructure and/or manpower of the international facilities that were used, e.g. by taking along Australian-made pieces of equipment or by contributing work-shifts in the case of collaborative experiments. Third, to reciprocate international hospitality by making available world-class Australian facilities to the international community in at least a few well-recognised fields (e.g. in Astronomy). I would be happy to give concrete examples of all three of these points, preferably in a direct presentation.

2. I will restrict my answer to concrete instances of international research facilities at which my colleagues and I have performed significant work in the past or have possible future interests. I make no claim of completeness. On the contrary, there exist very many major installations all around the world, of a kind and of a magnitude that we do not have in Australia but access to which is imperative if Australian scientists are to remain on par with modern developments and, even more importantly perhaps, for Australian post-graduate students to be trained at levels competitive with those in the rest of the world.

a) Accelerators:
- CERN SPS, Geneva
- TRIUMF, Vancouver
- Indiana University Cyclotron Facility
- SLAC Stanford
- Tohoku University LINAC, Japan
- Saskatchewan Accelerator Centre, Saskatoon, Canada
- CEBAF Accelerator Centre, George Washington University

b) Neutron Sources:
- Institut Laue-Langevin High Flux Reactor, Grenoble, France
- University of Missouri Research Reactor, Columbia, Mo.

- NIST (Formerly NBS) Research Reactor, Washington D.C.
- Los Alamos Neutron Scattering Centre, LANL, New Mexico
- ISIS Spallation Source, Rutherford Laboratory, U.K.
- Oak Ridge National Laboratory High Flux Research Reactor, USA
- Argonne National Laboratory Spallation Source (IPNS), USA

c) Synchrotron Radiation Sources:
- Photon Factory; Tsukuba, Japan
- Brookhaven National Laboratory
- Lawrence Berkeley Laboratory Centre for X-ray Optics

d) High Voltage Electron Microscopes
- Lawrence Berkeley National Laboratory
- Arizona State University Centre for Electron Microscopy
- Universite Claude Bernard, Lyon, France.

e) Laser Fusion Facility
- Lawrence Livermore Laboratory, USA

3. In all the above cases, Australian participation in research is an established fact. Access was and will continue to be granted provided that good proposals are put forward. (In some cases collaboration with local researchers is a mandatory “ticket” which gains admission.) What is often lacking is the ability to contribute significant items of equipment (to alleviate the feeling that one is a “hitch-hiker”) and easy access to travel money to cover reasonable expenses. What is also often lacking is the possibility of taking along one’s research student(s) who would benefit from the experience. The limitation, most often, is finance for travel expenses.

The above pre-supposes that reciprocal rights will be available at Australian facilities. However, in recent years, alas, we have not been in a position to reciprocate because no large world-class research facilities have been built here for quite a long time.

4. Regarding funding mechanisms, I would be opposed to the idea of direct funding for the overseas installations, i.e. I do not envisage advantages in Australia having associate membership or full membership in any of the organisations such as CERN or ILL. Instead, I would favour money flowing through Australian research groups paying their way in collaborative experiments and having available travel funds at short notice for experiments approved and scheduled at major overseas installations. Major components of equipment, bought or preferably built in Australia should also receive special funding.

No mechanism other than peer review appears reasonable as well as cost effective. The general program of research should be judged by a panel of respected assessors (e.g. the ARC Committees) backed, if necessary, by reports from referees. In general, approval by the Scientific Council or the Scheduling Committee of the overseas research facility in question should be prima-facie evidence of acceptability, leading to an almost automatic grant, subject only to minor scrutiny. (Currently, one frequently finds oneself in double jeopardy, having to have acceptance overseas followed by further major scrutiny by the ARC.) It should also be remembered that time is of the essence: travel money should be made available at relatively short notice for approved programmes.

Evaluating the benefits of work should be by periodic reports on the resultant publications and on the number of Higher Degree students trained.

The above paragraphs attempted to address the Terms of Reference of the Working Party. The more general issue of the need to access advanced facilities and the training and industry implications is intimately tied to the broad question of the need for basic research in physics. Since physics is the cradle of technology and today’s physics is tomorrow’s engineering, little needs to be added to the reams and reams already written about this.

The choice of fields of research may need to be addressed, that, at first blush, some may seem to be of greater immediate industrial relevance. Since I am talking only about pure, basic research, and since the source of tomorrow’s technological breakthrough is today’s unpredictable, no superficial judgements are possible, in spite of the fact that some research facilities may be more avant-garde than others. The only valid criterion, in my opinion, is the excellence of the science produced. That is a subject for assessment by established, reputable scientists and no others.

I am willing to amplify any of the above comments in an interview, at your convenience. Meanwhile, I hope to have been of help.

Yours sincerely,
A.G. Klein
President,
Australian Institute of Physics
Physics Problems

The ASTEC Report "Profile of Australian Science" points to Physics as the once area of Australian Science which is in decline. Indeed, the Chairman's covering letter to the Prime Minister notes: "Physics and areas of other fields which draw on principles from physics are particularly at risk". This is disturbing but not altogether surprising to those of us working in Universities and the CSIRO. For many years we have felt under pressure from lack of student interest and reduction of resources when the cost of physics research is increasing faster than inflation.

The report uses bibliometric measures to determine the significance of Australian contributions to the various areas of science. Such measures have inevitable uncertainties and are open to criticism on a number of fronts. First, the particular classification of areas will influence the result. Physics is one area, but astronomy, optics, semiconductors, and material science are separate areas. Many workers in these areas would regard themselves as physicists, but in the analysis their publications would not count as contributing to the health of that discipline. The sub-area of solid state physics is the poor relation, having been in a real decline over the past ten years. This may be the effect of the classification and the shift of workers into the areas of semiconductors or superconductivity or materials and away from the more traditional solid state physics.

Second, the set of journals chosen for the study may miss many papers published in particular fields causing a bias against the contribution from that area. Third, many publications from Australian authors when collaborating with overseas colleagues have their addresses as footnotes rather than in the main title and the bibliographic process will miss them. This is particularly true where Australians are working in large overseas establishments, an increasing phenomenon in solid state and high energy physics.

A detailed study of the bibliometrics may alter the numbers and weightings to some extent; such an analysis is being carried out at Monash University. However, it seems unlikely to alter the basic conclusion that Physics has problems which must be addressed.

These problems arise out of Australian society, its current values, the preoccupation with money manipulation and the Australian cringe particularly in the manufacturing and business areas. Australian business has always had a short term view of its activities so investment in research which may lead to profitable development twenty years, ten years or even five years away is too uncertain and beyond the horizon of significance. Australian scientific research has been justified as being necessary for the understanding and possible exploitation of overseas developments. The possibility of significant contributions or significant developments being made and exploited here is not regarded as important or likely.

It must be acknowledged that Australia's well funded medical research makes a significant contribution (4%) to international research and is well referenced. Our biological sciences also are more significant internationally than physics. While we may look to structural factors to explain the relative lack of physics research success, justifications and arguments will be measured against the more satisfactory performance of other disciplines.

The problems in physics relate to three obvious areas: people, teaching and research. To a large extent these problems are linked.

The number of students taking physics in the final year of secondary school is static while the numbers taking other sciences is increasing. This leads to a static number of students in tertiary physics courses while other sciences are increasing. Students are finding physics less attractive than other sciences; reasons must be sought as to why this is so. Explanations have been offered. There is a decline in the number of physics teachers in high schools and very few teachers in the junior years have a physics background at all. Students are not properly introduced to physics as an understandable and interesting science and are very quick to absorb the teacher's discomfort with the difficult subject. In senior years the course has been traditionally introduced with an extensive and mathematical mechanics course which is attractively rigorous to the practising physicist but ultimately repelling to mere mortals with an interest in science. Changes in the organisation of the curriculum at one girl's school have led to the retention of students in Year twelve. This shows that more people can be attracted to physics if the curriculum is appropriate.

A career with a major in physics is not particularly attractive either financially or for the prospects of advancement. The rewards for a physicist in research are modest and business in Australia is distinguished by its lack of understanding of science or the value of research. Bright students flock to medicine, dentistry, vet science and commerce where the rewards are far greater and the status much higher. The challenges the society emphasis today are those of the take-over and money manipulation. Creativity and effectiveness have given way to simplistic notions of efficiency. The sciences and physics in particular suffer from a lack of new talent, a change from the heady days of the 1950's and 1960's when the first Spurnik challenged western countries to compete scientifically in the race for space.

We expect our best scientists to study for 4 years at a university on no income, to become research students on $15,000 for 3-4 years while their friends earn up to $30,000 per year. We expect them to be dedicated and work 60 hours a week to gain their scientific meat ticket, the PhD, to spend several years overseas working for only fair rewards and to return to an uncertain future on a salary of $35,000 after a period of 6-8 years, at an age of nearly 30.

Doctors, lawyers, business people are well ahead and established by this time. Why should bright students tread the uncertain science path? We are fortunate that some are foolish enough to do so.
The relative decline in student numbers at tertiary institutions has the effect of starving the physics department of funds. Universities have been receiving less money per student for a number of years and student/staff ratios have increased over the last decade to the point where student/staff ratios in Universities are higher than in secondary schools. This means that more difficult ideas and greater quantities of information are transmitted to a larger number of students by fewer people. Personal contact, individual attention and small group teaching is reduced and effectiveness is sacrificed to the demands for a crude "graduates per staff member per hour" statistic. Staff members' time for scholarship and research is eroded and the contribution to new knowledge is inevitably reduced. The ASTEC report documents this effect. 

Universities are now funded on the effective number of full time students (EFTSU). The Government has reduced the grants per EFTSU to Universities by the "claw back" of funds. University grants come as an average cost of a student and do not take into account the difference in cost of first year students, final year students or postgraduate students. Most universities then divide the money between the faculties, schools and departments based on the EFTSU system, sometimes with weighting factors to take into account the differences in size. The relative decline in physics student numbers means that physics departments' funding is declining faster than other departments with the consequent pressure to reduce the academic and support staff by natural attrition. In those few departments established in the late 1960's with young staff, the attrition has yet to assist their financial problems. The reduction in funds, the reduction in staff numbers and the general ageing of the active physics community have lead to the decline in the contribution of Australian physicists to internationally recognised research. 

Research policy for government laboratories has emphasised applied research, collaboration with industry and the recovery of research costs. It is clearly desirable for CSIRO and other laboratories to seek collaborations but the consequence is that laboratories often are faced with working in scientifically trivial areas, of interest to the backward Australian manufacturing industry. It is inevitable that the contributions to international research will decrease with this deflection from state-of-the-art interests. 

The problems of Australian manufacturing industry have long been debated and many solutions have been proposed. The niche market strategy, in which gaps in the market are exploited to gain a foothold, has lost favour due to the difficulties encountered in entering overseas markets without substantial backup. But the main problem is with the structure of Australian Industry itself. Too many of the companies operating in the Australian market are foreign owned and foreign controlled and their research and most development takes place overseas. Governments for decades have encouraged overseas companies to invest in Australia without requiring them to invest in Australian research and development. The fear is that the overseas companies will not come if controls and requirements are too stringent. The Kodak exercise is a recent example of the ability of a foreign company to blackmail the government to serve the company's interest without returning anything to Australia except the continued employment of some hundreds of workers. 

To further exacerbate the problem many Australian companies have no research beyond quality control or basic development and do not see any reason to do research. Companies prefer to purchase licenses for new technology overseas rather than pursue research here and most companies have no research facilities at all. Some such as BHP and CRA have quite large research laboratories and are the bright spots in an otherwise bleak picture. 

Few Australian companies have an idea of the value to their company of people with PhD degrees. There have been suggestions for alteration of the structure and nature of the degree to equip graduates with skills more appropriate to industrial needs. Some of the suggestions do have merit. However, German PhD graduates from my own area of pure research find no difficulty in obtaining employment in German industry, with Bosch or Porsche or Mercedes of Siemens or IBM (Germany) and so on. These people have investigative skills, experimental skills, analytic skills and the ability to obtain the background knowledge in a new area all of which enable the development of new ideas and the solution of existing problems. 

Both political parties lack strategies for addressing the problems of Australian industry, believing that macro-economic strategies will so influence the market place that companies will respond appropriately for the future. When the "future" is at most two years away it is unlikely that companies will spend money on activities that will hold profits 10 to 20 years hence. For those of us who remember similar policies being pursued for the last 40 years with the consequent decline in the industry that did exist, the current promises of an improvement in Australia's trading position seem rather hollow. 

The solutions to the problems for the discipline of physics in Australia must be many faceted. It is essential that the part physics plays in the structure of modern science is recognised and action is taken to improve its health in schools, universities, in research institutions and in industry. 

Physics and science teaching in the junior secondary schools must be improved, Syllabuses and strategies to make physics accessible to a larger number of students in the senior schools, particularly women, should be devised. In-service courses and opportunities for further study should be made available to science teachers to improve their competence in physics. Technical support is required in schools to develop experiments and to assist with laboratories. 

University physics departments should be funded at a level which enables them to teach effectively and to perform research of the highest quality. Policies are urgently required to enable physicists to gain access to overseas research facilities which is becoming essential in most physics areas. Research students should be supported adequately and longer term positions established to ensure continuity of effort and to build up skills in particular areas. There needs to be significantly improved salaries and career prospects for physicists in universities and research laboratories.

A more flexible and longer term approach to the balance between pure and applied research is needed in Government research laboratories. Australian and overseas companies should be actively encouraged to perform or fund research by the allocation of a percentage of turnover to their own or outside research. An export consultative unit should be established to advise companies in Australia on the best research strategy for that company in Australia.

