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President's Column

At a recent seminar on Education in New South Wales, Professor Harry Messel was asked to define subjects which were ‘easy options’. His somewhat intemperate reply was that ‘science and mathematics were hard options, the rest were easy’.

While the hackles rose on at least half the audience, he has a valid argument.

The object of education is to teach students to think as deeply as their individual mental capacities enable them. In case this statement raises hackles among readers of this journal, I will make an entirely equivalent and non-controversial statement. The object of training a runner is to enable him to run as fast as his physical capabilities permit.

To this end, we try to teach something in depth. What that something is does not matter very much. Once the student knows that he can reason a difficult problem through, he has the confidence to use his intelligence on other subjects.

To satisfy this criterion, the subject must have depth and the possession or lack of depth defines ‘hard’ or ‘easy’ options. A very considerable amount of rigorous thought has gone into building up the logical basis of science and mathematics. This thought constitutes the depth.

There are many other subjects with a similar rigorous background; languages, history, archaeology come to mind. There are others with little or no depth; psychology, sociology, education. These substitute jargon for depth, assertions for logic. If the student sees through the jargon, they are easy options.

In many of our courses we have substituted easy for hard versions, e.g. science is hard, but the history and philosophy of science is easy; French is hard, learning about France is easy. This is a backward step.

Institute Affairs

EXHIBITIONS

As part of the 3rd AIP National Congress, a physics exhibition will be staged. The Congress Committee is seeking contributions of exhibits demonstrating physics effects, progress in our knowledge and understanding of the physical world, teaching aids and illustrations of physics in action in Australia.

After the Congress, arrangements are being made to circulate an exhibition to museums in each State, for display to the public. For this purpose it will be necessary to focus attention on some aspects of “The Growing Edge” of physics and the AIP Council has recommended that this be on new information about the earth and planets.

Help Wanted

Anybody who has exhibited material that could be made available or who is willing to help with the preparations of special exhibits or with other aspects of these exciting projects is urged to contact either of the persons listed below at the earliest opportunity:

Dr P. Dallimore, Physics Dept, WAIT, Bently, WA 6102.

Dr J. R. Bird, The Science Centre, 35 Clarence St., Sydney, NSW 2000.

31ST COUNCIL MEETING

The 31st Council Meeting of the AIP is to be held in Canberra on 5 and 6 September 1978. This is the only Council Meeting to be held during 1978 and it will make the major decisions relating to activities, budget and subscription levels for 1978/9. AIP members who wish to put forward suggestions or views on any aspect of Institute Affairs should contact a member of their Branch Committee or the Honorary Secretary of the AIP.

COMING EVENTS

The AIP is supporting a special speaker to attend the International Conference on Nuclear Interactions which is to be held in Canberra from 28 August to 1 September 1978. The speaker is Professor W. Greiner, a leading theoretical physicist from the University of Frankfurt. Professor Greiner will visit most AIP Branches to lecture on the topic “Is the Vacuum Really Empty? From Aristotle to Black Holes”.

The Australian Physicist, July 1978  81
Science and the Environment
— a Submission

from the Australian Institute of Physics to the inquiry into Industrial Research and Development by the Senate Standing Committee on Science and the Environment.

This submission discusses ways in which Australian industry can become more competitive, through successful innovation. The term “innovation” is used to describe the process of transforming a new concept or invention into a commercially viable product. Research and Development is part of the innovation process. In order to be successful commercially, however, innovation also requires a variety of other activities ranging from marketing to production engineering. The art of successful innovation is to control these widely diverse activities sufficiently well in order to produce a product within tight time and budgetary constraints.

Many Australian companies are highly innovative. This is particularly true of small companies, which can respond quickly to meet market pressures and opportunities. Such companies are usually highly entrepreneurial and, because of their small size and flexibility, can operate successfully in a very competitive market. Some larger companies have achieved the same result by sound, far-sighted management. Most large Australian manufacturing companies, however, find it difficult to compete with overseas organisations, and require some form of protection in order to survive. The inability to innovate successfully is undoubtedly a contributing factor to this situation.

The reasons for the present low level of innovation in Australian industry are largely historical, and are part of a pattern of neglect stretching back for many years. In the period soon after World War II, Australia was unable to procure many of the goods necessary for its development. Industries were established in those years that were in some instances uneconomic, or would shortly become uneconomic, but which could continue to operate while supplies of goods were restricted. The existence of protective tariffs allowed this situation to continue.

Tariffs have played an important role in maintaining stability and full employment. They have had unfortunate consequences, however, which have become obvious only since their sudden reduction a few years ago. Tariffs encouraged overseas industry to set up local manufacture with imported technology at a level that could not be justified in a free trade environment. Such industry was given no motivation or incentive to innovate. The development and exploitation of technology which was specifically Australian did not happen to any significant extent. Exceptions occurred where dictated by the special properties of local raw materials or other local requirements, as in the brown coal and wool pulp industries, for example. The amount of innovation, however, was small, particularly in comparison with other countries.

This situation was aggravated by the reluctance of large government corporations, such as Telecom and the electricity authorities, to innovate. These authorities are required to provide a service at a minimum cost. Clearly this can be done more easily and with greater certainty if overseas technology is used. However, such a policy makes no allowance for the social effects of a positive attitude towards innovation. It also closes off yet another potential avenue for the exploitation of local development.

Government attitudes towards science and technology have also reflected the low priority given to local innovation. According to data taken from Project SCORE, only 6% of government research and development funds are spent in industrial organisations. This figure has remained practically unchanged since 1968-69, and is very much lower than that in most other countries. Universities and government laboratories undertake research programs which, to a large extent, are conceived and prosecuted in the absence of any industrial input. (This statement is supported by data taken from a recent compilation of CSIRO Research Programme Objectives. Less than one third of CSIRO programmes are listed as having interaction with industry). The low level of interaction between universities and government laboratories on the one hand and industry on the other is accompanied by very little job mobility between the sectors. This position is aggravated by the existing tenure system, and by the significantly lower salaries received by research and development workers in industry.

At present, therefore, institutions tend to be inward looking. There is insufficient information and personnel exchange with industry. (Even the highly innovative small industries operate with minimal contact with the scientific community). This lack of interaction reduces the benefits to all sectors. There is considerable emphasis on fundamental research with too little attention or support given to applications-related activities. Joint appointments, to a university and industry for example, are almost unknown in Australia, yet they are quite common overseas.

Government attempts to stimulate industrial research and development have been ill conceived and ineffective. The former Industrial Research and Development Grants Act and its replacement, the Industrial Research and Development Incentives Act, both allow a grant of up to only 25% of total expenditure. This money is paid retroactively, and is taxable. Such support is therefore marginal, and unlikely to change significantly the attitudes of management to the development of new technologies. Other government funding of R & D in industry, through research contracts for example, is
entirely inadequate in comparison with other countries. It is obvious that a country of Australia's population cannot afford, and should not attempt to develop all of its technology requirements. It must not be concluded from this, however, that we should develop no technology. Australia has a strong competence in basic research, but is seldom able to exploit advances made from such work in a proper commercial sense. There is clearly a pressing need to re-think our attitudes to science and technology, particularly in regard to its utilisation by industry. To achieve this end, Government policies relating to science and technology must consider all aspects of the innovative process, from research through to commercial exploitation, and should include realistic export incentives and aggressive economic nationalism such as is expressed in the Buy-American Act. Industry in other countries receives such support -- it is naïve to believe that Australian industry can compete on world markets without it.

RECOMMENDATIONS
1. Positive measures must be taken to increase the interaction between scientists in industry and in universities and government laboratories. A substantial improvement in the situation would result if, as in several other countries, the government adopted a policy of obtaining a significant fraction of its research and development requirements from industry. It is relevant to note that Canada has done this, and claims positive benefits from the initiative. The interaction generated by contracting industrial research requirements to universities and CAE's would also be highly beneficial to both sectors.

2. The mobility of scientists between the different sectors should be encouraged. The present salary differentials between industry and government scientific positions should be reversed to compensate for the absence of tenure in industry.

3. Joint appointments between government laboratories and universities, and industry should be established. At the present time, only one such joint appointment is known in Australia.

4. More emphasis should be given to science and technology related to specific national requirements. It is not suggested that all research should be justified in this light, as there is a strong case for undirected fundamental research aimed at the advancement of knowledge. The emphasis on such work in Australia, however, is too great relative to that given to mission-oriented research. The ARGC, for example, should consider the potential practical usefulness of research proposals, along with its other evaluation criteria, and ARGC membership should include representatives from industry.

