SERC BULLETIN

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IN THIS ISSUE

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The Science and Engineering Research Council is one of five research councils funded through the Department of Education and Science. Its primary purpose is to sustain standards of education and research in the universities and polytechnics through the provision of grants and studentships and by the facilities which its own establishments provide for academic research.

SERC Bulletin **summarises topics concerned with the policy, programmes and reports of SERC. SERC's** *Annual Report* **(available from HMSO bookshops) gives a full statement of current Council policies together with appendices on grants, awards, membership of committees and financial expenditure.**

Enquiries and comments are welcome and should be addressed to the editor, Miss J Russell, at the Science and Engineering Research Council, Polaris House, North Star Avenue, Swindon SN2 1ET; tel Swindon (0793) 26222.

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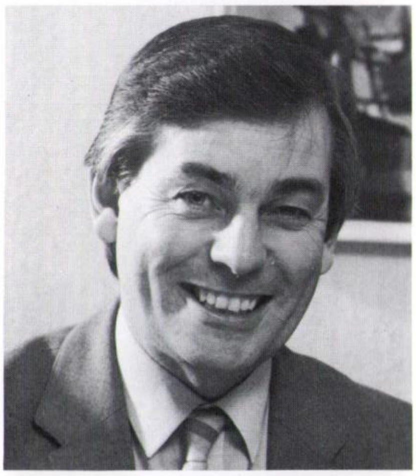
Dr Brian Davies, Director of Computing

Dr Brian Davies has been appointed SERC's first full-time Director of Computing. Formerly head of the Computer Systems and Electronics Division at Daresbury, Dr Davies took up his post on 1 October 1984. The appointment was the result of recommendations by the Computer Review Working Party last year. His duties are to run the Council's computing infrastructure and networking activities; to run the Rutherford Appleton Laboratory (RAL) mainframe service; to advise on the coordination of the provision and replacement of the various Boards' computing resources; to advise Council on computing matters; and to liaise with the Computer Board and other bodies involved in the provision of research computing.



Dr Brian Davies

Dr Davies's first two major tasks were to get agreement at Board and Council level on what items of the existing portfolio of computing activities should be included in infrastructure and to secure appropriate funding; and secondly to take up another of the Working Party's recommendations, that the RAL mainframes should be run on a direct charging basis - and to propose to Boards and Council how this might be done.

"The general position in SERC computing at the moment is one of considerable change," said Dr Davies recently. "The devolution of some facilities from central funding to funding directly by Boards, together with the introduction of new charging arrangements for the mainframes at RAL, are big enough changes in themselves. Since they also coincide with a period of severe financial restraint in the Council as a whole, it is clear that Boards and their users will be more and more concerned to see that the computing facilities they fund are relevant to their needs and are provided efficiently. The providers of the facilities are well aware of this and I am sure they will respond accordingly."

Congratulations

Appointed Knights Bachelor in the New Year Honours list:
Sir John Kingman FRS, Chairman of Council
Sir Diarmuid Downs CBE, FEng (Chairman and Managing Director of Ricardo Consulting Engineers plc), member of Council and Chairman of the Engineering Board.

Elected Fellows of the Royal Society:
Professor W J Albery (Professor of Physical Chemistry at Imperial College of Science and Technology), member of the Science Board and Chemistry Committee.

Professor J L C Culhane (Professor of Physics at University College London and Director of the Mullard Space Science Laboratory), member of the Astronomy, Space and Radio Board and the Engineering Board.

Sir Diarmuid Downs CBE, FEng (see above).

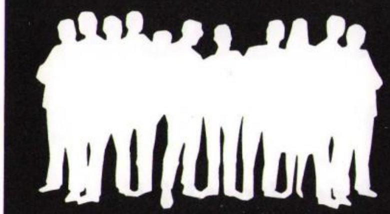
Professor R M Needham (Professor of Computer Systems and Head of the Computer Laboratory, Cambridge University), member of the Engineering Board and the Nuclear Physics Board.

Awarded Thomas Young Medal and Prize:
Dr J D Lawson FRS (Deputy Chief Scientific Officer at Rutherford Appleton Laboratory), for his many contributions in the field of charged particle physics.

Awarded the Dufton Medal:
Mr G P Hammond and Dr F Alamdari (School of Mechanical Engineering, Cranfield Institute of Technology) awarded the Dufton Medal by the Chartered Institute of Building Services (CIBS) for their paper on buoyancy-driven convection in rooms, supported by the SERC Energy in Buildings SPP (see page 16).

Front cover picture *(Photo CERN)*

Muons and muonium can be used as microscopic probes of the structure and dynamics of materials. This wire-chamber spectrometer is used in muon spin rotation studies at CERN. *See page 8.*



Council commentary

Estimates 1985/86

The Council has submitted its estimates for 1985/86 to the Department of Education and Science at a level of £297,960,000. This figure includes a sum of £6,950,000 added by the Secretary of State which frees the Council from a levy originally imposed on it to facilitate restructuring at the Natural Environment Research Council and the Agricultural and Food Research Council. The addition will allow increased spending on capital equipment and on research grants.

Forward Look 1986/87 to 1990/91

In February Council, in a preliminary debate on its Forward Look, heard presentations from Board Chairmen on the plans of their Boards. This year's exercise is unusual in that it represents the first stage in the development of a long-term strategy for Council whose main elements will be incorporated in a published corporate plan later this year. As part of this exercise, and recognising that, in view of likely long-term funding constraints, new endeavours could only be supported by the release of resources from exisiting activities, Boards were asked to re-examine their programmes radically to see where major changes could be made, and to indicate for which new high priority areas they would bid.

The final shape of the Forward Look submission to the ABRC was discussed in March.

Reports of the Working Parties on the Needs of Engineering and Engineering Design

The Council considered these reports in detail, agreeing that the issues raised in discussion would be valuable in the context of the forthcoming Forward Look debate. The Council encouraged the Engineering Board in its work of increasing the attention paid to the evaluation and dissemination of the research it funded, in its review of the support of postgraduate education and in its design initiative.

Review of the Alvey Programme

At its January meeting the Council considered a report by the Engineering Board on its first annual review of the Alvey Programme. In common with the Board, the Council was generally satisfied with progress in this novel type of programme.

International organisations

In December 1984 and January 1985 Council considered reports on its collaboration with various international organisations and approved contributions to the Institut Laue-Langevin, the European Space Agency; the South African Astronomical Observatory, and the European Incoherent Scatter Scientific Assocation.

Senior Fellowships

Two awards were made for 1985. Professor D R Cox FRS of the Department of Mathematics at Imperial College of Science and Technology was given a three-year extension to his present two-year fellowship while a five-year fellowship was awarded to Dr C J Leaver of the Department of Botany at the Edinburgh University.

Mesosphere, stratosphere and troposphere radar

In November Council approved a proposal for the construction of a Mesosphere, Stratosphere and Troposphere Radar facility which will be a national facility under the scientific direction of the University College of Wales, Aberystwyth. The vhf facility will complement satellite projects, balloon-borne measurements and other approaches to the study of the middle atmosphere.

Major new grants

ENGINEERING

Professor E G S Paige, Dr C J R S Sheppard and Dr L Solymar (Oxford University): £433,981 over four years for research in device aspects of analogue information processing.

NUCLEAR PHYSICS

Professor K W Allen (Oxford University): up to £863,000 over two years for experimental research in nuclear structure physics.

Professor J M Reid (Glasgow University): up to £312,000 over two years for experimental research in nuclear structure physics.

SCIENCE

Professor Sir Sam Edwards, Professor V Heine and Professor D J Thouless *et al* (Cambridge University): £368,000 over four years for research into the theory of condensed matter.

COMPUTING

Professor K W Sykes (Queen Mary College): £370,655 over four years for the Distributed Array Processor Support Unit.

Spinks Studentships

The SERC Biotechnology Directorate has launched a new scheme to attract engineers into biotechnology. The Spinks Studentships offer three years of postgraduate training for outstanding graduates in biochemical, chemical and process engineering. The Spinks awards will operate along SERC's existing guidelines for Cooperative Awards in Science and Engineering (CASE) but with certain distinctive features to help train graduates for positions in senior management within industry. Projects will contain a strong element of process design and offer an insight into the broader issues of industrial policy-making. Companies participating in the scheme will add £1500 per year to the basic studentship grant provided by SERC.