Australia cannot afford to allow the discipline of physics to become a second rate provider of service courses and relinquish its important research role.

Dr John Riley
La Trobe University

Australian Physicis Volume 27, Number 3, March 1990

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Science Teachers With Physics Degrees

Dear Editor,

I refer to the article in the November 1989 edition of the "Australian Physicist" by John Campbell concerning the production of physics teachers for secondary schools.

In this very interesting, forthright document he makes the claim "In the whole of NSW, just two science teachers have physics degrees".

Well I am a science teacher in NSW and I have a physics degree (Syd 1974) and I would like to know :-

1. Were I counted, if not does that make three?!

2. If I was, who is the other person so I can send them my regards.

Yours faithfully,

Phillip Kennedy MAIP
Head Teacher (Science)
Wellington High School
NSW

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Englishman Joule

Dear Editor,

Your correspondent may well have identified a clutch of French physicists (Australian Physicist 26, 258 November 1989). However James Prescott Joule was of Derbyshire/Lancashire stock for at least three generations back.

Yours sincerely,

J.R. Prescott
Professor Emeritus
Department of Physics and
Mathematical Physics
The University of Adelaide

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More Changes of Nationality

Dear Editor,

I was interested by the list of French physicists and mathematicians compiled by Drs Chadderton and Barbara (Australian Physicist, November 1989, p.258). A striking feature of the list is the heavy concentration of names from the early 19th century, a period when French physicists not only dominated the field but more or less invented it, at least in the form in which we know it. By contrast, a list of German contributors - which would probably include at least as many well-known names - would be heavily skewed to the late 19th and early 20th centuries.

May I add a few names that should surely appear in any French roll of honour of this kind, namely those of Descartes, Berthollet, Malus, Dulong, Petit, Arago, Regnault, Gay-Lussac, Messier, P. Curie, Bécquerel, Perrin, Carnot and Coriolis? With a little more effort, I'm sure one could think of others.

However, a quick check would have removed a few names from the list you published, their owners not being French, namely Struve (Russian); Lagrange (Italian - though admittedly he spent most of his working life in Paris); Joule, Boole and Airy (English); Napier (Scottish); and Courant, Bessel and Landé (German). There is at least one misprint (Galois, not Galvsi). I do not recognise the names Decante (Descartes?), Thévenin and Lebange; they do not appear in the biographical dictionaries I have consulted.

Yours faithfully,

R.W. Home
Department of History and Philosophy of Science
The University of Melbourne

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Joule is a Pom Again

Dear Editor,


To the best of my knowledge, his experimental work, which set the foundation for the First Law of Thermodynamics, was conducted in Salford. One possible exception is the (possibly apocryphal) report of water temperature measurements made at the top and bottom of a waterfall whilst on his honeymoon in Switzerland.

The curse also of the Second Law of Thermodynamics for no mention of Nicolas Léonard Sadi Carnot, born 1 June 1796 in Paris. Add to this the Laws of Jacques Charles, Joseph Gay-Lussac and Edmé Mariotte and your correspondents are under severe pressure. Even the deafness of Guillaume Amontons would be penetrated by the cries of the 'sans culottes'. They should flee while they can before they suffer the fate of Laplace, but they can expect no help from the Montgolfier brothers.

Sincerely,

Professor T.F. Smith
Department of Physics
Monash University

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The Editorial Board wishes to implement the idea of a section in The Australian Physicist devoted to matters of interest to those involved in Physics Education at the secondary school level. This will focus on items of interest to teachers and students. Articles, hints, ideas for experiments and discussion of matters common to Year 11-12 Physics syllabi at a level useful to teachers, secondary students or both are sought. Preliminary plans are for a four page insert, published quarterly, with the insert also being available for distribution to schools. Please send all contributions to the Honorary Editor (See address on contents page)
Optical Instruments In Australia In The 1939-45 War: Successes And Lost Opportunities

H C Bolton,
Department of Physics, Monash University, Victoria

The work of many University physicists in Australia during the 1939-45 war was channelled through the Optical Munitions Panel centred round T.H. Laby of Melbourne. An opportunity is taken here, not of giving details of the work but of comparing how it was organized compared with the development of radar in Australia. Looking back at this optical work, we can applaud its successes at the time and although there were scientific and commercial consequences we can regret that these were not as many as the effort deserved and reasons are suggested for this. Comparisons are made with similar work in Canada, Japan and New Zealand.

Introduction
The work of Australian scientists in the war of 1939-45 has been admirably surveyed by Mellor (1958). Further details and a newer perspective have been given by Home (1988). Among the most successful work that physicists and engineers did was that of developing radar for Australian conditions and it is worth noting briefly how it was done to compare with the optical work. The radar grew out of fundamental studies of the ionosphere and radio propagation in the 1920s and 1930s in which many scientists were trained in Australia so that when in 1939 the UK radar technique was offered to Australia, there were trained workers ready to receive it. The consequences of this wartime work on radar were profound after the war because the equipment could be adapted rapidly to make the early measurements in radio astronomy, a situation similar to that in the UK. The history of radio astronomy in Australia has been comprehensively studied (Sullivan 1984, 1988). In broad terms this work on radar was performed by the CSIR Radiophysics Laboratory in Sydney and was Government-directed with a commitment to a line of ideas.

When the UK offered the knowledge of radar to Australia there was a choice; should Australia take delivery of radar as it was or should she develop it herself? Radar in the UK and indeed in crowded Western Europe was designed for its local geographical problems arising from short national boundaries and close countries, but Australia has a different problem with a long coastline and a scattered population. Also the war began in Europe in 1939 and the Japanese did not enter it until December 1941 so that the concept of local attack was at first not so important. The decision was made to undertake the research, development and manufacture of radar and there were far-reaching consequences. The technical problems in Australia required new solutions and they were found. More importantly, the scientific independence from the UK expressed in the decision engendered self-assurance and self-esteem. There was thus a research climate created in which further impressive work was done, especially in radio astronomy using the same radar equipment. Solid ground on which to make the decision was created from the ten years’ pure research of the Radio Research Board under T.H. Laby, Professor of Natural Philosophy at the University of Melbourne and J. Madsen, Professor of Electrical Engineering at the University of Sydney. Melbourne concentrated on electrical atmospherics and Sydney on the ionosphere. This was exactly the right background against which the radar decision was sensibly taken. In science there can never be any avoidance of fundamental ideas; no-one knows the technological applications or the informed technical discussions that will have to be made. It is worth quoting from Mellor (1958, p.45), “There can be no doubt that Australian science made one of its most valuable contributions to the war effort by assisting the introduction of radar. That it was able to do so was to a large extent due to the sound foundations laid earlier by the Radio Research Board in training physicists and providing research facilities... Few better illustrations could be found of the rewards that may come from scientific research undertaken in the first instance in the pursuit of knowledge alone”. The Australian work on radar was begun in the Radiophysics Laboratory of CSIR and there were many interchanges of personnel and ideas between Australia, UK, Canada and the USA, all of which must have strengthened the feeling of independence in Australia. The existence and the after-effects of these interchanges served after the war as a constant reminder to Australia of the world-wide scope of science and helped her away from her dependence on UK traditions of training and outlook. This work on radar helped to break the “Cambridge connection” that was so strong among the early physicists in Australia.

The Start Of The Optical Munitions Panel

The very successes of the work on radar both during the war and afterwards raises a question about the other major effort where physicists were employed, namely, in the work on optical instruments. Radar had drawn only a few university scientists into the war effort but the university physicists were eventually well-organized and the prime mover was T.H. Laby of Melbourne. In 1939 he was President of Australian Branch, recently formed, of the Institute of Physics (IOP) and it is not an exaggeration to call him the leader of the community of physicists in Australia. In August 1939, just before the outbreak of war, he wrote to the Prime Minister, R.G. Menzies, to ask how University physicists could help in the coming war. Laby’s character was built on devotion to the UK as the mother country and to Cambridge University as the source of all good science. When his research teacher Lord Rutherford died, Laby wrote an appreciation (1944). He said “Great as Rutherford was a physicist to me he was a still greater man; he rendered most valued service to science in all the member nations of the British Commonwealth”. Laby felt himself an essential part of the Cambridge connection which he saw centred on Rutherford. Laby was a master of “classical physics”. He was a great admirer of the Cambridge tradition of research with its

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emphasize on fundamental studies. Laby’s scientific work had been largely a blend of the classical area of measurements of thermal conductivity together with the modern subject of X-rays especially soft X-rays. With the latter work he carried on the Australian tradition of X-rays started by W.H. Bragg in Adelaide and R.H. Threlfall in Sydney (Home, 1936). Laby is known to every science student through the book of tables of data (Kaye & Laby). Making an optical instrument is a classical problem and its use is at the heart of many classical scientific experiments. The problems of making and using optical instruments were exactly what Laby’s fertile classical imagination could handle so well. Added to this was an ability to be a good if dominant administrator. Laby recognized also the difference between Australia and the UK. Quoting from the appreciation again: “The relation of scientific activities of the State in Great Britain to pure science is very different from what it is here. Governments in Australia rarely seek the advice of any scientific society but in England the position is very different. There the Government has for long relied on the advice of the Royal Society of London... This was no new feeling for Laby; in the 1914-18 war scientists were not on the whole organized to contribute to the war effort and Laby found himself helping D.O. Masson, Professor of Chemistry in the University of Melbourne with his experiments on gas masks but was frustrated at not being able to do more (Hartung, Tape). Laby, in writing to Menzies in 1939, was trying to make Australia a little like the UK. Menzies answered his letter by asking the physicists for their detailed proposals and although there was a meeting of Lany and A.D. Ross (Professor of Physics at the University of Western Australia and secretary of the Australian Branch of the IOP) with members from the Departments of Supply and Defence there was no call from the Government until June 1940.

The delay of nearly one year in organizing parts of the science community occurred in the UK also. There was a dramatic change in the tempo of the war after the rapid advance of the German armies to the channel ports in the middle of 1940 and there was a corresponding response from the scientific community. At the same time there appeared an anonymous book called Science in War (1940). This book was produced at white heat and some of the authors are now known, among them being S. Zuckermand and J.D. Bernal brought together by Zuckermand’s dining club, the Rota of Quots (Zuckermand, 1928). The publication of this pamphlet, while it irritated some of the leaders of science, can scarcely be claimed to have had a deep primary significance in the crisis in British political and military life in 1940. The President of the Royal Society of London was then W.H. Bragg who played a leading role in the harnessing of science and scientists to the war effort (Caroe, 1978). One of the British responses was the interviewing of all science undergraduates by C.P. Snow and the psychologist H.S. Hoff who together placed them in the most appropriate scientific organization. The combination of Snow and Hoff was known familiarly as the Snowhoffs and its appointees were later called Snowmen and Snowwomen, of whom the author was. The response of the physicists in Australia to the crisis of June 1940 was a meeting in Melbourne taken by L.J. Hartnett and attended by physicists T.H. Laby, E.L. Sayce and H.J. Frost, (both of the Munitions Supply Laboratories) together with others. Hartnett had been Manager for General Motors Holden in Australia and in May 1940 was asked by the Prime Minister to take over the Head of Munitions at the newly formed Department of Munitions. The Director-General of Munitions was Essington Lewis, formerly of BHP. The new Department had the task of organizing the production of all ordnance for the services and anti-tank guns were a special task. Australia was making a two-pounder anti-tank gun from British designs and the GMH factories were converted to its production. Hartnett was alerted to the fact the the telescope sight for this gun formerly coming from the UK was no longer available after Dunkirk. At the meeting, Laby suggested calling in physicists from several laboratories in Australia thus enabling many of the Australian university physicists to be brought together in common action. Hartnett’s meeting also recommended that Laby should set up a group to provide the optical specifications of telescopic sights and other instruments, the lenses of which could be manufactured in Australia. This group became the Optical Munitions Panel and its first meeting was a month later on the 23 and 24 July. Of the six Australian Universities only Queensland was not represented eventually on the Panel but its physicists did other war work. Three Government Laboratories were drawn into the Panel; Munitions Supply Laboratories, Melbourne, Commonwealth Solar Observatory at Mt. Stromlo (now Mt. Stromlo Observatory) and the CSIR National Standards Laboratory, Sydney. There were service representatives on the Panel. Between July and December 1940 inclusive there were six meetings of the Panel and from then on it met at two-monthly intervals; there were 32 meetings in all (Minutes). The Panel designed and arranged to have made optical instruments, mainly for the Army. The headquarters of the Panel were in the Department of Natural Philosophy of the University of Melbourne. The photograph shows a meeting of the Panel, most likely in the University of Melbourne. Some optical instruments are shown on the tables.

The war of 1939-45 started as an optical war; there were still service traditions of being able to see the enemy by eye. At the beginning there were strong connections to the 1914-1918 war exemplified by the decision of the Panel to manufacture optical glass, the first time it has been made in Australia, which was helped greatly by the book by Wright which had been written to explain the work in the USA to develop its own optical glass industry during the 1914-18 war (Wright, 1921). Largely because of the development of radar in Britain and Australia just before and during the war of 1939-45 there was a change in the character of the assistance that physical scientists gave to war work. Following the discussion at the Panel meetings on 30 November, 1 & 2 December 1943 the Panel changed its name and in 1944 was called the Scientific Instruments and Optical Panel in order to give it the chance to widen the scope of its work, but the momentum in optical work was then large and the Panel continued in optical development until the end of the war. Radar, as a subject of investigation, certainly appealed to the physicists and had developed strongly in its own laboratories, especially CSIR’s Radiophysics Laboratory; those working on optical problems must have been tempted into radar problems and L.H. Martin of the University of Melbourne did transfer (Caro & Martin, 1987). The committee is still known familiarly as the Optical Munitions Panel by many of those who worked on its problems and it is appropriate to retain this or just “Panel” in this article.

