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AT LAST, THE SCORE

Report Number 1 on Research and Development Expenditure by the Commonwealth Government in 1968/9 has been published recently. It identifies the extent of Commonwealth interest in various fields of science and the way in which funds and manpower were applied in support of broad objectives during that financial year.

Within the very broad categories of natural and social sciences the total expenditure was $198 million—3 per cent. of the Commonwealth Budget and 0.7 per cent. of the GNP. Seventy per cent. of this expenditure went to the Commonwealth's own agencies, 14 per cent. to higher education, 10 per cent. to business enterprises and the remainder to State, overseas and non-profit organizations.

Intramural Expenditure

The work of the Commonwealth agencies can be subdivided in a variety of ways. For example 11 per cent. of the intramural expenditure ($139 million) was on basic research, 50 per cent. on applied research and 39 per cent. on development—the step beyond research where the systematic use of its results is directed towards the introduction of new or improved products, processes, systems or methods.

The subdivision amongst disciplines was as follows: social sciences—8 per cent., medical—1 per cent., biological—11 per cent., physical—10 per cent., chemical—8 per cent., earth—12 per cent., engineering and applied—42 per cent., agricultural—8 per cent.

In terms of broad objectives 42 per cent. was spent on economic development, 39 per cent. on defence work, 8 per cent. on community welfare, 7 per cent. on big science (civil space and nuclear projects) and 4 per cent. on the advancement of science.

Expenditure within the Commonwealth agencies on physical sciences was distributed as follows (in millions of dollars): astronomy—2.527; meteorology, standards, instruments—3.178; lasers, optics—2.857; mathematics and computing science—0.922; molecular physics—0.293; nuclear physics—1.513; solid state physics—0.931; wool physics—0.646; other physics—0.721. Topics within the earth sciences included: meteorology—2.052; geophysics—3.021; upper atmosphere sciences—3.601; and within the engineering and applied sciences: communications—3.335; electrical and electronic—7.378; nuclear engineering—4.286; under water acoustics—2.277; and many other topics.

CSIRO, the Department of Supply and the AAEC together accounted for 74 per cent. of the intramural expenditure and over the five years from 1963/4 to 1968/9 these showed a growth rate of 9 per cent. per annum which was similar to the growth rate of the Australian GNP.

Extramural Expenditure

Commonwealth contributions to outside organizations included: higher education, natural sciences—$20.5 million; social sciences—$6.5 million; petroleum search subsidy—$12.5 million; industrial research and development grants—$5.3 million; developing countries—$0.75 million; State agriculture projects—$7.5 million; miscellaneous—$6 million. The first item more than doubled in the period from 1964/5 to 1966/9 but no break-down is given for the distribution amongst disciplines or topics.

The Future

Originally it was intended to repeat the survey in 1973/4 and if in fact this is done the results might reveal not only the influence of growth and inflation but also something of the effects of emphases and policies of the new Commonwealth Government.

Will this information be available before 1978? Surely the business of government is not so confused that many of the main features of money and manpower deployment could not be summarized in a much shorter period. On the other hand, are these facts and figures of any real use?

It is interesting to compare the expenditure in a field of personal interest with that in other areas, but where are the spokesmen for science or for physics who can provide rational arguments for maintaining the status quo or for changing the pattern of investment of Australia's growing resource of tertiary-trained talent?

SMALL ADS

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WILEY Books

ELECTRICITY AND MAGNETISM
Diagnostic Tests
By W. A. Rachinger (Monash University)

This book is a self-help aid to students taking introductory Electricity and Magnetism courses and consists of a set of closely structured, multi-choice tests designed to test students' understanding and abilities progressively through the course. (1973, 303 + viii pages. Paper $4.95)

PHYSICS
The Foundation of Modern Science
By J. B. Marion (University of Maryland)

Physics is presented as the best medium for understanding the scientific nature of our world, our place in it, and how matter and energy relate to each other and to man. The book stresses modern physics and astrophysics but provides the foundations from classical physics to understand these. (1973, 333 pages, $10.96)

THEORETICAL PHYSICS
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By M. Mizushima (University of Colorado)

Theoretical Physics teaches all the important subjects in graduate physics in a unified way. Examples: Green's functions for almost all fields, spinors for classical and quantum relativity, metric tensor treatment in special and general classical relativity and quantum mechanical relativity, group theoretical treatment of atomic, molecular, nuclear and elementary particle physics. (1972, 720 pages, $22.00)

GRAVITATION AND COSMOLOGY
Principles and Applications of the General Theory of Relativity
By S. Weinberg (Massachusetts Institute of Technology)

Gravitation and Cosmology covers general relativity and its applications to astrophysics and cosmology. The text proceeds from a full exposition of the fundamentals of the theory to an analysis of current research. (1972, 657 pages, $18.95)

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PATENTS FOR INVENTION

R. G. Shelston
Shelston Waters, Patent and Trade Mark Attorneys

Extract of talk given to the NSW Branch, October 1972.

Introduction

In 1624, the Westminster Statute of Monopolies banned all grants of privilege or monopoly by the Crown, with a famous exception set out in Section 6: "except monopolies in respect of any manner of new manufacture so as also they be not contrary to the law or mischievous to the State by raising prices at home or hurt of trade or generally inconvenient". That definition of what the Crown may grant a monopoly for is still the only definition of invention in our present Patents Act.

A patent is, in effect, a contract between the inventor and society in which the inventor is given a Statutory Monopoly for a limited period in return for him describing the invention so that when the Statutory Monopoly expires, everybody may avail themselves of it. There is nothing that is quite such public property as the subject matter of an expired patent.

As literacy developed in the community it became customary to describe an invention by way of a written specification. Quite obviously the parties to the contract are in conflict. The more the inventor, in good faith, describes his invention—the more tricks of the trade that he discloses—the easier it becomes for somebody to omit one of those details and thereby claim that he is not copying the patented subject matter. The practice therefore arose of dividing the specification into two parts. The first part of the specification is the description of the invention and how to carry it into effect. The second part contains the claims which define the scope of the monopoly granted to the Patentee.

If you are ever faced with the need to decide whether you are infringing a patent, look not at the body of the patent specification but rather at the claims or numbered paragraphs at the end of the specification and interpret those to decide whether you want to do is within the scope of any one of those claims.