The Directorate received a good response to the announcement of the scheme early this year, and four three-year projects have now been approved. These involve the Departments of Chemical Engineering at Birmingham University, Bradford University and University College London in collaboration with Celltech, ICI and John Brown Engineers and Constructors Ltd. The studies will cover the extrusion of cell pastes for enzyme immobilisation, shear and turbulence effects on microorganism behaviour, process design for use of temperature-sensitive constructs, and the design of biocatalytic reactors. A small number of top-quality students short-listed for awards were invited to meet the academic and industrial supervisors of the four projects at the Confederation of British Industry on 1 April. The emphasis of the meeting was as much to allow the students the opportunity to assess projects and supervisors as it was for supervisors to assess the students. Four of the highest quality students have now been offered Spinks Studentships, each linked to one of the high-level training projects.

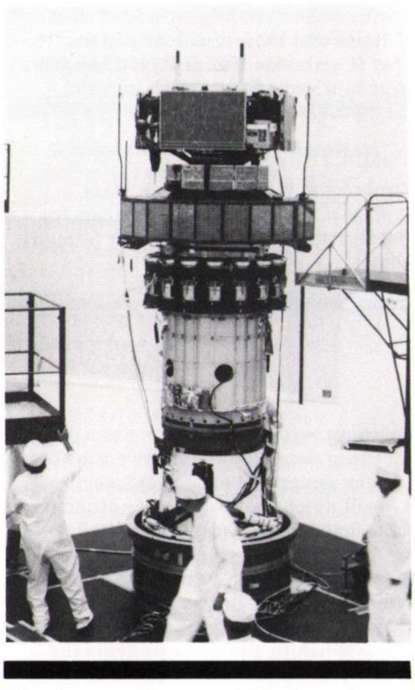
AMPTE mission — successes and problems

The three AMPTE satellites (Active Magnetospheric Particle Tracer Explorers) achieved another of their major goals on 27 December 1984 by producing an artificial comet. And then, in January, the UK satellite developed a serious problem.

The Christmas 'comet'

The purpose of the experiment in December was to simulate under controlled conditions the interaction that takes place between the solar wind (the stream of ions and electrons which flow from the Sun) and material expelled from the surfaces of comets by solar radiation. The experiment was highly successful - the comet-like interaction developed as planned, and complete sets of measurements were obtained by two spacecraft within the 'comet' and from airborne and ground-based instruments.

Two canisters ejected from the German spacecraft (the Ion Release Module) exploded to release an expanding cloud of barium atoms 64,000 miles above the Eastern Pacific Ocean. The atoms, 5×10^{24} in number and of total mass 1.25 kg, were ionised within tens of seconds by solar ultraviolet light to be transformed into a plasma of barium ions and electrons. The barium ions emitted light which was visible in the dawn sky from the Western USA (Pacific Standard Time 0432). Due to continued cloudy conditions, which had caused an attempt on Christmas Day to be abandoned, the 'comet' was largely obscured from the prime observing sites and the main observations were made by two aircraft.



The three satellites stacked in launch configuration. The US craft, CCE (Charge Composition Explorer) is located at the top; the German IRM (Ion Release Module) at the base, with the UKS nested between.

These showed over a period of some 12 minutes the appearance of the new 'comet' approximately 140 miles across, with a tail developing to a length of over 7,000 miles, which is more than ten times the angular diameter of the Moon. These events were caused by the expansion of the barium plasma being resisted by the pressure of the solar wind and the magnetic field embedded within the solar wind. The German spacecraft, initially at the centre of the cloud, and the UK spacecraft, 100 miles away at the beginning of the event, observed clearly that the flow of the solar wind was impeded so much by the barium cloud that its unusually high speed of more than 1,3000,000 mph that day was halved. The magnetic field was expelled from the cloud with a consequent amplification of the field outside. This major interruption of solar wind flow released energy which produced a rich variety of plasma wave oscillations, and a tenfold increase in the energy of solar-wind electrons.

The solar wind that flowed around the edges of the cloud drew away some of the particles to form the visible tail, while the pressure exerted by the solar wind on the front caused the whole phenomenon to accelerate, tail first, downstream. While it was not anticipated that these barium particles released into the solar wind at the dawn flank of the Earth would eventually penetrate into the radiation belts within the magnetosphere, the American spacecraft (the Charge Composition Explorer) remained alert to the possibility that some particles might enter.

The data from the three spacecraft and the ground and airborne observing sites are currently being intensively examined in order to clarify and refine the initial impressions so that they can be of value in connection with the forthcoming spacecraft investigations of the Giacobini-Zinner comet later this year and Halley's comet in 1986.

Silence from UKS

Less than three weeks after the success of the December experiment, the UK satellite (UKS) of the AMPTE mission ran into trouble. On 16 January the Operations Control Centre at the Rutherford Appleton Laboratory (RAL) lost contact with the satellite, which until then had been functioning normally. Extensive checks on ground equipment and operating procedures eliminated the possibility of this problem being due to a fault at the ground station and in the following days various means, including the use of NASA's Deep Space Network, were used to try to re-establish communication with the UKS, without success. And so, after five months of faultless operation, in which about 70% of the science had already been obtained, the UKS mission terminated prematurely.

Meanwhile, AMPTE's remaining two satellites, the West German Ion Release Module and the American Charge Composition Explorer, continued to work well and add to the considerable wealth of data and discoveries already provided by the three-satellite AMPTE mission. UK scientists continue to be fully involved with the results.

The early loss of the UKS was disappointing, but full attention has now been focused on the analysis and interpretation of the substantial set of results. The UKS was a major milestone in UK scientists' efforts to understand the mysteries of the far-from-empty space between the Earth and Sun. These efforts have provided an extra dimension to the first studies of injections of tracer particles into the solar wind. Early in the mission, it was decided to operate the spacecraft instruments twice as frequently as had been planned, and as a result about 70% of the original aims were achieved, and a total scientific return very close to that originally envisaged was obtained. The UKS was designed and built at low cost and in record time. Such a performance from an essentially high-risk venture is a credit to the satellite design and construction teams at RAL and the Mullard Space Science Laboratory (MSSL) of University College London, and the scientific groups which provided the on-board instrumentation. The five experiments on board the UKS were provided by Sussex and Sheffield Universities, MSSL, RAL and Imperial College with UCLA.

European Space Agency: future programme

SERC's space astronomy and geophysics programme is entirely carried out through international collaboration and in particular through participation in programmes of the European Space Agency (ESA). This highlights the importance to SERC of decisions taken at a special meeting of ESA Council held in Rome at the end of January, where Ministers from ESA's eleven Member States, two Associate Member States and from Canada, which has close cooperation links with ESA, met to decide on a future programme for European cooperative space effort up to the end of this century.

The plan of activities endorsed by Ministers in Rome should lead to the development of a comprehensive autonomous European capability in space over the next two decades. ESA's present activities in its science and applications programmes will be expanded and strengthened, and new programmes in launcher development and space station infrastructure will be initiated. Ministers agreed to accept the offer from the President of the USA to participate in the International Space Station project, subject to the achievement of a satisfactory agreement, and agreed to initiate the 'Columbus project' which is aimed at the development of space station elements which will initially form part of the International Space Station. Ministers also agreed to plans for the development of a new generation advanced launcher system (Ariane 5) equipped with a large cryogenic engine HM60. Future projects which are proposed for inclusion in ESA's programme - the development of an autonomous European space station together with the development of a manned reusable launcher - would allow ESA to develop into a truly independent space power by the 21st century.

Space science

The plans for an expanded space science programme submitted to Ministers in Rome were based on a survey of the needs of the European astronomy and solar system science communities, and identified areas where Europe could play a determining role and maintain its position at the forefront of space science. The proposed programme as described in the report *Space Science Horizon 2000* is founded on four cornerstones:

- the solar-terrestrial programme
- a mission to asteroids or comets, including the return of material
- an x-ray spectroscopic mission
- a spectroscopic mission in the far infrared/submillimetre wavelengths.