No attempt was made by the Panel to have a central research institution. At the first meeting of 23 July 1940 item 23 of the Minutes gives the outline of the way in which the associated laboratories were expected to work. J.S. Rogers as Liaison Officer. Dr Woolley (in) charge of optical appraisement and analysis. Allocates work in optical area to separate panels in

State. Each state will connect with Industrial Instrument Makers'. The Panel was advisory to the Ordnance Production Directorate of the Ministry of Munitions and this Directorate placed the orders for the instruments with a number of firms. There were no less than 25 establishments, including firms and university physics departments making and assembling the optical components; 43 different types of optical instruments and 26,237 individual instruments were manufactured, a remarkably large number. Full details are given in Appendix III of the main body of the history of the Panel (Rogers). In the course of exploring what individuals did who were working for the Panel a Questionnaire was sent out to as many as could be contacted. It is clear that most of these found their work for the Panel as interesting and as formative as any other postgraduate training. Their work and later careers are summarized in the Appendix.

It is worth comparing this work in Australia with that in New Zealand which faced similar problems of isolation from the UK. A similar small optical industry was created in war-time in Auckland by P.W. Burbridge, Professor of Physics at the University of Auckland (Atkinson, 1976). This work was guided by the Auckland Technical Development Committee; Burbridge headed a team to make sights for mortars with his chief technician A.D. Harris. By the end of the war, they had produced 240 mortar sights, 4160 assorted bubbles for Army instruments, 600 mirrors for signal lamps and working parts for 1000 hand prismatic compasses. In addition, assorted development and servicing work for the Armed Services was performed by University groups in Auckland (Burbridge and Leech) and Christchurch (T.R. Pollard see Neutze & Beardsley). This was funded through the New Zealand Department of Scientific and Industrial Research. The official history of New Zealand in the 39–45 war refers to development work for radar in Canterbury University College in conjunction with CSIR (Davin).

A Survey Of Some Of The Panel's Production: Comparisons With Canada & Japan

Optical glass

The decision to make optical glass in Australia was taken at the first meeting of the Panel. The story is a tribute both to the scientific skill of Professor E.J. Hartung, Professor of Chemistry at the University of Melbourne and to the industrial abilities of the Australian Window Glass Co., Sydney, which undertook the manufacture. In a tape recording, Hartung states
that Laby asked him, almost certainly in 1940, if he could make optical glass which up to that time had not been made in Australia (Hartung, Tape). Hartung’s reply was “I don’t see any reason why not. It is a very big place and we ought to get sufficiently pure sand”. It was just the kind of problem that would have appealed to Hartung who was a general chemist and full of enthusiasm for any project he undertook. He had made European visits in 1922 and 1931 and visited the Zeiss optical works on Jena and the associated Schott optical glass works.

The minutes of the Panel of August 1940 read; “The manufacture of optical instruments would be a wholly new Australian industry. Lenses are not at present made with the accuracy necessary, there is no glass available for making prisms which are needed in many instruments and there are no trained operatives available”. All these deficiencies were remedied. There were certainly spectacle lens manufacturers in Australia but they had not ground and polished lenses for the accuracy of the best optical instruments. Even at its first meeting the Panel understood that it would have to collaborate actively with the expanding optical industry and act as its research laboratory.

Hartung made reports to the Panel on the progress of his own experiments and trial runs at AWG on glass making and his sixth report of 6 November 1941 announced the commercial production of the first crown and flint glasses; the pot expert was C.W. Death (Hartung, Reports). The report contained the welcome words “Orders for optical glass should therefore be placed without delay”. It was an occasion that any scientist or technologist would see as a successful point in an experiment and under peace time conditions would have been noted by writing an article for publication, perhaps as a letter to Nature'. At first it might have been thought that during the war Hartung would have hesitated over such a publication for security reasons but it is clear that such an industrial effort would be going on in the various combatant countries and Hartung published a short article in Nature (Hartung, 1942). It ended with the phrase that there is “...an abundant supply of excellent material for munitions purposes”.

Japan’s attack on Pearl Harbour in December 1941 was only a few weeks away. By the time the Pacific war began Australia had an assured supply of optical glass adequate to meet all the demands of the fighting forces. The Australian production of optical glass was only one month behind that of Canadian Research Enterprises Ltd which had been established in August 1940 as a wholly government-owned company, operating under the Ministry of Munitions with the full freedom of a private enterprise (Anon, 1942). The minutes of the Panel of December 1941 stated that “...the Panel expresses its appreciation of the high standard of technical excellence which has been achieved in the manufacture of optical glass”. This success of Hartung was a great recommendation of the chemists to Laby the physicist; the two university departments felt themselves to be close with physicists and chemists sharing in a joint scientific venture. Laby, with his feeling that physics was a superior science to all others, was prepared to accept other scientists when they did something that he could recognise as physics or as contributing to physics.

It is clear that this production of optical glass depended critically on Hartung’s skill as a chemist and also on his enthusiasm and ability to get quickly into a new subject. Radford comments on his enthusiasm as follows; “In Hartung the deep capacity observed by his colleagues for enthusiasm in every subject he pursued may have been a distracting influence” (Radford, 1978). But not for the subject of the moment and his enthusiasm is nowhere better illustrated than in the production of glass where he was the right person for the occasion. He retired in 1953 from the University of Melbourne. After the war he had indulged his long-standing interest in astronomy and made his own observatory at his home at Mt. Macedon, Victoria. He had observed Halley’s comet in 1910 and a note on his observation is preserved (Hartung, note). He wrote a useful book for observers of the southern stars (Hartung, 1968). After his death his 12 inch telescope and hut were offered to Monash University and it is erected on the roof of the Physics Department for teaching undergraduates. It is felt that Hartung would have appreciated this decision.

The work on optical glass in Australia was paralleled closely by that in Canada (Anon, 1942). The Canadian firm of Research Enterprises Ltd began with 2 employees and by 1942 had a technical staff of 100 with 84 graduates of Canadian Universities and a total staff of 3000. Help in making the pots came from the Bureau of Standards in Washington, USA. It also drew on the experience of Chance Bros & Co Ltd., of Birmingham UK. The first melt of Research Enterprise was in 5 June 1941 and by November 1941 it was producing 31/2 tons per month. Bausch & Lomb, the big US optical firm, trained nine glass polishers for the Canadians. As in Australia, there had been few instrument makers before the war. The Canadians hoped that their local optical industry would not lapse after the war, a sentiment shared in Australia. Nothing like this external support that Canada obtained was available to Australia, through when J.J. McNeill was seconded from MSL for training in optics in the Department of Physics, Imperial College, London, he arranged for the offer of the position of foreman of the Optics Section of MSL to be made to H. Hunt of Adam Hilger, UK. Hunt arrived in 1941 and stayed in Australia until the end of the war training many younger optical craftsmen including T.C. Allids who followed J.J. McNeil to the CSIRO Division of Chemical Physics after the war where he was head of the optical finishing shop (Bolton, 1983).

In view of the large part that the Japanese optical industry now plays in the world’s current production of cameras, binoculars, microscopes and small telescopes it is instructive to ask what was the Japanese effort in the 1942-45 war. In December 1945 a US Naval Technical Mission to Japan issued a report on “Japanese Optics”. (1945). The summary of the conclusions are quoted here;

1. In the past five years Japan has made a phenomenal growth in optical glass manufacture.

2. Japan has at present, fairly modern and efficient optical factories.

3. No spectacular developments have been made in Japan, but rather adaptations and modifications have been made of the optical systems used in German and US manufacturers.

4. Japan has capable scientific personnel who understand modern optical requirements and are cognizant of the shortcomings in the Japanese processes of glass manufacture.

5. The Japanese exhibited a tendency toward large size (aperture) visual optical instruments, particularly in the field of binocular telescopes (80, 120, 150 mm apertures).
This tendency may represent a futile attempt to offset deficiencies in their radar development.

The data do not seem to be available to enable a critical comment to be made on conclusion 5 except to say that if the qualities of the optical glass and the figuring of the lens surfaces are maintained, the light-gathering capacity and consequent determination of colours are improved with increasing objective size. Admittedly the larger binoculars are heavier but this is not a large price to pay for a better optical instrument.

The Japanese optical industry began effectively in the 1917-18 war with the formation of Nippon Kokaku KK (Japan Optical Company, JOC) in July 1917 by the merger of three small optical firms, one of which dated back to 1881 (Rotolini, 1983). There were 200 employees at the beginning of JOC. Eight German technicians joined them in January 1921. At first it was an optical firm not a camera manufacturer and in this, there was a parallel with the development of Zeiss and Leitz who also began as optical manufacturers. Instruments made were microscopes, telescopes, transits, and surveying instruments. The JOC researched optical glass manufacturing in the 1920s largely reproducing German glass. It became well known in scientific and industrial communities in Japan. After the 1923 earthquake it was re-organised by the Japanese Navy Ministry. Photographic lenses were made in the 1930s.

After Japan entered the war in 1941 there was a great expansion in glass production stimulated by Government pressure. JOC was chosen by the Government to be the largest supplier of optical munitions for the Japanese Services growing until it had 19 factories and 23,000 employees. During this time the Fuji Optical Company in Odawara began to make optical glass; it had already made photographic chemicals. By the 14 August 1945 when it was bombed the plant was making 30 tons of optical glass each year. The US report states that the practices in the optical shops were fairly standard. Almost certainly the techniques of making optical glass were re-discovered by many persons at this time, Hartung among them. It is a great stimulant towards success in a scientific enterprise when it is known internationally that a certain technique can be made to work.

The JOC produced 41 types of glass and the Fuji Optical Co. 33 types; together they produced 130 tonnes. It appears that few substantial innovations were made by the Japanese in their war effort in optics and attention was concentrated on copying the constants of established optical systems from abroad. The Japanese optical glasses were slightly different in refractive indices and dispersion and corresponding changes had to be made in the curvatures and positions of the optical components.

After the war the JOC was re-organized under the occupation for civilian production only and was reduced to one factory and about 1400 employees. It returned to the pre-war scientific equipment but decided to make a camera of their own probably in 1946; the acronym NIKON was chosen, now familiar worldwide. Given the pre-war background to the Japanese optical industry and the conclusions of the US Mission revealing a vast effort in the war, it is no wonder that this was one contribution to the success of the Japanese optical instruments in the post-war world.

We can compare numerically the output of optical glass from Australia with that from Japan. In Chapter V of the History we can read that the total production of usable optical glass from the ASW’s annexe from the 12 months ending on 30 September 1943 was 21 tonnes. Remembering that this work started from scratch during the war this is a tribute to Hartung’s skill as a research scientist and to the whole-hearted industrial cooperation of the AWG. It must be seen as an example of how science and industry worked together in Australia with a clear aim.

Graticules

At the beginning of the war the graticules for the Services were made at the Munitions Supply Laboratories (MSL) by a combination of ruling and etching. The glass blank was covered with a “resist”, a thin film of acid-resistant material. A large mechanical pantograph used a fine point to rule the pattern through the resist and the exposed glass was etched by the vapour of hydrofluoric acid. The grooves were filled with a black ink. This was a slow process and only one graticule per day was ruled; the increasing number of graticules needed called for a faster production method. By June 1941, Professor E.J. Hartung had completed a substantial amount of research on the problems of optical glass and the production lines at the Australian Window Glass Co., were being established (Hartung, Reports). The problem of making graticules in quantity was presented to him and at the meeting of the Panel in June 1941, Hartung was encouraged to continue his preliminary experiments on the production of graticules by graphing and etching and given the specific orders for graticules for two telescopes. Hartung’s experiments showed that this technique would satisfy the production and space was found in the Botany School at the University whose Head Professor J.S. Turner was put in charge of the production. Two laboratories of the school were converted into a Graticule Annex. By 11 November 1945, the Graticule Annex made 25,500 graticules of 73 different types (Turner). Examples of these graticules donated by J.S. Turner are in the Museum of Medical History, University of Melbourne.

Binoculars

The Australian Army Priority List of instruments of August 1940 contained 3,500 Binoculars of 6 x 30 i.e. of magnification 6 and objective diameter 30 mm and separate eyepiece focusing. This was a standard instrument of the time; that made by Zeiss was very popular (the author’s instrument which dates from the 1914-18 war has still excellent optics). The panel made a successful prototype and recommended that they should be made in Australia not only because of the immediate need by the Services but also because of the Panel’s view that the country needed an optical industry and a regular big order of an instrument as relatively straightforward as a binocular would have been admirable way of starting the industry. A local firm was prepared to make the mechanical parts. This feeling was close in spirit to that of Laurence Hartnett who as Director of the Ordinance Production Directorate tried to get Service orders for the binoculars but delivery was so slow that they did not arrive until 1944 and 1945 and then to add insult to injury, many of them were made in Canada (no doubt by Research Enterprises) and the USA. It was then learnt that the UK had transferred the order to the other countries. It is not hard to see this as the crushing effect of the imperial role being played by the UK and the Establishment in Australia and as a lost opportunity for a scientific industry in Australia.

