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TRANSMISSION ELECTRON MICROSCOPY IN GEOPHYSICS

A. C. McLaren
Department of Physics, Monash University

Introduction

Transmission electron microscopy (together with the complementary techniques of optical microscopy and X-ray diffraction topography) is now being used increasingly for the direct observation of crystal defects in geologically significant materials. It is the object of this article to review briefly these techniques and to give some examples of results which have been obtained. In order to put this in context, I have prefaced it with some geological considerations from which emerges the relevance of solid state physics to certain areas of geology and geophysics. Therefore, it is hoped that what is to follow will be of interest to both earth scientists and physicists.

Metamorphism is the general term given to the changes, both physical and chemical, which take place in rocks, due mainly to heat and pressure, subsequent to their formation. The study of metamorphism is one of the major branches of modern geology. That part of such studies which deals specifically with movements and deformations of the earth’s crust brought about by forces deep within the earth is called geotectonics (or simply tectonics after the Greek tektonite meaning building). These tectonic processes are very largely responsible for rebuilding the land surface of the earth, which is continuously being eaten away by the external forces of weathering. Many other geological processes on the earth’s surface, as well as in the mantle, are associated with the dynamical behaviour of the crust and this serves to emphasize the importance of tectonics in geology. The final aim of geotectonics is the determination of the structure and history of the earth’s crust and the mechanical processes which brought it about.

Geotectonics, being a geological discipline, is essentially an observational, descriptive, and speculative science. Like geology itself, it has developed very largely independently of physics, taking from it only those parts which appeared to be needed for its own purposes. Experiments and mathematical theories which are intimately related in physics, are simply not part of traditional geology. However, geologists have at times attempted to reproduce in the laboratory certain tectonic processes by using easily deformable materials to simulate the earth’s crust. Such attempts to reproduce nature are of limited use unless the mechanical properties of rocks are known under conditions existing in nature. It is not surprising, therefore, that there is now an increasing interest in the experimental and theoretical investigations of the mechanical properties (in particular, the plastic deformation) of minerals and rocks. It should be stressed that such experiments do not attempt to reproduce naturally deformed rock textures, although this sometimes occurs; the aim is to make definitive determinations of the mechanical properties of geologically significant materials and to develop sound theories to explain their behaviour. The information obtained may then be applied to practical geological problems, provided the very much greater periods of time involved in natural geological processes are taken into account. In such studies, geotectonics and physics meet to form a new subject known as tectonophysics, which now has its own journal. Although tectonophysics is clearly as much a part of materials science as it is of geology, it has been developed almost exclusively by geologists. They have been quick to use those parts of solid-state physics, physical metallurgy, and ceramic studies which appear relevant, but the general approach, terminology, and experimental techniques have naturally been those of geology. In particular, the independent terminology has not facilitated communication between geologists on the one hand and solid-state physicists and metallurgists on the other. A strong case can be made for geology to adopt the terminology of the more fundamental sciences, at least in this field of study.

It has sometimes been implied that the basic mechanisms of the deformation of rocks will be different from those of metals. This is because of the relative chemical complexity of rocks, the more complicated crystal structures of the constituent minerals, and their brittleness under ordinary conditions. However, there is growing evidence that under the conditions at which rocks and minerals deform plastically, recover and recrystallize, the fundamental mechanisms and the submicroscopic textures which develop are very similar to those of metals. Therefore, tectonophysics has much to gain from a close association with materials science in its broadest sense.

The basis of materials science is solid-state physics,
which has now become one of the major divisions of physical sciences. It has been pointed out by van Bueren [1961], that crystal defects have such a profound influence on the physical properties of solids that in some areas solid-state physics has become equivalent to the study of defect crystals. This is particularly true of mechanical properties, which are controlled to a large extent by dislocations. However, in a qualitative way, dislocations can be used to support almost any hypothesis. In order to produce sound theories, it is now necessary to make direct observations of dislocations in order to determine their concentration, nature, motion, and interaction with each other and other crystal defects such as stacking faults, twins, and grain boundaries.

In the Department of Physics at Monash we are using optical microscopy, X-ray diffraction topography, and transmission electron microscopy for the study of crystal defects in a number of important rock-forming minerals and related synthetic crystals. Observations are being made on undeformed, as well as on experimentally and naturally deformed specimens. This work is being undertaken in close collaboration with members of the Department of Geophysics in the Institute of Advanced Studies at ANU, Canberra, and its ultimate aim is to determine the role of crystal defects in the mechanisms of crystal growth and plastic deformation of minerals and rocks.

Experimental Techniques

Rock-forming minerals which are brittle under normal conditions of temperature and pressure can often be made to deform plastically at elevated temperatures. However, such materials can be plastically deformed under compressive stress at strain rates from $5 \times 10^{-4}$ to $10^{-8}$ s$^{-1}$ at temperatures as low as 300°C upwards if the sample is confined by a (more or less) hydrostatic pressure of a few kilobars. Several forms of deformation apparatus to work under these conditions (which approach to those existing deep in the earth’s crust) have been designed and used to obtain stress-strain data for a number of minerals and rocks. The operating slip systems have been determined principally from examination of slip bands (or lines) on the surfaces of the deformed crystals. Much additional information can be obtained from examination of thin sections (about 20μm thick) of both naturally and experimentally deformed crystals in the optical microscope, especially with crossed polarizers. Since these crystals are almost invariably optically anisotropic, deformation features such as deformation bands, kink bands, twins, and recrystallized grains can be observed and their crystallographic orientation determined.

Individual dislocations cannot normally be observed in the bulk of a crystal by optical microscopy. However, a number of methods have been developed for ‘decorating’ dislocations [Amelinckx 1964] usually by diffusing a metallic phase into the crystal. This requires the crystals to be heated so that the dislocation arrangements which are observed may be characteristic of the annealed crystal rather than the original plastic deformation.

The decoration method suffers from a number of other disadvantages, the most serious being that the decoration immobilizes the dislocations and often spoils the crystal for further study.

There are, however, several X-ray techniques for the direct observation of dislocations within a crystal without damage to the crystal. These methods of X-ray topography [Amelinckx 1964] are based on the dynamical theory of X-ray diffraction from perfect crystals, in which dislocations and other defects produce local variations of the intensity of diffracted beams. In the Land method, which has become widely used, a narrow well-collimated ribbon of X rays is passed through a relatively thin (about 0.1 cm), non-absorbing crystal oriented at the exact Bragg condition for a preselected set of reflecting planes approximately normal to the crystal plate. The diffracted beam passes through a slit in an opaque screen and to a photographic plate mounted normal to this beam. By scanning the crystal and the photographic plate simultaneously through the incident beam, a record can be built up of the intensity of the diffracted beam throughout a relatively large crystal (up to 2 cm × 2 cm in area). Thus an un magnified picture (or topograph) of the crystal and its defects is produced. The topograph may be subsequently enlarged photographically. In order to image individual dislocations it is necessary to collimate the beam so that the angular width of the diffracted beam is less than 100 second. Thus the technique is useful only for the study of defects in relatively perfect single crystals. In practice, it is found that the ultimate resolution is about 10μm so that it is satisfactory only for dislocation densities up to about 10³ cm⁻². Although the technique cannot be used, therefore, for highly deformed crystals, it is extremely valuable for mapping and determining the nature of dislocations and other features associated with the growth of both natural and synthetic single crystals.