In addition, the programme will include a number of medium and small-sized missions to be selected at the appropriate time according to the Agency's current competitive selection procedure. This programme will incorporate and expand ESA's present programme in which five missions are already under development: GIOTTO, the mission to Halley's Comet; HIPPARCOS, a space astrometry mission; ULYSSES, the International Solar Polar mission; the Hubble Space Telescope; and ISO, an infrared spectroscopy mission.

Ministers endorsed the need for an expanded space science programme in order to maintain Europe at the forefront of space science and agreed to an increase in the budget of 28% to be reached by 1989 in progressive steps. This should allow a substantial part of the *Space Science Horizon 2000* programme to be implemented, and the UK scientific community, together with scientists from other Member States, will now be involved in discussions with ESA over the details of such implementation.

In addition to astronomy and solar system science, the long-term programme provides for continuation of such basic research activities as geodesy, climatology and microgravity research, to be carried out under the optional programme of the Agency.

International Space Station

The endorsement by Ministers of ESA's plans for the development of space station elements under its Columbus programme and participation in the International Space Station project proposed by the USA heralds a new area of activity for ESA. The Columbus programme, in its initial stages, includes studies of a number of elements: a manned module for microgravity research; unmanned platforms for a variety of uses ranging from the mounting of astronomical and geophysical payloads to long-term microgravity research; a resource module for the provision of basic supplies (thermal, power, data etc) to the platforms or manned modules; and a servicing vehicle. The UK will take the lead in the development of the unmanned platforms, and proposes that their initial use should be in polar orbit. The programme also includes user studies - in particular the definition of a set of candidate missions for space station elements once they are operational. SERC will not itself be involved in the construction of the space station elements, but it is hoped that the community will have substantial involvement in the user studies and in any subsequent user programme.

The ministerial meeting was chaired by Mr Van Aardenne, Vice Prime Minister of the Netherlands, and the UK was represented by Mr Geoffrey Pattie, Minister for Industry and Information Technology. Preparations for the meeting took place at the normal ESA Council, which is chaired by Dr H H Atkinson, who is also SERC's Director of Science.

The US Space Station

In January 1984, President Reagan announced that the US would build a permanently orbiting manned space station to be operational within a decade. The space station complex will orbit the Earth in a 28½° inclination and, in addition to providing permanent habitation quarters, modules to supply resources such as heat, power, fuel to the station and orbital transfer vehicles, it will also contain experimental laboratory modules for research needing a microgravity environment. The central core of the station will be accompanied by one or more free flying unmanned platforms in 28½° orbit and in near-polar orbit; both the station itself and the platforms will provide facilities for mounting payloads for astronomy, geophysics, Earth observation and telecommunications. Facilities for retrieval, maintenance and refurbishment of such payloads are also planned.

President Reagan invited Western European countries together with Canada and Japan to participate in the Space Station project. ESA Member States, at the Ministerial meeting in Rome, decided to participate in the project by developing space station elements through the Columbus project.

The William Herschel Telescope

With the existing telescopes at the new international observatory on La Palma now being regularly used for scheduled observing, scientists at the Royal Greenwich Observatory (RGO) are now looking forward to 1986 when the giant 4.2 m William Herschel Telescope (WHT) will be installed on the island.

The telescope, named after the famous astronomer who discovered the planet Uranus in 1781, will be the world's third largest optical telescope with a single main mirror and it is expected that the already proven excellent observing conditions on La Palma, together with the most up-to-date light detectors, will give the William Herschel the edge over its larger rivals, the American 5 m and Russian 6 m telescopes.

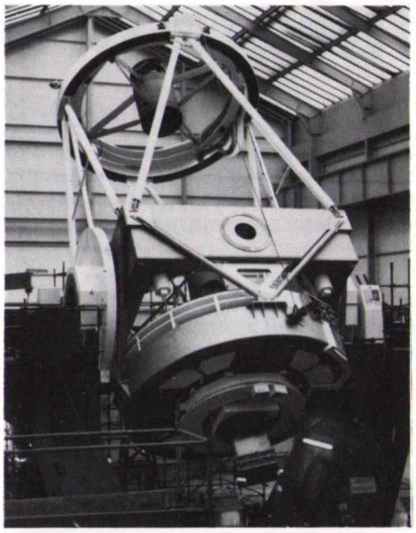
The WHT makes use of the 'altazimuth' mount, in which the telescope tube swings up and down about a horizontal axis supported on a mounting which rotates about a vertical axis, rather than the more traditional 'equatorial' type of mount, where the telescope's axis of rotation is tilted to lie parallel to that of the Earth. The new style of mounting allows the designer to optimise the structure, and the complex motions required to track a celestial object can be handled by sophisticated computer control.

The WHT's 4.2 m diameter glass-ceramic primary mirror focuses light to the prime focus where a correcting lens system ensures that the field of view is sharply in focus over a region 42 arcminutes across. Alternatively, a secondary mirror can be brought into operation to reflect light back down through a central hole in the main mirror to the Cassegrain focus. The telescope also has a third mirror located just above the main mirror and angled at 45° so that light can be diverted sideways, through an aperture in the main bearings to the Nasmyth platforms where large and heavy instruments and detectors may be placed.

The telescope, including the main mirror, has been manufactured and assembled at the Newcastle works of NEI Grubb Parsons Ltd. The WHT is the biggest telescope that the firm has made, but after a century in the business it is their last. Many famous telescopes have been constructed there including the UK Schmidt and the 3.8 m thin-mirror UKIRT.

A team of experienced mechanical, electrical, electronic and software staff from RGO have been involved in the final testing of the telescope prior to its being dismantled and shipped to La Palma. A large optical telescope like the WHT is a complicated mixture of heavy engineering, hydraulic bearings and high precision mechanical parts, driven by advanced servo systems and controlled by modern computers. The testing was complicated by the telescope being so large that it barely fitted into the factory: some of the roof lights even had to be removed to get the top ring installed!

Each subsystem has been thoroughly tested by the RGO team before being added to the telescope and an independent quality control inspectorate was continuously employed to ensure that the final product was correct. As any engineer will tell you, the testing of each subsystem is a vital part of a large project such as the WHT. The mechanical engineers checked the alignment, how the parts meshed and gave all the careful attention that two of the world's most accurate gear drives merit, while the electrical and electronic experts verified that the cabling was correct and that the multitude of sockets was properly made up and ready to take the rigours of a La Palma winter out in a freezing dome. Much of this cabling will not be used until the various instruments and detectors are installed in two years' time but it has to go inside the telescope structure now.



The 4.2 m William Herschel Telescope nearing completion at Newcastle.

The computer group had their minicomputer moved from RGO to Newcastle and finally, after a series of scheduled checks and tests, the telescope was brought under computer control for the first time. Nervous fingers hovered over the emergency stop button as the computer issued the commands to accelerate the telescope to maximum slew speed but the 180 tonnes of WHT ran up smoothly to maximum velocity and the data logged of the acceleration showed immediately how responsive and accurate the Marconi servo systems are. Many weeks of further testing and fine tuning followed until the team were satisfied that the performance of the telescope met the stringent specifications.

The distinctive 'onion-domed' building is nearing completion on La Palma, and the telescope is due to be installed in July 1985. The telescope will be accompanied by one of the largest vacuum deposition plants ever built, which will enable the staff to aluminise the primary mirror. The main vessel is 5½ m diameter and 6 m in length and is designed to obtain one of the most accurate reflecting surfaces for the primary. Without this quality of surface the telescope would not be able to utilise the exceptional seeing available at the site.

The distinctive 'onion-shaped' dome of the building which will house the William Herschel Telescope, photographed during construction.

Ralph Martin, Brian Mack, Chas Parker

Royal Greenwich Observatory

One man and his Watchdog

Safeguarding the solitary astronomer

The UK Schmidt Telescope (UKST) is one of the largest of its type in the world and is probably the most intensively used Schmidt telescope ever built. It is situated at Siding Spring Observatory in the picturesque Warrumbungles mountain range in New South Wales, companion to a host of other astronomical instruments, which are distributed over an area of 30 acres or more.

Despite its size and power, the UKST is highly automated and can therefore be easily operated by one person. The working schedule which was set up after commissioning in 1973 took full advantage of this feature and single manning at night has continued as the standard method of working for more than ten years. Observing duties are allocated in blocks of five or six nights to each member of the small team of scientific staff in turn.