In the middle of the war there was still a need for binoculars for the Services and in 1941 the Australian Government decided to impress all civilian binoculars with optical properties similar to the services specifications. The Panel was not consulted about this and knowing its interest on starting an optical industry in
OPTICAL INSTRUMENTS IN AUSTRALIA IN THE 1939-45 WAR

Australia, it is doubtful if it would have agreed with the decision. Even as received the impress the binoculars could not be handed over to the services as they had to be collimated (the two optical axes brought into collinearity) and many instruments needed graticules. Some 18,500 binoculars were impressed of which 8,000 were of good enough quality to be used. The effort of testing and reconditioning the binoculars was formidable. Had they been all of one type then some kind of mass production could have been organized. To illustrate, the Physics Laboratory of the University of Sydney under Professor A.U. Vowller, reconditioned about half the instruments and reported that there were 400 types of binoculars. As this huge time-consuming exercise proceeded, especially in the University of Sydney, it must have irritated those who realized what the country could have done.

With the entry of Japan into the war in December 1941 the battlefields became the tropical north and equipment of all kinds including scientific instruments such as binoculars and range-finder telescopes were found to suffer badly in the hot and humid conditions of the New Guinea Campaign. The scientific problems arising in overcoming the difficulties are mentioned in the next chapter but the essential point was that the interior of all containers including scientific instruments were exposed to a tropical climate in which fungi grew, even on glass. A binocular with adjustable focusing is almost certainly exposed in this way and the idea arose of making a fixed focus binocular that was entirely sealed. R.D. Wright, Professor of Physiology at the University of Melbourne showed that an eye with normal vision could tolerate differences in eyepiece focusing that could be set within reasonable limits and such a fixed-focus binocular could be used for distances down to 50 yards. This instrument never came into production as it was developed too late in the war; it was another example where a local optical industry could have made a mark.

Tropic Proofing

After the entry of Japan into the war equipment was suddenly transported to climates very different from those of Europe or North Africa. The hot, humid atmospheres of the tropics were ideal conditions for the growth of fungal infections. The Army was hurriedly equipped to stop the Japanese in New Guinea and there was a heavy loss of equipment of all kinds; photographs in the 1944 Report to the Army reveal this (Chapman, 1944). Professor C. Kerr Grant was the physicist on this mission. Optical instruments even though apparently sealed were liable to internal fungal damage and well assembled instruments sometimes lasted only a few weeks before becoming inoperable; the sealing was probably not sufficient to prevent the entry of water vapour. There was a scientific solution, which was to include a desiccating agent inside the equipment but if the sealing were not perfect the agent would have to be renewed frequently, a task impossible to guarantee under wartime conditions.

There were frequent references in the committees of the Panel in 1942 to the special difficulties of Tropic Proofing and Professor J.S. Turner of the Botany School University of Melbourne chaired a sub-committee of the Panel on this problem. Professor V.M. Trikojus, the Professor of Biochemistry at the University of Melbourne suggested that a substance he had been using in experiments on the sterilization of blood plasma for the Army Medical Corps might be an effective fungicide (Legge & Gibson, 1987). The substance was sodium ethylmercurithiosalicylate, at first called Merthiolate and later MTS anti-mould. It was effective as a fungicide when mixed with the black lacquer that was used to paint the internal metal parts of instruments. It was also incorporated in the luting wax used to seal the optical components. It was not fungicidal in itself but when acted on by water, produced a vapour that was fungicidal. The tropical conditions were simulated in a Tropic Proofing Chamber built in the department of Natural Philosophy at the University of Melbourne. MTS did have its difficulties: from the start of the experiments it was known to contain mercury and could yield a poisonous substance and in aqueous solution it attacked aluminium and aluminium alloys. The experiments with painted instruments and MTS were mainly supervised and done by Turner and E. Matthaei. The experiments were not achieved without vigorous objections from T.H. Laby especially about the possible corrosion even though little was found in the short times of the laboratory tests. Laby's objections were so strong that they suggested that he might have met difficulties in some of his early experiments with mercury and mercury compounds. However, the Army accepted the laboratory tests and built a new three-story wing to the Botany School to accommodate the expansion of the work.

A full report was made on Tropic Proofing which discussed the whole work of Turner's group (Turner et al., 1945, 6, Trikojus, 1946). It contained a section containing material written by J.W. Blamey, the physicist. Using the conclusion of the mycologists that the moulds growing in the optical instruments were of common kinds, probably enclosed during the assembly of the instruments before being taken to the tropics, and the growth occurs due to the humid air eventually getting into the partially sealed instruments, Blamey showed by simple calculations that there were a variety of causes for the air entering. The humidity inside would rise due to mass air movements through small, (microscopic) holes in the sealing. Variations of atmospheric temperature and pressure caused the enclosure to "breathe"; a decrease of temperature of the instrument lowers the internal pressure thus driving air into the instruments. In addition to the mass transport of air and water vapour in and out of the case of the instrument on account of the variations of pressure and temperature, diffusion through these small holes in the sealing is not negligible. In fact, diffusion through a hole in a thin membrane is relatively efficient. The diffusing substance is not merely restricted by a region bounded by the area of the hole, but the act of diffusion takes it through the hole into a "half-space". This effect was examined theoretically by J.W. Blamey independently of its earliest examination by the physicist J. Stefan in 1881 in connection with evaporation. The confirmation of Stefan's ideas was made by Brown and Escombe; it is an important factor in the transpiration of leaves (1900). Quoting from the report of Turner et al. "Similarly, diffusion from or to a small object from surrounding space as in evaporation of a water drop or absorption by a drying agent is proportional to the linear dimensions of the object and not the surface area or mass". The report mentioned that captured Japanese instruments did not appear to have been tropic proofed as many were badly infected.

The work on the protection of equipment for tropical conditions has been continued in Australia as no doubt it is in many countries. The work of P.J. Upsher of the Materials Research Laboratories, Melbourne the successor to MSL, has used electron microscopy and shown how the fungi attack a surface even of relatively hard materials (1985, 86). The fungi have hyphae, branched tube-like growths which make up the
body of a fungus, and the hyphae put out special branch-like roots and a cement which attaches the parent hyphae to the material enabling the hyphal branches to tunnel into polymeric material such as PVC or paints. The corrosion of harder glass surfaces is by the metabolic products of the fungi. The attack on a surface is on an atomic scale well below one micron. The definition of visible smoothness depends on the wavelengths of light which are of the order of half a micron; penetration of the hypha into the surface is by a defect in the surface that is much smaller and quite undetectable by optical means. There are now new fungicides for controlled release of a fungicidal vapour inside sealed components.

Miscellaneous

Together with many small projects undertaken by the Panel there were some surprisingly large requests made to it. In 1942 L.J. Hartnett was in the USA which had entered the war in December 1941 and he found that it was short of prisms and lenses and was asked if an order could be placed for them in Australia. The order was for 2000 full sets of optics for one telescope and 5000 prisms for another. This must have been surprising and encouraging to Hartnett to find that Australia had in the brief space of two years achieved a reputation for both quality and the ability to supply in quantity. The order was accepted and the supplying laboratories were the Commonwealth Solar Observatory, the Munitions Supply Laboratories, the Optical Annex at the University of Melbourne. The order was fulfilled in September 1943 but even before this, in May 1943, the USA asked if Australia could supply a larger order in which 1.3 million optical parts were required, a task well beyond the capacity of Australia.

J.S. Rogers had visited the USA in 1943. He was absent from the September and December meetings of the Panel but was back for that in February 1944. While he was in the USA he had seen her large scale production of optical elements and in his view it was unlikely that Australia would be called upon. It will be seen that the USA order was handled by four laboratories that were essentially research and not commercial. Nevertheless we can see that by 1943 Australia was able to consider orders that could have been handled by an incipient scientific industry. In August 1941 the Union of South Africa asked Australia if she could supply samples of the optical munitions. The request came before the Panel but it was too early to say with confidence that there would be enough Australian optical glass and the request had to be turned down. In April 1942 India asked if Australia could supply optical glass and several thousand pounds were sent, partly Australia's own glass and partly from her stocks of US glass.

T.H. Laby's Retirement As Chairman Of The Panel

Laby's health suffered under the pressure of his work and he had spells away from the University. When he was absent, the Panel was chaired by his deputy, C. Kerr Grant of Adelaide, as for example the meeting of July 1943. After Laby's death in 1946, a fine obituary by his former student H.S.W. Massey summarized his attitude to science as one whose "...primary interest was in precision experimental physics but was aware of the importance of other branches" (1946). Massey also refers to the great contribution that he made to the defence of Australia through his chairmanship of the Panel. This "...could not have been made if in the preceding years a firm tradition of high quality physics had not been built up largely in the Department of Natural Philosophy at Melbourne under Laby. Laby sacrificed himself to this end".

Laby had resigned from his Chair at the University towards the end of October 1943 and he appears in the minutes as Dr Laby for the November 1943 meeting of the Panel onwards. The Chairmanship of the Panel became increasingly a burden and after the stormy meeting of 28 March 1944 he felt obliged to resign (Law, Tapes). The next meeting of the Panel in May 1944 was chaired by Kerr Grant. Its minutes record a visit from G.R. Harrison the spectrophotist from Massachusetts Institute of Technology on behalf of the US National Defence Research Council, a compliment to the international standing that the Panel had already achieved. Laby's resignation as Chairman of the Panel had been accepted by the Prime Minister and was noted at this May meeting.

At the final meeting of the Panel in November 1945 Kerr Grant spoke of the work done by Laby for the Panel. Kerr Grant said "Australia was highly indebted to him for the zeal with which he devoted himself to the work of the Panel in its early years. Dr Laby had never spared himself and it was his overwork which had led to his breakdown in health which had necessitated his resignation". The formal resolution of the Panel stated that "...The success of the work of the Panel has been due in no small manner to the zeal and unsparing efforts of Dr Laby".

The Influence Of The Panel In The Post-War Years

There were many discussions in the Panel meetings on the future of optical work in Australia. There was a firm conviction amongst the Panel members that optical research should continue at Australian Universities after the war. The members perhaps misgaged the feelings in the Universities that arose after the war ended; everyone was glad it was over and they could get back to their own research which had perhaps, been abandoned during the war. Recalling that the optics of lens, prism and mirror making was a well-founded subject in classical subject but there seems no reason to query the judgement that it would be good for the scientific community and for the commercial health of Australia to have an optical industry with a support in applied optics research. Could this be done?

The Panel thought that an Australian optical industry could develop in two ways: 1, optical instruments would still be needed for the Services and for Government Institutions; 2, optical instruments such as microscopes, binoculars and telescopes would be needed in education and for the general public. Both seemed sound ideas given the science of the time. No one could have foreseen the domination of the world markets in the post-war years by the Japanese optical industry or the invention of the transistor and the integrated circuit and the way compact and reliable electronic circuits would change the manner of doing scientific experiments and Service science.

It was considered that the Optical Annex at Hobart would not be able to survive without Government support but the Panel were of the firm opinion that both research and production should continue there. It will be recalled that the Canadian experience was to create a commercial firm Research Enterprises even during the war. A decision from the Directorate of Ordnance Production (DOP) was that from 31 May 1945 it was not intended to continue the Ministry of Munitions upon its present scale and organization but to revert to Department organization "customary with our form of Government". There was no indication that the Government wanted to foster an optical
Dr Briggs pointed out that the centralized government-owned company in Canada was preferable to the present methods of using private companies in Australia. The Chairman replied that the present conditions in Australia must be allowed to continue until difficulties occurred which made intervention necessary.

The UK was discouraging about Australia producing optical glass during the war and the reason must have been that the UK saw this move as partly destroying her position as supplier to the British Commonwealth of Nations. Also, the UK decision-makers may not have known that Australian scientists and industry could make optical glass, and could have misjudged the capabilities in Australia. Perhaps the largest and best equipped optical laboratory and workshops were at MSL, eventually under J.J. McNeill, but after the excitement of producing the microscope, they were allowed to run down.

Some individuals were influenced and motivated to stay in optical work. J.J. McNeill was one of those and to do so, transferred to CSIRO in particular designing and making the spectrometer for the commercially successful work on Atomic Absorption Spectroscopy under his friend and colleague A. (later Sir Allan) Walsh (Bolton, 1943). Perhaps the best individual success story was that of W.H. Steel who started with wartime work at Australasian Wireless Association and then joined CSIR National Standards Laboratory where he spent his professional life in optics becoming an international expert in interferometry (Steel, 1987). At the end of the war, the Commonwealth Solar Observatory in Canberra under R. v d.R. Woolley had a first-class workshop and a spirit of working with optics that helped to establish their post-war work and reputation in optical astronomy (Gascoigne, 1984). In Western Australia S.F. Williams worked with A.D. Ross on Panel problems during the war and later established reputations in vacuum spectroscopy and optical astronomy.

There was one industrial success that did grow out of the wartime work on optics and that was the work in Hobart (Waterworth, notes). The brothers E.N. and P.H. Waterworth played a big part in the story. E.N. Waterworth established his own one-man business in the 1920s in Hobart designing and making scientific research equipment largely for Professor A.L. McAulay, head of the Department of Physics at the University of Tasmania and for Dr Kurth, head of its Department of Chemistry. Waterworth achieved success in 1926 with an automatic record-changing mechanism. His brother P.H. Waterworth having qualified as an optometrist at the London School of Optics became a partner in the Hobart family firm of Waterworth & Ross. McAulay was asked by Hartnett on 25 July 1940 if there was any capacity for the production of precision optics in Tasmania. As in so many other laboratories of the time the strict answer to this must have been “no” but McAulay replied that if he were told what was required, they would attempt it. McAulay after getting his B.Sc. at the University of Tasmania made the classic scientific move for a Dominion physicist and worked for his Ph.D. at Cambridge under Rutherford. In the words of E.N. Waterworth, McAulay was trained, as were all Rutherford’s students to do “research with the equipment you had rather than wait for what you wished you had”. This phrase must not be viewed as expressing a simple-minded acceptance of any present deprivation but as an active collaboration with a current situation to get something of scientific worth out of it. Existing scientific techniques and possible scientific problems are linked, often inextricably, with many interactions.
Optical Instruments in Australia in the 1939-45 War

McAulay was asked by the Panel to make the test plates, both flat and spherical, which could be used in other operations and with his student F.D. Cruickshank began in the Physics laboratory of the University. The work involved the development of the tools for grinding and polishing and for measuring the accuracy of the test plates. The machinery needed was designed and built by the two Waterworth brothers.