Individual dislocations and planar defects can also be observed by transmission electron microscopy. As with X-ray topography, the defects are made visible by a diffraction-contrast mechanism, and a knowledge of the dynamical theory of electron diffraction (which has many similarities to the X-ray theory) is essential for the interpretation of the images of defects [Amelinckx 1964]. Transmission electron microscopy has probably made a greater contribution than any other technique to our understanding of the nature of dislocations in general and to their role in the mechanisms of plastic deformation, work hardening, recovery, and recrystallization in metals. This is very largely due to the high resolution of the technique, which is routinely of the order of 10 Å. One of the main limitations of transmission electron microscopy is the necessity for the specimens to be of the order of 1000 Å thick so as to be transparent to the electron beam. Although such specimens may be prepared from bulk metal samples by electropolishing techniques, no equally universal and satisfactory method has been available until recently for non-metals. Of necessity, most of our observations
on non-metallic minerals have been made on crushed fracture fragments. However, in the past year, we have succeeded in putting into operation three ion-bombardment thinning units with which we are now able consistently to produce extensive thin areas from a wide range of non-metallic materials. For the first time we can now examine in the electron microscope particular regions (selected under the optical microscope) of single crystals and also the individual grains and grain-boundaries of a rock. This technique was pioneered as long ago as 1955 but only recently has it begun to be applied.

Results and Discussion

In the past our research at Monash has concentrated upon quartz, because of its importance in rocks of the earth's crust. This work is continuing, but along with it we are taking an increasing interest in materials associated with the mantle.

Both electron microscopy and X-ray topography have been used successfully to determine the atomic nature of the two important parallel-axis twins (Dauphine and Brazil) which commonly occur in quartz. This enabled us to recognize the basal planar defects in experimentally deformed natural quartz as thin bands (up to 1000 Å thick) of Brazil twin, which involves a change of hand of the screw axis of the quartz structure. In this work, which was carried out in collaboration with Professor D. T. Griggs at the Institute of Geophysics in the University of California, Los Angeles, it was also shown that the change of hand resulted from almost pure shear and that this twinning was the predominant mode of deformation at low temperatures. At temperatures above 500°C, dislocations began to play a more significant role in the deformation mechanism.

Later Professor Griggs found that the strength of quartz is dramatically reduced above a critical temperature which decreases with increasing hydrogen content of the quartz. Electron microscope observations of experimentally deformed synthetic quartz (which can contain up to one H per 10^5 Si) have supported the idea that this weakening is due to the hydrolysis of Si-O-Si linkages. The strength has been defined in two different ways: either as the initial flow stress or as the stress required to produce a certain plastic strain (say 3 per cent). Our work on this hydrolytic weakening has been carried out with Dr B. E. Hobbs at ANU and indicates that the reduction in initial flow stress with hydrogen content is due to a decrease in the Peierls stress (the fundamental friction to the glide of dislocations in a slip plane). On the other hand, the weakening as defined in the second way, is due to the influence of hydrogen in promoting dislocation climb (recovery) and therefore reducing work-hardening. At low temperatures synthetic quartz can work-harden so rapidly that an initial flow stress is not observed—the plastic region of the stress-strain curve is a smooth extension of the elastic region. Under these conditions the dislocation density is observed to increase from about 10^9 cm^-2 to 10^12 cm^-2 for only a few per cent plastic strain.

Optical features, known as deformation lamellae, are often observed in the grains of naturally deformed rocks. In experimentally deformed synthetic quartz these lamellae are frequently approximately parallel to the most active slip plane so that, together with other deformation features, they hold some potential for delineating the active slip planes in natural quartz crystals and therefore the physical conditions of deformation in a rock under geological conditions. The new ion-bombardment thinning technique for electron microscopy has made it possible for us to find that these optical features are due to dense tangles of dislocations similar to the 'carpets' of dislocations which develop during stage II hardening of face-centred cubic metals. As in metals, they also appear to be associated with work hardening and thus the operation of intersecting slip planes.

It appears that these observations of work hardening and recovery of experimentally deformed crystals will be important in understanding the deformation (and, in particular, the creep) of rocks in the crust. In view of this a programme has just started on a series of deformed quartzites from an area whose basic geology has been determined.

One of the basic problems of geophysics is the determination of the physical mechanisms and causes of earthquakes. Most theories assume that the elastic energy which is released during an earthquake was built up in the focal region over long periods of time and it has been suggested that creep in the mantle is involved. Seismic observations indicate that the mantle has a plastic layer. It is therefore relevant to study the mechanical properties of materials thought to have originated in the upper mantle or in the lower crust, such as olivine and basalt. Although our observations are clearly preliminary, both electron microscopy and X-ray topography show that the dislocation arrangements in natural olivine are characteristic of a material which has undergone creep. These arrangements have also been correlated with optical features.

In conclusion it should, perhaps, be pointed out that several other groups are using transmission electron microscopy to study geological materials. Nissen and Bollmann in Switzerland have made a detailed study of the feldspars, mainly because of an interest in phase equilibria. In the USA a group headed by Dr J. M. Christie at UCLA is using a 1-MeV electron microscope to study moon rocks. Although the use of transmission electron microscopy in geological studies is still not large, there are indications that its use will probably increase rapidly. Now that a suitable method of specimen preparation is available, electron microscopy may well have an impact on some areas of geophysics similar to its impact on metallurgy following the initial observations of dislocations in 1956.

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Acknowledgements

It is clear that our work has depended considerably upon the collaboration with geologists and geophysicists and I would like to thank Professor J. C. Jaeger, FAA, FRS, at ANU, and Professor D. T. Griggs at UCLA for the generous, friendly hospitality and encouragement I have received in their Departments. However, I would particularly like to thank Professor R. Street for his enthusiastic support and the great pleasure I have in being a member of the Department which he created.

References

The following references provide a basis for the topics covered:


BOOK REVIEWS


Reviewed by M. J. Puttock, CSIRO National Standards Laboratory, Sydney.

When two first-rate experimental physicists combine to write a book on a topic which for both, in complementary fashion, has been the raison d'être of their scientific activity for some two decades or more, the reader is entitled to expect something good. The reader will not be disappointed, the authors have produced a small treatise, on what is perhaps the most intriguing fundamental constant in physics, which not only gives an excellent account of experimental determinations of $c$ from the 17th century but which is also a joy to read.

The theme which runs right through this book is precision and the elimination, and/or assessment, of errors. The earlier work, particularly that prior to 1900, is of necessity treated less fully than the most recent highly precise determinations, and the authors have subjected their own work to quite rigorous analysis. One chapter deals specifically with the relationship of the standards of length and time to $c$, the effect of their inherent inaccuracies and of the inaccuracies arising from the refractivity of air.

Sufficient electromagnetic theory is given for the understanding of the various experimental techniques—cavity resonator, microwave and radio-wave interferometers, modulated light and microwave, etc.—and for the understanding of the calculations, computation of corrections, and analysis of errors.