5. The funding of science and technology in universities and government laboratories should be accompanied by realistic support for commercial exploitation of new developments. An examination of such programs which operate in other countries reveals that comparatively little emphasis is given to this important aspect of technology development in Australia. Industrial capability suffers as a result.

6. The charter of large government instrumentalities (such as Telecom and the Electricity Authorities) should include an inducement to innovate; a proportion of new developments should be based on locally generated technology. This requirement is not met by the present R & D strategy of these organizations, which appears to be aimed at generating enough expertise to evaluate the relative merits of overseas developed technology.

7. The Industrial Research and Development Incentives Act should be amended to provide significant incentives for industrial R & D. In order to achieve this, the present grant of 25% of project cost should be at least doubled. Grants should be made for work undertaken prior to the agreement date. The present restrictive guidelines on acceptance of a project should be eased. For example, grants should be made available for development projects which appear technically promising but which do not offer definite or immediate prospects of financial returns. There appears to be a reluctance to support such projects through the I R & D incentive scheme, and industry is usually not able to commit funds to speculative research of this nature. Nevertheless, the developments which are likely to generate most economic impact are precisely in these high risk areas. They should therefore be actively supported.

A.I.P. Third National Congress

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The Australian Physicist, July 1978 83
Physics in Ghana—A Personal View

Dr. Tom Beer,

Dr. Tom Beer is a Senior Research Fellow in the Physics Department of WAIT engaged in meteorological and oceanographic work. He spent five years at the University of Ghana. From 1973 to 1976 he was a Senior Lecturer in Physics, under the sponsorship of the Australian Development Assistance Agency.

Education in Ghana is based on an adaptation of the British model. Elementary education consists of six years of primary schooling (P1-6) and four years of middle schooling (M1-4). Students enter secondary school at any stage of their middle schooling provided they pass a Common Entrance examination. Though primary education is free and compulsory it appears that only about 70% of children in the age range 6-11 years are to be found in the schools at any given time. (McClelland, 1972).

Approximately 5% of pupils proceed to secondary schools where they study a grammar school pattern of education culminating in the General Certificate of Education (GCE) examination at Ordinary level after five years and at Advanced level after two more years. The 0.4% of students who successfully negotiate the system can then enter one of three universities: the University of Ghana in the capital, Accra, responsible for law, medicine, agriculture and African Studies in addition to the arts, sciences and social sciences; the University of Science and Technology in Kumasi which provides training in architecture, engineering, arts and science, and Cape Coast which trains graduates to become teachers and hence limits its faculties to arts and science.

The universities themselves are modelled on the British system. The oldest university, The University of Ghana, started as a college of the University of London in 1948. When the University attained autonomy in 1961 it was set up under an act similar to that of British civic universities (Ashby, 1964) except that the governing body, the Council, was dominated by government representatives and the Vice-Chancellor was himself, a government appointment.

Nowadays there is a certain amount of criticism levelled at the colonial powers for having set up African universities in the image of their home university. The Times Higher Education Supplement (Evans 1977) recently claimed that "this model has proved inappropriate and irrelevant not only for the conditions of poverty which characterize such nations, but also for the task of contributing to the solution of their urgent developmental problems". This may indeed be true but it neglects the determination of the indigenous population during colonial rule to build an education system that was every bit equal to that of their colonial masters. During the era of decolonization, any radical educational innovation would have been untenable since it would have been interpreted as an attempt to foist upon them a system different from that of Oxford which was, obviously, the paragon.

The founding fathers were further confirmed in their views by the example of the University of Liberia. This institution, founded in the interwar period, was based on the ideal of the U.S. liberal-arts colleges. In their zeal to avoid this same situation, no-one in Ghana questioned whether or not the University of Liberia was fulfilling an appropriate community role within its own culture. There was unanimous agreement that standards must be maintained.

And standards are maintained. Very well indeed. Sometimes even too well. For a number of years I was an examiner for the Physics A level Examination of the West African Examinations Council, and I became increasingly concerned that the criteria for a successful paper was that it should be demonstrably more difficult than the London and Cambridge GCE A level papers.

The universities themselves also take great care with their standards. Final year undergraduate papers for both general and honours degrees are scrutinised by external examiners before being given to the candidates, and their marked scripts are checked by the external examiner afterwards, in order to ensure that the standard of a Ghanaian degree is identical with that of a comparable British degree. Until recently all the external examiners were flown in from the U.K., but over the past few years external examiners from neighbouring African countries have been used in greater numbers. The University of Ghana Physics Department's last three external examiners were Professor J. Ziman from Bristol (1969-1971), Professor Onowumichili from Josukka, Nigeria (1972-1974) and Professor O. A. A. from Ibadan, Nigeria (1975-1977).

Some of the legacies of the colonial system have proved expensive and troublesome for the University. One of the early decisions made when the University of Ghana commenced, and one followed by the other two universities, was to make the institution completely residential, with each student living in a hall of residence. This was, I believe, a wise move designed to mitigate the effects of the variable home backgrounds from which many of the students come. Besides providing suitable accommodation, the university, it was argued, would provide adequate nutrition to ensure that the student's study would not be impaired for want of an adequate diet. These laudable aims have come to grief on the twin rocks of inflation and student numbers. The system worked well for twenty-five years but, in the University of Ghana, when the student numbers reached 2600 it became clear that changes would need to be effected. As a stop-gap measure, all rooms in halls of residence were converted to double occupancy and work began on the construction of two new halls.

Nevertheless the University was reluctantly forced to admit non-resident students who were expected to find their own accommodation within the city. This was a drastic step, because all three universities are far out of the town, the public transport system is precarious and accommodation is hard to find and exorbitantly expensive.

The problem of accommodation becomes even more acute in relation to the academic staff. Colonial tradition, and necessity, decreed that Western style housing had to be built for the teaching staff and rented out (at a very nominal cost) by the University. The standard rental is 10% of one's salary. The whole public service and the state-owned corporations also provide staff housing. Since virtually nobody pays his whole rent himself, the rentals being charged for Western style housing are astronomical. When I left in 1976, a two bedroom bungalow was rented at $600-$800 per month.

The universities were unable to maintain a staff housing program to keep pace with the growth in student numbers. For a while houses were rented from downtown landlords and
staff put up there, but the universities recently found themselves unable to pay the above rents, which are aimed primarily at the U.N. and diplomatic personnel. During the 1975/1976 academic year no new appointments could be made to the University of Ghana unless the appointee already had housing! Solutions to this problem have been difficult to find since any incentive scheme to force staff to buy or build their own homes had to take cognizance of the profits being reaped by various academic staff members who did own their own homes, and were renting them out at exorbitant rents whilst paying the University quite modest incomes in return.

The great disadvantage with the universities' ideal of feeding all the students was that even at the best of times, students grumble about their food. Ghana has not had the best of times for the last fifteen years, and most of the campus disturbances (which seem to follow the well known tropical biennial oscillation) can be traced back to gastronomic grievances.

Ghana, like all developing countries, works on a cash crop economy, and its cash crop is cocoa. The world cocoa price reached a peak in 1957 and has been depressed ever since. Due to various factors, Ghana has to import much of its food, and due to the low cocoa price the government did not have the foreign exchange to do this in large quantities. This, combined with the effects of the Sahel drought in Northern Ghana, pushed the price of food beyond the universities means and led to the halls of residence being forced to charge students for their hitherto free meals.

The Students

The question "What are Ghanaian students like?" seems to be one of the commonest responses to the discovery that one has taught in a University in Ghana. Further, it is usually couched in tones of advanced commiseration based, presumably, on expectations of tales of woe.

The answer, is, of course, personal opinion, though there are a number of constraints which channel the students into a far more limited spectrum than their Australian counterparts. In view of the competition for school and university places, the lower limit is quite high. No one really incompetent can survive the system past the common entrance examination. The upper limit is artificially low, because the best school leavers tend to filter off to overseas universities and into the more attractive fields of engineering and medicine. Given this distribution, the level of achievement of students is unsurprising. The outright failure rate within the universities is low but so is the proportion awarded first class honours. In its twenty five years of existence, the University of Ghana has awarded only one first class honours degree in Physics, out of the twenty four honours degrees awarded.