In February 1941 Rogers suggested to McAulay that he make roof prisms, which contain an exact right angle and are used in binoculars and other instruments. Before the Australian optical glass was produced, sufficiently thick pieces of glass were made at the University of Melbourne by welding together sheets of quarter inch thick plate glass and blocks of this were cut at Hobart into suitable sizes by home-made diamond saws followed by grinding and polishing. It must not be thought that this way of making a large block of glass was invented in Melbourne; it was part of the optical tradition. It was practised at the firm of Adam Hilger Ltd., UK, which under the direction of F. Twyman. In a letter of 1931 from F.P. Bisacre, managing director of the publishing firm of Blackie & Sons Ltd., Glasgow to his friend and long-time correspondent William Stone of Melbourne, he described how he had visited Hilger and described how the firm made large blocks of glass by joining thinner pieces of glass together (Stone, letters). The temperature of the composite was raised to within 50°C of the annealing temperature of the glass which then fused into one block.

The pace of the activity at Hobart was such that more space was soon needed and by May 1942 a new building was erected adjacent to the Physics building, with a further floor added within a year. This was the "Waterworth Hobart Annexe"; E.N. Waterworth became its manager. The prisms were so that Hartnett on a visit to the Frankford Arsenal, USA in 1942, finding it short of prisms arranged for a shipment of about 1000 roof prisms mainly from Hobart (Melior, 1958). In the June 1942 meeting of the Panel (the Chairman Layin, in a brief review of the two years' work on optical munitions expressed his highest appreciation of the work done at the Hobart Annexe. In 1942 the Annexe started making photographic lenses for the RAAF. The problems presented by a camera lens are different from those of a telescope. The lenses in a telescope used by the eye produce an image to be viewed close to the geometrical axis whereas the photograph taken through a camera is over a wider angular range and the focus must be sharp over that range. McAulay and Cruickshank developed a novel method for the design of these lenses (McAulay and Cruickshank, 1945). Their first lens was a 14 inch f/4.5 Tesser type. The lenses had to be designed ab initio as the refractive indices of the optical glasses available were not the same as the prototype that had to be copied. The computing needed was done by a group of young women using Marchant desk calculators. These lenses were tested by A.G. Fenton and Mr Robinson. The photographic lenses required large blocks of glass, for instance the 14 inch f/4.5 lens has an aperture of 3.1 inches and blocks big enough for this, even by the method of joining plates together, were not available. Also, moulding blocks of glass by their flat surfaces occasionally left detectable blemishes on the junction. The next solution devised in the Hobart Annexe was to fuse two truncated cone-shaped blocks by their small faces. This fused block was rotated and put under pressure while being heated at the fused junction which gradually expanded up to the final size, sometimes 5 inches or more and any trapped blemishes were eliminated in the fusing. Samples of glass made by this method were exhibited at the Panel meeting of September 1944. By 1945, the Annexe was working on 14 Ministry orders as well as reconditioning binoculars.

While this early development of the Hobart Annexe was proceeding, McAulay was not a member of the Panel. The minutes show that both McAulay and A.D. Ross of Western Australia were present by invitation as corresponding members at the meeting of 24-26 February 1941 in Canberra. At that meeting the members of the Panel visited the laboratories of the Commonwealth Solar Observatory and short talks were given to technical problems by members of the Observatory. Such visits and talks were given at many of the Panel meetings. McAulay appeared on the Panel as a full member only at the meeting of 28-30 October 1941 in Adelaide. Neither McAulay nor Ross were regular attendees at the Panel meetings.

The meeting of 5-6 December 1944 was held at Hobart. By now the end of the war was in sight; the Allied forces had landed on the Normandy beaches in France and were advancing eastwards across Europe; the Soviet armies were advancing westwards out of their territory. McAulay had asked the Panel to consider the future funding of the Hobart Annexe. The panel recognized that the Annexe was in reality a private firm working under the Ordinance Production Directorate and was different from the other university laboratories. McAulay had also written to Sir David Rivett, Secretary of CSIR on 20 September 1944, to see if CSIR would be interested; Rivett had referred the matter back to the Ministry of Munitions (Australian Archives). While there was general support on the Panel for the principles that the production of optical glass should continue, that research should be maintained and that there was a need for an optical industry in Australia to have scientific support like that now

Theoretical Particle Physicist Research Fellow Grade 1
SCHOOL OF PHYSICS

The above position is funded by the Australian Research Council to work with Dr G.C. Joshi on the project "Exotic Generations". Applicants should have a PhD in theoretical physics with a background in particle physics. An appointment will be offered until 31 December 1991 but may be renewable, subject to continued funding.

Enquiries may be directed to Dr Joshi, School of Physics, telephone (03) 344 5088; Fax (03) 347 4783. Email address: U6401S3111 RWA. DRIJMU.02.

Salary will be within the range: $27,535-$31,308 per annum. A contribution towards the cost of travel to and from relocation in Melbourne may be made to an account established in interstate or overseas.

Closing Date: 27 April 1990. Position Number: 6401A211.

Applications, in duplicate, including names, addresses and fax numbers of at least three referees and quoting the relevant position number should be addressed to The Director, Personnel Services, The University of Melbourne, Parkville, Victoria, 3052.

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being given by the Panel, it was clear that the Panel discussions did not lead to a definition of a solution and no resolution was passed.

The combination in Hobart of McAulay and Cruickshank at the University and E.N. Waterworth in the Annexe was a well-balanced practical example of the situation the Panel had, in principle, wished to see made permanent. The Hobart Annexe was still finding its demand for a variety of lens systems towards the end of the war and when university laboratories were beginning to think about post-war research in other fields, a substantial amount of scientific activity in Hobart stayed with optical work. The Tasmanian Education Department found itself unable to get slide projectors for its schools and an order to the firm of E.N. Waterworth, later of Park Street, Hobart led to a design of a reliable and robust slide projector. It was known and approved by many as the “Waterworth” and became familiar throughout Australia. Some Government projects continued after the war and helped the firm. New ideas in optical design appeared from H.A. Buchdahl of the Department of Physics at the University of Tasmania; Buchdahl had been there during the war and together with Cruickshank had given talks to the Panel on methods of optical computations after the meeting of 5-6 December 1944 (Buchdahl, 1946). By 1962 the price list of E.N. Waterworth contained 94 named items including projectors, stereoscopic lenses, microscopes, eyepieces and prisms with “prices on application” for special items. For ten years after the war, F.D. Cruickshank at the University of Hobart was a consultant to the firm with a team of computers, as the persons were then called, working under him. Recalling that McAulay had moved very quickly to establish the optical work at Hobart without being a full member of the Panel, the whole effort during the war and its commercial consequences, is a fine example of scientific entrepreneurship in the Australian context. It is the combination of the research scientists McAulay and Cruickshank acting as advisers and the technical skills of the Waterworth brothers that makes this a model for scientific industrial development in Australia that has been followed too rarely.

Buchdahl’s theoretical ideas in optics have recently developed with his analysis of the generic structure of the power series of geometrical optical aberration theory (Buchdahl, 1984. Buchdahl & Forbes, 1986).

Review Of The Panel’s Work From a Current Standpoint

We may ask first the question, why was it so successful? The optics of scientific instruments is a very old scientific subject; even in the 13th Century, Roger Bacon the English Franciscan friar, credited with the invention of spectacles, held that optics was the fundamental physical science. At the start of the present century the practical principles of making optical glass and lenses were firmly laid down and soon the great industrial names such as Zeiss in Germany, Chance in the UK, Bausch and Lomb in the USA became well known. These practical principles were part of classical physics and they were in monographs and reasonably accessible. Laby was a master of much classical physics both in designing and doing experiments and in assembling data. The man, the field and the need were all there at the right time in 1940. The tricky things were in making a large supply of optical glass and this needed a good general chemist; Hartung was just that person.

Certain individuals became drawn into optical research but there was nothing that remained as solid as Australia’s reputation in Radio Astronomy? The answer has to be, no. The optical work at Hobart was certainly organized by McAulay and Waterworth along industrial lines and, under Waterworth, developed after 1945 into an optical industry known and selling at least in Australia. But while Radio Astronomy surged ahead by the research effort of big research teams in CSIRO and later at Sydney University a large optical industry with a reputation equal to that of Radio Astronomy would have had to survive with large markets almost certainly world wide and these markets were effectively captured by the Japanese optical industry. And while the Australian Government encouraged primary producers it did not invest the same goodwill in secondary industry and especially scientific industry. Also Cruickshank and Buchdahl at Hobart were the only University physicists to continue in optical research, especially optical computation and theoretical optics. Nearly all the other physicists working for the Panel went into newer fields of research. To have kept the very large wartime effort in optics going that the Panel had started and to have maintained its initiative and converted it into a modern industry with world-wide markets could have been done but it would have needed something like a National Institute of Optics perhaps as part of CSIRO together with a fiscal policy of protection that successive Australian Governments have not been willing to support. The efforts of Waterworth in Hobart remain as a splendid reminder of what could have been done on a larger scale. There was indeed a lost opportunity.

Acknowledgement

The author is grateful for a great deal of help from many correspondents. First, he must thank the persons who worked on the Panel problems during the war and who answered so readily and fully the Questionnaires that he sent to them. These helped in his understanding how the laboratories were working especially during the hectic years at the beginning of the Panel’s activities. An abstract is given of the Questionnaires in the Appendix and the Questionnaires themselves, together with other sources for this work, will be presented to the University of Melbourne Archives. Particulars thanks must go to E.N. Waterworth for allowing the author to use his unpublished History of Optics in Hobart; to Cecily Close of the University of Melbourne Archives for much help with sources and in understanding the problems involved with them and for reading parts of the manuscripts; to the University of Melbourne, the Master, Monash College, and the Chemistry Department of Monash University for invitations to give public lectures on various aspects to the work; to W.A. Rachinger of the Department of Physics, Monash University for reading part of the manuscript; Professor R.W. Home of the University of Melbourne and to W.E. James of James Optics, Hawthorn, Melbourne for reading and commenting on the whole of an earlier draft of the manuscript. Photographs of the two Australian microscopes and of the Waterworth slide projector are in the permanent display of photographs of Australian scientific instruments in the Department of Physics, Monash University.

Appendix

In Rogers’ History there are many persons mentioned and it seemed to be useful, especially for other workers in the field, to write brief biographies of as many as possible. Correspondents were helpful in answering a Questionnaire about their contribution to be optical work and in giving details about later careers. The style for the biography is that used by Professor R.W. Home of the Department of History and

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OPTICAL INSTRUMENTS IN AUSTRALIA IN THE 1939-45 WAR

Philosophy of Science at the University of Melbourne in his unpublished "Physics Bibliography" which covers all publications in physics from Australia to 1945.


CRUICKSHANK, F.D. - Educ. Univ. Tasm. (Physics) Senior Lecturer in Physics. Worked on design of optical instruments with McAulay.


GASCOIGNE, S.C.B. - Educ. Univ. Auckland (M.Sc) Univ. Bristol (Ph.D. Astronomical Optics) Mt. Stromlo, 1941. For Panel helped with optical design work of Observatory and was part of successful team of physicists. Research on observational aspects of stellar evolution, the distance scale, faint star photometry: Commissioning Astronomer, Anglo-Australian Telescope at Siding Spring.


HARTUNG, Ernst Johannes - Professor of Chemistry, Univ. Melb, to 1953. Researchers; reaction dynamics of ferric ions, specific heats of liquids, photo decomposition of silver halides using the Steele-Grant microbalance, spectrographic investigations of helium in spa gases of Daylesford, Victoria with G. Ampt. Syme Prize Univ. Melb. 1926. Astronomer with own 12 inch telescope.


LABY, Eudora Betty - b. 1920 of T.H. Laby, Univ. Melb (Hon M.Sc. 1985). For Panel, Laboratory Assistant in School of Natural Philosophy, Univ. Melb; Measurements of refractive indices, prism angles, focal lengths, especially with components of Australian optical glass; calculations of lens designs using optical ray tracing. After war, research assistant for 3 years in CSIR Div. Aeronautical Research, then to Prof. T.M. Cherry, Maths Univ. Melb. for 3 years. Senior Tutor Dept. of Statistics Univ. Melb. Retired 1985.

New Guinea in 1944 on scientific mission on tropic proofing. 


MEDLEY, Diana (Mrs. F.B. Hall) - b. 1922. Educ. Univ. Melb. (Arts Faculty). For Panel, technical assistant; precise metrology of prisms, optical design assistance using calculating machines, testing optical components using Twymon interferometer, tropic proofing. Private secretary to J.S. Rogers for 6 months. Post-war secretarial positions, husband 


SACH, Colin - Technician in and eventually in charge of workshop Univ. Melb. Dept. Chem. under E.W. Hartung made the furnace for the experiments on molten glass.