The final chapter deals briefly with a number of new determinations currently in progress or under consideration. The references, and bibliography, are comprehensive and provide excellent extension reading.

There are, regrettably, a number of errors in the text which indicate poor proofreading and a few for which the authors must accept responsibility. Australian scientists will be intrigued to find that South Africa is the home of the Commonwealth Scientific and Industrial Research Organization! The textual errors, however, do not detract from the value of this book to all scientists and it should be compulsory reading for all science undergraduates.


Reviewed by A. G. Klein, School of Physics, University of Melbourne.

This excellent book fills the dual needs for a basic text as well as a compendium of current practice in nuclear electronics. It begins with a chapter on Radiation Detectors and Related Circuits which, in a somewhat condensed form, deals with the electronic aspects of detectors and design considerations for preamplifiers. The middle chapters contain clear and accurate discussions of such topics as pulse shaping, amplitude and time resolution, and analogue-to-digital conversion, alongside descriptions of techniques used in pulse amplifiers, discriminators, coincidence circuits, time-to-pulse-height converters, etc. The topics are systematically treated and well illustrated with many examples drawn from recent literature.

Up to this point we have a thorough, well-referenced review of signal processing in nuclear physics. There follows a chapter on Digital Circuits which, while admirably clear on the basic ideas, is somewhat more sketchy and does not attempt to cover the vast literature in this field. The final chapter, on Data Processing, is little more than a glimpse into the broader possibilities opened up by computer techniques: on-line computers are only briefly mentioned.

A knowledge of basic electronics is assumed throughout the text but Laplace Transforms and Noise are treated in an appendix. A Bibliography of over 900 references lists most of the important contributions to the field up to 1968 and, together with the text, forms a valuable index to the 'top 100 circuits'. It is to be hoped that a cheaper edition will allow all experimental physicists to own a copy.

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HARVARD PROJECT PHYSICS

P. E. Ciddor
CSIRO Division of Applied Physics, National Standards Laboratory

Introduction
In 1973 senior secondary pupils in NSW will be offered a new syllabus in science. There will be a multi-strand terminal course for non-specialists, and a choice of two specialized courses, one comprising 6 hours per week for each of two subjects chosen from Physics, Chemistry, Biology, and Geology, the other comprising 4 hours per week each of Physics, Chemistry, and either Biology or Geology.

The Syllabus Committee of the Board of Senior School Studies is considering various sets of resource materials for the new syllabus. The PSSC course in its present form is thought to be too academic. One of the well-documented courses is Harvard Project Physics (HPP), which is receiving considerable support in the USA. During 1970, trials of HPP are being run in three independent schools, within the framework of the present Higher School Certificate syllabus and examination. In 1971 about twenty more schools, government and private, will join the trials.

To assist the trial schools, a group was established at Macquarie University, consisting of two teachers on secondment from the Department of Education and three tutors from the School of Mathematics and Physics who have experience as schoolteachers. The NSW Section of the Education Group offered to assist in this work, and this report is largely based on our participation so far.

The Harvard Approach to Physics
The most characteristic and striking features of HPP are its multi-media resources and its historical and cultural emphasis. The avowed aims of the originators of the course were as follows:

1. To provide an alternative to the rather academic PSSC course in order to stem the drift from physics in US schools.
2. To provide a coherent, tested course, emphasizing concepts and the historical and cultural background.
3. To supply the teacher with sets of resource materials which would appeal in one way or another to every pupil, and which would be adaptable to existing classes and facilities, especially PSSC films and equipment.
4. To stimulate fresh consideration of the role of the teacher and of the use of new teaching techniques.

From a start in 1964, a vast array of material was developed, and was revised annually until 1969. The first full-scale publication will be during 1970, but the trials have covered some 8000 pupils in 100 schools in the USA.

The basic course consists of six units:

1. Concepts of motion,
2. Motion in the Heavens,
3. The Triumph of Mechanics,
4. Light and Electromagnetism,
5. Models of the Atom,
6. The Nucleus.

For each of these units the student is supplied with
(a) a text,
(b) a reader, which contains short stories, classical papers, poems, Scientific American reprints, biographies, etc.,
(c) a set of test papers,
(d) programmed-learning booklets on topics such as vectors,
(e) a laboratory handbook.

The teacher has a guide, which reprints all the students' material (except the reader), and is generously supplemented with marginal hints on presentation, solutions to problems, advice on setting-up experiments, guides to further reading, suggested teaching schedules, directories of film loops and films, etc. The intention is to supply enough information to remedy any deficiency in the teacher's background.

The library of film loops contains about 50 titles, and extensive use is made of PSSC films.

The Trials Program in NSW—A Progress Report
In response to an invitation from the Board of Senior School Studies, three teachers with experience in PSSC teaching undertook to run trials of HPP subject to the constraint that their pupils must sit for the standard Higher School Certificate examination at the end of Sixth Form.

The Education Group sponsored a symposium in June at which progress in the trials was reported to over 150 people, largely teachers. Professor S. T. Butler, Chairman of the Science Syllabus Committee, briefly explained the background to the trials, and then Mr I. Guy (School of Physics and Mathematics, Macquarie University) described the aims and methods of HPP physics. The preceding section of this article is based on Mr Guy's talk.

The next speaker was Mr A. J. Rentoul (Knox Grammar) who discussed his experiences with two classes, each of 22 selected pupils. Both classes intend to sit for level 2F Science (a full, professionally-oriented course in physics and chemistry with some treatment of biology and geology). In addition, one class will sit for the Level I paper in Physics (based on additional work in one or two specified topics, such as quantum theory, rotational dynamics, and the periodic table). The second class will sit for Level I Chemistry. (In
each case the chemistry work is also based on a new course—Chemical Studies.) The classes do 6 periods per week of the ‘major’ topic and 4 of the other. At the present rate, the course should be completed in 4½ terms (50 weeks), leaving adequate time for the Level 1 topics, revision, and material not in HPP but required for the HSC examination. Mr Rentoul emphasized the following points:

1. Film loops are in constant use and must be readily accessible as must air tracks, Polaroid camera, etc.
2. Very little time is spent in lecturing to the class; instead, the emphasis is on experiments, readings, viewing film loops, and solving problems.
3. Students must be weaned from passivity and examination domination and encouraged to experiment, observe, and discuss.
4. The teacher must adopt a stimulating style, and must guide each student to the media best suited to him.
5. Most of the teacher’s work is done before class, in preparing equipment, selecting films, etc.
6. The Readers were particularly appreciated by the more able pupils.

Sister M. Neal (Convent of the Sacred Heart, Rose Bay) spoke briefly of her experience in teaching HPP to an unselected group of 17 girls. The humanistic approach and relevance to real life situations appealed strongly to most girls.

Practical demonstrations of some of the experimental equipment were given after the symposium. Some of the equipment was made commercially for HPP, and some was modified PSCE or other school equipment. A substantial number of prototypes made by the group at Macquarie were shown.

Some Physicists’ Comments on the Course Materials

Through the courtesy of Longman of Australia, a set of printed materials was made available to the Education Group. What follows is a selection of comments made by various members of CSIRO and University staff who have read one or other of the Units.