Although many astronomers will be working with the other telescopes on the site and several families live within the Observatory grounds, the Schmidt telescope observer is normally the only person in the UKST building at night, and over weekends or public holiday periods may be working alone for several days at a time. It is therefore possible that an injured observer could remain undiscovered for some considerable time. In addition to the obvious danger of that situation there are features of the work which add to the hazards, stemming from the fact that the observing is of course done at night at very low light levels.

Safety

An obvious way to minimise these dangers would have been to introduce two-observer operation. There was, however, opposition to this from the staff, many of whom preferred to work alone. Observing requires careful concentration but a single observer is sufficient since Schmidt telescope exposure times are long, typically one hour, and the operation of the telescope is fully automatic once an exposure has been started. On the other hand, there was clearly some potential danger in the situation and there was concern about this. It was felt by the staff that some form of emergency call-out system was needed in case an accident occurred in which the observer was unable to telephone directly for assistance.

Initially enquiries were made to commercial organisations specialising in safety but the ideas offered were either inapplicable, too clumsy, or too expensive; no one offered a viable solution that gave a sufficient degree of increased safety for the observer. It was under these circumstances that ideas evolved from a number of separate initiatives and eventually coalesced into the system now known as Watchdog.

The Watchdog system

The system is based on a Commodore PET microcomputer. It is designed to monitor the observer throughout the duty period and to give an alarm if he or she fails to 'check in' during a preset time. The PET controls a number of other devices through a simple interface. The components of the system are as follows.

The PET microcomputer: monitors the other equipment and activates the alarm when necessary. It has a built-in clock.

An automatic telephone dialler: can be programmed with any two telephone numbers. On receiving the appropriate signal from the PET it dials each number in turn and gives a 40 second alarm tone. Because the unit is not able to recognise when a valid connection has been made it repeats the procedure every five minutes until manually reset.

A radio receiver and miniature transmitter. The observer carries the transmitter at all times and can activate the alarm sequence by pressing a button. To prevent false alarms the button must be held down for about ten seconds.

Remote alarm and report stations. The laboratories and offices in the UKST building are quite extensive and a number of remote stations are connected into the system to allow the observer to check in without returning to the computer itself. An audio-visual alarm is built into each unit to warn the observer when the period allowed for check-in is coming to an end.

Emergency power supply. The Observatory is in an area prone to spectacular thunderstorms and power interruptions are fairly common. The system is protected by an uninterruptable power supply which switches to battery power during a blackout.

The person who receives the emergency call alerts one of the other groups at the Observatory (usually the night assistant at the Anglo-Australian Telescope, which is about 500 metres away).

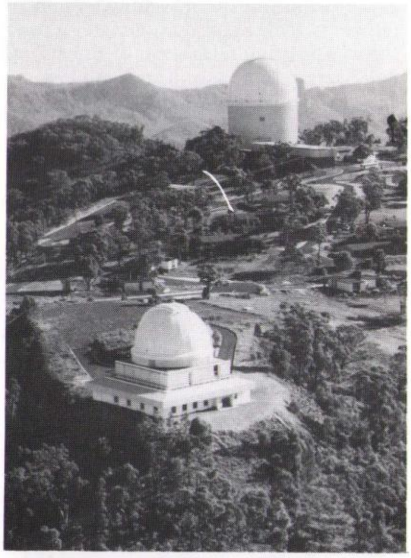
The system has now operated successfully and almost continuously for over two years. The various time cycles are programmable (but only within certain limits) so that the observer may set them to match the preferred work pattern.

The system is controlled by a lockout switch so that if the observer wishes to leave the building for any reason it is possible to disable the alarm. The key for this lockout switch is attached to the key for the observer's vehicle but in spite of this on at least two occasions an observer has gone out without switching off: the wrath of those woken from sleep in town more than 17 miles distant has ensured that no one makes this mistake twice!

The technology is advancing so rapidly and the costs of the components are dropping so fast that the system could be improved considerably if it were being rebuilt. Even as it stands, Watchdog is flexible and reliable and gives personal security at least as good a that provided by the nightwatchman who at one time was a statutory member of staff at many an Observatory.

Ken Russell

Royal Observatory, Edinburgh



The 1200 metre peak of Siding Spring mountain, with the dome of the 1.2 metre UK Schmidt Telescope in the foreground, above the square building which houses workshops, darkrooms and offices. In the background is the dome of the Anglo-Australian Telescope.

Using muons to probe materials

A brief introduction to the use of muons and muonium as microscopic probes of the structure and dynamics of materials.

In the list of elementary particles used extensively in materials research and in condensed matter science, the muon is fast establishing itself alongside the electron, the positron and the neutron. The muon is a short-lived particle, having either negative or positive charge. In this context the negative muon plays its expected role of 'heavy electron'; for instance it can substitute for an atomic electron in the so-called exotic atoms. But in many circumstances the positive muon plays instead the role of 'lightweight proton'. Implanted in a material, the positive muon reacts and binds chemically (as does a proton), in particular forming a hydrogen-like atom known as muonium, with the positive muon as atomic nucleus. Muonium is the 'light isotope' of hydrogen, with about one tenth the atomic mass.

The analogy between a proton (which experiences the strong interaction) and the muon (which does not) would perhaps worry the nuclear physicist. But the fundamental differences between the two particles are relevant only at much higher energies than those which are the concern of solid state physics and chemistry. If the unstable muon still seems a somewhat exotic probe to use, it is exactly the properties of its radioactive decay which make it so useful. When it decays, the muon emits a positron preferentially along its spin direction. This natural asymmetry allows the rotation and relaxation of the muon polarisation to be monitored. A close analogy can be made with nuclear magnetic resonance (NMR), which monitors the rotation and relaxation of proton polarisation, but the powerful 'nuclear technique' of single-particle counting makes muon spin rotation (μSR) much more sensitive.

The essential requirement is a source of low-energy muons, for implantation in samples. These presently exist at a number of accelerator laboratories. At the European Particle Physics Laboratory at CERN, for instance, one of the many international collaborations is dedicated to studying the properties of condensed matter as 'seen' by positive muons.

Universities and research institutes from Britain, Sweden, Italy, West Germany and France have been using the technique of μSR since 1976 to investigate magnetic, electronic and transport properties of solids and liquids in the experimental halls of the oldest CERN accelerator, the 600 MeV synchro-cyclotron.

The study of interstitial particles in metals, and especially of the hydrogen-in-metals problem, is a prime example of the utility of this lightweight, radioactive, isotope of hydrogen. Information on the position and diffusion of the interstitial muon is readily available on an individual-event basis even for materials in which hydrogen itself is difficult to study. This is typically the case for low-temperature studies in metals and alloys where, in addition, muons offer the possibility of testing quantum diffusion and related quantum-mechanical effects.

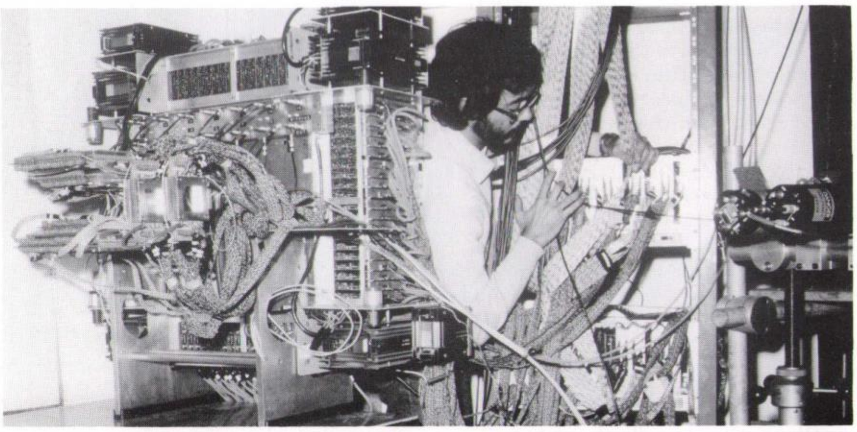
The specific role of the muon as a probe of local magnetic fields has also stimulated many studies of the fundamental properties of magnetic materials, their phase transitions and related critical fluctuations, complementing the information available from well-established techniques such as neutron scattering and nuclear magnetic resonance. Among the many μSR experiments performed so far in magnetism, those on spin-glasses and antiferromagnets have revealed features of the spin systems that other methods could not detect.