WOOLLLEY, Richard van der Riet - b. 1906, d. 24 Dec. 1986. Director Commonwealth Solar Observatory, (now Mount Stromlo Observatory) 1940. For Panel, appointed as “one of
the best mathematicians in the country". In middle of 1939-45 war, Observatory staff grew from 10 to over 70. Established the only workshop and laboratory where a complete telescope could be built under one roof. Total of 11 types of such instruments made. Post war, used the legacy of a first class workshop and optical expertise to establish astronomical telescopes. Astronomer Royal UK 1956-1972, Director South African Astronomical Observatory 1972-1977. FRS.

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E.J. Hartung, Professor of Physics, University of Melbourne. Tape Recording of Reminiscences held by University of Melbourne Archives.

E.J. Hartung, Handwritten note on the observation of Halley's Comet 1910. Held by Dr. K. Thompson, Dept. of Physics, Monash University.

E.J. Hartung (1968), 'Astronomical Objects for Southern Telescopes' Melbourne, UMP.


Sir Ernest William Titterton, 1916-1990

CMG, MSc, PhD, DipEd(Birm), FRSA, FAA

Sir Ernest Titterton died on Thursday, 8 February at Jindalee Nursing Home in Canberra. After a serious car accident in September 1987, Sir Ernest was severely disabled and spent most of the subsequent time at Jindalee. He remained intellectually active until the time of his death and had almost completed his memoirs using a voice-activated recorder.

Born in Tamworth, Staffordshire, Sir Ernest became Sir Mark Oliphant’s first student at Birmingham in the late thirties, beginning an association that was to span his lifetime.

Before his appointment to the first chair in nuclear physics in 1950, he played a significant role in the two major developments undertaken during World War II, firstly as a research officer with British Admiralty working on radar and, then at Los Alamos as a member of the British mission, collaborating with the Manhattan project. While he gained fame for having ‘pushed the button’ to initiate the first test at Alamagordo, the consequences of his time at Los Alamos were more profound. It made him a member of an old boys network of virtually every leading nuclear physicist—both experimental and theoretical, in the Western world. Most of them had lived and worked in an isolated, close knit community for a number of years. Such contacts proved invaluable in establishing a new department in the Acton bushland and were readily evident from the calibre of visitors and staff he attracted to work in the laboratory and to attend local conferences. Moreover, graduates from the Department were readily accepted at the leading research laboratories.

Sir Ernest came to the ANU after a short term as head of a research group at Harwell. There and over many years in Canberra, he developed techniques using nuclear emulsions to study rare modes of fission and the photo disintegration and spectroscopy of light nuclei. He was a prolific author of books and articles relating to the effects of radiation and the risk factors associated with reactors.

Always a controversial figure in Australian affairs because of this uncompromising support for nuclear energy, Sir Ernest made many outstanding contributions to the Australian National University. As head of the Department of Nuclear Physics, he established a world-class laboratory based around several accelerators but culminating in 1975 with the completion of the 14UD betatron, then the highest voltage electrostatic accelerator in the world. The 14UD has proven to be an outstanding success, continuing to provide the basis for productive mainstream research. Selection of the 14UD, with much new but largely unproven technology, reflected his remarkably bold but soundly based judgement. Completion of the project stemmed from his enthusiasm and drive. He expected no less from his staff and technical group than he gave to the Department himself. This approach may not always have made him popular but he never failed to maintain the deep respect of those working with him.

During the time of his appointment as Dean and then Director of the Research School of the Physical Sciences between 1966 and 1973, his initiative led to substantial enhancement of facilities and establishment of new research departments that have contributed much to the present stature of the School.

He also contributed much to AINSE, the Australian Institute of Nuclear Science and Engineering. This organisation serves as the essential link between Australian universities and ANSTO (previously AAEC) to give University researchers access to ANSTO facilities. The extensive use of nuclear techniques in such diverse fields as zoology, archeology, anthropology, chemistry and materials science amply demonstrates the importance of AINSE. Sir Ernest was a member of the steering committee that established AINSE and represented the ANU for 26 years from the time of the inaugural Council meeting in 1958. He was Vice-President between 1967 and 1972 and President in 1973 and 1974.

Sir Ernest retired in 1981 but maintained a lively interest in nuclear physics and the University until the time of his death. The retirement period was marked by further controversy during and after the McClelland Royal commission. As chairman of the Australian safety committee appointed to monitor the British tests during the fifties, Sir Ernest was sharply criticized and accused of near treason in the final report. Rarely has it been more evident that the past is the proper territory of thoughtful historians. Hindsight, conditioned by political and scientific changes evolving over a thirty year period, cannot and should not be used to judge the past.

A private funeral was held on 10 February. His ashes will be scattered among the Channel cliffs. He is survived by his former wife, Lady Titterton, and three children.

The department of Nuclear Physics has suggested that Sir Ernest’s many friends and colleagues make a contribution to TADACT in his memory. This organisation provides technical assistance to the disabled in the ACT region. Donations (tax deductible) should be sent to Mr D Wrigley, RMB 901, Burra Road, Queanbeyan, 2620.

T.R. Ophel
Department of Nuclear Physics
Australian National University

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A Vacuum Society for Australia

Tony Simpson, Convenor, VSA Steering Committee

During the second half of 1989, the existence of a new Australian science/technology association, the Vacuum Society of Australia, was fairly widely advertised. Prior to this, a steering committee consisting of representatives from two Australian vacuum equipment manufacturers, three importers of vacuum equipment, government research laboratories and academic institutions, had met regularly over a period of several months carefully deliberating the issue of starting an Australian vacuum society. The VSA is the result of these meetings.

What is this new society all about? What are its aims and objectives, and what does its existence imply for the other societies which cater for the interests of scientists and technologists in Australia?

VSA Constitution

The constitution of the VSA which has now been formally incorporated in the state of Victoria, states that the objectives of the society are essentially as follows:

(i) to allow people involved or interested in the production of vacuum, or in vacuum science and techniques, or in applications of vacuum, to come together in a united body.

(ii) to engage in and/or encourage the spread and advancement of knowledge of vacuum science and technology, and of the areas of vacuum applications by means of:
   (a) teaching in educational institutions and short courses
   (b) seminars, lectures, workshops, symposia and conferences
   (c) equipment exhibitions
   (d) literature circulation to society members

(iii) to represent Australia in the International Union of Vacuum Science Techniques and Applications

(iv) to collaborate with other societies if it is in the interests of the VSA and the development of vacuum science, techniques and applications to do so.

Who is Eligible for VSA Membership?

Summarising the VSA constitution, basically any individual or company with an expressed interest in vacuum science or in any area involving the application of vacuum may become a society member. The national committee of management may give approval for membership by other individuals or groups as deemed appropriate.

VSA Attributes

A number of important features arise from the VSA constitution. Some of these allow for a broader and more industrially oriented outlook than is found in some learned societies.

Firstly, the constitution allows for a membership composed of scientists and technologists coming from a diversity of backgrounds. As well as physicists, there will be a large percentage of chemists, engineers, and other technical people.

Secondly, it allows for a broader range of qualifications within its membership because membership is not restricted to persons of any specified level of skill, training or formal education, but is offered on the basis of a capacity to benefit from services provided by the society and to contribute to the activities of the society.

Thirdly, it has an active commitment to the provision of education and training because vacuum technology and many of its fields of application are not catered for in most of the formal education courses currently available, even though they are widely used in today's technology.

Fourthly, it predisposes a strong orientation towards industry, who use vacuum science in generating national productivity and the provision of services. This orientation includes the provision of services for industry in the form of specialised training through short courses, dissemination of information through workshops, symposia, equipment exhibitions, conferences, and literature dedicated to the topics of interest, and the involvement of industry in the activities of the society. (Some learned societies are more like a vacuum society in this aspect.)

Indicators of the affinity that vacuum societies have with industry and the development of industrial technology are evidenced in the establishment of a vacuum society steering committee with a majority representation from industry, the attendance profile of short courses in vacuum science offered in Australia over the last ten years, and the current membership profile of the VSA, in which approximately two thirds are from industry or industrially oriented research in government laboratories.

Why have a Vacuum Society? (some history)

National vacuum societies emerged in their respective countries primarily because the production and measurement of high vacuum in industrial and research technology involved a new coordination of knowledge from a number of separate fields, including chemistry, engineering and physics. In developing the technology for the quality of vacuum being demanded, vacuum scientists undertook research projects involving all of these fields. The theme of improvement in production and measurement of high vacuum and ultrahigh vacuum was the main driving force behind national vacuum societies prior to nineteen sixty.

During this period, one aspect that has become a major activity in many national vacuum societies became established, that is the provision of national education and training in vacuum science and technology. As vacuum has continued to take on an increasing importance in industrial productivity this role has become more firmly established in countries with national vacuum societies.

In the post nineteen sixties period, with the technology for providing high quality vacuum adequately developed for the increasing needs of research and industry, and with the involvement of industry in manufacturing state of the art equipment in a competitive marketplace, vacuum societies found a further role, that of servicing the specific areas in which vacuum was being used in research and industry.

The recent evolution of industrial technology has been accompanied by a rapid expansion of interest in interdisciplinary areas not fully belonging to the traditional science/engineering categories. As many of the people working in these new areas have been involved in the use of vacuum, there has been a natural progression to develop the servicing of
their interests within the interdisciplinary framework already provided by national vacuum societies. If one considers the industrial performance of individual nations, there is a correlation between this performance and the existence of popular and active national vacuum societies. Such countries as France, Japan and the USA may be taken as examples. Countries in which strong developmental efforts are being made, such as Brazil and India, also have active vacuum societies.

During much of this period of global industrial development, Australia has been largely content to muddle along with a lower level of technical expertise in industry, and local policies have favoured a drain of innovation and expertise from our shores to other countries rather than the opposite. In this environment the potential of a national vacuum society may have gone unrecognised and it may have been for this reason that the Vacuum Physics Group of the AIP did not evolve into a national vacuum society of the post nineteen sixties form. The result has been a decay of interest in the AIP Vacuum Physics Group and the isolation of vacuum users from one another.

The Steering Committee of the VSA believed that there is now a need for an active national society servicing industrial needs in the ways I have previously outlined. The society does not have to be a competitor with learned societies such as the AIP and the RACI because it serves a different purpose. However, the VSA will look to these societies to build up a strong groundbase of expertise for servicing and interacting with industry through short courses, workshops, and conferences as well as through communications in the society newsletter and personal consultation. The VSA will in its turn provide a service to the vacuum users in these societies by establishing firmer interdisciplinary links between the vacuum applications areas.

Projected Structure of the VSA
A national committee is being established to coordinate the activities of a number of separate sub-committees, each of which will be responsible for organizing an aspect of the society's commitment. These are summarised in figure 1.

In addition it is proposed that wherever the number of members is appropriate, they will be encouraged to form state chapters of the society to coordinate local activities, such as short courses, guest lectures, and topical workshops or symposia. Local activities are already being generated in Melbourne and Sydney. It is anticipated that the other states will form chapters as activity in their regions begins to grow. The state chapters and their interests will be represented on the national committee.

In concluding this introduction to the Vacuum Society of Australia I urge all of you who are involved in or interested in vacuum applications areas to give this development your enthusiasm and support.

If you wish to join the society during the introductory free membership period (made possible by the generous contributions of founding corporate members, and lasting till June 1990) write to:

Honorary Secretary
Vacuum Society of Australia
Applied Physics Department
Footscray Institute of Technology
PO Box 64
Footscray VIC 3011

CSIRO Division of Manufacturing Technology

Research Directions
In collaboration with industry partners, the CSIRO's Division of Manufacturing Technology's research is directed to developing new and improved products and processes which will improve the competitiveness of the Australian metals and related engineering industries, and to developing and applying integrated manufacturing technologies and derived products that will enhance productivity in the manufacturing sector.

Under the leadership of its inaugural Chief Dr R.H. (Bob) Brown, the Division of Manufacturing Technology (DMT) was established in 1980. It now operates specialist and complementary research laboratories in Victoria, South Australia, New South Wales and Queensland, from where its 130-strong staff are able to contribute...
an exceptionally high level of combined skills in engineering, metallurgy, materials science, and computer science. The Divisional Headquarters is located at Preston, Victoria.

The Division of Manufacturing Technology functions as one of the five independent Divisions which make up the CSIRO Institute of Industrial Technologies.

The DMT’s research is directed towards assisting the Australian manufacturing industry with the development of new and improved products and processes, where the projects are conducted in collaboration with industrial partners. Collaborative projects have defined commercial objectives and are conducted within the framework of the Division’s principal cross-disciplinary Research Programs, viz., Manufacturing Processes and Materials (MP&M) and Integrated Manufacturing (IM).

The scope of the Division’s industrially-oriented projects which have major significance to the Australian manufacturing sector include research involving welding, casting and other material processing technologies, the mechanics and control of processes, the planning of flows of products and flows of information, and design for production.

Division’s Research and the Australian Manufacturing Sector - Intellectual Property and Industrial Collaboration have provided “The Key” to Successful Commercial Developments.

Throughout its nine years of operation, the Division of Manufacturing Technology has consistently pursued its stated policy of engaging in the joint development of products and processes that are of commercial significance to Australia. This policy positively reflects the commitment and realistic innovative vision for improving the future of Australian manufacturing that is provided by its management team led by Chief Dr Bob Brown and Assistant Chief Dr Graeme Ogilvie, the successful achievements of whom have become well recognized and highly regarded by the Division’s many Australian industrial collaborators and the local manufacturing industry generally.