The most striking feature is undoubtedly the generous amount of historical background. Particular care is taken to set the work of Galileo, for instance, or of Faraday, in the context of contemporary knowledge and concepts. The historical context is emphasized by a number of Time Charts, in which the periods of artists, politicians, musicians, poets, novelists, and so on are shown alongside the life span of, say, Newton. The cultural background is illustrated by poems and paintings, many of which reflect the science of the day. Portraits and biographies appear in generous numbers.

The Readers, of course, add greatly to this background, and it is hard to imagine anyone failing to find at least a few interesting articles in each book. To give an idea of the contents, here is a selection (from among 21 items) in Reader 5, ‘Models of the Atom’:

A chapter from a book by C. P. Snow on ‘Failure and Success’,
L. Infeld on Einstein,
Gamow on Mr Tompkins and Simultaneity,
Einstein and Infeld on Elevators and Gravitation,
Schrodinger on Wave Mechanics,
‘The Sentinel’ by A. C. Clarke (the genesis of ‘2001’),
Feynman on Looking for a New Law.

There is little mathematical development in the texts, the emphasis is rather on the observation of new phenomena and the hypotheses and new concepts which arose to account for them.

The experimental work is marked by two features: the simplicity of the apparatus and multiplicity of methods for studying one topic. The idea seems to be that three or four different ways of doing an experiment will be tackled by members of a class, who will then compare notes. In many cases the film loops become raw observational data. For example, a slow-motion film of a falling sphere is to be timed and measured in a study of the law of falling bodies. In another example a photograph or transparency of portion of the moon is used, in conjunction with data on the angle of the sun, etc., to measure the height of a lunar mountain. The teacher’s guide supplies hints on how to set up apparatus and how to cope with faults or misadjustments, and where to buy (in the USA) special items.

One whole Unit (No 2) is devoted to astronomy, and there is a large number of projects in positional astronomy. Some of these require observations over many months, and of course the descriptions are geared to the northern hemisphere. (The Syllabus Committee in NSW will require publishers of approved material to adapt such material to Australian conditions).

The Role of the Education Group

In addition to organizing the symposium in June, and two introductory talks in March, the Group has offered to help in the development of experimental equipment and in the adaptation of the texts to local conditions. The precise tasks and the procedural arrangements remain to be settled, but already Mr J. McAllan (CSIRO) has prepared a set of notes on the adjustment and use of the astronomical telescope which is standard (and hitherto unused) equipment in all High Schools. It is hoped that these notes and the HPP film loops will enable the trial schools to engage in the practical astronomy which is a major component of the Harvard course.

The Group has also offered to act as a clearing house for inquiries as to sources of materials, specific problems in physics, and the availability of tours of relevant industrial organizations.

Two members of the Group, Mr M. Henderson (Sydney Teachers’ College) and Mr J. Kirby (Macquarie), together with Mr B. Price (Education Department), have been sponsored by the US National Science Foundation and Longmans to attend summer schools on HPP in various parts of the USA.
INSTITUTE AFFAIRS

16th MEETING OF COUNCIL

The 16th Council Meeting was held in Clunies Ross House on 25 and 26 May 1970. Following a resolution of the previous Meeting, no central Institute funds were made available to subsidize travel to this Meeting, and three Branch Chairmen who were unable to attend in person (Queensland, Tasmania and Western Australia) were represented by proxies. The President, Mr A. F. A. Harper, was in the chair.

Finance

The Honorary Treasurer reported that at the halfway point in the financial year the expense levels were running close to budget. Further investment of reserve funds had been arranged, to take advantage of the current high interest rates.

Unpaid subscriptions continue to present a problem. A list of 47 members unfinancial for 1969 was tabled, and it was resolved that the names of those who had not paid by 31 July 1970 would be removed from the register.

The Honorary Secretary reported that the Institute had applied for and been granted exemption from Victorian stamp duty, following similar successful action by the NSW Branch.

Administration

The Institute had been sharing staff and an office in Clunies Ross House with the Australian Institute of Refrigeration, Air Conditioning and Heating, Inc. (AIRAH) for a period approaching two years. The Honorary Secretary reported the results of an extended time study taken over 12½ months, which revealed that the office time had been apportioned between the two institutes in the ratio: AIP 50.5%, AIRAH 49.5%.

The level of staffing of the office (Mrs J. A. Mackenzie plus two part-time assistants) had proved to be inadequate to handle the volume of work satisfactorily, and the decision had been taken to replace one of the part-time assistants by one full-time.

Recently AIP and AIRAH had been approached by the Solar Energy Society, which was about to transfer its world headquarters from USA to Australia. The SES had requested admission to the office partnership on an equal one-third basis. It was noted that even after employing additional part-time staff to handle SES work there would be substantial cost saving to the two original partners. Council approved the admission of SES to the partnership, subject to the agreement of AIRAH and of the Ian Clunies Ross Memorial Foundation.

Membership

The Honorary Registrar reported that corporate membership had increased to 1232 and overall membership to 1549.

The Institute reserves the grade of Honorary Fellow for those whom it especially wishes to honour. Council unanimously resolved to invite Mr K. C. Lang, Emeritus Professor H. C. Webster, and Sir Frederick White, three distinguished Fellows of the Institute to accept Honorary Fellowship. Citations appear elsewhere in this issue of ‘The Australian Physicist’.

‘The Australian Physicist’

A report from the Editor stated that the new printers were providing excellent service and that the delays in publication had been overcome. It was now necessary to increase the amount of advertising revenue to make the journal more nearly self-sufficient financially.

It was stressed that more editorial material was also needed, both articles and information on Branch and Group activities.

Lectures and Conferences

The NSW Branch Chairman reported that the conference on the Geophysics of the Earth and the Oceans, held at the University of NSW on 19-23 January 1970, had been most successful.

The Queensland Branch, in conjunction with the Astronomical Society of Australia, was to hold a conference on ‘The Physics of Stellar Atmospheres’ on 27-29 May, immediately following the Council Meeting.

A conference on the Transport Properties of Matter was to be held by the NSW Branch at the University of Sydney, on 27-29 August 1970.

The Victorian Branch Chairman reported that the 1970 Pawsey Memorial Lecture would be delivered by Dr C. H. B. Priestley in October.

The 1971 Conference and Summer School, organized by the NSW Branch, was to be held in Armidale on 8-12 February. Topics were to be Nuclear Physics, the Physics of Simple Liquids, and Biophysics.

Group Activities

The Biophysics Group observer reported that the Tenth Annual Meeting of Physics in Medicine and Biology was to be held at Clunies Ross House on 24-28 August 1970. A trade exhibition was to be included in the arrangements.

The Vacuum Physics Group was to hold its Second National Symposium-Exhibition at the University of Sydney on 24-26 August 1970.

The Geophysics Group, whose secretariat had moved from South Australia to Victoria earlier in the year, was bringing the Stable Auroral Red Arcs project to a successful conclusion.

The Education Group was also in the process of moving its secretariat, from Western Australia to South Australia.