Example

A client came to me and said "I have just come back from Switzerland and while I was there I saw a new joint for the stem of a beach umbrella. This is a very good joint—can I have a patent for it?" I advised him that he could not have a patent because, just seeing something in Switzerland did not make him an inventor. However, I said that if he could modify it or add some improvement it could be possible to get a patent for the improved version. Before long he devised such an improved version and I prepared a patent application.

The specification contained phrases such as: "This invention relates to joints of the kind incorporated in the stems of beach umbrellas and the like whereby the two stem portions on each side of the joint may be angularly aligned in any selected one of a number of positions. Such joints are commonly comprised of two joint halves and a clamping through-bolt ..." Further on we find a statement of the advantages accruing when the heads of the joint are off-set; that is to say (according to the specification) "when the common axis of rotation extending through the two heads of the joint about which the joint halves may be turned relative to each other lies on one side of the axes of the joint sockets ..."

Now, a layman could be forgiven for thinking that this specification asserted that the invention resided in the joint with off-set heads which had been seen in Switzerland. But it was necessary honestly to claim the invention and Claim I read as follows: "An improved umbrella joint of the kind comprising two joint halves each of which includes a socket and head thereon having a radially serrated face and a clamping through-bolt or the like to hold the serrated faces in frictional engagement characterized in that the head on each joint half is offset ..." and then we let the cat out of the bag: "and in that at least one joint half has a spur on its socket, said spur being so placed in relation to said offset heads that the spur and heads may cooperatively function as a bottle opener".

This emphasizes the need for a careful reading of the claims to find out what is or is not protected by the patent.

Obtaining a Patent

The primary right to a patent resides with the inventor although, in Australia, he can assign his right to another person, a group of persons or to a company and an application for a patent may be made in the name of the assignee. There is no restriction in Australia on the applicant, in the sense that he may be a foreigner, a juvenile or he may be an imbecile—in fact a few of them are.

The question often arises as to whether an assignment of an inventor's rights has occurred in the case of an employee. Many an employer thinks that if his employee invents something using his time and material and equipment, then the invention belongs to him, the employer. This is not necessarily so. The master and servant situation is decided on the principle of whether or not an assignment may be assumed because of the circumstances of the employment.

If you are employed as a technical or scientific person in a company's research and development section, you are expected to develop things and anything that you come up with will belong to your employer. However, if you happen to be a floor-sweeper or a tea-lady or an
accountant—or something of that lowly kind, who is not paid to invent—then anything that you develop belongs to you irrespective of when and where you developed it.

It is also necessary before the master can appropriate an invention, that it come within his field of business interests. If you are working for an ice-cream maker and, in his time and using his facilities, you invent a mousetrap—then that invention is yours because there is no call on you to invent mousetraps in the course of your employment. Of course, if you have signed a conditions of employment contract, then the whole matter is settled in the terms of that contract. If you are an employer your Patent Attorney can supply you with a suitable draft contract.

Nature of an Invention

An invention is 'any manner of new manufacture' and as such is basically a vendible product—something that can be wrapped up and handed from one to another—or some method for making, improving or preserving such a product. This excludes from the protection of the patent law a lot of very ingenious devices and a lot of hard work.

No mere principle or natural law or discovery of it can amount to a patentable invention; so the man who first discovered the effect of light on silver halides made an important contribution to human knowledge, but the man who first smeared gelatine and powdered silver iodide on a glass plate was the one who had a patentable invention.

You can't get a patent for a method which produces nothing of use. During the Battle of Britain, a Company found that incendiary bombs could be extinguished very effectively by a weak chemical solution. However, the Court ruled that this was not patentable subject matter because the result of putting the method into effect was merely an extinguished incendiary bomb and there is nothing quite so useless as that. The principle remains although this particular case could well go the other way today in view of more recent decisions.

A method of testing which may be of great assistance in an industrial activity may be difficult to patent because the sole product is information.

A mere scheme or plan is not patentable. For example, it is customary to colour kerosene blue so that people will not use the wrong liquid in kerosene lamps and blow themselves up. Although this might be a good idea it is still in the nature of a scheme or plan easily put into effect and thus ought to be available to anybody and is not patentable.

Written matter is, in general, unpatentable and this is significant at the moment because of the inventive thought and care involved in the programming of computers. Also, biological processes may be unpatentable because they are not of an industrial nature.

As well as being a manner of manufacture, an invention must be new in Australia, but of course anything that is just not known is not necessarily new.

A new use of an old article is not necessarily a patentable invention, and a collocation of old integers may not be new. Things that are joined together must produce a result somewhat in excess of the sum of their old separate activities or abilities to be patentable. A patent cannot be obtained for making articles out of a new material unless the invention really resides in the discovery of a new property peculiar to that material.

Working directions for an old article, even though they may point out a way of using the thing more efficiently than was previously known, are generally not patentable.

An invention must also be ingenious—it must involve some exercise of the inventive faculty even although no one can define ingenuity and still less can anyone quantify it. The courts have decided that a scintilla of ingenuity will suffice.

There are also some statutory exclusions from patenting. For example, the Commissioner of Patents may refuse to grant a patent for a substance used for food or as an ingredient for food or as a medicine for internal or external application—which is nothing more than a mere mixture of known ingredients. So one thing that is not patentable in general is a patent medicine. You may get a patent for a medicine if the ingredients react together in some way or for a new drug that never existed before.

The best way available to laymen to decide what is a 'new manner of manufacture' is to go to a Patent Attorney and disclose the invention fully. A Patent Attorney's 'graft' is honesty and if he says that it is not a patentable invention, you can assume that that is a genuine opinion.

Patenting Procedures

The first step for an individual applicant is usually a Provisional Patent Application—a simple document, usually without drawings or too much verbosity. This costs $4 if you do it yourself or about $75 if you get it done by a Patent Attorney and it gives you a period of 12 months within which you may exploit the invention, publicize it and see if it is a money-maker both here and overseas. At the end of this period, if you wish to proceed, you 'Complete the Application' by supplying a Complete Specification to the Patent Office. This is a rather more elaborate document—always with drawings if the invention is amenable to illustration by drawing, and with claims which define the scope of the monopoly sought. The work involved in preparation and lodgement of a Complete Specification varies enormously, depending on the subject matter, but for an average kind of an invention it will cost about $250.

Having filed your Complete Specification, your application can remain in abeyance for 5 years if you so require; but at any time within this period you may ask for its examination by the Patent Office. Almost invariably you then receive an official report that says that you cannot have a patent because there is something wrong with the specification or the facts supporting it, or the invention is not new anyway. Your Patent Attorney then argues the matter for you and almost
always a patent issue, but frequently a patent with less scope than you thought you were entitled to at the outset. The request for examination—covering official fees and the attorney's charges at the time—will probably amount to about $150.