As Dr Brown has explained “Most of the Division’s research is undertaken under formal agreements which establish teams of CSIRO and industry working closely together - both within the industry and within CSIRO. Our effectiveness in achieving a new commercial product or making a significant process improvement - through a successful R and D collaboration - has been reliant on the Division’s (now well proven) ability to: carry out well prepared negotiations; respect confidentiality at all stages of the development; detect and protect commercially viable intellectual property; delay or suppress publications when and where necessary; and ensure that the collaborative endeavour is properly managed, swiftly and effectively brought to the agreed completion/commercialisation stage.”

The Division’s impressive research achievement record has involved both commercial successes with small and large companies. Dr Ogilvie is of the firm belief that “A key to returning manufacturing to Australian ownership and control is through the control of the intellectual property relating to the products or processes that are developed as a result of collaborative research investigations.” And although Dr Ogilvie admits “It may only be medium to large companies with a commitment and experience in R and D, coupled with an understanding of the complexities and problems relating to intellectual property, which are likely to use the control of intellectual property in their and the national interest”, he maintains that the Division’s critical observation of research conducted in the Australian manufacturing sector has indicated that even the largest company can have difficulty in assembling all the relevant expertise to conduct the R and D that is necessary to produce a new marketable product or process. According to Graeme Ogilvie “Our experience has clearly demonstrated that a collaborative or joint venture approach is a much more effective way to the marketplace than the sole pursuit of innovation. In true collaborative research - i.e., where a need or recognisable potential for achieving a product or process improvement has been identified, and each partner has genuinely encouraged close contact between people at all levels in both organisations - this Division has found the gaps in the skills, experience and knowledge in one party tend to be complemented and covered by the other partner.”

Research Programs

Through collaboration, and with particular reference to the needs of industry, the Manufacturing Processes and Materials Research Program aims to:

- develop new and improved technologies based on the electric arc;
- develop new and improved methods for the production of materials and components;
- exploit industrially important developments arising from advances in the technology of high currents; and
- develop a better understanding of those materials behaviour and production processes that are relevant to Australian manufacturing industry.

Manufacturing Processes and Materials (MP & M) research is currently undertaken in the project areas of surface treatment, arc welding, industrial lasers, as processing of industrial products, and solidification and alloy studies. The MP & M Research Program Adviser is Dr Graeme Ogilvie.

In accordance with identifiable industry needs the Integrated Manufacturing Research Program aims to:

- encourage and support the widespread utilisation of appropriate integrated manufacturing in Australian industry;
- collaborate with industries to develop integrated manufacturing systems and products which support integration;
- perform strategic research into the application of engineering and computer science to the design, planning, control, processing and integration of manufacturing systems and products;
- and thereby contribute to the long-term competitive position of Australian industry.

Integrated Manufacturing (IM) research is currently undertaken in the project areas of flexible manufacturing systems, robot applications, control of machines, sensors/vision, assembly automation, CAD/CAM, manufacturing information technology, and shop-floor scheduling. The IM Research Program Adviser is Dr Laszlo Nemeth.

Research and International Market Potential

While the Division’s earlier collaborative research endeavours were conducted in association with Australian manufacturers exclusively, recent experience has shown that numerous Division-developed products have been clearly identified as possessing international market potential. As a consequence the Division is now pursuing a number of its unique developments with overseas commercial organisations in both the Manufacturing Processes and Materials and Integrated Manufacturing Program areas.
Laboratory Activities
Adelaide (Woodville)
Laboratory Research
In the Adelaide Laboratory, commercially-oriented research conducted in Manufacturing Processes and Materials includes developments in welding, gas tungsten arc welding, surfacing, thermoplastic bonding, cast-bonded composite products, wear-resistant materials and surfaces, and tooling materials and processes. Collaborative research conducted at Adelaide in the Integrated Manufacture Program includes investigations into computer-aided plant design, resource scheduling, and knowledge based systems and artificial intelligence techniques, and in particular those systems and techniques which are applicable to manufacturing situations.

Sydney (Lindfield)
Laboratory Research
The Sydney Laboratory's research in Manufacturing Processes and Materials involves Laser Materials Processing, and recently efforts have been concentrated on the establishment of an Industrial Laser Centre. Prominent amongst the research efforts in Integrated Manufacture currently undertaken in the Sydney Laboratory are projects in Assembly Automation and Robotic Applications.

Brisbane (St. Lucia)
Laboratory Research
In the recently established Brisbane Laboratory the Division's research efforts have initially been concentrated in the Manufacturing Processes and Materials area, with an emphasis on Solidification and Alloy Studies.

Melbourne (Preston)
Laboratory Research
Solidification and Alloy Studies are also included in the Melbourne Laboratory Manufacturing Processes and Materials research Program. Other industrially important Melbourne-based research in this Program include technologies and novel developments such as plasma spray torch, arc reactor for materials processing, battery testing, physical vapour deposition coating, machining and metrology, die thermal control and analysis, microwave feed horn manufacture, die casting and surface modification using electric arc. By contrast the Melbourne developments in the Integrated Manufacture research field embraces diverse achievements such as genetic robot/cell control, CNC (computer numerical control), machine modelling, robot servo control, applications and developments in machine vision, and the 'DMT - Castflow' die casting software, etc.

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Fourth Australian Conference on II-VI Semiconductor Compounds
Green Gables Chalet, Warburton
23-25 April, 1990

II-VI Semiconductors 90 will cover fundamental and applied research relevant to narrow- and wide-gap II-VI compounds and alloys. It will provide a forum to present and discuss recent advances in materials preparation, characterisation and devices. Special emphasis will be given to new growth techniques, studies of defect and impurity states and opto-electric devices.

The topics of the conference will include:
- Materials preparation and structural properties:
  - Surfaces and Interfaces
  - Optical properties
  - Transport properties
  - Magnetic effects, semimagnetics
- Physical properties:
  - Theoretical concepts
  - Band structures
  - Point and extended defects

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Diode-Pumped YAG Lasers

ADLAS offer a wide range of compact, rugged solid-state lasers for scientific, industrial and medical applications. The lasers employ a YAG or YLF crystal as the gain medium, which is end-pumped by a 810nm laser diode. The all solid state design eliminates the need for high voltage power supplies, flashlamps or cooling water and results in exceptional reliability in a sealed, maintenance-free package.

CW output powers range to 350mW at 1064nm and 45mW at 1319nm. A frequency-doubled version is available with up to 80mW output at 532nm. The output beam is of TEM00 mode with a diameter of approximately 1.5mm and divergence of approximately 1.5mrad. All CW lasers may be externally modulated to provide pulses of 500ns minimum duration.

Q-switched versions are also available at 1064 and 1047nm, with pulse energies up to 80 microjoules in a 15ns pulse.

For more information, please contact.

Paul Wardill
Coherent Scientific Pty Ltd
138 Greenhill Road
UNLEY SA 5061
Phone: 08 271 4755
Fax: 08 271 1202

New 899 Ti:Dye Ring Laser Combines Titanium: Sapphire and Dye

The full potential of a tunable laser system using both titanium:sapphire and dye gain media has been released. Coherent has introduced a new CW tunable laser system, the Model 899 "Ti:Dye" Ring Laser - the first laser designed to operate with both titanium:sapphire and dye. The 899 Ring Laser is continuously tunable from 370nm in the UV to over 1 micron in the infrared, the largest CW tuning range ever offered. With titanium:sapphire, the 899 Ring Laser has achieved record output powers in broadband, in single-frequency operation and when frequency doubled. With frequency doubling the UV output can be extended down to 270nm.

The Model 899 Ring Laser is available in a wide range of system configurations including broadband ring, scanning single-frequency and actively-stabilised, scanning single-frequency. Over 5 watts of single-frequency output have been demonstrated using an 899 titanium:sapphire laser pumped by an Innova 200 20W argon ion laser. All 899 systems can be upgraded at any time to any of these configurations. Conversion between dye and titanium:sapphire operation is a simple procedure of exchanging gain media, rearranging two mirror mounts and realigning.

Much of the success of the 899 is due to the laser's stable Invar resonator and fundamental optical design. In developing the broadband version, the Model 899-01, Coherent invested considerable engineering time and expense to achieve a resonator so stable, simple and easy to align that it could serve as the foundation for a whole new family of advanced tunable lasers. Without a high level of stability and performance in the basic resonator, more advanced versions would not have been possible.

Until now, titanium:sapphire lasers have been designed either for higher or lower power operation, but not both. With it's unique, variable threshold resonator design and optimally doped titanium:sapphire crystal, the 899 delivers the highest specified output power available with either small or large frame pump lasers giving over 600mW output with a 6W pump and over 3W output with a 20W pump laser.

The basic stability of the resonator, the wide tuning range, the upgrades to advanced performance, and the flexible pumping capabilities combine to make the 899 the clear choice for any application requiring a CW tunable laser.

For more information, please contact Norman Jones or Paul Wardill at Coherent Scientific.
Phone (08) 271 4755
Fax (08) 271 1202
Photomultiplier and Photodiode Power Supplies

Oriel Corporation of Stratford, CT announces new power supplies for their family of photomultiplier and photodiode detectors.

The Photomultiplier Power Supplies provide a highly regulated voltage of up to 2kV for photomultiplier tubes. The voltage supplied to the PMT can be controlled and switched on and off via a computer of 0-9 V input and circuit breaker. Two photomultiplier tubes can be powered simultaneously with minimal independent drift.

Oriel's 70704 Photodiode Supply is a compact, regulated bias supply for solid state detectors. It provides both a regulated 0-100 VDC bias for photodiodes, and a regulated +/-15V for detectors with transimpedance such as germanium and pyroelectric detectors.

For information of these power supplies or Oriel's large range of detectors contact -

Lastek Pty Ltd
GPO Box 2122
Adelaide SA 5001
Phone: 08-231 2155
Fax: 08-231 2169

Optics Teaching Kits from Newport

Newport offer a number of thoughtfully-configured teaching kits which develop and explore various topics in modern optics. Each kit comes complete with all required equipment, including tools, and is comprised of research-quality Newport equipment. In addition, each is accompanied by a detailed manual which is both an introductory text to the topic and an instruction guide for a series of carefully-designed projects. The emphasis in each kit is on building an understanding of core principles before progressing to the investigation of sophisticated devices and applications.

Kits currently available include:
Projects in Fibre Optics explores the potential of optical fibre in communications, and as a sensor technology.

Projects in Holography includes transmission, reflection and rainbow holograms, optical data storage, vibration analysis and more.

Projects in Optics investigates topics including diffraction, interference, coherence, polarisation and spatial filtering.

Projects in Holographic Non-Destructive Testing uses a thermoplastic camera to explore real-time holography, fringe analysis, mechanical and thermal stress, vibration analysis.

Each of the above kits makes an ideal, self-contained course for students, researchers or engineers. Their flexible, modular design will also provide the basis for a modern optics laboratory which will serve over many years of research.

For further information on Newport's optics teaching kits, please contact:
Spectra-Physics Pty Ltd
2-4 Jesmond Road
Croydon Vic 3136
Phone: (03) 723 6600
Fax: (03) 725 4822

Nanosecond Nd:YAG and Dye Lasers

Continuum Inc. (formerly Quantel International), a leading U.S. laser manufacturer, offers a comprehensive range of pulsed, nanosecond Nd:YAG lasers, a compatible dye laser, and wide selection of frequency conversion options.

The YG-600 family of YAG lasers offers a choice of pulse energies at 1064nm ranging from 250mJ to 1400mJ. Corresponding second harmonic pulse energies are 100mJ and 750mJ. Third and fourth harmonic options are also available.

The modular and compact design of the YG600 family means that lasers can be upgraded to higher specification, and the power supply for even the largest laser will easily fit under a standard optical table.

The excellent beam quality and shorter pulse widths of Continuum's YAG lasers can lead to significant benefits over competing systems of similar pulse energy in applications where small focussed spot size and high peak power are important. For applications where narrow line width is required, an injection seeding option is available.

The TDL-60 dye laser can be pumped by the 1064nm, 532nm or 355nm output of any of the YG600 series YAG lasers. A wide range of options for operation in the dye fundamental, for frequency doubling, and frequency mixing, extend the wavelength range of the output from 205nm in the UV to 4.5 microns in the IR. A choice of bandwidth from 0.05cm⁻¹ to 100cm⁻¹ is available. The TDL-60 is controlled by easy to use 'menu' style software on a P.C. compatible computer.

Continuum also manufacture a wide variety of other pulsed laser systems, including hybrid mode-locked picosecond YAG's, picosecond dye lasers, high (500Hz-1000Hz) repetition rate YAG's, regenerative amplifiers for mode-locked C.W. pumped YAG's, combination nanosecond/picosecond YAG's and custom built Ruby and Nd:Glass lasers.

For more information on any of Continuum's products, please contact Norman Jones or Paul Wardill at Coherent Scientific:
Phone: (08) 271 4755
Fax: (08) 271 1202

Compact New UVH Inchworm Motor

Burleigh Instruments has recently introduced a new, compact version of its ultra high vacuum (UVH) Inchworm motor. The UVHM Micro-Inchworm series motors represent almost a factor of two reduction in size from previous models.

The motors are constructed entirely from low outgassing materials including alumina, PZT ceramic, silver and beryllium copper. The motors can withstand bakeout temperatures of 150°C.

For UVH positioning applications, the Micro-Inchworm motor will occupy less space inside vacuum chambers and should allow quicker pump-down sequences. Particularly for Scanning Tunneling Microscope applications, the small size of the Micro-Inchworm will deliver improved rigidity and higher resonant frequency.

For more information, please contact:
Paul Wardill
Coherent Scientific Pty Ltd
138 Greenhill Road
UNLEY SA 5061
Phone: 08 271 4755
Fax: 08 271 1202
BOOK REVIEWS

Prompt Critical

What are those Mysterious Little Fireballs?