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Training and Employment of Physicists

Following the publication of Mr F. Argy’s paper in the January 1970 issue of ‘The Australian Physicist’, there had been considerable discussion on the implications of the results of the 1968 Survey of Physicists. A small committee was set up, headed by the Victorian Branch Chairman, to investigate this question and report back to Council.

Equal Pay for Women Physicists

Following a motion carried at the 7th Annual General Meeting, Council agreed to refer this matter back to the Branches so that a considered policy could be formulated.

By-Law 43 (2)

Branch committees had found it difficult to operate under this By-Law, which prevented a committeeman (with certain exceptions) from holding office for more than four years. In particular, it tended to prevent experienced committeemen from becoming Chairmen of Branches. Council agreed to change the period from four to eight years. A formal notification of this amendment appears elsewhere in this issue.

17th Council Meeting

The dates of the 17th Council Meeting were set as 29 and 30 October 1970.

AMENDMENT TO BY-LAW 43 (2)

Notice is hereby given to all members that By-Law 43 (2) has been amended by deletion of the word ‘four’ and substitution of the word ‘eight’. The By-Law now reads as follows:

‘No member may hold the office of Chairman or Vice-Chairman for more than two consecutive full terms of office nor shall any committeeman hold office for more than eight consecutive terms of office excepting the office of Honorary Treasurer or Honorary Secretary or Honorary Secretary-Treasurer.’

J. G. CAMPBELL
Honorary Secretary

ELECTION TO HONORARY FELLOWSHIP

Honorary Fellowship of the Institute is reserved for distinguished persons intimately connected with physics or a science allied thereto with whom the Institute specially desires to honour for outstanding services in connection with that science. Previously honoured in this way have been Dr G. H. Briggs, the late Dr H. R. Lang, Dr J. S. Rogers and the late Emeritus Professor A. D. Ross.

Council has now unanimously agreed that Mr K. C. Lang, Emeritus Professor H. C. Webster and Sir Frederick White, all fellows of the Institute, should also be so honoured in recognition of their outstanding services. Citations appear below.

K. C. Lang, MSc, MA, FInstP, HonFAIP

Mr K. C. Lang, who is a Superintending Scientist in the Canberra office of the Department of Supply, graduated MSc with first class honours and the Kerosen Research Scholarship in 1931, and MA in Mathematics in 1932. Much of his career as a physicist was spent as Physicist in charge of Metrology in the Defence Standards Laboratories. He was engaged on this metrology work during World War II when it was a matter of prime national importance that the establishment and dissemination of standards for defence production should be done at a high level of skill and with expedition.

Mr Lang has been a Fellow of the Institute of Physics since 1945, and is a founder Fellow of the Australian Institute of Physics. His election to Honorary Fellowship marks his continuing and active interest in the affairs of professional physics in Australia over many years.

As a matter of simple statistics, he was an office bearer of the Institute of Physics or the Australian Institute of Physics for a period of eighteen years with the exception of a short break while he was overseas. He has been noted mainly for his duties as Secretary of the Victorian Division of the Institute of Physics, the Australian Branch of the Institute of Physics and the Victorian Branch of the Australian Institute of Physics. The number of years alone does not reflect properly the enthusiasm of Mr Lang for the task. He has always been willing to take on secretarial and treasurer’s duties, to participate in the organisation of exhibitions and seminars, and to be helpful in an un-sung way with the business generally of the Institutes. Even during his tour of duty in London he acted as a sort of unofficial liaison officer and took part in the early discussions which led to the formation of the Australian Institute.
Emeritus Professor H. C. Webster, CMG, PhD, DSc, FInstP, HonFAIP, FIEE

Professor Webster graduated from the University of Tasmania in 1926 and studied for his PhD at Cambridge, under the direction of Lord Rutherford and Sir James Chadwick. After spending two years at the University of Bristol he took up a fellowship in the University of Melbourne. In 1933 he joined the staff of the Commonwealth Radio Research Board.

Professor Webster's association with the University of Queensland started in 1937, when he was appointed to a lectureship in biophysics, and his interest in medical applications of physics has continued since that time. He has had an unbroken association with the Queensland Radium Institute, and has been a member of the Radiological Advisory Council and of the Queensland Health Education Council. He is the joint author of a book entitled 'Medical and Biological Physics'.

From 1940 to 1945, he was seconded to the CSIR for work at the Australian Scientific Liaison Office in London, and at the Division of Radiophysics in Sydney. In 1946 he returned to the University of Queensland as Associate Professor in Radiation Physics, and, when appointed to the Chair of Physics in 1949, he set out to build a department with a strong postgraduate school in ionospheric physics. His efforts have brought wide recognition, and he has undoubtedly rendered valuable service to Australian science. He was a member of the Radio Research Board from 1949 to 1970, serving as its Chairman from 1963 to 1970. He is a member of Commission VIII of the Union de Radio Scientifique Internationale, and was convenor of the Australian National Committee for the International Geophysical Year.

Professor Webster has also played an important part in the rapid development of scientific education that has taken place during the last decade. He was a member of the Commonwealth Advisory Committee on Standards for Science Facilities in Independent Secondary Schools, a member of the Advisory Board for Academic Studies for the Royal Military Academy at Duntroon, and a member of the CSIRO Studentship Committee. He was a member of the Australian Research Grants Committee, and a member of the Council and Executive of the Australian Institute for Nuclear Science and Engineering. During 1958-59, he was President of the Australian Branch of the Institute of Physics (London). He has maintained an active interest in the affairs of the AIP since its formation.

In spite of these national commitments, some of which have required a great deal of time and effort, he continued to give energetic and active leadership in the University of Queensland, both at the departmental and general administrative level and was at various times a member of the Senate, Chairman of the Research Committee, Deputy President of the Professorial Board, and Acting Deputy Vice-Chancellor.

Professor Webster retired from the Chair this year and is currently devoting his considerable abilities to his new position of Scientific Counsellor in the Australian Embassy in Washington, USA.

Sir Frederick White, KBE, PhD, HonDSc(ANU), HonDSc(Monash), HonFAIP, FAA, FRS

It would be easy to write a formal citation for Sir Frederick White since he has had a career of unusual distinction during which he has fully earned the many high honours bestowed upon him. But such a citation would appear superfluous as the story of his achievements is well-known to members and any cold formality seems particularly inappropriate since, in spite of his knighthood and his dominant position in the administration of Australian science, he is known affectionately to members as 'Fred', which symbolizes as well as anything his friendliness, his modesty and his complete absence of 'side'.

The Institute has reason to be grateful in that during the twenty-five years he served on the Executive of CSIRO, the last eleven as Chairman, Sir Frederick maintained a keen interest in the affairs of the Institute which he served in many capacities including Chairmanship of the Australian Branch of the Institute of Physics and the Physical Society. In spite of his innumerable commitments he is a regular attender at meetings and retains his interest in all branches of physics. However he cannot conceal the extra twinkle in his eye and the even more contented puff of his pipe whenever the subject is related to radiophysics.