The Patent Application is now officially accepted and advertised in the Patent Journal. For three months it is open to any member of the public to oppose the grant but if no one opposes it successfully then you've got your patent. One of the services a Patent Attorney provides for his clients is to read the weekly Patent Journal on their behalf and advise them of officially accepted applications which fall within their sphere of interest.

Protecting a Patent

Having obtained a patent it must be kept alive by annual injections of cash to the Patent Office. The first injection is $12 and the fees rise fairly regularly to the final one of $50. Thus, throughout the 16 years life of the patent a certain amount of money has to be spent on it. In return for this you have a Statutory Right to be the only person able to make, use, exercise or vend the invention in Australia.

If a person infringes the patent the police don't do anything about it and the Government doesn't do anything about it unless you do. You have to find out that someone is infringing it and be prepared to spend perhaps upwards of six or seven thousand dollars on an infringement action. If this is successful, the infringer will be ordered to deliver up infringing articles in his possession, the Court will grant you costs and issue an injunction restraining the infringer from carrying on with his infringing activities and you may claim damages or an account of profits from the infringer.

A Career as Patent Attorney

In order to become a Patent Attorney it is necessary to have a degree in science or engineering and to pass examinations set annually by the Attorney General's Department in respect of Industrial Property Law. These comprise seven papers, split into two groups which must be sat for consecutively, and usually they require at least three years of private study and experience in an Attorney's office. This combination of requirements is more attractive to science and engineering graduates than to law graduates who are seldom willing to take on the additional studies for a technical degree.

The main attribute needed in a Patent Attorney (apart from an ability to understand what his client is talking about) is a skill and real pleasure in the use of words. Much of his work involves devising that combination of words which will exactly describe his client's invention—no more and no less. For a science graduate with this attribute, patent work can provide a rewarding career.

A report from the US National Patents Planning Commission to the US Senate ended like this: "The American patents system is the only provision by the Government for promotion of invention and discovery and is the basis on which the development of our entire industrial civilization rests. The basic principles of the system should be preserved since it has contributed to the growth and greatness of our nation."

AUSTRALIAN INSTITUTE OF NUCLEAR SCIENCE AND ENGINEERING

RESEARCH GRANTS FOR 1973

The Australian Institute of Nuclear Science and Engineering awarded ANSIE Grants in the 1973 Series in support of the following projects (allocation of up to $145 394 for 96 projects):

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G. L. Paul—Neutron diffraction investigation of lanthanum lead manganate (up to $\$1500$).
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L. B. Harris—Effect of impurity segregation on mass transport in grain boundaries (up to $\$100$).
J. C. Kelly—Proton and ion channelling through crystal lattices (up to $\$1100$).
J. N. Mathur (Wollongong University College)—Distribution of K X-rays as a function of mass and atomic number in the spontaneous fission of $^{252}\text{Cf}$ (up to $\$300$).

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A. L. McCarthy—Digital recording of Stark broadened lines in plasmas—pilot study (up to $478).

I. R. Jones and M. H. Brennan—Non-linear wave phenomena at low frequencies (up to $2520).

E. L. Murray, I. F. Jones and M. G. R. Phillips—Fast z-pinch (up to $9980).

R. G. Storer—Wave-plasma interactions (up to $990).

**University of Western Australia**

H. H. Thies—Absolute measurement of neutron production (up to $600).

E. N. Maslen—Crystal structure analysis by neutron diffraction (up to $1130).

A. H. White and F. C. R. Cattell—Hyperreduced states of transition metal ions and complexes (up to $600).

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**NOTES AND NEWS**

**Record Voltage at ANU**

During testing of the tandem accelerator at ANU, the terminal reached 18 MV, the second highest voltage reached in the world. The accelerator is expected to be completed by mid-1973.

**Visitors to USSR**

The increasing flow of Australian academic visitors to USSR has presented difficulties to the Embassy in Moscow. Prospective travellers are urged to make contact with the Department of Foreign Affairs early in the planning of their visits.

**Wrinkles in Wool—Cause and Cure?**

The CSIRO Division of Textile Physics has found that wrinkling of woollen garments is largely due to the behaviour of the individual fibres. Wrinkling can be substantially reduced by leaving a garment to hang for up to a week after washing or pressing.

**Physics and Photosynthesis**

The invited address 'Physics and Photosynthesis', given by Professor A. B. Hope at the Eleventh Conference on Physics and Engineering in Medicine and Biology in Hobart, August 1972, has been published in the Australasian Bulletin of Medical Physics and Biophysics, and reprints are available from Mr K. H. Clarke, Physics Department, Cancer Institute, 278 William Street, Melbourne, 3000.

**Top Awards for 1973**

- **Guthrie Medal**—Sir H. Bondi; **Rutherford Medal**—Prof. J. M. Cassels; **Glazebrook Medal**—Prof. K. Hoselitz; **Thomas Young Medal**—Dr W. T. Welford; **Duddell Medal**—Dr A. Franks; **Charles Vernon Boys Prize**—J. W. C. Gates; **Maxwell Medal**—Prof. D. J. Thouless; **Charles Cres Medal**—Prof. D. R. Bates; **Brogg Medal**—J. M. Ogilby and Dr P. J. Black.

*The Australian Physicist, May 1973* 79
Safer Trolley for Gas Bottles
A highly stable trolley with built-in brakes has been developed for gas bottles of all sizes. Details are available from T. F. Wignall, Divisional Engineer, CSIRO Division of Chemical Physics.

England to Copy Melbourne's Science Centre?
The success of the Ian Clunies Ross Science Centre has led to proposals for a similar centre in London. The Governor of the Clunies Ross Memorial Foundation, J. E. Cummins, spoke in London recently to representatives of many professional societies, and found considerable support for such a project. However, because of the large size of English institutes, a staff of 1000-2000 would be required, which implies an enormous office building.

Indian Optics Journal
The Optical Society of India has recently been founded with P. K. Katti as President. The official publication of the Society is the Journal of Optics, at present published as a quarterly journal. This contains original and applied research in all branches of optical physics and technology. The subscription rate is £2 sterling, which should be sent to the Treasurer, The Optical Society of India, Department of Applied Physics (C.U.), 92 Acharya Pratulla Chandra Road, Calcutta-9.