After more than 2000 years of observations, ball-lightning is still a mystery. What exactly is it? How is it created? Why does it behave in so very peculiar ways; and so on. If it were not for a few occurrences which were observed by highly trained physical scientists, many other physical scientists would be insisting that the phenomenon of ball-lightning is purely psychological. Don’t laugh, or be too much of a sceptic, because this is exactly what happened in the case of electrophonic sounds from meteor fireballs and aurorae. That a few people claimed to hear meteor fireballs (and aurorae) simultaneously with seeing them was an ancient-century-old riddle which most meteor scientists dismissed as a psychological artefact produced from the sighting. Ten years ago I showed that electrophonic sounds had a straightforward scientific explanation (Keay, Science, 210, 1115-18, 1980), and the psychological theories have now been dropped. Not so for ball-lightning, because no satisfactory mechanism has yet been found.

Many hundreds, if not thousands, of papers and several monographs have been written about ball lightning - all to little effect. At the First International Symposium on Ball Lightning, held in Japan in 1988, a Hungarian scientist, George Egely, went so far as to state that "not only the BL itself but even its damage patterns cannot be simulated under laboratory conditions" (his emphasis). This indicates also that a new physical phenomenon is to be sought as a principle behind BL". Wow! That should bring the heavies in.

The proceedings of the Symposium have now appeared in print, and much of it makes fascinating reading (some parts are terrible - for example, what level of brightness is "grimy"?). But the overall impression is akin to groping in the dark. There was no shortage of ball-lightning models under discussion at the Symposium. All of them were attempts to mathematically describe some form of self-contained plasma. The most satisfying one seems to be the fluid dynamical model advanced by Karl Nickel, who worked on the problem about four years ago as a visiting research fellow at the ANU.

But all of the theories, models and what-have-you, are trapped up by the existence of some nasty physical incommensurables. For example, the energy density required for producing some of the damage recorded would, if electromagnetic, lead to immediate break-down of the surrounding atmosphere and the ball would become much larger. Worse still, such balls have been observed to contract sufficiently to pass through small orifices, such as key-holes. Other incommensurables, just as serious, are discussed by Egely and others and cannot be dismissed lightly.

The Science of Ball Lightning (Fire Ball) is typical of many published conference proceedings. The variations in camera-ready format spoil the presentation, and the quality of reproduction of the photographic evidence is rather poor making many pictures look faked, or at least unconvincing. Translation into English from the variety of languages used is not very good. "Report frequency falls off with rising sea-level." Shades of the greenhouse effect. What they meant to say was "Report frequency falls with increasing height above sea-level". And there are more like that.

Edited by Yoshi-Hiko Ohtsuki, one of the symposium participants, Science of Ball Lightning (Fire Ball) is published in a hardcover edition by World Scientific for US$51. The contents of its 340 pages are of variable quality as you would expect of conference proceedings, but it does bring one up-to-date on a fascinating scientific mystery.

Colin Keay
Book Reviews Editor

A number of the articles are concerned with the technology involved in performing large scale quantum mechanical calculations, for instance there is a very lucid contribution on the Schwinger variational method as well as a survey of methods used to solve the close-coupling equations. There are also contributions describing calculations based upon the Dirac equation. These are timely since there is increasing interest in the structure of heavy atoms, partly motivated by the need to unravel atomic parity-violating experiments. The remarkable minimisation of the energy, inherent in the usual variational approaches to the Schrodinger equation, does not necessarily guarantee success when dealing with the Dirac equation because of the presence of the negative energy continuum. The remaining articles are in the applications area, with most emphasis placed upon the photo-dissociation of molecules.

My own feeling is that this volume will appeal most to members of the A&M community who are interested in the two areas covered by the volume, the technology required in quantum mechanical calculations and the applications to astrophysics. Like most members of the series the book (at US$99.50) is better suited to the library than the individual.

J. Mitroy
Department of Theoretical Physics,
Australian National University

Photon-Atom Interactions
M. Weissbluth
Academic Press, Boston, 1989
xii + 407 pp, US$69.50 (hardcover)

The purpose of the book is to introduce some of the new concepts and formulations of photon-atom interactions with emphasis on the quantum and statistical aspects. Normal undergraduate courses in classical electrodynamics, statistical physics and quantum mechanics would provide sufficient background to enable the book to be used for either classroom or self-instruction at either third or fourth year level of a BSc course. There are only a few insignificant typographical errors. It is an eminently clear and detailed exposition of the subject of photon-atom interactions from the viewpoint of a physicist who appreciates that the laws of nature are drawn from experience but are aptly described by mathematics. The mathematics is
explained step by step with sufficient working to enable a student to work through the text with the minimum of assistance. Features of the text are the frequent explanations of the theory and its physical consequences. There are adequate references at the end of each chapter and a further reading list on the main topics.

The first chapters introduce stochastic processes, the density matrix, the time-developed operator and time-dependent perturbation theory, correlation functions, Green's functions and two-sided Feynman diagrams so that a third year undergraduate could understand and use the mathematical tools and concepts. The text reveals the strength of the density operator formalism and its compact representation. The close formal connection between a system of spin-1/2 particles in a time-varying magnetic field and an atomic two-level system in a radiation field is established early in the book and is used to develop some of the concepts of modern optics.

Also the concepts of pure and mixed states are well treated. An excellent example is a two-electron system in a triplet state in which the two electrons are correlated, the wave function for the complete system is known but those for individual electrons are not, i.e. the composite system is in a pure state but the individual electrons are in mixed states. The text presents a good discussion of the concept of coherence. The notion of coherence as used for a system described by a coherent state of mixed states which are characterised by non-vanishing off-diagonal matrix elements of the density operator is not an obvious one. Less familiar is the definition of a coherent state as a normalised eigenstate of the annihilation operator. However the two definitions are clarified by many examples, the most interesting being for a coherent superposition of the spin-1/2 system and an incoherent thermal distribution.

The statistical properties of coherent states as minimum uncertainty states are explored and compared with the properties of squeezed states. The properties of squeezed states, of course generated by a 'squeeze operator', and their consequences for applications to low-noise detection systems, are discussed.

Subsequent chapters deal with quantisation of the radiation field; absorption, emission and scattering and topics such as the optical Bloch equations, photon echoes, line shapes and finally nonlinear and multiphoton processes. A section on two-sided Feynman diagrams, used as a means of keeping track of the various orders of expansion of the density operator, is very well presented. Such diagrams are given a prominent role in representing details of the various-order nonlinear susceptibilities.

The description of the difference between fluorescence and Raman scattering shows the author's style and clarity. The former is a two-step process in which the steps are statistically independent and individually observable, each is a first order, one photon radiative process. Raman scattering is a single (two-photon) radiative process that cannot be decomposed into individual observable steps, the 'intermediate states' are not separable in time and are not detectable. Good fundamental scattering notions! The subsequent derivation of the appropriate polarisability tensors is thorough and instructive; the measurable quantities and possible experiments are clearly indicated. Nonlinear wave-mixing processes became a reality with the advent of lasers capable of producing high-intensity coherent radiation. The text gives simple interpretations of a general coherent n-wave mixing process, which range from the simple statement that the fields interchange energy among themselves in a non-linear medium, i.e. through various combinations of the input frequencies, to the full quantum derivation of the complex polarisability showing Feynman diagrams for the susceptibilities. Some examples of three and four-wave mixing processes, such as sum- and difference-frequency mixing, the DC Kerr effect, Optical Kerr effect and parametric processes are discussed.

The book is the most instructive and professionally enjoyable reading I have encountered in recent years. It is excellent value at US$69.50.

J.F. Williams
Physics Department
University of Western Australia

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**Fundamental Processes of Atomic Dynamics**

J.S. Briggs, H. Kleinpappe and H.O. Lutz (Eds)

NATO ASI Vol 181

Plenum Press, New York, 1988

xi + 693 pp, US$120 (hardcover)

This book is unusual for a review/conference volume since a large number (about half) of the articles are related to two common themes, namely quantum defect theory (QDT) and the hyperspherical treatment of two electron systems. Due to the common themes, the volume can be expected to remain useful a lot longer than most review volumes.

QDT is concerned with providing a unified view of bound and continuous states of charged particles (usually electrons) in the field of an ion. It is known that energy levels of monovalent alkali atoms can be represented by the formula, $\lambda_0(\alpha+\beta)^2$, where $\mu$ is a quantum defect and depends mainly on 1 and only vary weakly from different members of the same series. The quantum defect also determines the phase shift of an ionised electron near threshold through the relation, $\delta_\alpha = \mu_\alpha$. It is less widely known that transition probability between different levels (or the continuum) can be given by the product of a single coefficient, $I_\alpha$, varying slowly with energy, and a standard function $F(\mu_\alpha)$. The systematic treatment of energy levels and rates for atoms with more than one valence electron is more complicated, but is possible within a coupled channels framework, and the systems of some very complicated systems can be described with relatively few parameters (which can be computed with ab-initio methods). From one perspective, the material presented is not particularly novel, but it is clear from the articles that the range of applications of QDT is very diverse.

The articles on experimental subjects give a reasonable sampling of those areas which are the current flavour of the month in A&M physics. Like most members of the NATO ASI series the book (at US$120) is much better suited to library than the individual although it does complement the text of U. Fano and R.V.P. Rau, Atomic Collisions and Spectra.

J. Mitroy
Department of Theoretical Physics, Australian National University

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**New Books**

Basic Vacuum Technology

A. Chambers, R. Fitch and B. Halliday

Adam Hilger/IOP Publishing, Bristol, 1989

xi + 166 pp, £15.00 (hardcover)

Synchrotron Radiation: Sources and Applications

G. Greaves and I. Munro (Eds)

Adam Hilger/IOP Publishing, Bristol, 1989

xiii + 504 pp, £58.00 (hardcover)
CONFERENCES AND MEETINGS

1990
April 1-6  Government, Engineering and the Nation, Canberra.
            Conference Manager, IE (Aust) 11 National Circuit, Barion ACT.

            Andrew Stevenson, CSIRO Division of Materials Science and Technology, Clayton.

April 23-27  International Conference on Physics Education Through Experiments.
            Prof. Zhao Jinyuan, Nankai University, Tianjin, China, tel (086) 02 318264

June 4      First Australian AVHRR Station Operators Meeting, Canberra.
            Jeff Kingwell, CSIRO Office of Space Science & Applications, tel (062) 70 1824.

June 5-7    Workshop on Remote Sensing of Global Change, Canberra.
            Bev Rose, CSIRO Office of Space Science & Applications, tel (026) 70 1801.

            IREE (02) 327 4822.

July 9-12   3rd International Conference on the Structure of Surfaces, Milwaukee, USA.
            Dr M. Read, UNSW, tel (02) 697 4562

July 9-13   5th World Conference on Computers in Education, Sydney.
            WCCE/90 PO Box 319, Darlinghurst 2010. Tel (02) 211 5855

July 16-20  Nonlinear Optics Conference.
            LEOS, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331, tel (201) 562 3895

Aug 5-10   15th Congress of the International Commission for Optics, Bavaria.
            Prof. F. Lenzl, DLR Optoelectronik, D-8031 Oberpfaffenhofen, Fed. Rep. Germany

Aug 12-16  International Conference on Optics for the Life Sciences, Munster.
            G. von Bally, University of Munster D-4400, Munster, Fed. Rep. Germany

Sept 24-28 Joint Conference of Australian Radiation Protection Society and Australian College
            of Physical Scientists and Engineers in Medicine, Adelaide.
            SAPMEA, GPO Box 498, Adelaide, 5001.

Oct 1-4    11th European Conference on Surface Science, Salamanca, Spain.
            Laboratorios Física de Superficies, Instituto Ciencia de Materiales CSIC,
            Serrano 144, 28006-Madrid, Spain.

Oct 8-12   5th Australian Remote Sensing Conference, Perth.
            Dr Norm Campbell, CSIRO Division of Mathematics & Statistics, Floreat, WA.

Oct 16-18  Communications '90. Electronic Communications in the 1990s.
            Conference Manager, IE Aust, tel (062) 70 6349.

Dec 27-31  International Conference on Teaching Physics - "Changing Face of Physics
            Education in Developing Countries", Karachi.
            S.A. Hasnain, Department of Physics, University of Karachi, Pakistan.

1991
            R.L. Dewar, Department of Theoretical Physics, R.S. Phys.S., ANU, GPO Box 4,
            Canberra ACT 2601, tel (062) 49 3949/49 3943, fax (062) 49 1884.
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- Full page - $185, 2 columns - $122.50
- 1 column - $62.50 or half column - $31.25

**Inserts** are $350 for 1 issue (2,600 distribution)

* Separations for full colour are an extra $300

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**Advertising Bookings** must be made by the 14th of the month before the date of issue and copy for typesetting and artwork sent to:

- **Advertising Manager**
  - Tel: (049) 62 0911
  - Fax: (049) 60 1137
  - Impress Studios
  - PO Box 189
  - Jesmond NSW 2299

**Camera Ready Artwork** for bookings already made must arrive by the 21st of the month before the date of issue and be sent to:

- **Judith Nikoleski**
  - Tel: (049) 62 0911
  - Fax: (049) 60 1137
  - Production Manager
  - Impress Studios
  - PO Box 189
  - Jesmond NSW 2299

or courier to:

- The Technology Centre (adjacent to Newcastle University)
- Rankin Drive
- Shortland, Newcastle, NSW

**Advertising Agencies and AIP members rate**: Less 10%