University students are also very status conscious and well aware that they are an elite being given a passport to security and a degree of wealth unimaginable to the average Ghanaian, who earns a per capita income of $300. A graduate secondary school teacher earns seven times this amount, and a University lecturer earns twenty times this amount. This exalted position of academics within Ghanaian society fosters a strong academic and theoretical orientation within the students. Words in textbooks take on a ritual quality which make the suggestion that the author could be mistaken appear heretical.

Due to the poor laboratory preparation that students have had in their secondary schooling, most of them view physics very much as a theoretical exercise in manipulating equations and plucking theorems out of thin air. I certainly found the theoretical orientation and mathematical ability of the undergraduates that I taught at the University of Ghana, to be far superior to that of the undergraduates at the Western Australian Institute of Technology. However, the converse is also true. The Australian students at W.A.I.T are far superior in their manual dexterity and their willingness to try a practical, rather than a theoretical, approach to the solution of a problem.

This difference may be partly ascribable to the different home backgrounds of the two sets of students. In Australia it is common for a child to have handled and used his father's tools from an early age - at the very least he will almost certainly have swung a hammer and pulled with a screwdriver. The same will not be true of the African child - except possibly for the fortunate son of a carpenter or other village craftsman - and many a university entrant in science and engineering has never handled the most elementary of tools.

One of the most popular first year experiments that we had was an experiment designed to measure the inertial mass of a piece of metal by constructing a torsional pendulum. Simple manual crafts were required in its construction, drilling holes and bolting metal together and the students felt that they were visibly learning new skills during this experiment. How these skills would be applied in their subsequent careers is less obvious. The social system militates against a "big-man" (i.e. an important man) wielding a shovel, screwdriver or drill. This type of manual skill obviously requires no academic training and is therefore quite inappropriate for a university graduate.

The employment opportunities for university graduate physicists may indeed reinforce this view. Ghana has very little indigenous industry, and no foreign company resident in Ghana seems to want to hire a Ghanaian physicist for its R & D work. All graduates try to get a job with the civil service upon graduating, unless they are lucky enough to be accepted for a higher degree which will, in due course, lead to a university teaching position. The main civil service employer of physicists is the Ghana Atomic Energy Commission. Most graduates very reluctantly end up as secondary school teachers, a fate that even graduates of the University of Cape Coast try to avoid. In contradistinction to the high esteem in which university teaching is regarded, high school teaching has a very low status in society, only marginally better than elementary school teaching, despite the country's need for qualified teachers.

The image of a schoolteacher in many people's minds is that of a primary or middle school leaver who, as soon as he has graduated from the classroom returns to teach in it. These under-educated teachers have a reputation for pretension and autocracy that has demeaned the whole profession in most people's eyes.

With such limited, and unpleasant, job prospects it is not surprising that Ghanaian youth is clamouing to study law, medicine, engineering,
Faculty of Science students in Physics Courses at the University of Ghana

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TABLE 1.

The sudden and dramatic drop in science enrolments between 1970 and 1973 was a reason for concern and even retro- spect, inexplicable.

For some unknown reason students did not want to enrol in science in those years, but just as suddenly, in 1973, student numbers rose to their original levels. Fortunately the size of the establishment of a university department at the University of Ghana is determined by the number of teaching hours involved, so that the Faculty survived the lean years on an establishment whose size was determined by the exigencies of the fat years, and was well prepared for the subsequent restoration of student numbers. Had the Faculty’s size been determined by student numbers then the resulting confusion would have been horrible to contemplate.

Graduate Training and Research

Does a country like Ghana need graduates in Physics? Perhaps this seems a strange question to ask. It might seem obvious that a country committed to western style development and industrialization would be in dire need of physicists. It certainly does not seem so when one is actually working there. There are few institutions outside the universities and schools which can employ physics graduates usefully and even the schools might be better off with education graduates specializing in physics than with disgruntled physicists.

For the foreseeable future, no Ghanaian physics graduate need be without employment, provided he is indeed willing to teach in a secondary school. Though Ghanaization – the replacement of expatriate personnel with indigenous ones is almost complete in the civil service, the educational system at tertiary level relies very heavily on expatriate staff who, in general, arrive under the auspices of the British Council, Canadian International Development Association, U.S.A.I.D. and other services.

Ghanaians are needed to replace these expatriates, and the need for teachers is expected to increase as a larger percentage of primary school learners manages to enter a secondary school.

Australian relations with Ghana have been friendly and cordial. Australia maintains a High Commission in Accra which represents most of West Africa, with the Australian High Commission in Nigeria representing the rest of West Africa. To further foster these friendly ties, Sir Mark Oliphant was invited to give the 1969 Aggrey-Fraser-Guggisberg Memorial Lectures, which he did, choosing “Science and Mankind” as his theme (Oliphant, 1970). At his suggestion, in the following year, the Australian government sent Dr. McElhinney from A.N.U. for a short visit to advise on the initiation of geophysical teaching and research, an important work that is still being largely done by expatriates (e.g. Hastings, 1977).

Though the Ghanaian Universities maintain a steady process of Australian students studying under Commonwealth Scholarships, when I was appointed to a lectureship in Physics at the University of Ghana I was the only Australian in a tertiary position within the country, a circumstance that helped persuade the Australian Development Assistance Agency (ADAA) that it could well support my work there, in addition to the other project that they were financing: a feasibility study for the construction of a third dam on the Volta river.

Much of the research, and most of the experience gained in developed countries is quite inappropriate to developing countries. Ramage (1956) points out how the success of meteorological forecasters sent to tropical countries totally failed to improve their forecasting for 50 years because they all applied the inappropriate theory of fronts as developed by the Norwegians – to tropical air masses.

Establishing the role of scientific research in relation to developed societies has proved to be a muddy and slippery path. Establishing the role of scientific research in relation to developing societies is a veritable quixote. One person who tackled the problem (Jones, 1971) reached the unsurprising conclusions that researchers in a developing country should:

1. Help select and adapt existing scientific and technological knowledge to meet local needs;
2. Maintain contact with development agents elsewhere of potential local importance;
3. Augment existing knowledge in fields of potential relevance.

In other words, they should be engaged in a transfer of technology rather than a transfer of science. This process, when instituted, can lead to some surprising results. Both India and Brazil have thriving space programmes at a time when the U.S. is winding its programme down. The reason is that both these countries, which span vast distances, view satellite communication as being the only feasible means of linking the country at a reasonable cost. In this case it proves worthwhile to abandon the intermediate technology of ground based communication systems and jump straight into a rather expensive technology. Provided one can get satellite time then it can even prove to be relatively cheap to do this (Lawrence, 1973). The University of Ghana has maintained an active research interest in the problems of satellite communication in the tropics, but the political differences between the English and French speaking states of West Africa have so far prevented any agreement being reached on the use of satellite for regional communication.

Scientific research in Ghana as in the most developing countries (Moravcsik and Ziman, 1975) is dominated by the shortage of foreign exchange which, in the end, determines the direction and amount of research that will be done. Many developing countries, including Ghana, have a tradition of physics research in solid state physics and ionospheric physics because these are relatively inexpensive fields to pursue. It is difficult to disagree with the sentiment that science in developing countries should
be geared to a transfer of technology, but the whole reward system of science is geared to a different ethos, one which the Ghanaian Universities have. A scientist is judged by the acclaim of his international peers on the basis of his published work. Under these circumstances, faculty staff engaged in research, often in relative local isolation, tend to follow the dictates and fashions of the world's scientific community. Research work is thus frequently more relevant to the problems of the developed world than to local needs. Overseas training often exacerbates these tendencies, even when it is ostensibly aimed specifically for scientists from developing countries.

The International Centre for Theoretical Physics, in Trieste, exists to foster research in developing countries by running courses for graduate personnel from the developing world. (Morovski & Ziman, 1975). Unfortunately the centre chose to interpret Theoretical Physics in its narrowest sense and concentrates heavily on running courses in nuclear theory, elementary particles, and so on. I believe that Trieste has provided the financial and moral wherewithal for people to continue working in socially unproductive fields whereas otherwise they may well have been forced to tackle more relevant issues.

The justification that one can advance for Trieste is that it works on the premise that research, per se, is a necessary activity in the training of scientific and technical personnel and their teachers, and it provides a research environment every four years for a scientist, teacher or civil servant whose heavy teaching and administrative load makes research, or even contact with research, virtually impossible. This is indeed a real problem that needs to be solved in some way, though the universities have already gone much of the way to solving it by retaining the concept of a sabbatical leave.