CONFERENCES

Lattice Defects in Ionic Crystals
An EPS Conference will be held on 2-6 July, 1973 in Marseilles. The Conference Secretary is Dr F. Beniere, Lab d’Electrochimie, Université de Paris, VI, 9 Quai St Bernard, 75005 Paris.

Atomic and Molecular Physics
The 6th National Conference organized by the IOP will be held at University College, Swansea, UK on 26-29 March, 1974.

Optical Information Processing, Sydney 1974
An International Conference sponsored by IJO and the AAS will be held on 19-21 August 1974. First Notices have been widely distributed, but anyone desiring information should contact the Conference Secretary, P. E. Ciddor, National Standards Laboratory, Chippendale, 2008.

A conference on ‘Diffraction Studies of Real Atoms and Real Crystals’ to be held on 19-23 August 1974 will cover real atoms in crystals, extended defects, and the use of dynamical effects. Details from Dr A. McL. Mathieson, CSIRO Division of Chemical Physics, PO Box 160, Clayton, Vic. 3168.

Details of this conference to be held on 25-31 August 1974, are available from Dr A. McL. Mathieson (see preceding notice).

9th Australian Spectroscopy Conference
A conference on visible and infrared spectroscopy, lasers, galactospectroscopy, electron-nuclear interactions and instrumentation will be held at the ANU, Canberra on 13-17 August, 1973. About ten well-known overseas speakers will present invited papers. Enrolment may be made by 11th June with the Organizing Secretary, c/- Aust. Academy of Science, PO Box 216, Civic Square, Canberra, ACT 2608.

Nuclear Structure: Heavy Ions
The IOP will hold a conference on 5-7 September 1973, at the University of Manchester.

Spectroscopy in Environmental Studies
A two day meeting organized by the Spectroscopy Group of The Institute of Physics will be held at the University of Aberdeen on 26 and 27 June 1973. It is envisaged that the papers presented will deal with spectroscopy applied to problems of pollution of the land, sea and air.

Further details and application forms from The Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.

First National Quantum Electronics Conference
This meeting will be held at Owens Park, University of Manchester on 10-13 September 1973. The Conference will include laser physics and laser design, industrial and scientific application of lasers, optoelectronics, quantum optics, non-linear optics and quantum metrology. Details may be obtained from The Meetings Officer of The Institute of Physics.

Electron Diffraction for the Investigation of Structure
A conference will be held at The Institution of Electrical Engineers, London, on 15-16 November 1973. Electron diffraction from gases, from surface structures and from bulk material will be included, and strong emphasis will be placed on new experimental techniques and theoretical methods for obtaining structural information.

Invited papers will be presented by Drs P. E. Champness and G. W. Lorimer (Manchester), Professor D. W. J. Cruikshank (U.M.I.S.T.), Dr C. A. English (Sussex), Dr J. Hutchison (Oxford), Dr M. Prutton (York) and Dr J. W. Steeds (Bristol). Offers of contributed papers, together with a short outline, should be sent to either of the joint conference secretaries, Dr I. S. Kerr, Department of Chemistry, Imperial College, Prince Consort Road, London, SW7 2AY (01-589-5111) or Dr J. A. Venables, School of Mathematical and Physical Sciences, University of Sussex, Brighton, BN1 9QH (0273-66755) by 1 September. Details from the Meetings Officer, The Institute of Physics.
AN AIR TABLES MECHANICS LABORATORY

C. H. Barnes
Physics Department, University of Western Australia

Introduction
A few years ago, the course given to first-year physics majors at the University of Western Australia was changed. As part of the new course, a mechanics laboratory was set up in which the experiments are all done on air tables and using Polaroid photographs to record the results. Students spend eight weekly periods of two hours duration in this laboratory. During each laboratory period, the students (working in pairs), all do the same experiment on one of the ten identical sets of apparatus which are provided. Each experiment is designed to relate closely to the lectures of the preceding week. The sessions are supervised by two demonstrators. By repeating both the lectures and the laboratory course three times during the academic year, and running laboratory sessions twice a day, a maximum annual intake of 600 students can be accommodated; numbers presently run about 450.

The Apparatus
Commercial air tables with a surface area of 60 cm by 80 cm have been mounted as shown in figure 1. The camera can either be positioned at a particular point (usually over the centre of the table) or can be pulled along a pair of rails by a piece of string wrapped around a motor-driven capstan. Other additions and modifications include stroboscopic illumination, a vibrating-walls attachment with reciprocating linear motion, special pucks and air supply system. The approximate cost of setting up the laboratory in 1970 was $7400 plus 100 man-weeks of design and construction work. Anybody who is interested in further details should contact the author of this article.

The Experiments
Two duplicated instruction books are provided for each student—one describes the apparatus, and the other the eight experiments. Following the description of each experiment are two or three assignment problems based on the concepts of the experiment. Students are asked to purchase (for 45 cents) a transparent graticule in the form of a grid of roughly 1 mm squares. This provides a standard scale for distances on the photograph, and when required, the coordinates of the puck positions can be read off the graticule.

Quantitative analysis of the phenomena on the table is done in terms of a system of units devised for use in these experiments and not related to the conventional units. Thus one division (approximately 1 mm) on the graticule defines the length unit (one 'metre'); the mass of one of the magnetic pucks is taken as one 'kilogramme' and the time interval between strobe flashes (when that instrument is adjusted to a reproducible setting of 400 flashes per minute) is defined to be one 'second'. Quantities such as 'newtons' and 'joules' are then defined in the usual way in terms of these units.

The eight experiments have roughly the following content.

1. Rectilinear motion. (2 photographs). The motion of a puck moving at constant speed across the table is photographed from a stationary camera, and again, (on a double exposure), a repetition of the motion is recorded from a moving camera. Students are asked to verify the transformation of velocities. The table then is given a reproducible incline by inserting shims under the end levelling screw. The camera records the accelerated motion of a puck down the incline. This is done five times (on a multiple exposure) for a variety of inclines.
of inclines, and students are asked to determine the accelerations (‘metres sec\(^{-2}\)) and to work out the force on the puck (mass 1 ‘kilogramme’) in ‘newtons’ per unit shim thickness used to tilt the table.

2. Conservation of Momentum. (4 photographs). A variety of collisions between pairs of plastic and magnetic pucks is analysed for momentum conservation in both stationary and moving frames of reference. In one case, the pucks are made to stick together on impact.