It is already obvious that our new Honorary Fellow has no intention of retiring from scientific affairs. Shortly after retiring from the Chairmanship of CSIRO he left for London to serve as Leader of the Australian Delegation to the Commonwealth Agricultural Bureaux Review Conference. He was also recently elected Chairman of the Council of ANZAAS and no doubt he will assume many other responsibilities. In spite of these, his fishing experiments, and his wide circle of friends, it is to be hoped that Sir Frederick will be able to maintain an active interest in Institute affairs and that his friendly figure will often be in evidence at our Meetings.
THE REGISTER

CHANGES IN MEMBERSHIP FROM 8 JUNE 1970 TO 13 JULY 1970

Fellowship
New Elections
Opat, G. I.
University of Melbourne, Victoria
Pilbrow, J. R.
Monash University, Victoria

Associateship
(a) New Elections
Townsend, P. N.
Royal Melbourne Institute of Technology, Vic.
(b) Transfer
Cashion, J. D.
Monash University, Victoria

Graduateship
(a) New Elections
Lung, P. W.
Varian-Techtron Pty Ltd, Springvale North, Vic.
Myint, K.
Arts-Science University, Mandalay, Burma
(b) Transfers
Brown, K.
BHP Central Research Laboratories, Dudley, NSW
Burns, A. R.
Western Australian School of Mines, WA
Creer, J. G.
Monash University, Victoria
Price, D. C.
Monash University, Victoria
(c) Resignation
Walsh, R. L.
New South Wales

Students
New Elections
Collins, A. R. (NSW)
Currie, P. D. (Vic.)
Hawke, G. S. (NSW)
Holland, G. J. (NSW)
Louis, J. P. (NSW)
Silins, J. (Vic.)

Subscriber
Resignation
Fjelstul, C. R. (Qld)

Company Subscribers
Resignations
Astronic Imports (Vic.)
EMI Electronics (SA)

BOOK REVIEWS

AN INTRODUCTION TO X-RAY CRYSTALLOGRAPHY, M. M. Woolfson. Cambridge University Press. ix + 380 pp. £4.25.

This book has been designed for the senior undergraduate or graduate student beginning a career in crystallography. It succeeds exceptionally well in this aim and is eminently suitable as a basic text book for any research worker using techniques requiring the collection and analysis of the relative intensities of Bragg reflections from a crystalline solid.

In Chapter 1 the symmetry of the crystalline state is discussed with particular emphasis on how to use the International Tables of X-ray Crystallography.

Chapter 2 contains an account of X-ray scattering theory. The treatment is very clear with precise definitions of symbols and quantities.

Chapter 3 is devoted to scattering from a crystal and introduces the concept of the reciprocal lattice. In Chapter 4 Fourier transforms and convolutions are introduced with many detailed and clear worked examples.

Chapter 5 deals with experimental techniques, particularly the photographic methods. One particularly useful section, which is ignored in most books is a detailed description of a systematic alignment procedure for crystals. The principles of all common instruments are described with diagrams. The corrections to the experimental data for the Lorentz factor, polarization, absorption, and extinction are explained in Chapter 6.

Various physical tests for the lack of a centre of symmetry are given in Chapter 7. These include measurements of piezoelectricity, pyroelectricity, and optical activity. The emphasis is on simple methods of measurement with apparatus usually available to the crystallographer.

Chapter 8 contains methods for finding a trial structure. These include Patterson methods, heavy atom methods, anomalous scattering, inequality, and sign relationships.

Finally refinement procedures are given using both Fourier and least-squares methods.

Each chapter is followed by a set of problems with the solutions given in an appendix.

This book is the best text I have seen for that part of a course in crystallography dealing with structure analysis. I thoroughly recommend it to all laboratories and students.

Reviewed by T. M. Sabine, Australian Atomic Energy Commission, Lucas Heights, NSW.

This book contains the papers presented at an international conference held in September 1968. It opens with a section on X-ray optics including a comprehensive article on X-ray interferometry. There are several short articles on recent developments in X-ray reflection optics, the figuring of X-ray lenses, and applications in solar astronomy.

Electron microprobe analysis is considered next with emphasis on experimental limitations.

In the section on quantitative microprobe analysis, most of the discussion is about methods used to calculate corrections to experimental data. These corrections are required because of the lack of knowledge of the exact value of quantities like the mass-absorption coefficient.

Instrumentation is discussed with emphasis on recent advances such as the use of solid state detectors, scanning systems, detectors for back-scattered electrons, and grazing-incidence grating spectrometers.

There is an article on proton microanalysis in which a proton beam is used to excite characteristic X-radiation in heavy elements. The complimentary technique of characterizing the capture of γ rays from light nuclei is also mentioned.

The photo-emission microscope, based on the emission of photo electrons from the surface of a specimen irradiated with ultraviolet light, is suggested as particularly suitable for metallurgy, although the theory is not well understood.

As examples of the limits that are reached, analyses for beryllium and oxygen are discussed in detail. It is recognized that bonding effects may influence the intensity of the X-radiation excited in specimens containing oxygen.

Several papers are devoted to the use of Kossel-line techniques for determination of lattice spacings and crystal orientations on a microscale.

The final third of the book is devoted to miscellaneous topics including examples of the use of microprobe techniques in metallurgy, geology, and biology.

In general this book is beautifully produced, even to colour plates, but suffers badly from insufficient editing. My impression is that all papers given at the conference are reproduced without very much consideration of their relevance. There is, for example, a paper on the small-angle scattering of neutrons by magnetic materials, which, irrespective of the merits of the paper, has nothing to do with X-ray optics. In another paper we are treated to the statement "We now perform the correction calculation twice, using for the value of the mass-attenuation coefficient in question first the upper boundary value, and then the lower boundary value of the uncertainty range. The difference between the results indicates the resulting uncertainty. I can recommend this book only to libraries specializing in the literature of microprobe analysis.


Reviewed by R. J. Bray, CSIRO Division of Physics, Sydney.

Our knowledge of the sun has expanded enormously in recent years, and the last decade has seen the publication of a number of specialist monographs dealing with particular aspects of the subject, including chromospheric flares, sunspots, the solar granulation, the corona, and solar radio astronomy. Therefore, a single volume devoted to solar physics cannot attempt to cover the whole subject in depth but instead must concentrate on up-to-date reviews of some of the more important growing-points. The present book, the proceedings of a NATO advanced study institute held at Lagonissi, Greece in 1965, admirably fulfils this aim. Although some of the papers are of such specialized interest that a journal would be a more appropriate medium of publication, nearly one-half are valuable reviews of topics currently exciting considerable interest. These include accounts of recent solar models (Pagel), element abundances in the sun's atmosphere (Müller), inhomogeneities (Michard), shock waves (Schatzman), solar magnetic fields (von Kluber), chromospheric physical conditions (Giovannelli), flares (Bruck), and solar observations from space vehicles (Goldberg). The level of exposition is appropriate to research students and established workers in the field; both categories will find much to interest them.


Reviewed by C. N. Watson-Munro, University of Sydney.

This is the third volume of a series which the editors claim is 'to provide a vehicle for surveys stemming from the various branches of plasma physics and to provide communication among them'. I think a fairer description of the book would be 'some topics in theoretical plasma physics of principle detailed interest to the authors'. With so many exciting things happening in plasma physics, particularly in the Russian and the American containment experiments, one would have hoped that a book with the title 'Advances in Plasma Physics' might have mentioned a subject such as this, or some of the interesting information and results coming from astrophysics.