The usefulness of μSR as a tool is increased because muonium atoms can interact with the medium being investigated. The electron-muon hyperfine interaction provides the experimenter with a wealth of information about static and dynamic properties and has stimulated theorists to the solution of some unusual problems associated with isotope effects. This area, which involves the dynamics and phase-transition properties of molecular crystals and some fundamental problems in basic chemical reactions, has called for a close collaboration with the community of chemists. The timescale of μSR (10^{-9} to 10^{-5} sec) is very well suited to studying the kinetics of chemical reaction, and has provided information on the early stages of chemical reactions and free-radical formation.

Over the last few years, several unique spectrometers have been developed around the muon beam at CERN. These include a low-temperature facility in the milli-Kelvin range, high-pressure equipment, and detectors able to give a spatial, as well as temporal, resolution of the individual muon decays. These developments guarantee a fundamental future role for the CERN μSR collaboration.

But the success of μSR has inevitably quickly saturated the experimental time available on the two continuous muon beams in Europe, at CERN and at the SIN Laboratory, also in Switzerland; these cannot now satisfy the demand.

The new possibility of an intense muon source at the Spallation Neutron Source (SNS) at Rutherford Appleton Laboratory is looked upon with great hope by the μSR community. The SNS muon source could assure the natural expansion of European research in μSR and provide superb facilities for a wide spectrum of research embracing physics, chemistry, biology, metallurgy, and related disciplines. The pulsed nature of its beam will also enrich the potentialities of the technique, and enormously enhance the rate at which data may be collected.



A wire-chamber spectrometer used to reconstruct the tracks of muons and positrons from decay events *Photo: CERN*

Laser lights at Daresbury

Research work at the Daresbury Laboratory is largely divided into two areas, one associated with the Nuclear Structure Facility (NSF) and the other with the Synchrotron Radiation Source (SRS). The NSF is mainly concerned with nuclear physics; the SRS is used to study systems of atomic dimensions and larger. In essence the accelerators explore different worlds: the nuclear world characterised by dimensions of 10^{-13} cm and the atomic world where sizes are measured in units of 10^{-8} cm. However in some research fields these two seemingly disparate worlds combine and nowhere is this more true than for the laser experiments at the NSF. Here precision laser measurements of atomic energy levels are used to give important information about the structure of the nucleus.

How then does this coupling arise? Although atomic energy levels are almost entirely determined by the number of protons in the nucleus, there are small changes brought about by the structure of the nucleus. Two effects result from the finite nuclear size and the nuclear moments. The former causes a shift in the energy of the atomic levels while the latter produces a splitting known as hyperfine structure. These effects are very small – typically an energy level might be altered by a few parts in a million – but because of the precise monochromatic nature of laser light they can be measured very accurately.

Measurements of this type are not in principle anything new. What is different is that because of increasing sensitivity they can now be carried out on radioactive nuclei, and since the majority of known isotopes are radioactive, this gives a much broader scope to the work. In addition, this technique is the only one which can measure the radii of unstable nuclei.

Two techniques

The starting point of the measurements is the NSF accelerator which is used to produce radioactive nuclei. Two techniques are now available depending on the lifetime of the isotopes. For long-lived isotopes the radioactive atoms are placed in a small oven which is heated to produce a narrow collimated atomic beam. A light beam from a tunable dye laser is then made to intersect this beam at right angles. When the laser wavelength is scanned across an atomic transition, photons are absorbed by the atoms. These atoms can then decay by spontaneous emission in all directions and hence a photon detector (photomultiplier) placed near the intersection can be used to signal the resonance position. This is of course the basis of resonance fluorescence spectroscopy. In the NSF experiments the techniques have been refined to such an extent that samples as small as 10^{-11} g can be measured. Already measurements have been made using this method on a number of radioactive samarium nuclei.

The results are providing some fascinating information about nuclear sizes and shapes along an isotopic chain, as one

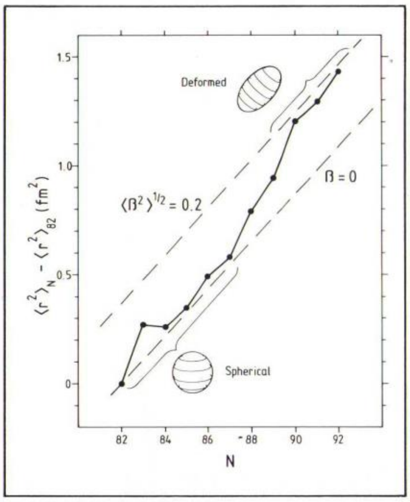


Figure 1. Changes in nuclear radii for samarium isotopes.

moves away from the closed shell at neutron number 82. As an example, *figure 1* shows how the nuclear radii change as neutrons are added to the nucleus. The distinct alteration in slope at around N = 87 is caused by the nucleus changing from a sphere to a prolate spheroid (rugby ball shape). Another obvious feature is the pronounced saw-tooth pattern. This is a real effect and implies that the nucleus with odd N is significantly smaller than the average of the two adjacent nuclei with even N. As well as being of considerable theoretical interest, it serves to illustrate the extreme sensitivity of the measurements.

At the same time work is progressing on measurements of isotopes with lifetimes down to 10 msec using a collinear method *(figure 2)*. To show how the system works, take a specific example of the experiments on the neutron-rich isotope samarium 138. This can be produced by bombarding a target of molybdenum 96 with a beam of titanium 48 ions from the NSF tandem. The nuclear reaction which produces the isotope involves the fusion of the two nuclei followed by the emission of an alpha particle and two neutrons (or two protons and four neutrons). Because of the large momentum in the titanium beam, the samarium nuclei can be made to recoil through a thin window into the ion source of the Daresbury isotope separator (DOLIS). Radioactive ions are extracted from this ion source and accelerated up to 100 keV where they are separated according to their mass. The narrow beam of samarium 138 ions is then charge-neutralised in a low pressure vapour to form a fast atomic beam. This beam is then made to collide with a tunable laser beam which is scanned across the atomic transition of interest. Resonantly scattered photons are collected with a cylindrical mirror and focused via a plastic light-pipe on to a cooled photomultiplier.

Because all the atoms which are ionised pass through the beam this method is inherently more efficient than the thermal atomic beam technique. Typically about 10^4 atoms per second can be detected but it is hoped in the future to progress towards the magical one atom per second!

In addition to being very sensitive this is an on-line technique and hence short-lived isotopes can be studied. Measurements can therefore be made close to the point where the nucleus becomes unstable to proton emission. Here the relative imbalance of Coulomb and nuclear forces can be expected to produce some unusual effects.

Derek Eastham

Daresbury Laboratory

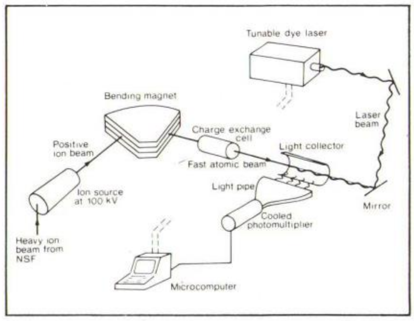


Figure 2. Equipment for collinear laser spectroscopy of fast radioactive atoms.

First results from Spallation Neutron Source

The long-standing plan for neutrons in 1984 was successfully achieved at the Spallation Neutron Source, with first neutrons being produced in a test run on 16 December 1984. The Facility, which has been under construction at the Rutherford Appleton Laboratory since approval in 1977, is now set to become the world's premier pulsed source for neutron-scattering research.

An immense amount of work had to be completed during the period following the progress report in last Spring's *SERC Bulletin* (Vol 2, No 10). The synchrotron ring was completed and a 70 MeV proton beam circulated in January 1984. Subsequent milestones included acceleration of the proton beam to 140 MeV in April and to 550 MeV in June 1984. These commissioning runs demonstrated the successful operation of a number of major subsystems - the synchrotron vacuum system, the magnet and RF systems with their associated power supplies, and the computer control system. A major step was achieved when a 550 MeV proton beam was extracted from the ring in September, with good intensity and low beam loss.