3. Conservation of Energy. (1 photograph). The photograph is of a collision between two magnetic pucks, one of which is a dumbbell-like arrangement of two small magnets and usually leaves the encounter spinning. This, and the photographs of the previous experiment are examined for conservation of translational energy.

4. Force and Potential Energy. (1 photograph). A fixed magnetic puck is held at one end of the table between parallel guide rails which constrain a second puck to move along the line of their centres. The mobile puck has known forces applied to it, in the direction of the fixed puck, by tilting the table. The magnitude of the force is inferred from the thickness of the shims used, and the results of the first experiment. Measurement of equilibrium puck separations is done manually in centimeters; these are then converted into separations, \( r \) (‘metres’), as they would appear in a photograph, using a conversion factor which is provided. A log-log plot gives the force law in the form, \( F = A/r^3 \), where \( r \) generally comes to be between 4 and 5. Students are then asked to derive the potential energy as a function of separation by analytic manipulation of their results for the force law. Finally, a photograph is taken of the mobile puck moving across the level table between the rails towards the fixed puck, while traversing the camera to separate the approaching and receding motions. A comparison is made between the incident kinetic energy, (measured on the photograph), and the potential energy at the distance of closest approach, (from the derived relationship and the separation from the photograph).

5. Particle Motion in a Circle. (2 photographs). A puck is set rotating about the centre table bearing with a constant centripetal force provided by a weight on the end of the string, and the puck motion gradually spirals in as friction dissipates the motion. In the second photograph the string is manually shortened in stages to pull the puck into the centre. Students are asked to recognize and analyze the differences between the two types of motion which, in both cases, are photographed in multiple exposures at three stages of development.

6. Rigid Body motion. (1 photograph). A large diameter puck is pulled along the table by a tape which passes over a pulley at the edge of the table and carries a weight at its lower end. Correlation is obtained between the linear and angular motions.

7. Oscillations. (2 photographs). A puck is set oscillating between the guide rails under the action of two opposing coil springs. The motion is photographed from a camera which is traversed across the line of the motion. The measured accelerations are plotted against position in a graph whose linear characteristics confirm the simple-harmonic nature of the oscillation. In contrast, the second photograph is one of a magnetic puck oscillating between two similar magnetic pucks fixed at the ends of the guide rails; the motion is clearly not simple-harmonic.

8. Kinetic Theory. (6 photographs). Twenty plastic pucks (diameter 4.5 cm, about the smallest that can be used on the table), provided with marker pips are photographed four times in brief exposures to the strobe illumination as they are agitated by the shaking walls. From the short trains of spots that appear in the picture, approximately eighty puck velocities can be calculated. Displaying these in a histogram gives a result like a Maxwellian distribution; students are asked to work out a value for the r.m.s. velocity. In a subsequent photograph, the pip-carrying pucks are replaced by nineteen similar pucks but without pips, plus a single puck which is twice as heavy and carries a pip. Twenty repeated exposures of the motion of this puck gives data from which its r.m.s. velocity can be calculated. Comparison of its mean kinetic energy with that of the lighter pucks illustrates the equipartition of energy. Finally, the motion of a ‘firefly’ puck, (same size and mass as the other pucks on the table), is recorded in a time exposure from which a distribution of path lengths is derived. The mean free path is worked out.

Conclusions

The complete course involves the taking of nineteen photographs per pair of students. A typical intake of students comprises, say 450 students. Experience has shown that about 25 per cent of the film is wasted. This involves the department in providing roughly 700 packs (of 8 exposures) of film per year, or an annual cost for film of about $1600.

This expense, (plus the cost of the equipment), must be weighted against the value of the course. Even the dullest student responds with enthusiasm to the combined ‘magic’ of the air tables and the instant pictures. Moreover, after two years of operation it is clear that the experiments are extremely worthwhile for the better student. The accuracy of the results is variable with the experiment, but in general one expects, say 10 per cent. The fact that it is no better probably acts as a healthy deterrent to the student who regards an experiment only as an exercise in obtaining an acceptable numerical result. Thus, the greatest impact seems to derive from the conceptual content of the experiments. Concepts such as ‘acceleration’ and ‘potential energy’ are forcibly revealed as tangible quantities which can be measured and manipulated, and are more than mere numbers to be encountered in abstract problems.

However, one suspects that the poor to average student probably derives little beyond the benefit he
would get from a more conventional, (and less expensive!), laboratory. In retrospect, it might be wondered whether some compromise wouldn’t be equally effective for most students. Thus, one might arrange only one or two sets of such apparatus as has been described, with demonstrators to take the pictures, say on transparencies, which could then be projected for analysis in front of an audience of passive students. There is no doubt that the students do derive a certain satisfaction from manipulating the apparatus themselves; the question is whether this justifies the cost.

Acknowledgements

The idea to establish the laboratory was provided by Professor A. J. F. Boyle who was associated closely with its development. Various members of the technical and workshops staff contributed their skills both in design and construction. Mr T. Zeffert has had charge of the running of the laboratory and has suggested a number of valuable modifications and improvements to the apparatus.

THE REGISTER

Changes in Membership from 20 February 1973 to 20 March 1973

Associateship

(a) New Elections
Lang, M. M. University of New South Wales
Newton, C. S. Australian National University, ACT

(b) Transfers
Bryce, M. E. Education Department, WA
Richardson, D. D. Australian National University, ACT
Richardson, R. G. University of Tasmania
Sajklowyz, N. University of New South Wales

(c) Resignations
Butler, J. E. (NSW) Smith, K. S. (Vic.)

Student
New Election
Poole, G. T. (Vic.)

Subscriber
New Election
George, D. F. M. (SA)
Company Nominees
Resignations
Joyce, K. (NSW) Nixon, J. C. (Vic.)

Graduateship

(a) New Elections
Garrett, C. University of Melbourne, Vic.

INSTITUTE AFFAIRS

RELATIVITY AND SPACE TRAVEL

A talk on this subject was given by Dr Graham Derrick of the NSW Institute of Technology, to the NSW Branch on 10 April 1973. Outlining the literally astronomical proportions of the Universe Dr Derrick began with the observation that our ‘home’ galaxy the Milky Way contains some 10^{11} stars and is 10^{2} light years in diameter. This galaxy is in turn one of the largest of a local cluster of 17, which also includes Andromeda and the Magellanic Clouds. The latter are our nearest galactic neighbours, readily visible in the night sky. The speaker went on to ask: “Can we go and have a closer look at some of our immediate or more distant galactic neighbours?” He cited two immediately apparent difficulties:

1. The universe is large and human lifetimes are short:

2. Quantities of fuel required for travel over such distances are prohibitive. Other difficulties include radiation hazards, psychological problems of long space flights, food supplies and the limitations on ARGC funds for such ventures.