Some of the administrative load will disappear as the new generation of qualified physicists comes forward to shoulder part of it. At the moment, Ghana feels it necessary to belong to as many United Nations agencies and sub-committees as it can. In practice this means that the same handful of top civil service scientists (e.g. The Directors of the Ghana Meteorological Services, the Geological Survey, etc.) are at overseas committee meetings more than they are at home. With time, the less important committees will be dropped, or delegated to more junior representatives.

As Ghana succeeds in training its new graduate level physicists, the need for middle level technical expertise becomes ever more apparent. There is no shortage of manual labour in the country, and every effort is being made to ensure a sufficient of graduate level expertise. However, the provision of technical level training in Ghana is woefully inadequate. The technicians within the universities usually began as messengers or cleaners, and by dint of loyal service were upgraded to technician, whereupon they started to receive background training in the field. In a few cases this has worked well, but in many cases it has not, so that the younger better-educated technicians (who usually have O-level qualifications) resent the superior positions of these older men. Furthermore there is no coherent national policy on technical education, most of which is handled in an ad hoc manner by the various employers. The single technical school in the country - the Accra Polytechnic - requires O-level passes for entry and concentrates on a restricted range of mechanical and electronic skills. Furthermore, students attending the polytechnic do not receive the generous government allowances that university students receive, and the concomitant financial sacrifice propels most O-level graduates into a desperate hunt for jobs, which are scarce at this level of achievement.

**Conclusion**

Though Ghana has boldly embarked on a scheme of physics education based on the Western model, the weak infrastructure on which it is based will have to lead to a local adaptation and a re-evaluation of the role of the graduate in the Ghanaian society. Physics is, in essence, a philosophy devised by western man to explain his world. It has proved to be remarkably fruitful and successful, though it may well have passed its heyday (Rose and Rose, 1969). Within this framework it deserves to be studied, as English or French deserve to be studied. However the current ethos of science inculcates a belief that the only worthwhile science is high quality, new, original work. This may be an unrealistic aim for an African society since I believe that some of the basic assumptions of western science - the idea of free enquiry, of a rigorous critical attitude - and of skepticism to received dogma - do not fit into the norms of traditional African Society. To expect an African to become a first rate scientist in the Western mould not only requires him to do his thinking and his work in a second language, it requires a break with the traditional features of a hierarchical, status conscious society. Eventually Ghana and the other African countries will synthesize a scientific form based on their own culture and their own values, but present attempts to graft a full blown research ideal into a poor developing society serve to discredit science and its practitioners.

**References**


The Australian Physicist, July 1978
Physics in the Twenties
Some Personal Reminiscences

by Walter Boas

Walter Boas was born in Berlin in 1904. He studied physics at the Technische Hochschule, Berlin from 1922 and obtained the first degree (Diploma in Engineering) in 1928. From 1928 until the end of 1933 he worked in the Kaiser-Wilhem-Institut für Metallforschung (the predecessor of the Max-Planck-Institut) mainly on problems of the plasticity of metal crystals and was awarded the Doctorate of Engineering in 1930. After 5 years in Switzerland he joined the Department of Metallurgy of the University of Melbourne in 1938 and was Senior Lecturer in Metal Physics until 1947. He then transferred to the CSIR Division of Tribophysics and was Chief of that Division until his retirement in 1969. Since then he has been Senior Associate in Metal Physics at the University of Melbourne.

The twenties was the decade during which it became increasingly clear that classical physics as we knew it then based on Newtonian mechanics failed to explain the phenomena occurring on the atomic scale, that new ideas were required, and during which quantum mechanics was created. It was an exciting period. I was then a student of physics in Berlin and some personal recollections may be of interest. However, I think that before relating these I should give a general picture of the atmosphere and life in Berlin as we, young students interested in scientific, intellectual and political matters, saw it and felt it.

Student in Berlin

We had gone through a gruesome war during which we often went hungry. The military defeat was followed by a revolution by which we got rid of the Kaiser, of militarism and the dominance of the officers' and the big landowners' classes, and, in Prussia, of the much hated three-class system of parliamentary elections in which the taxpayer had one, two or three votes depending on the amount of taxes he paid. We were enthusiastic about the success of the revolution; we felt that this was the end of an era and were full of hope for the future which we, the young generation, were to build up. From 1919 until November 1923 we had an inflation which sent prices up by a factor of $10^{12}$ and this made all savings worthless. The experience of these years made us conscious of the fact that established authorities could be toppled, that the traditional security of savings and stability of prices no longer existed. We had witnessed great changes in the social, economic and political systems in which we had been brought up. These changes were accepted as facts of life; we were prepared for further changes to occur in the process of building a better future. Thus new ideas fell on fertile ground, creativity was fostered and imagination stimulated.

There was an extraordinary concentration of talent in Berlin which made it the most cosmopolitan and exciting capital in Europe. The regular orchestra concerts had such masters as Furtwangler, Bruno Walter, Klemperer as conductors, and Schnabel, Cortot, Casals as soloists; Bruno Walter also directed Mozart overtures; outstanding productions of Hamlet, Julius Caesar, Midsummer Night's Dream and Richard III (all in German) filled the theatres; art exhibitions of works by the Expressionists and Futurists, by Picasso, Chagall gave rise to violent discussions; Josephine Baker and Marlene Dietrich appeared in cabarets - these and many other famous artists whose names are still well known even now, after 50 years, gave Berlin the atmosphere of creative activity in the arts.

The Physicists

Equally unique was the concentration of outstanding men in the various branches of science. Speaking only of physicists there was firstly Max Planck. He was the much venerated professor of theoretical physics at the University, about 65 years old; his lectures were very dull and dry keeping strictly to his books.

Nernst, about 6 years younger, was professor of experimental physics. He was small, almost completely bald, with a high-pitched squeaking voice. We, the students, did not take him quite seriously. He was pompous and vain and there were many anecdotes about him, most of them probably not true but still characteristic of how he may have acted. Amongst the certainly untrue stories is that in his famous textbook on Theoretical Chemistry (the field we now call Physical Chemistry) the alphabetic index contained the Third Law of Thermodynamics under the letter M: "My theorem".

Einstein, about 45 years old, was a much admired and publicly known figure. He was humane, kindly and witty but could also be biting. He would spare no effort to explain his ideas on relativity and cosmology to young people or to an audience not trained in physics and mathematics. For instance, he spent a couple of hours with a school boy who had written to him on some problem in relativity. In January 1921 he gave a public lecture at a special meeting of the Prussian Academy of Science (a very dignified and formal body) which I attended though still a schoolboy. The title of the lecture was "Geometry and Experience" and he tried to explain the concept of four-dimensional and finite but unbounded space. We were asked to imagine two-dimensional beings who were living on the surface of a sphere and did not know of the possibility of a third dimension. These beings would move all over the spherical surface just as bed bugs crawl all over us (DDT had not been invented at that time and bed bugs were a hazard encountered when travelling, particularly in warmer countries) but they would never be stopped by a boundary. However, when they had multiplied as bed
bugs do, the surface would be crowded and it would become obvious that the space was finite. Only Einstein could get away with such a picture without raising a protest by the dignified audience.

The centre of discussion on the latest publications was the physics colloquium held every second Wednesday from 5 to 7 o'clock in a small lecture theatre which was crowded by the staff and senior students of the University, the Technische Hochschule and the various Kaiser-Wilhelm-Institutes (the predecessors of the Max-Planck Institutes). These colloquia were organized by Max von Laue who held a chair of theoretical physics at the University and selected topics and speakers for the next session. Laue was, of course, famous for the discovery of X-ray diffraction by crystals and it was embarrassing to talk of Laue diagrams in his presence. So it had become a habit to say "the diagrams which, in your absence, Sir, we call "Laue diagrams". The colloquia were usually attended by all the leading physicists present in Berlin — Planck, Nerst, Einstein, Laue, Simon (who later became Sir Francis), Fritz London, Wigner, Szilard, Otto Hahn, Lise Meitner, Gustav Hertz (collisions of electrons and atoms), Paneth (use of isotopes as tracers, separation of isotopes), Schrodinger (after 1927), Hevesy (discoverer of Hafnium) and many others.