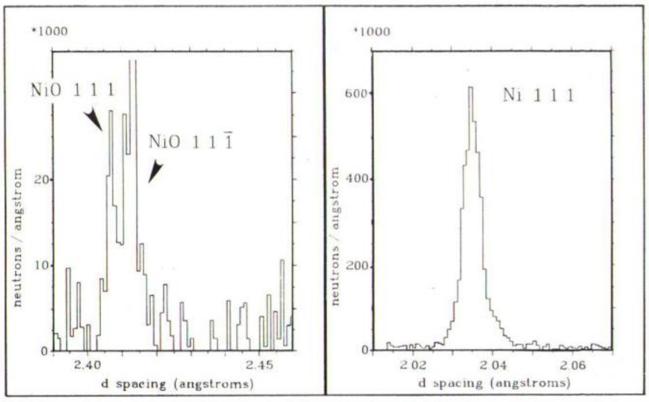
Meanwhile work continued on building up the target station with its associated components. The December run required installation of the uranium target, the neutron moderators, and the shielding and collimation components required to provide clean thermal neutron beams. The operation of the moderators alone was a remarkable achievement, with the ambient-temperature H_2O, 100 K liquid CH_4, and 25 K liquid H_2 moderators all being operated together *in situ* for the first time.

Neutron spectra were measured both on the available spectrometers and on special assemblies designed to characterise the source behaviour. All the evidence confirmed that the facility is operating as designed. Most pleasing of all, new experimental data, including phenomena not seen before in neutron scattering experiments, were measured for the first time, a happy pointer to the future.

Representative results, taken on the High Resolution Powder Diffractometer, are shown in the figure. With the successful operation of the facility for the first time, routine operation, and utilisation by the extensive university community of neutron-scattering scientists, should start in May 1985.

16 December 1984, 7.16 pm: It works! RAL staff and university visitors in the SNS control room, delighted as protons are successfully transported to the neutron-producing target at the first attempt.

W I F David and G C Stirling
RAL



A comparison of nickel oxide and nickel Bragg peaks. The peak splitting of NiO is the first direct observation of its kind with neutrons

Traditionally, crystal structures have been determined using x-ray and neutron single crystal diffraction techniques. Over the past 15 years, however, a more straightforward method involving powders and known as the Rietveld technique has become increasingly popular. The High Resolution Powder Diffractometer at RAL is significantly superior to existing neutron powder diffractometers and promises to extend their power considerably.

Diffraction data shown here were collected for powder samples of nickel and nickel oxide. Comparison with the 111 Ni peak clearly shows that a splitting occurs of the 111 and 11$\bar{1}$ NiO Bragg peaks. Although the statistics are poor, this splitting was observed in a number of spectra for a number of different reflections. These important straightforward observations of the rhombohedral distortion of nickel oxide are the first direct measurements of their kind.

High pressure neutron scattering facilities

Neutron scattering techniques, as a sub-atomic probe of matter and of interatomic reactions, are now used in an ever-increasing range of scientific disciplines. Often the phenomena being studied are only evident under special physical conditions of the sample, the most usual being temperature, over a range from cryogenic to about 2000 K. But some phenomena are only induced under pressures of several thousand atmospheres and often at cryogenic temperatures.

For neutron scattering studies at these very high pressures a large number of individual pressurising devices has been developed at the various neutron research centres around the world.

In all cases the design of these devices has been essentially the art of achieving compromises in design between the use of materials having high intrinsic strengths and toughness, and their often poor neutron transparency. Account has also to be taken of changes in material strength at cryogenic temperatures. These problems are further exacerbated in that neutron scattering samples need to have quite large volumes, usually not less that 300 mm^3, in order to produce adequate scattering data from relatively diffuse neutron beams. Clearly large sample volumes also imply larger and thicker-walled sample containers. Nonetheless cells have been designed having working pressures of up to about 50 kbar.

At the Spallation Neutron Source, three types of high pressure devices will initially be provided similar to the facilities presently available to visitors to the Institut Laue-Langevin (ILL) in Grenoble. Two of these devices will be variable pressure systems operating up to maximum pressures of 2 and 5 kbar, while the third system will be statically loaded and be capable of containing the sample at up to 30 kbar pressure. The two variable pressure systems will permit pressure changes to the sample while it is in the beam, thus enabling structural changes to be directly observed as a function of pressure. The pressure resolution will be about 0.01 kbar.

The 2 kbar variable pressure unit will be used only at ambient temperatures using oil as the pressurising medium. The sample cell is made from the null matrix TiZr alloy which has a flat scattering response to thermal neutrons. The cells are unreinforced thick cylinders having sample volumes of up to 5000 mm^3. They were originally developed by Dr G Neilson of Bristol University for neutron studies of pressurised liquid systems.

The 5 kbar variable pressure unit employs helium gas as the pressurising medium. The aluminium alloy pressure cell and its high pressure seals were designed by Paureau and Vettier at CNRS, Grenoble. This cell can be operated down to liquid helium temperatures in a specially adapted cryostat. Both pressure and temperature of this system can be independently varied over the ranges 0 to 5 kbar and 300 to 4.2 K, respectively.

The 35 kbar cell (illustrated) is based on a design by McWhan of Bell Laboratories, New Jersey. The thin- walled aluminium sample capsule is held between two opposing tungsten carbide pistons within the bore of an externally supported alumina cell. Pressurising is achieved by loading the pistons to a predetermined value of up to 10 tonnes and subsequently mechanically locking them under load. Hydrostatic pressure is transmitted to the sample within the sample capsule by either Fluorinert (a carbon-fluorine compound manufactured by the 3M Company) or a deuterated methanol-ethanol mixture. This static loaded device can also be used in cryostats over the temperature range 300 to 1.5 K. Pressure calibration of this device is made by including with the sample some NaCl whose diffraction pattern is well known as a function of pressure and temperature.

The ILL, which has functioned as a neutron research centre for 12 years, already provides apparatus similar to these, but in addition during 1984 two new variable pressure systems were introduced; these are:

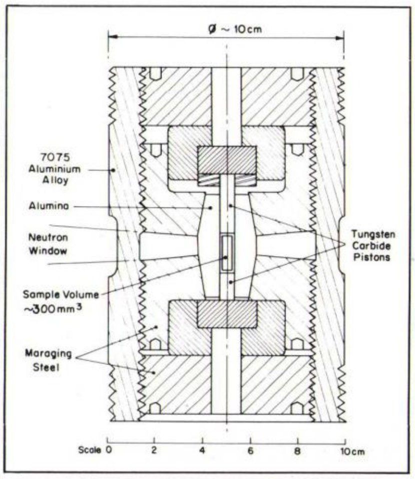
- ☐ Beryllium copper alloy helium pressure cell with an extended pressure range to 10 kbar.
- ☐ A flat hydraulically pressurised cell having sapphire windows which is intended for low angle scattering experiments.

Also recently available to visiting scientists to the ILL is a uni-axial stressing apparatus for single crystals. This has a maximum stress capability of 15000 N on the sample and is designed for use with a helium cryostat.

From the variety of individual pressurising devices available for neutron scattering work, clearly high pressure is becoming a very important factor in the understanding of matter in the solid state.

With the Spallation Neutron Source now successfully operating and providing neutron scattering facilities to an increasing range of sciences, it is expected that high pressure facilities will be one of the most important physical variables available to its users.

Ian Bailey
RAL



30 kbar clamped pressure cell

Materials commonly used for neutron high pressure cells

Material	Main alloying constituents %	Ultimate tensile strength
Al alloy 7075	1.5 Cu 2.5 Mg 5.8 Zn 0.2 Cr	5.0 kbar at 300 K 6.5 kbar at 4.2 K
Alumina	99.5% Al_2O_3	25 kbar compressive
Maraging steel	18 Ni 4.8 Mo 8.0 Co remainder Fe	19 kbar at 300 K
Ti Zr null matrix	Ti 67% Zr 33%	10 kbar at 300 K

Computer-aided design of integrated circuits

In 1977 SERC set up central facilities for the design and fabrication of integrated circuits (see *SERC Bulletin* Vol 2 No 7, Spring 1983). Here we outline the recent enhancements to the facilities for the computer-aided design of integrated circuits.