The first difficulty was examined by assuming that a rocket was allowed to accelerate continuously at a comfortable rate of one g (which turns out to be nearly 1 light year per year squared). Using established relativity theory it appears that the elapsed time \( t \) as measured on board the rocket is related to earth time \( t \) and distance from earth \( s \) by:

\[ t = \sqrt{\frac{s}{c^2}} \]
\[ x = \left( \frac{e^2}{g} \right) (\cosh g \tau / c - 1); \]
\[ t = \left( \frac{e^2}{g} \right) \sinh g \tau / c. \]

Using these formulae the rocket-time and earth-time for various one-way trips were calculated:

<table>
<thead>
<tr>
<th>DESTINATION</th>
<th>DISTANCE</th>
<th>ROCKET-TIME</th>
<th>EARTH-TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pluto</td>
<td>6 \times 10^{-4}</td>
<td>13 days</td>
<td>13 days</td>
</tr>
<tr>
<td>\alpha-Centauri</td>
<td>4.3</td>
<td>2.4 years</td>
<td>5.2 years</td>
</tr>
<tr>
<td>Magellanic clouds</td>
<td>1.7 \times 10^4</td>
<td>13 years</td>
<td>1.7 \times 10^5 years</td>
</tr>
<tr>
<td>3C286</td>
<td>10^{11}</td>
<td>23 years</td>
<td>10^{11} years</td>
</tr>
</tbody>
</table>

Further calculations which allow the rocket to decelerate for the second half of the outward journey so that it comes to a rest at its destination (using the drag of intergalactic dust on extended wings a few square miles in area) indicate that a round trip to \( \alpha \)-Centauri and back would take 8 years rocket-time (including 1 year at the destination for observations). The corresponding time elapsed on earth meanwhile would be 12 years, so that this journey would in principle be feasible within the life span of the crew's earthbound friends. On the other hand, a one-way trip to the Magellanic Clouds would take 23 rocket years, and 170 000 earth years. The return trip would in the circumstances be futile.

Fuel requirements were estimated on the assumption that maximum efficiency is attained when the entire rest mass of the fuel is converted to electromagnetic energy and ejected as gamma rays. On this basis the round trip to \( \alpha \)-Centauri would entail, for a 100 ton payload, a take-off mass of 600 tons. The Magellanic Clouds one-way trip would correspondingly have a take-off mass of some 8 million tons, and a ship destined for the nebula 3C286, 46 rocket years distant, would have to be 10^{10} tons. On this last voyage there would be a 1 per cent. probability of a collision with a star, whose photons would in any case be Doppler-shifted into the gamma-ray region ensuring a nasty lingering end to the trip.

Dr Derrick concluded his fascinating lecture by cautioning against uncritical acceptance of such results since it is not known that relativity can be applied over the enormous distances and times considered. The spirit of the evening was perhaps captured by a questioner who, referring to the massive space-ships and the dilemma of the travellers returning to a strange Earth in 340 000 years, asked “Why don’t we just ship the whole Earth to the Magellanic Clouds? We all get the trip and the time problem is solved!”

What People Are Saying

Some Priorities in Physics for the Seventies

1. “The task of selling the idea that physics is one of the noblest pursuits of the human mind: That it is part of our culture and one of the best examples of the heights to which the human spirit may achieve. That physicists are concerned with beauty, truth and integrity—in ways which the world of business could well take example from.

2. The need to alter the image of secondary school physics: I believe that we must involve ourselves more closely with secondary school teachers and students. By and large physics does not have a good image in the schools. New programmes in Chemistry and Biology have made our physics courses look old fashioned by comparison, and much of the present situation is due to the fact that we have been too busy to help . . .

3. But above all the professional responsibility of physicists must be broadened to embrace the concept of increased service to the academic community and to society: We need to actively sponsor physics in areas where society can make use of the talents and training that physicists possess as a result of their education. This probably means a return to some of the classical areas of physics like acoustics, heat, optics, the study of materials and mechanics, even if it means a reduction of time spent in areas like fundamental particle physics.

A physicist should be distinguished by the innovative skill that he brings to the problem at hand; by his concern for rigour and experimental accuracy; by his flexibility in being able to move from one problem area to another. A physicist should exhibit traits of tenacity and perseverance, and confidence in his work and that of other members of his team.”—John De Laeter, Proceedings of the First National Conference on Physics in Australian Colleges of Advanced Education, WAIT, August, 1972.

Goals for Science Policy in the 1970s

“It was agreed by the Ministers that new efforts by Member governments will be required in three main directions:

1. the expansion of research, development and innovation activities to meet social needs such as environmental quality, health, education and urban development;

2. continued stimulation of technological innovation in the economy to achieve qualitative as well as quantitative growth;


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

One reason for welcoming this book is because the reviewer feels strongly that there should be greater publication of collected 'Lectures' by senior physicists. In the competitive world of conference and summer school publishing in which this year's ideas are often hastily assembled, it is wise to remember that there is a great need for the definitive and permanent permanence in physics. The collected 'Lectures' of classic physicists are useful far beyond their year of publication. The present book by N. N. Bogoliubov is one of these. It is the second volume under the same title; the first, which appeared in 1967, was essentially concerned with the fundamentals of quantum statistics and of the method of second quantization, and was indeed a translation of Bogoliubov's lectures. It contained, remarkably, no references. The present second volume is a translation of three Dubna preprints together with an article which had already been published. Their dates of writing are around 1960; they all contain references. They are concerned with applications of statistical mechanical ideas.

The first part discusses 'quasi averages' and the second part is a long discussion of superconductivity based on the model hamiltonian which retains only electronic interactions between particles of opposite spin and moment. The third part deals with the hydrodynamics of a superfluid liquid, while in part four, the many body techniques are applied to the electrodynamics of the superconducting state and the relation to the self-consistent approximation explored.

The whole book taken with volume I invites comparison with those of Landau. Here we have the two recent Soviet leaders of theoretical physics, each having led strong schools and each expressing his separate views about similar problems. Landau is more direct and open, often heuristic; Bogoliubov is more deliberate, rational and deductive. Whom we would choose to guide our own work is often a question of personal choice; both approaches are necessary to physics.