The three articles in themselves are substantial contributions to theoretical plasma physics and could easily have been published as small monographs or elsewhere. The first paper by D. E. Baldwin, I. B. Bernstein, and M. P. H. Weenink on the 'Kinetic Theory of Plasma Waves in a Magnetic Field' discusses the propagation of these waves under a variety of conditions and includes...
some information on the decoupling of longitudinal modes. In the second article by I. B. Bernstein of Yale University, a novel perturbation expansion of the electron Boltzmann equation is used to obtain the usual transport coefficients in a weakly ionized gas. The last contribution by E. C. Harris is a discussion of a method of treating nonlinear phenomena in plasma by the use of quantum-mechanical models. It seems curious to introduce quantum behaviour and then take the classical limit, but this method of treatment does bring out some information that cannot be got in the normal classical way.

I recommend that the book should be available in the library of any organization undertaking plasma-physics research; it could be particularly useful for physicists who are giving graduate lectures in theoretical plasma physics.


Reviewed by H. J. Goldsmid, School of Physics, University of New South Wales.

In the early 1950's, a few enthusiasts started to work on compounds formed from the Group III and Group V elements in the expectation that they would be semiconductors with perhaps superior properties to those of silicon or germanium. For a long time their hopes remained for the most part unrealized but, at last, one of the compounds, gallium arsenide, sprang into prominence when it was discovered that it could provide a source of microwave oscillations (the Gunn effect) and that it could emit laser light. It is about the second of these two most important applications that this book is written.

The book consists of articles by eight different authors. So often such collections fail to cover their topic adequately, leaving wide gaps in some areas with overlap in others. Happily, these pitfalls have been avoided by Dr Gooch and his colleagues, and we are presented with a complete and comprehensive treatment of the injection laser. Indeed, no single author could have covered the whole field at such a uniformly high level. We are taken from a really detailed theoretical discussion of the device, through various aspects of the technology of gallium arsenide and the physical behaviour of semiconductor lasers, to a critical description of their many applications.

Each article is sufficiently self-contained for it to be comprehensible on its own. Thus, someone with a casual interest in the subject would get a good idea of the principles and capabilities of gallium arsenide lasers by reading just those contributions by Hambleton and by Gooch himself. The materials scientist, intrigued by the problem of producing pure, stoichiometric crystals of a volatile compound, would surely find Rowland's article on the preparation and properties of gallium arsenide most useful. Similarly, the electronics specialist would be fascinated by Broom's discussion of amplifiers and switching devices. And for someone who wants to know the background to the development of the semiconductor laser, Hilsums' introduction is a masterpiece.

It goes without saying that the book should be read by anyone who is at all concerned with light-emitting devices. It should also surely be available in any laboratory where there is an interest in applications of semiconductors.


Reviewed by C. F. Bruce, National Standards Laboratory, Sydney.

The authors in their preface state that 'the book is generally meant for people who want to know about and work with lasers'. It is quite obviously written by people who do know about and work with lasers and the authors are to be commended for their clarity, conciseness, and expert coverage of the really important knowledge and literature on gas lasers.

At least three-quarters of the book is devoted to basic principles which are important in understanding and constructing gas lasers. There is a full chapter on Lamb's theory of gas lasers and the chapters on transverse and longitudinal mode structures and on the output power of lasers are full of valuable material. The authors have been refreshingly selective in their literature references though it is surprising that no mention is made of the classic paper of Schawlow and Townes which was really the stimulus for all developments on gas lasers. Frequency stabilization of lasers is treated very briefly in a small section. The final chapter on construction of gas lasers has all the authenticity and practical realism to be expected from people thoroughly competent in this field. There is much valuable practical information here that, to my knowledge, does not appear in any other book.

I strongly recommend this book to anyone working with gas lasers.


Reviewed by M. J. Kenny, AAEC Research Establishment, Lucas Heights.

This recent addition to the Methuen Monograph range provides a basic description of the experimental and theoretical aspects of cloud and bubble chambers. It makes easy and interesting reading for anyone with a working knowledge of physics and desires of expanding that knowledge.

The introductory pages deal briefly with the historical aspects from the time of C. T. R. Wilson to the present, and then the mechanism of drop and bubble formation is described. The treatment is essentially descriptive, supplemented by straightforward mathematics. Logically, the book then moves on to the formation of tracks, dealing with both atomic and nuclear interactions of incident fast particles.

A considerable fraction of the book is devoted to the technology and physics of different types of chambers. The text is well illustrated with diagrams showing the principles of operation of a variety of chambers and this
is supplemented by a number of plates showing actual installations. The various types of liquid used and methods of illustration are considered in some detail.

Having established the operating principles and construction techniques, the author discusses the methods of extracting data from the film and the errors which may be involved. It is pleasing to note that this is quite up to date in discussing computer-controlled automatic scanning by the 'Sweepk' system.

Finally there is a look into the future where the proposed 20 000-litre CERN liquid-hydrogen bubble chamber is outlined. The author has succeeded in presenting his subject clearly and logically and has taken the trouble to catalogue over 200 references at the end. Since much of our knowledge of fundamental particles has been made possible by the use of bubble and cloud chambers, many physicists will find this book useful.


Reviewed by A. Reichel, Department of Applied Mathematics, University of Sydney.

This text-book is a well-balanced presentation of modern mathematical methods in Applied Science. It is eminently suitable for an honours degree or postgraduate course. This reviewer is sorry that the book was not available about five years ago when he was working in one of the fields to which the author gives special attention. At that time, many of the techniques presented here were only available in scattered research papers and fairly advanced books. The author lists over 100 titles in his bibliography, mostly from research workers whose contribution has been definitive.

The first chapter on Analytic Functions contains an excellent treatment of analytic continuation and multiple-valued functions. This chapter lays the foundation for later chapters, viz: Fourier Transforms and Dispersion Relations, the Weiner-Hopf Technique and Boundary Value Problems for Sectionally Analytic functions. These latter topics, which were shown by Muskhelishvili and others to have great power in problems of Plane Elasticity, have found application in many fields of applied mathematics and physics.

The chapter on Distributions is very pleasing. The author has steered a course between the banality of the 'engineering' approach on the one hand and the elegant but suffocating 'point-set topological' approach on the other. Generalized analytic functions and their use in boundary value problems are also discussed.

The book concludes with two chapters concerned with application of the methods to Neutron Transport Theory and Plasma Physics.


Reviewed by G. A. Bell, National Standards Laboratory, Sydney.

The Committee on Data for Science and Technology (CODATA) of the International Council for Scientific Unions was established in 1966 for the purpose of promoting and encouraging on a world-wide basis the production and distribution of collections of critically selected numerical data on material of interest to science and technology.

This compendium is the first publication of CODATA and lists current work on the production of numerical data under the following broad headings: nuclear; atomic and molecular, including spectroscopy; solid state; thermodynamics; and chemical kinetics. The book is organized on a project basis and under each entry lists the Institution and the project director. This is followed by a brief description and critical analysis and concludes with a list of relevant publications.

In fields familiar to this reviewer and some of his colleagues the coverage was very thorough and in other fields most informative.