At the colloquia, seminars and lectures we saw and had contact with these scientists many of whom were Nobel Prize winners. We students were certainly not conscious that such a concentration of outstanding men was quite extraordinary and perhaps even unique. However we did realize that we were witnessing how ideas developed and new concepts were formulated.

The Bohr Atom

In the early twenties Bohr's model of the atom seemed to give a very satisfactory basis for the quantitative explanation of atomic spectra, the Stark and Zeeman Effects, properties of matter such as the electrical and thermal conductivities of metals, the specific heats and their change with temperature, and many chemical phenomena. When the Compton Effect was discovered in 1923 and explained in terms of the laws of the conservation of energy and momentum there was a general feeling of satisfaction that the Bohr theory was definitive and that further refinement of the theory would eliminate some of the quantitative disagreements with experimental results. The structure of physics seemed to be stable and final — apart from some minor questions.

For instance, there were difficulties with the anomalous Zeeman Effect, the fine structure of the spectral lines of the alkali metals, multiplets of atoms with several valency electrons and the Einstein-de Haas Effect. However all these difficulties were overcome, at least qualitatively, by the hypothesis that the electron has a spin and a magnetic moment (Goudsmit and Uhlenbeck 1925).

Further, when Pauli postulated the Exclusion Principle in 1925 and thus explained the periodic table of the elements this was considered as another success of Bohr's concept of the structure of the atom although there was no logical basis for the principle.

The Worries

However by that time one was already worried about some of the details of the theory. In a discussion on spectra at one of the Laue colloquia, Nernst asked how an electron which was going to jump from one orbit to another knew from the beginning to which orbit it would jump so that it could emit light of the right frequency all the time. Would an electron never change its mind during the jump? This question seemed to be silly (although unknown to us Rutherford had written to Bohr in the same terms in March 1913) and Einstein got up, patted Nernst on the shoulder and said "Nernst, sit down. This is a point you will never understand." What a snigger went through the audience!

One had also become conscious of several inconsistencies in the theory:

1. The quantum conditions had been imposed on classical mechanics without explanation and without belonging to it in any logical way.

2. There were difficulties in the use of the quantum number k related to the angular momentum.

3. The maximum velocity of the rotating electron required to produce the spin was about 300 times the velocity of light, contrary to the theory of relativity.

4. The theory of the fine-structure of one-electron spectra, band spectra and multiplets of the anomalous Zeeman Effect was not in quantitative agreement with the experiments.

5. The perturbation theory, so successful in astronomy, if applied to the multi-body problem gave wrong results.

All these points indicated that the more the theory was refined the worse became the agreement with experimental results. The general feeling was well expressed by Pauli in a letter to Kronig written in May 1925: "At present, physics is rather confused. Anyhow, it is much too complicated for me and I wish I had become a film comedian or something like that and had never had anything to do with physics".

The Revolution

It was clear that something had to happen but I don't think we expected anything quite so revolutionary as the idea that a moving particle was equivalent to a group of waves. In other words the behaviour of matter could equally well be described in terms of particles and of waves! This idea was put forward by Louis de Broglie in his Ph.D. thesis (Paris 1924) in which he also derived the relationship between the wavelength of a moving particle and its momentum, \( \lambda = h/p \).

We were stunned by de Broglie's theory and did not accept it without great doubts; it did not seem to have any meaning in reality. However in the following year Einstein and Ehrenser concluded from de Broglie's theory that electrons should be diffracted by crystals in the same way as X-rays. Two years later, in 1927, electron diffraction was indeed observed experimentally by Davison and Germer using nickel crystals and by G.P. Thomson using polycrystalline films of aluminium, gold and platinum. In the meantime Schrodinger had developed his famous wave-equation and Born, Heisenberg and Jordan (in Gottingen) had formulated quantum mechanics using matrix algebra (1926) which Schrodinger showed to be mathematically equivalent to his formulation.
Schrodinger’s reputation as an outstanding physicist was established by then and when Planck’s retirement was imminent (he turned 68 in 1926) Schrodinger’s name was put forward as a possible successor. Schrodinger had not been seen frequently in Berlin and in order to look him over he was invited to give a talk at a Laue colloquium in 1926. The rumour had gone round as to the purpose of this colloquium — a talk by a speaker not resident in Berlin was a rare event — and so we all, students and staff, went to hear the man who had shaken physics with his wave-equation 12 months earlier. The lecture room was still more overcrowded than usual. Schrodinger was obviously extremely nervous — who wouldn’t be in front of such an audience; he was only 39 years old and Planck’s chair was the most coveted chair of theoretical physics in Germany. Although his talk was rather disappointing he was appointed to the Chair.

The new idea of wave-particle duality had then been generally accepted although the meaning of the waves was still a mystery which gave rise to heated discussions. It was clear that atomic processes could not be visualized in terms of processes which were plausible and familiar from macroscopic observations. This became still more obvious after Heisenberg had established the Uncertainty Principle (1927).

However, these discussions about principles did not hinder the further development of the theory. Two important applications to solid state physics were made in 1928. Heisenberg solved the old problem of ferromagnetism, and Sommerfeld applied Fermi-Dirac statistics to the “free” (conduction) electrons in metals and explained why they did not make the large contribution to the specific heat required by the classical theory.

Thus by 1929 the days of rapid change in fundamental concepts in physics were over. Not all problems in physics had been solved but the basis had been laid for the understanding of the behaviour of matter, particularly of solids which led to the development of solid state technology. The main interest then turned from atomic physics to nuclear physics. The neutron was discovered, the neutrino was postulated and expensive accelerators were built for experiments with particles of ever increasing energies. Another era had begun.

“We have not assumed that the quantum theory, as opposed to the classical theory, is essentially a statistical theory, in the sense that only statistical conclusions can be drawn from exact data . . . In the formulation of the causal law, namely, ‘If we know the present exactly, we can predict the future,’ it is not the conclusion, but rather the premise which is false. We cannot know, as a matter of principle, the present in all its details”.

W. Heisenberg
Letters

Education and Training?

SIR,

The submission by Professor Sabine to the Williams Committee, as published in the *Australian Physicist*, (May 1978, p.60), calls for the recognition of a distinction between the processes of education and training in our society. While parts of any school curriculum, and some tertiary institutions, must fall clearly into one or the other role, I disagree that all institutions must be so rigidly divided along these lines.

Professor Sabine's contention that "the primary and secondary educational system belongs to the educational division and should have no role in preparing people for work or influencing their choice of occupation", I find quite incomprehensible. Does he seriously intend that children ought to spend 10 or 12 years of their lives undergoing an "educational" process that leaves them untrained for a subsequent occupation?

There might be some logic in attempting to split the tertiary system into "education" and "training" divisions; we undoubtedly require avenues whereby people can be intensively trained in special occupational skills (e.g. Technical Colleges; apprenticeships). We also value the Universities for the opportunities they offer to promote our intellectual development. But, training for an occupation, whether as a nurse, a farmer, a lawyer or an astronaut, extends the intellect; and education, whether in archeology, astronomy, medicine or music, affects both our choice of occupation and the degree to which we realize our potential in it. Training and education are intimately interwoven in the fabric of society.

John C. Macfarlane

Solar Energy

SIR,

In the May 1978 *Australian Physicist*, B. H. Briggs suggested that the Australian Institute of Physics should consider setting up a 'Solar Energy Research Fund'. I would support this idea and hope that our Council will give full consideration to the proposal.

However, my purpose in writing this letter is to draw your attention to the fact that in November 1977, the Western Australian Government established a Solar Energy Research Institute to encourage research and development into solar energy applications in Western Australia. While the aim is to use existing research facilities in tertiary institutions, private companies and the State Energy Commission, the Solar Energy Research Institute will have the ability to purchase and construct facilities needed for research and development. The Government made $250,000 available as an initial funding allocation and a number of grants have already been given for designated projects. In fact it is hoped that the results of some of these projects will be presented at the Third National Congress in Perth in January, 1979.

When the Institute was initiated, it was planned to encourage private industry and overseas bodies to contribute finance, either for general solar research or for specific projects. With respect to the suggestions made by Dr. Briggs, it is of interest to note that at this time twice as much money has been invested from non-Government sources, as by the Government. Thus there is some evidence that people are prepared to support solar energy research in a very positive way.