Reviewed by R. Weber, Physics School, Monash University, Clayton.

This volume comprises 13 plenary lectures, presented at the 1970 annual conference of the groups 'Semiconductor Physics', 'Low Temperature Physics', 'Thermodynamics', and 'Metal Physics' within the German Physical Society.

Accordingly, the contributions are reviews of recent experimental and theoretical research work carried out in West Germany. In general, the language of the articles is not too specialized (although only 3 of them are in English, all others in German) so that any physicist reading them should gain easy access to current trends and developments in areas other than his own.

To take but a few examples:—

'Acoustoelectric Effects in Piezoelectric Semiconductors' by N. Meyer and M. Joergensen comprehensively deals with interesting fringe effects as does R. Sandrock's 'Pseudopotentials in the theory of semiconductors' with the application of this method in various branches of solid state physics. In 'Laserlight, a new example of a phase transition', H. Haken shows that, although it is a system far away from thermal equilibrium, at laser-threshold all features characteristic of a second-order phase transition are found. The influence of point defects on the magnetic properties of type II—semiconductors is reviewed by H. Ullmaier.

And last but not least, E. Luescher in 'Quantum and Quasicrystals' discussed some lattice dynamics and transport properties of solid rare gas crystals. As in his textbook on undergraduate physics, Luescher intermingles precise scientific writing with humorous yet most relevant remarks, thus making the reading not only interesting but enjoyable too. I express hope that this article might stimulate a few amongst us to similarly relax the current tense tone of physical literature.


Reviewed by Moira Welch, Presbyterian Ladies College, Pymble, NSW.

This book was written for a terminal course in Physics for non-Science majors in the United States. The topics presented include vectors, light, mechanics, electricity and magnetism and modern physics, except relativity. The level is approximately that of the present second level (short) course for fifth and sixth year high school students in New South Wales.

Because his students come to the course with little enthusiasm and often downright antagonism, a situation familiar to physics teachers here, the author has set out to interest his readers by presenting the material in a narrative rather than mathematical style, using no mathematics beyond high school algebra. This approach tends to lose the definition and precision which is essential to the presentation of physics and this book unfortunately, has many errors, numerical and otherwise, misleading or unhelpful analogies and illustrations.

For example, in the section on circular motion, centripetal acceleration is derived by a lengthy description, rather than by vectors, which are clearly explained in an earlier chapter. In the treatment of light, diffraction by a slit would be more convincingly explained by the usual method of secondary wavelets, rather than by a 'simplification' which does not show the points at which
superposition occurs. An attempt to reduce the many rules of electromagnetism by referring both the motor effect and electromagnetic induction to the same right hand rule has apparently succeeded, but only at the cost of equating conventional current direction in one case with electron flow in the other.

There are problems at the end of each chapter, with a very helpful reading list, including good historical references, as an appendix.

The value of this text as background material for local courses is limited by the errors which could cause confusion among students, particularly those without natural aptitude for the subject.

**STATISTICAL PHYSICS, F. Mandl (Ed.).** John Wiley & Sons Ltd. 1971. xiii + 379 pp. $6.80 (paperback).

Reviewed by J. C. Macfarlane, National Standards Laboratory, Chippendale.

The Manchester Physics Series of textbooks, of which the book under review is the third, has been designed for undergraduates at English universities. The books correspond to lecture courses given at Manchester, with some additional material included. ‘Statistical Physics’ is recommended for second or third year students.

Mandl has discarded the historical treatment of thermodynamics and statistical mechanics as separate subjects, and presents them as integrated topics. In this way the first two chapters on the First and Second Laws lead directly to a treatment of paramagnetism in the third. Later chapters deal with simple thermodynamic systems, the heat capacity of solids, and the perfect classical gas. Quantal gases and black-body radiation are treated, and the final chapter considers systems with variable particle numbers, showing how the classical gas equation of state, for example, arises as a special case.

Some situations of practical interest (e.g. the liquefaction of helium by expansion cooling) are omitted; for these, the standard text of Zemansky is to be preferred. Otherwise this is a useful textbook, very attractively laid out, and good value for money.

**THE CALCULATION OF ATOMIC COLLISION PROCESSES, Kenneth Smith, John Wiley & Sons, N.Y., 1971. x + 218 pp. $11.50.**

 Reviewed by E. Harting, School of Physics, University of NSW.

This is an interesting book, being different in concept to other recent books on collisional physics. It is divided into two sections, dealing with single-channel and many-channel problems respectively. In each section, a clear and fairly leisurely development of the theory is followed by an account of how computer programs can be constructed to extract the numbers. For a physicist, this is a most satisfying way of treating a topic which has customarily (and, before computers, necessarily) been presented in a rather abstract way, with emphasis on analytical solutions of daunting complexity.

The book is intended as a two-semester course following a first course in wave mechanics, and its choice of topics is therefore somewhat selective. Taking the theory first, there are chapters on potential scattering, resonance phenomena and the static field approximation in the first section. I missed an account of the Born approximation for the phase shifts, and also feel that more physical explanation of resonances could have followed the discussion of the S-matrix. The many-channel section concentrates on the close-coupling approximation, and has useful sections on Racah algebra and the density matrix. No account is given of variational methods or of the Born and Bethe approximations.

The very lucid chapters on computational techniques include the Numerov and Runge-Kutta methods, and matching algorithms for solving the systems of coupled equations encountered in close-coupling calculations. Well chosen examples of the results of computations are discussed fully. Figures 29 and 30 are missing, but the Bibliography and Index are good.

I highly recommend this book for the uninitiated wishing to acquire a working knowledge in this field, particularly if it is read together with a book such as Geltman’s which fills the above mentioned gaps in the theory.


Reviewed by H. G. L. Coster, School of Physics, University of New South Wales.

This book is a collection of 19 articles by some 36 authors. The material was originally presented at the Coral Gables Conference on ‘Physical Principles of Biological Membranes’ held at the Center for Theoretical Studies at the University of Miami in December 1968.

All the articles are concerned with the structure and physical properties of cell membranes. On the whole they are well written and each is sufficiently detailed to provide a more or less self contained account of the theory or experimental work described. A useful feature is the inclusion of the discussions that followed the presentation of each paper at the Conference.