Circuit design and fabrication

At present there is an active academic community of about 300 electronic designers, mostly in university engineering departments. Their designs range from complex integrated circuits containing tens of thousands of transistors to small projects undertaken by students on SERC-supported MSc courses.

The designer has access to an SERC-supported computer system to convert his electronic circuit into a set of mask designs, each containing the pattern for one of many layers from which the circuit is built up. The precision mask plates are normally made at the Electron Beam Lithography Facility at Rutherford Appleton Laboratory (RAL). These plates are then sent to either Edinburgh or Southampton Universities where the circuits are fabricated on silicon. Some circuits are also produced using a brokerage service based at RAL.

A modern design system

In 1983 it was difficult to design large circuits, which had to be 'hand-crafted' because of the lack of sophisticated software. The designer had to generate the mask patterns in the computer by defining simple closed shapes, such as rectangles or polygons, and their interconnecting tracks. The shapes were assembled into groups which could be repeated within the design to form regular arrays. This process was subject to considerable error, and several passes through the mask-making and fabrication stages were usually required to produce a working chip.

Over the past two years, major enhancements have been made to the computer-aided design (CAD) system to prepare for the design of very large scale integration (VLSI) complexity - ie more than 100,000 transistors per chip. These modern CAD tools detect possible errors before fabrication, enabling working chips to be produced at the first attempt. The best available software has been brought together to form an integrated design system which runs on SERC computers. The various components of the system, from entering the design, through logic simulation, to circuit layout and verification, are:

Design entry As the number of computer programs required to design a chip has grown, it has become necessary to adopt a single design entry system. After an evaluation of available software, the Structured Design System (SDS) was licensed from Silvar-Lisco Ltd. This provides an interactive graphical way of specifying logic and circuit diagrams to the computer, and can be accessed from colour raster graphics terminals (Sigma and Westward) and with plotters (Hewlett Packard, Sigma and Benson).

The design descriptions are then converted automatically by SDS into the forms required by the simulation and layout programs described below, thus freeing the designer from the laborious and error-prone task of specifying his design from scratch for each program.

Logic simulation There are two tools available for logic and timing simulation. HILO, licensed from Cirrus Computers Ltd, provides gate and functional level simulation. BIMOS, licensed from Silvar-Lisco Ltd, is a transistor logic simulator specifically addressing the needs of MOS technology. It can model components ranging from complex RAM, ROM and PLA blocks to individual transistors. In addition HILO provides fault simulation and automatic test pattern generation facilities. Logic simulation is also provided within the UK5000 Gate Array system described below.

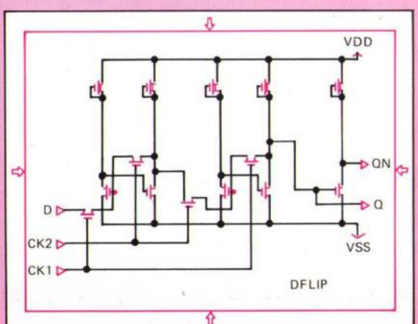
Circuit simulation The most widely used circuit simulation program is SPICE which was developed at the University of California, Berkeley. It is well suited to the simulation of a wide range of electronic circuits and offers DC, AC and transient analysis. It is currently the industrial standard circuit analysis program.

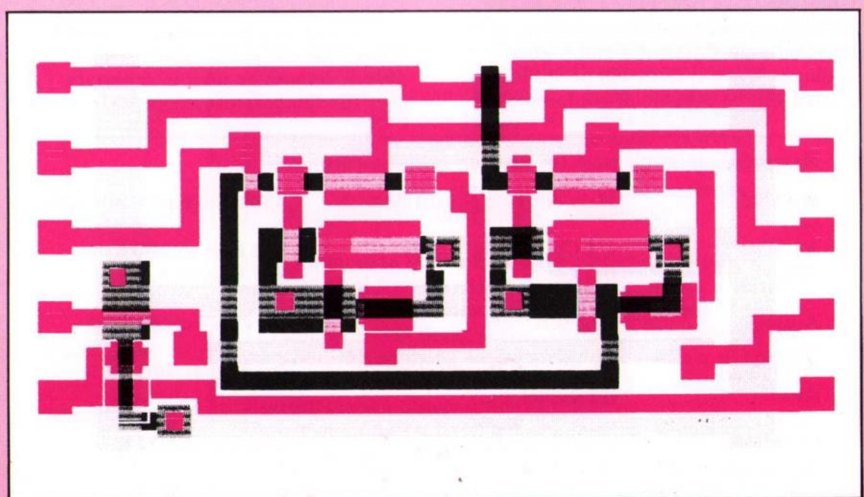
Gate array layout This is provided by the UK5000 system which is an integrated hardware and software gate array design system. It was developed in the UK by seven commercial organisations and Government establishments, including SERC, for the totally automated design of a digital integrated circuit containing up to the equivalent of 5000 logic gates. A description of the UK5000 project appeared in the *SERC Bulletin* (Vol 2 No 10, Spring 1984).

Representation of a D-type latch

Below: Circuit diagram

Right: Full layout of cell





A Design Centre has been set up at RAL to give users training and advice on the use of the UK5000 array. A graphics editing program is available to examine interactively the fine detail of any part of the chip and, if required, to add, delete or re-route a connection. The overall software suite is supported by the consortium maintenance centre at Standard Telephone Laboratories.

Cell layout SERC has negotiated an agreement with Silvar-Lisco Ltd to use the cell layout system CALMP. This consists of a set of programs for the automatic layout of integrated circuits using predefined cells from a library. The design description previously entered with SDS identifies which cells are required. CALMP automatically places the cells and interconnects them to construct the designer's circuit. Manual interaction to guide the program is also possible. Information can then be automatically extracted from the complete layout to enable an accurate analysis of the speed at which the chip will work.

Cell library A 5 micron CMOS standard cell library has been licensed from Silicon Microsystems Ltd to be used in conjunction with CALMP. It contains 88 cells including logic, latch and peripheral cells, with a full electrical and geometrical specification of each cell. The library has now been integrated with the relevant parts of the CAD system. In practice this has meant creating logic symbols and transistor level descriptions in SDS, functional models in HILO, and cell outlines and pin positions in CALMP for each cell in the library.

Layout verification A comprehensive suite of programs known as the Design Verification System (DVS) has been licensed from NCA Corporation. It provides designers with a wide range of verification tools to ensure the correctness of integrated circuit layouts prior to fabrication.

The range of analysis functions available with DVS includes electrical rule checking, network consistency checking, electrical parameter checking and geometrical design rule checking. These programs can be used to check designs which use the NMOS and CMOS processes available through SERC brokerage. DVS also provides software to access the commercial sources of masks used by SERC brokerage as well as to the Electron Beam Lithography Facility at RAL.

Full custom layout The GAELIC system has now been available for five or six years for designers requiring 'hand-crafted layouts. The interactive editing program, which supports colour raster graphics terminals, is the principal means of creating or modifying digital integrated circuit layouts where manual optimisation at the transistor level is required. It is the only means at present available for the layout of analogue circuits. Some other aspects of GAELIC are now being replaced by the more comprehensive facilities available in DVS described above.

Computers

The software is mounted on two Prime computers and the central batch computer at RAL. Designers access it in their departments from terminals connected to the Joint Academic Network (JANET). RAL staff are now installing the software where appropriate on computers located in universities and will support and maintain the software.

Support and training

Much of the software is complex and requires training to be used effectively. Documentation is provided and training courses given at regular intervals by RAL staff often with the help of the software suppliers. Where a training course is not immediately available, users and potential users benefit from a visit to RAL to receive instruction before starting to use the system. It is intended that the Design Centre established for UK5000 will also provide advice and training on other systems, especially the cell library.

An introductory brochure with a leaflet describing each package is available. A User Group holds regular meetings to discuss the use and development of the CAD system.