J. R. de Laster
WA Institute of Technology

Electron Spectroscopy—Student Concessions

SIR,

I write regarding our forthcoming Australian Conference on Electron Spectroscopy.

We have received representations from the Federal Executive and Victorian Branch Committee of the AIP regarding the level of the student registration fee for the Conference.

In particular, it has been pointed out to us that students frequently have to meet a significant proportion of all their conference expenses out of their own pockets, and that this problem is becoming increasingly acute with the reduced finances available to university departments.

We are therefore pleased to announce (through your columns if we may) that the registration fee for bona fide students has been reduced from $40 to $20.

John G. Jenkin
for the Organising Committee

THE A.I.P. THIRD NATIONAL PHYSICS CONGRESS

GO WEST YOUNG MAN

The Australian Physicist, July 1978 91
Australian Tracking Stations to Support Venus Space Probe

The Minister for Science, Senator Webster, has announced that the Honeysuckle Creek, Tidbinbilla and Orroral Valley tracking stations near Canberra will play an important communications role in support of the two NASA spacecraft to be sent to Venus.

The Pioneer Venus 1 spacecraft was scheduled to be launched by NASA from the Kennedy Space Centre, Florida, in May, and Pioneer Venus 2 will be launched in August. Both are scheduled to reach the planet in December.

The Honeysuckle Creek and Tidbinbilla tracking stations will support the mission by tracking, transmitting commands and receiving data from the spacecraft during their flight and during their scientific study of the cloudshrouded planet. The Orroral Valley station will provide communication support for the second-stage Centaur rocket used to launch the Pioneer Venus 1 spacecraft.

The two spacecraft will explore the atmosphere of Venus, study its surface by radar and determine its global shape and density distribution. They may shed light on why Venus has such a different atmosphere and climate from Earth despite the fact that it has a similar mass and is at a comparable distance from the Sun.

Pioneer Venus 1, an orbiting spacecraft, will make remote-sensing and direct measurements of the planet for at least eight months. Pioneer Venus 2, a multiprobe spacecraft, will separate into five separate entry craft 12 million kilometres out from the planet and measure the atmosphere from top to bottom during a period of about two hours before being silenced upon crashing into the surface. [Minister for Science, Media Release, 19 May, 1978]

ANU Involved with “First” for World Astronomy

Dr Michael Dopita, Research Fellow in the Mt. Stromlo and Siding Spring Observatories of ANU’s Research School of Physical Sciences is a member of the international astronomy team which has made the first observations of the ultraviolet radiations of the remnant of an exploding star. This type of observation is made from a satellite.

Dr Dopita has been working for nine months on ultraviolet spectrophotometry of supernova remnants with Dr Piero Benvenuti and Dr Sandro D’Odorico, the former from the European Space Agency and the latter from the Astrophysical Observatory, Asiago, Italy. The team was using its first allocation of time on the European Space Agency/UK Science Research Council/NASA International Ultraviolet Explorer satellite launched from the USA in March.

The satellite picked up radiations from the shock wave travelling through space as a result of an explosion of a star. Interstellar gas is heated by the shock to about 250,000°C and 97% of the subsequent radiation is in the far ultraviolet. Normally most of this radiation is blocked from the Earth by its atmosphere, hence the necessity to use satellites for observation.

The shock wave observed on April 9 is emitting radiations of H, He, C, N, O, Si and Ne. It resulted from a supernova about 20,000 years ago, the force of the original explosion being equivalent to about 1,000 billion billion megations of TNT.

Dr Dopita says, “Supernova remnants are very significant because we think that most of the elements of which the earth is composed had their origin in exploding stars.” [ANU Reporter, Vol. 9, No.5, April 1978]

New Equipment for ANU

Later this year new equipment, from West Germany, will be installed at ANU which should provide valuable data on impurity control in nuclear fusion research.

Dr Philip Martin, who has recently returned from the Max-Planck-Institut für Plasmaphysik says that impurity control is one of the major hurdles in obtaining high enough temperatures for fusion. The experimental capability of the new equipment will, he says, enable a more comprehensive picture of ion-surface interaction to be built than has previously been possible. Ion-surface interaction is essential to obtain information about impurities which increase radiation losses and dilute the fuel. [ANU Reporter, Vol. 9, No.5, April 28, 1978]

The “Usefulness” of High Energy Physics

Questioning the “usefulness” of high energy physics research has damped down considerably in recent years. One reason for this is the present liveliness of research, another is that high energy physics research is finding extensive applications in a variety of fields.

Accelerator and detector technologies have opened up new applications in, for example, medicine, as intense neutron sources and in a host of synchrotron radiation applications. More recently it has been thought that heavy ion accelerators could be the instruments to implode deuterium-tritium pellets and this could prove of practical value in energy production.

At present an idea is emerging for using accelerated proton beams to breed fissionable material. Perhaps the present unease about fast breeder reactors has prompted the increased interest in finding an alternative way to sustain the fuel supply for “conventional” fission reactors.

The energy potential from the total known natural reserves of uranium-235 is only a fifth of that of the known oil reserves. Not many decades can go by before all the fissile uranium ore of high grade is used up. The current procedure for manufacturing fissile fuel from non-fissile material is to use a fast breeder reactor. There are, however, several worries about this technique, mainly because of the high energy density in the breeder reactor core, which is not easy to control, and because of the dangers inherent in producing large quantities of plutonium-239.

Another approach to breeding is to start with thorium-232 and breed fissiable uranium-233 and here a conventional thermal reactor would serve. However, the breeding process for thorium is not quite efficient enough – the average fission has to yield over 2.3 slow
neutrons and the uranium-233 to thorium-232 cycle falls short of this in practical systems. Thus an economic source of neutrons could perhaps be used to top up the available neutron supply. It is here that accelerators could be used - not to undertake the full breeding process but to top up what is achieved within the reactor itself.

One 1000 GeV proton from an accelerator could produce about 50 thousand neutrons. As yet spallation neutron yields from various targets have not been systematically studied, but there is certainly incentive to start. [Cern Courier, No.5, Vol 18, 1978]

Announcement of a new temperature scale between 0.5K and 30K

The Consultative Committee for Thermometry of the International Committee of Weights and Measures has approved at its May 1978 meeting a new temperature scale, the EPT-76, which is an abbreviation of the French title “Echelle Provisoire de Temperature de 1976 entre 0.5K et 30K”. Temperatures on this scale are denoted T_{76}.

The text of the scale is to be published by the BIPM (Pavillon de Breteuil, F-92310 SEVRES) in French and English; copies will be available at the XVth International Conference on Low Temperature Physics to be held at Grenoble (France) in August 1978. The scale along with its background and derivation is to be published in Metrologia early in 1979.

The scale is designed to resolve inconsistencies between the liquid helium vapour pressure scales, the IPTS-68 and thermodynamic temperature in this range. The scale is also designed to be thermodynamically smooth and to join with the IPTS-68 at 27.1K. This scale is based on temperatures which have been assigned to eleven reference points, namely the four lower fixed points of the IPTS-68, the triple point of neon, the boiling point of helium and the superconducting transition points of cadmium, zinc, aluminium, indium and lead. The scale can be realised by interpolation between the fixed points by using the differences which are given between T_{76} and the 1958 “He and 1962 “He vapour pressure scales, the IPTS-68 platinum thermometer scale and various low temperature laboratory scales. The assigned temperatures of the reference points and differences from the established scales are intended to be consistent with both paramagnetic salt susceptibility and gas thermometry.

Measuring Wool with Lasers

An instrument that rapidly and automatically measures the fineness of wool fibres has been developed in the CSIRO Division of Textile Physics. A Sydney manufacturer, Digital Electronics, is now producing commercial instruments in collaboration with the Division.

The new instrument, known as the “fibre fineness distribution analyzer” can measure fibre snippets at the rate of 50 per second. The instrument electronically processes the measurements and passes the signals to a computer that prints the results in the form of a histogram showing the spread of fibre diameters. It completes a measurement cycle, in which several thousand fibres are measured, within a few minutes.

The operator drops a pinch of fluffy snippets, pre-washed in petroleum spirit, into a liquid circulating system. The liquid breaks up the fibres and carries them through a glass cell, where some of them intersect a circular beam of red light from a helium-neon laser. The fibres scatter the light in proportion to their diameter. The scattering events produce pulses in the detector and electronic processing records these in terms of fineness.