In terms of the number of articles the subject matter is about equally divided amongst electrical and ion transport properties, studies in membrane structure and various studies of artificial systems and theoretical models. Fittingly the first article is a review of membrane dielectric properties by K. S. Cole who pioneered much of the biophysical work on cell membranes.

With one or two notable exceptions, the bulk of the material in the book has also appeared elsewhere in the scientific journals.

An important omission from the book and one which is common in books of this type, is the lack of cumulative index. It would seem that if the book is to be promoted as a monograph in its own right rather than merely the Proceedings of a Conference, it would be worthwhile and extremely useful to produce such an index.
Notwithstanding this, the book should prove very useful to those in the field despite the fact that the original material was reported nearly 4 years ago. To workers either just entering this field of research or those who merely want an insight into some of the problems that concern membrane biophysicists at present the book should also prove very useful. At a price of $7 the book is a very good buy.


Reviewed by D. W. Emerson, Department of Geology and Geophysics, University of Sydney.

This short and useful book reviews the fields of rock magnetism and geomagnetism and their use in studying the age and tectonic history of rocks. The book incorporates well written sections on basic physics, magnetic minerals, rock magnetization, field sampling, laboratory measurements, statistical analysis of results, reversals and geomagnetic and geological applications. An excellent selected bibliography is appended. It is considered that the book would be suitable text for undergraduates. It would also be a useful addition to the bookshelves of professional geophysicists not actually working in palaeomagnetics but requiring a good, up to date conspectus of the subject.


Reviewed by D. W. Emerson, Department of Geology and Geophysics, University of Sydney.

This second edition of Parsons' popular text contains a good, concise compendium of exploration geophysical methods updated somewhat from the first edition which was published in 1962. The extent and detail of coverage although uneven is adequate. Chapters 6, 7 and 8 on seismic, radioactive and airborne methods while sufficient are poor in comparison to the general excellence of Chapters 2, 3, 4 and 5 on the magnetic, gravity, electrical and electromagnetic methods. However it should be remarked that induced polarization (an electrical technique of great importance in modern exploration) could have received a fuller treatment. A shortcoming of the book is the lack of cited references for the petrophysical data. This is strange as the list of references is otherwise very complete and comprehensive.

This book is considered to be an excellent text for undergraduate instruction. The writer has recommended it to students for many years and will continue to do so. Also it will be of great benefit to the field exploration geophysicist requiring a refresher and updating reference.


Reviewed by J. C. Kelly, University of New South Wales.

This book has grown out of a course of lectures given by the author at Monash. It aims to guide the reader from a basic knowledge of band theory to the stage where he can perform computer calculations on the band structure of specific solids. A large number of methods and approximations are covered resulting in twenty-one rather staccato chapters in 191 pages with five additional appendices devoted to useful theories, functions, expansions, matrices and numerical methods making up the rest of the book.

The first five chapters, 'One Electron Equation', 'Crystal Lattices and Reciprocal Lattices', 'Bloch Functions', 'Eigenvalues', 'Density of States and Constant Energy Surfaces' summarise the basic concepts and theoretical ideas. The second section of the book is devoted to a consideration of the specific advantages and limitations of most of the known methods with a great deal of specific advice on how to use a computer most economically for particular problems: for example—cellular, tight binding, augmented plane wave, scattering matrix and quantum defect methods.

It is not just another book of analytic formalism. It should greatly help the budding theoretician to get his problem on to a computer and to make a reasonable choice of the model to use.

Amongst minor format criticisms I would list the trembly nature of many of the diagrams. Figure 3.1 for example has a much greater degree of uncertainty than Heisenberg would have insisted upon.

The book is to be commended to anyone trying to produce an itinerant electron model for a specific solid.


Reviewed by P. J. Jennings, School of Physics, University of New South Wales.

This book presents a comprehensive treatment, at an elementary level, of several of the branches of physics which have undergone major development since 1850. Under the label of 'Modern Physics' we find grouped the foundations of quantum physics, solid state physics, spectroscopy, special relativity, nuclear physics, cosmic rays and high energy physics. The treatment is mainly historical and detailed descriptions of early experiments in each of the above areas of physics are given. The Schrödinger equation is introduced by analogy with the wave equation for the motion of stretched strings and the conventional one-dimensional problems are solved. The treatment of solid state physics is brief and is confined mainly to a qualitative discussion of band theory and the properties of semiconductors. Over one hundred pages is devoted to nuclear physics but it is mainly concerned with descriptions of early experiments and the development of particle accelerators.

There are many other books available which cover the same material. The special features of this book appear to be the extensive list of references to original papers and books and the worked examples which appear throughout the text. Little attention is given to
technological developments, and no mention is made of the social consequences of modern science nor of the philosophical problems of quantum physics and relativity.

It is hard to imagine how this book could be useful as a text for a University physics course.


 Reviewed by D. G. Drummond, Electron Microscope Unit, University of Sydney.

The author has achieved a tour de force by covering the essentials of the conventional transmission electron microscope and its 'million volt' development, the scanning electron microscope and its high resolution developments, the X-ray microanalyser, the mirror electron microscope and electron-energy analysing and selecting instruments; by explaining electron scattering processes, and both amplitude and phase contrast mechanisms of image formation; and by dealing faithfully with electron lenses—electrostatic, electromagnetic, superconducting and multipole—their aberrations and possibilities, as well as many other aspects of electron optics, all in some depth, in about 250 pages.

Mathematical explanations are by no means skimmed but—as the dust jacket truly claims—they are 'everywhere subordinate to the physical explanations' so that the working microscopist can get a real insight into the principles underlying his subject without becoming lost in the mathematics. The first appearance in the text of each mathematical symbol used is indexed in a table at the beginning of the book.

Only one dubious statement has been noted: The double condenser is credited (p. 89) with 'concentrating' the beam; other things being equal it surely only limits the area illuminated without increasing the intensity per unit area.

Two curious omissions are that no mention is made of permanent magnet lenses, and one can find no reference to the book by Zwyerkin et al., of 1945, on 'Electron Optics and the Electron Microscope'. The final chapter on specimen preparation seems a little out of context, and though informative, would be inadequate as a laboratory guide.

As a treatise on electron optics other books may be more comprehensive—and much longer—but this is an excellent up to date introduction to the subject for those whose interest is in electron microscopy as such, and many of these will feel no need to go beyond this authoritative 'introduction'.

It is a rare pleasure to be able to recommend with so little reservation a book that has been so much needed, and which no student of electron microscopy can afford to miss.

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