The book contains also a classified list of over 100 handbooks covering physics, chemistry, earth sciences, and biology. It concludes with a chapter on units and symbols, basic physical constants, and nomenclature.

This book is reasonably priced at DM 48 and would be a valuable addition to the library of any institution concerned with numerical values of physical properties.


Reviewed by W. C. MacKlin, Department of Physics, University of Western Australia.

Although it plays an important role in a wide diversity of phenomena, much of our knowledge of the water substance, and its changes of state, has been acquired only relatively recently. The present book gives a timely, up-to-date, and comprehensive account of the structure, growth, and properties of ice.

The first chapter on the water molecule (electronic configuration, vibrational modes and spectra, and intermolecular forces) forms the basis for a detailed treatment of the crystalline structure of ordinary ice and for a systematic review of its other pressure- and temperature-dependent forms. It serves also to coordinate the discussion of the growth and various properties of ice, and to demonstrate how these rise from the structure of the water molecule itself. The section on the homogeneous and heterogeneous nucleation of supercooled water is preceded by a summary of the current models of liquid water and of the theory of growth from the melt, and the growth of ice both from the liquid and from the vapour phase is treated in some depth. The latter half of the book is concerned with the thermal, mechanical, and electrical properties, and the effects of lattice imperfections on these properties.

As the author states, the book has been written for two groups of readers, namely, advanced undergraduate students or graduate students who are interested in applications of quantum mechanics, thermodynamics and solid-state physics, and for research workers interested specifically in various aspects of the behaviour.
of ice. Emphasis is placed on basic physical principles and a background knowledge of these principles is assumed. The text is clearly written and the material presented well-documented. The book will serve well the interests of both groups.


The intention of this book appears to be the ambitious one of treating a very full range of the theory and application of differential equations at a level suitable for a competent classical analyst. There are few adequate texts of this kind and it is with some regret that I feel compelled to write that generally the standard of the present work falls far short of what is most required. The writing is careless, there are many misprints and even quite elementary results are wrongly stated. For instance on p. 11 Theorem 1 states 'If equation (11), \[ A(x, y)dx + B(x, y)dy = 0 \] has a unique solution on an interval \([a, b]\), then it has infinitely many integration factors'. This is just nonsense. The definitions of general solution and complete solution lack clear formulation and discussion. In Part I the existence theorems are established for equations with real variables, though much of the later work in this part on linear differential equations can only be adequately developed in the complex domain. The discussion of singular solutions (Section 4) has no value. Part I ends with sections on Sturm–Liouville methods and Green's function for ordinary linear differential systems; but three of the five illustrative examples do not fall within the limits of Sturm–Liouville theory.

Part II, on Partial Differential Equations, sets up the classification of 2nd order linear equations, into elliptic, parabolic, and hyperbolic types and considers the reduction to canonical form. There are chapters on the simplest kinds of equations of these types and some of the classical results are derived. The book ends with sections on Modern Methods using Fourier Transforms, Hilbert Space, and Theory of Distributions. These appear to be written better than the main and classical part of the book.


This book discusses a few basic physical principles. The author claims it is for 'literate with a fair degree of intellectual curiosity'. The presentation is novel for a physics book, and usually entertaining and stimulating. Discussions on symmetry, Lorentz contraction, and so on are interrupted by a Greek chorus in the form of a dialogue between Poet and Scientist.

The questions at the ends of chapters are very interesting, particularly in the earlier chapters. Straight physics is interspersed with questions from the humanist's background, most of them telling illustrations of the subjects discussed and of considerable value for science students. For example, after chapters on the wave-particle nature of light there are questions like 'Name some concepts which have survived the test of time despite their purely intuitive or instinctual origins, and make a prognosis of their chances of survival in the foreseeable future'.

The book is certainly good reading for physicists and from the point of view of the physicist it is very suitable for the humanist. It would make good reading material in a course on history and philosophy of science, and modern courses in matriculation physics would find it suitable as supplementary reading. Its main aim is to show the humanist how the scientist thinks (or perhaps how he thinks he thinks).

In this it is fairly successful. But after all the humanist does not normally think this way, and I suspect he will find heavy going in some of the sections with close analytical arguments. As the author is determined to use minimal mathematics, such arguments become very long. I would be surprised if most non physical science students read thoroughly more than a third of the book, unless compelled by an examination. However the book achieves its aims almost completely and if the humanists persevere with it, even after skipping a few bits, it will be for the good of us all.


This is basically a collection of formulae and useful hints for designers of air-cored solenoids. It is very well presented and begins with a careful discussion of optimizing the performance from simple constant-current-density solenoids. Other sections deal with the design of non-uniform current density solenoids, superconducting solenoids, and pulsed devices. A pleasing feature is the use of a large number of tables and graphs to summarize the choice of design parameters for such a wide variety of applications. The author is well known for his work in magnet design at the Francis Bitter National Magnet Laboratory where he designed the world's highest continuous-field solenoid (225 kOe) and is now mainly concerned with the application of high magnetic fields to medical and industrial problems.

This book must be of considerable use to anyone who has to design high-field solenoids of any type. Also any physicist who wishes to carry out some degree of optimization in the design of simple lower-field solenoids should find it a useful source of hints and references.

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AUSTRALIAN ATOMIC ENERGY COMMISSION
RESEARCH ESTABLISHMENT, LUCAS HEIGHTS, NEAR SYDNEY.

SCIENTIFIC EDITOR

Location: Research Establishment, Lucas Heights, near Sydney.

Qualifications: Open to both male and female graduates. A degree in Science with experience as a Scientific Editor or in the writing of scientific papers for journals preferred, but applications from graduates with an interest in this type of work will also be considered.

Duties: Assistant to the Scientific Editor, working in close contact with Research Scientists and Engineers in preparing papers and reports for publication. Opportunities will be given to write reviews and articles on the work of the Research Establishment for wide circulation.

Salary: Depending upon qualifications and experience within the range of Scientific Services Officer, male rates, Class II $5,905-$6,631 or Class III $6,868-$7,573. Female rates $428 less than male rates.

Applications: Close on 15th September, 1970. For information and application forms 'phone the Recruitment Officer on 531-0111 or write to the Director, A.A.E.C., Research Establishment, Private Mail Bag, Sutherland, N.S.W.

CSIRO
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SCIENTIFIC EDITOR

A physicist is required to assist with the editing of the Australian Journal of Physics. The successful applicant will be expected to undertake all phases of editorial work on papers that have been accepted for publication in the Journal. The Section, which is responsible for this and other scientific publications by CSIRO, is located at East Melbourne, Victoria.

QUALIFICATIONS: A degree in science, with physics as the major subject, or equivalent qualifications. Some experience in the preparation of scientific papers would be an advantage.

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CONDITIONS: The appointment, which carries with it Commonwealth Superannuation Fund or Provident Account privileges, will be conditional upon passing a medical examination. An initial probationary period of twelve months may be specified.

Applications, quoting reference number 11257, and stating full name, place, date and year of birth, nationality, marital status, present employment, details of qualifications and experience, together with the names of not more than four persons acquainted with the applicant’s academic and professional standing, should reach:
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