More information on this instrument can be obtained from: CSIRO Division of Textile Physics, “The Hermitage”, 388 Blanland Road, Ryde, NSW 2112. [CSIRO Industrial Research News 128, May 1978]

Friction and Fact

Every driver has an opinion about wheels slipping on wet roads, skidding around corners and tyres getting too hot to touch on different road surfaces. These problems are now being subjected to serious scientific enquiry at the University of New South Wales.

The mechanical components of a Leyland Mini with only one wheel on the drive axle have been mounted on the rear of a test vehicle. The wheel can be brought into contact with the road surface by a hydraulic system, which can be adjusted for the required loading. The test wheel can be adjusted to any steering angle and can operate either with free rotation, or with the Mini engine running, as a drive wheel. The friction of the wheel on the road surface, whether it is accelerating, varies in loading, and the character of the road surface are all recorded.

Dr Yandell, of the School of Civil Engineering, hopes that this research will lead to the development of accurate methods determining the surface texture required to make roads as safe as possible. [Uniken, No. 7, 1978]

PhD at Seventy-Five

Ten years after retiring at the age of 65 as a lecturer in the School of Physics, University of NSW, Dr Alf Schwartz graduated on 27 April as a Doctor of Philosophy following his original research in crystallography. Dr Schwartz who fled Austria in 1939 to escape the Nazi persecution of Jews, has a theory for longevity based on work. He said, "I don't play bowls, I don't play golf, I don't fish and I don't want to sit around waiting for my grave to open up before me, so I work and Physics is what I like to work at - it's as simple as that." [Uniken, No. 7, 1978]

New Plasma Research Department at ANU

A Plasma Research Laboratory with departmental status has been established in the Research School of Physical Sciences. Dr S. M. Hamberger has been appointed Head of the Laboratory. [ANU Reporter, May 1978]

Lightning Risk

An interesting article with the above title appeared recently in Search written by S. A. Prentice of the Department of Electrical Engineering, University of Queensland. Of the many naturally-occurring phenomena which have potential for harm to living beings, damage to property and interruption to essential services, none appears and acts with the speed of lightning. Lightning risk is therefore of a special nature and the article discusses the circumstances under which lightning occurs together with the measures needed to minimize the effects of a strike. [Search, Vol. 9, No. 6, 1978]
Elections to Academy of Science

The President of the Academy, Professor G. M. Badger, announced on 27th April that the Prince of Wales had accepted election as a Royal Fellow of the Academy.

The Academy was founded by the Queen in 1954 when she personally presented a Royal Charter of incorporation to the Foundation President, Sir Mark Oliphant, in Canberra.

The Duke of Edinburgh was elected a Royal Fellow in 1962.

Prince Charles will sign the Academy’s Charter Book during his next visit to Australia which it is hoped might coincide with the Academy’s twenty-fifth anniversary in March 1979.

At the annual meeting of the Academy today eleven new Fellows were elected. This honour is conferred on scientists for distinguished contributions by research to the advancement of the natural sciences. A few places are also reserved for those who have rendered conspicuous service to the cause of science in other ways.

Dr. L. M. Clarebrough, CSIRO Division of Chemical Physics, Melbourne: Distinguished for his contributions to physical metallurgy and metal physics, particularly by studies of atomic sized defects in metals and their relation to macroscopic properties.

Dr. R. D. S. Fraser, CSIRO Division of Protein Chemistry, Melbourne: Distinguished for his studies of the structure of fibrous proteins, particularly wool and other keratins.

Professor B. Halpern, University of Wollongong: Distinguished for his contributions to several areas, sensitive procedures for the detection of amino acids, microanalysis of proteins, and isotope techniques for the diagnosis and study of metabolic disorders and genetic defects.

Dr. A. Kerr, University of Adelaide: Distinguished for his contribution to plant pathology, particularly his method of biological control of crown gall in stone fruit crops.

Dr. P. G. Law, formerly Director of the Antarctic Division, Melbourne: Distinguished for his organization of scientific research and exploration in Antarctica over a period of 19 years. His personal participation in, and strong leadership of, these activities has established him as a major figure in Antarctic research.

Professor B. W. Ninham, Australian National University, Canberra: Distinguished for his contributions to statistical mechanics and, by the application of mathematics to chemical physics and colloid science.

Dr. C. B. Osmond, Australian National University, Canberra: Distinguished for his contributions to plant physiology, particularly relating to photosynthesis, photorespiration, and ion absorption and metabolism.

Sir Ian Potter, Company Director, Melbourne: Distinguished for his conspicuous service in the cause of science through financial advice and support to many scientific institutions and projects.

Dr. S. R. Taylor, Australian National University, Canberra: Distinguished for his studies of the abundances of trace elements in geologic materials and the application of the data to geochemical and cosmochronal problems.

Professor N. S. Trudinger, Australian National University, Canberra: Distinguished for his contributions to pure mathematics, particularly in the solution of partial differential equations.

Dr. W. T. Williams, Consultant, CSIRO Division of Tropical Crops and Pastures, Townsville: Distinguished for his contributions to plant physiology, taxonomy and ecology. He has made important advances in the numerical analysis of biological data.

New President of Academy of Science

At the annual meeting of the Academy of Science in Canberra on 27th April, 1978 Dr. L. T. Evans, until recently Chief of the largest Division of CSIRO, the Division of Plant Industry, was elected President of the Academy for a four-year term.

Dr. Evans is a distinguished plant physiologist who is influential at the international level in agricultural research. He is currently spending six months at the International Rice Research Institute in the Philippines and will then go to the Cereal Plant Breeding Institute at Cambridge. He recently succeeded Sir John Crawford as chairman of the international technical advisory committee on agricultural research for the development of the Third World. He is a Fellow of the Royal Society.

Dr. N. K. Boardman, a member of the CSIRO Executive, was elected Treasurer of the Academy and Professor R. Porter of Monash University, Melbourne was elected Secretary (Biological Sciences).

The following were elected to the governing Council of the Academy: Dr. H. J. Frith, Chief of the CSIRO Division of Wildlife Research; Professor D. H. Green, Department of Geology, University of Tasmania; Professor A. J. Pittard, Department of Microbiology, University of Melbourne; Professor H. R. Wallace, Department of Plant Pathology, University of Adelaide.

Science Medals Awarded

At the annual meeting of the Academy of Science two scientists were honoured by the award of medals.

Professor A. E. Ringwood, Professor of Geochemistry in the Research School of Earth Sciences at the Australian National University, was presented with the Matthew Flinders medal and delivered the Flinders lecture which was entitled Origin of the Earth and Moon.

The Flinders lecture is one of the most prestigious awards of the academy. Professor Ringwood is distinguished for his studies of the composition and properties of the Earth’s mantle.

Dr. R. N. Manchester of the CSIRO Division of Radiophysics was presented with the Pawsey Medal for distinguished research in experimental physics by a scientist not over the age of 35.

Dr. Manchester has an international reputation for his work on the radio stars known as pulsars.

The Pawsey medal was established to commemorate the pioneering contributions of the late Dr. J. L. Pawsey to radio-astronomy in Australia.
A Two Channel
Multiphase Signal Source
H.A. von Biel, University of Canterbury, Christchurch, New Zealand

ABSTRACT
A programmable, multiphase signal source is described for application in radio frequency polarization measurements and interferometry.

INTRODUCTION
In this paper a simple, accurate, and versatile multiphase oscillator is described. The device utilizes digital integrated circuits and, although it was specifically designed for polarization measurements of high-frequency electromagnetic waves (von Biel, 1977), it should be equally as effective in numerous other applications.

DESCRIPTION OF THE OSCILLATOR
A block diagram of the programmable multiphase oscillator is shown in Figure 1. The device is constructed entirely from TTL integrated circuit components, and operates as follows:

A crystal controlled oscillator (of frequency $f_0$) furnishes clock pulses at a rate equal to 8 times the desired local oscillator frequency. The clock pulse-rate is divided by eight in a chain of 3 binary dividers. The output is a symmetrical square wave of frequency $f_0/8$, which constitutes the serial input to a 8-bit shift register. Each time a clock pulse is applied to the shift register, the contents in the 8 registers is advanced by one position, with the serial input providing the information for register 1. As a consequence the 8 outputs from the shift register will be identical in shape and frequency to the serial input, but each differing in phase by 45° from its neighbour.

The 8 outputs from the shift register are next introduced to a programmable 8-line to 1-line multiplexer which acts as a switch between any one of its 8 input signals and its output channel, which constitutes the "slave" oscillator. The "master" oscillator is derived from any one of the outputs from the shift register. In addition to the 8 different (binary) control signals A, B, C to the 8-to-1 line multiplexer two additional control signals are provided so that control signal “9” renders the slave oscillator inoperative, and control signal “10” renders the master oscillator inoperative but restores operation of the slave oscillator.

It should be apparent from the description of the oscillator that differential phase errors between the “master” and “slave” oscillators are dependent only on the differential propagation delay between the 8-to-1 line multiplexer and the master oscillator buffer. Typical propagation delays for these devices (TTL 7400 series) are 20 nano seconds and the differential propagation delay is certainly much less than 5 nano seconds. Thus, for a 1 MHz local oscillator, the differential phase error will be constant for all phase differences and will certainly be much less than ±1.5°. In practice, for 180° phase difference between “master” and “slave”, complete cancellation was observed when the oscillator signals were added. (The frequency of the oscillator was 1.4 MHz).

APPLICATION
The oscillator described in this paper was designed to yield an output frequency of 1.4 MHz; consequently, for increments in phase of 45° the clock frequency must be 11.2 MHz. These figures should not be interpreted as representing the limits in performance; the shift register employed can be clocked at a rate of 36 MHz so that, for the components shown, the maximum output frequency can be as large as 4.5 MHz. There is, of course, no lower limit to the useful frequency. Higher frequencies may readily be obtained by frequency conversion of the two output signals, or else, by choosing appropriately “fast” logic devices.

References
Reviewed by R. P. Netterfield, National Measurement Laboratory, CSIRO, Sydney.

The ninth volume of *Physics of Thin Films* contains four review articles. The first review by J. L. Vossee "Transparent Conducting Films" discusses two types of films, thin metal layers and conducting oxides.

The second article, "Metal Dielectric Interference Filters" has been compiled from the work of many physicists and discusses filters having from one to several metal layers.

H. Raether has written a comprehensive review titled "Surface Plasma Oscillations and Their Applications" where he discusses the excitation of plasmons on the surface of rough and smooth conducting films by either electrons or electromagnetic radiation. The last chapter "Magnetic Bubble Films" by P. Chaudhari and co-workers reviews the rapid progress made in this field, discussion centres on amorphous materials and single-crystal garnet layers. Packing densities of 10⁸ bits/cm² have been observed.

All the review articles provide an up-to-date summary of both the theoretical and practical achievements that have been made in their respective fields and this volume should be a valuable reference for scientists working in these areas. This book should also be an interesting addition for those working with thin films in general. They no doubt already have access to the previous eight volumes.

Reviewed by A. B. Dexter, University of Adelaide.

Cybernetics is a subject which could be considered to be of general interest to scientists. It studies the principle of information and control which govern human activity and many natural processes. A lot of ground is covered in this book ranging from logic through Turing machines, digital computers and the brain to the analysis of language, with much else besides. Mostly the presentation is good but occasional slips occur. The expression for the entropy of a stochastic resource appears to have been misunderstood. The example of the low redundancy of James Joyce's English has been plagiarised from the classic work of Shannon and Weaver (1949).

Much time has been lost during publication because the most recent references are dated 1973 and are quoted as being 'in press'. For this reason, many of the recent advances in growth areas, such as pattern recognition, are not included.

I think that Wiener (who coined the word cybernetics) managed to convey a greater sense of excitement in his 1948 and 1961 books. However, they now have a distinct air of quaintness about them and something more modern is definitely needed. Professor George's book can be recommended to fill that role as an undergraduate or general text. But that, and no more.

EUROPE'S GIANT ACCELERATOR. Maurice Goldsmith and Edwin Shaw, Taylor and Francis Ltd. London 1977, x + 261 pp. £35.75. Supplied by the ANZ Book Co. Reviewed by S. N. Tovey, Department of Physics, University of Melbourne.

This book describes the building of one of the world's most complicated machines, the 400 GeV Super Proton Synchrotron at CERN. One of the authors was head of CERN's Public Information Office for most of the decade during which the accelerator was being designed and built, and the result is a lavishly illustrated and factually accurate account of the two intertwined tales.

The first is the story of an engineering project. Each stage in the construction is discussed in non-technical language and with fascinating details. We learn that the outside of each of the 100 magnets were jack'd-up by 1/5 mm to allow for the earth's curvature; or of the problems of power supply when the consumption, 135 MW, compares with the total demand of neighboring Geneva, and varies from zero to maximum every six seconds.

The second story is a human one. Perhaps CERN's greatest achievement is that the scientists and governments of about 12 countries have succeeded in setting up an organization where nationalism and chauvinism is rarely encountered. The book pays tribute to many of the people concerned, from the 'practical dreamers' who founded CERN to the machine builders.

I hope that libraries will purchase this book; its price places it beyond the range of many individuals who would like to read it.

Reviewed by J. Middlehurst, CSIRO Division of Food Research, North Ryde, NSW.

When all else fails, heat transfer problems must be solved by numerical methods. One has the choice of using a simulation language such as R.S.I.L. or A.C.S.I.L. or of setting up the computer solution oneself; the authors chose the latter course.

After a simple introduction to heat transfer, the equivalence between the finite difference equations and the partial differential equations is shown for the three standard co-ordinate systems. Implicit and explicit difference systems are introduced, the main emphasis being on Crank-Nicholson. There are sections on choosing grid systems, the effects of boundaries, interfaces, composite structures and non-uniform thermal properties.

In the solution of actual problems, Jacob and Gauss-Seidel iterative procedures are used and simple relaxation methods are introduced. Most of the problems relate to high temperatures but this is no handicap.

There is considerable repetition of equations and statements. This is irritating when the book is read at one sitting, but would be of considerable help to the casual reader looking for the solution to a problem, as each section tends to be complete within itself with the minimum of reference to previous sections.

Overall the book is an excellent introductory text for the physicist or chemical engineer working in this area and who has had only modest mathematical and computing experience.
Conferences

Materials Under Strain
A conference will be held at the Department of Engineering Science, University of Oxford, on 28-30 March 1979, sponsored by both the Materials and Testing Group of the Institute of Physics and by the Institution of Mechanical Engineers. Information about the programme may be obtained from Dr J. Harding, Department of Engineering Science, University of Oxford, Parks Road, Oxford OX1 3PJ, UK. Registration forms are available from the Meetings Office, Institute of Physics, 47 Belgrave Square, London SWIX 8QX.

Future Energy
An international conference on future energy concepts will be held at the IEE London on 30 Jan - 1 Feb, 1979. Information: IEE Conference Department, Savoy Place, London WC2R OBL.

Laser-Plasma Interactions
A conference will be held at the University college of North Wales, Bangor on 4-5 January 1979. Information may be obtained from The Meetings Officer, Institute of Physics, 47 Belgrave Square, London SWIX 8QX.

CSIRO
EXPERIMENTAL OFFICER division of Chemical Physics Clayton, Vic.

FIELD: X-RAY DIFFRACTION

DUTIES: To collaborate in the completion of an automatic X-ray diffractometer system involving interfacing to an in-house distributed computer system. To participate in a research program on the diffraction of X-rays and its applications.

QUALIFICATIONS: Degree or equivalent qualification in physics or chemistry with experience in computing and diffraction studies.

SALARY: Experimental Officer Class I or 2: $10,059 - $16,178 p.a.

TENURE: This is a temporary position available for a period of 12 months. Applications quoting reference number 582-152 stating full personal and professional details, and the names of at least two referees, should reach The Acting Chief, Division of Chemical Physics, CSIRO, P.O. Box 160 CLAYTON VIC. 3168 by 21 July, 1978.

UNIVERSITY OF MELBOURNE
LECTURESHIPS (LIMITED TENURE) IN THE SCHOOL OF PHYSICS

Applications are invited for two Lectureships (limited Tenure) in the School of Physics. The current research interests of the School are high energy physics, diffraction physics, low energy nuclear physics and theoretical physics.

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

QUALIFICATIONS: Ph.D. with postdoctoral experience.

SALARY: $14,984 — $19,684 per annum.

Limited tenure appointments are of two to five years duration.
The first position can be taken up on 16 January 1979 or as soon as possible thereafter, and the second position can be taken up on 17th August 1979 or as soon as possible thereafter.

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