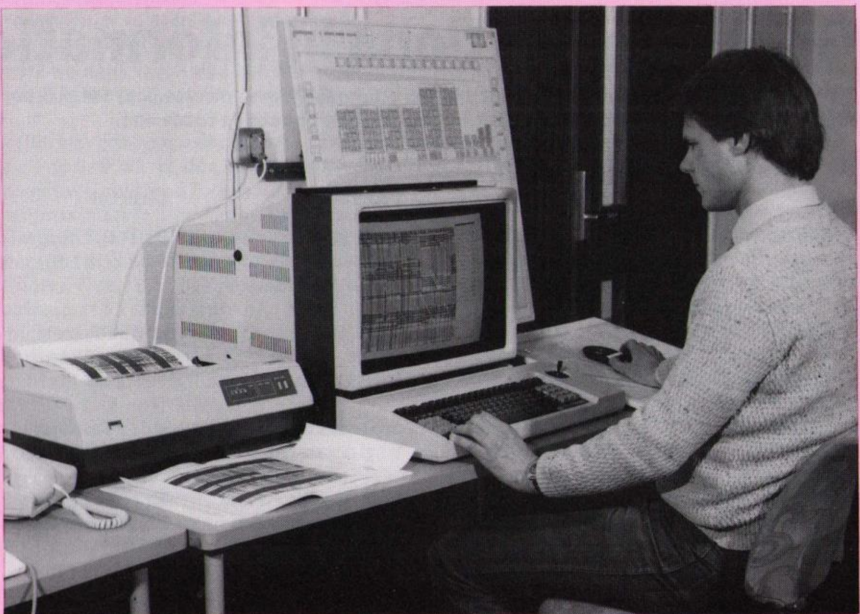
The future

The integration of all these tools into a comprehensive design system has opened up the design process to a wider range of engineer, who need no longer be a specialist in integrated circuit design to produce working circuits.

There are two different strands appearing in integrated circuit design. Designs may be produced quickly with gate arrays or cell libraries where very efficient use of silicon is not important. However, there is also a requirement for 'hand-crafted' designs making optimum use of the silicon area to achieve high densities of integration or performance. Sophisticated design work-stations are becoming available to support this second approach. The system developed and used by INMOS is being evaluated in a project funded by the Alvey Advanced Information Technology Programme, and is being integrated with the design system at RAL.

Much work remains to be done and gaps in the overall CAD system have to be filled. For example work is in hand to provide a means of designing printed circuit boards which is integrated with the other CAD tools. Nevertheless users are today successfully producing complex designs in several application areas including image processing and telecommunications. Much progress has been made in a relatively short time and there are exciting prospects for the future.

Dr A D Bryden
RAL



VLSI design workstation with graphics terminal, data tablet and colour plotter.

Computing and design techniques for control engineering

The Information Engineering Committee of the Engineering Board has approved a major coordinated programme in the control system design field - Computing and Design Techniques for Control Engineering (CDTCE).

Over the past decade, SERC funding has encouraged the development of significant new tools for control system design which include:

Complex variable methods, at Cambridge University;
Inverse Nyquist Array methods, at University of Manchester Institute of Science and Technology (UMIST);
Dyadic Approximation methods, at Sheffield University;
Optimisation techniques, at Imperial College of Science and Technology;
Self-tuning regulator techniques, at Oxford University and UMIST.

This work has placed the UK academic community in a strong position in control theory and has attracted considerable international interest. One outcome of the work is the existence of several computer-aided design (CAD) software packages, for example CLAD–P, now marketed by Cambridge Control Ltd, and CADCUM from UMIST. Also, several far-sighted UK and overseas companies have adopted some of these techniques for their products or operations.

Past SERC - supported work has thus resulted in an extensive body of theory and techniques for the modelling, analysis and design of multivariable control systems, which is attracting interest from UK and overseas firms. However there is, as yet, no practical design procedure for systems with more than three inputs and three outputs which will yield manageable design information or will produce simple and reliable controllers. Moreover no really satisfactory techniques yet exist for the design of controllers for systems with rapidly varying parameters, uncertain parameter estimates and the need to reject specified forms of disturbance.

The industrial requirements for improved control - system design arise from a number of factors. These include tighter constraints on energy usage, more flexible batch chemical processing, high speed and accuracy in robotic and flexible manufacturing systems and improved flight and satellite control systems.

Techniques developed with SERC support have not yet been adaquately transferred into industrial application except, perhaps, by the recruitment of experienced postgraduates into industrial control system teams, a process which has been called technology transfer 'on the hoof'.

The new CDTCE initiative aims to tackle some of the problems outlined above by the following measures:

☐ The support of academic research on new, robust design techniques for multivariable control systems with significant non-linearities or widely varying parameters.

☐ The development and provision of the appropriate computer-aided design software environment in universities as a basis for the research activity and the embedding of the design techniques into the CAD environment.

☐ Encouragement of the industrial use of design techniques arising from the programme by a number of routes, including:

Encouraging the availablity of well supported software tools via academic groups and software companies;

Sponsoring specialist workshops and seminars in aspects of CDTCE;

Identifying opportunities for Teaching Company Scheme arrangements and other industrial academic colloborative projects in the CDTCE field.

Enquiries from companies, universities and polytechnics interested in this programme will be welcome. Please contact Mr P H Hammond, SERC Coordinator for CDTCE, or Mr P Hicks, Secretary to the Control and Instrumentation Subcommittee, at SERC Central Office, Swindon.

Grant applications in information technology

There is evidently still some uncertainty in the community over mechanisms for making grant applications in the information technology field. We shall now attempt to clear up any remaining confusion.

The Council's support for research in IT is in two parts: work supported under the Alvey programme, and research supported outside the Alvey programme through the normal grants mechanism. Procedures for applying for Alvey grants were set out in two letters from the Council's Director for IT, Dr David Thomas; one, of 15 August 1983, was addressed to Heads of Departments, Registrars etc; and a subsequent letter dated 13 August 1984 explained how intellectual property rights were to be treated under the Alvey programme. Copies of the letters are available from Dr D M Worsnip at the SERC Swindon office (ext 2104). Since a substantial proportion of the funds so far allocated to Alvey has now been committed, potential applicants are advised to consult the Alvey Directorate at Millbank Tower, Millbank, London SW1P 4QU.

The contact points are:

Programme	Director
Intelligent Knowledge-Based Systems	Dr D B Thomas 01-211 6108
Very Large Scale Integration	Dr W Fawcett 01-211 7866
Software Engineering	Mr D Talbot 01-211 0050
Man-Machine Interface	Mr C M Barrow 01-211 5854
Large Scale Demonstrators	Mr S L H Clarke 01-211 0299
Infrastructure and Communications	Mr D L A Barber 01-211 5945

Applications falling outside the Alvey programme are treated by the Council in the normal way. Applicants who are unsure whether their proposals will fall inside or outside the Alvey programme should consult the Swindon office; contact points are:

Control and instrumentation	Mr P Hicks ext 2401
Computing	Mr M Hotchkiss ext 2260
Communications and solid state devices	Miss P C Davis ext 2161
Microelectronics facilities	Dr K D Crosbie ext 2448

All-optical switching device

Sheffield University's multiple quantum well research has enabled semiconductor materials to be custom-designed for an optical waveguide switch.

Advances in crystal growth technology in recent years have allowed the realisation of a new class of materials referred to as low-dimensional semiconductors. Such engineered solids normally comprise a succession of thin alternating layers of two different semiconductors, the two components having very nearly the same lattice constant so that they form a single crystal sandwich. Much recent research has utilised the III-V semiconductors GaAs and $Ga_{1-x}Al_xAs$ as constituents of the sandwich, since gallium and aluminium atoms are very similar in size and consequently both compounds are closely lattice-matched over the complete range of aluminium fraction x.

GaAs has a direct energy gap of 1.4 eV and this increases with increasing aluminium composition in the ternary alloy; for example in $Ga_{1-x}Al_xAs$ with x = 0.3 it is 1.8 eV. When a junction between these two materials is grown, most of the band gap difference appears as a sharp step in energy in the conduction band at the interface. In a multilayer structure of the type referred to above, a series of potential wells is thus created for electrons in the GaAs regions, whereas the GaAlAs barrier regions are devoid of carriers. If the well thickness is comparable with the de Broglie wavelength for electrons within it, say 100 Å, then motion normal to the layers becomes strongly quantised. This in turn gives rise to a wealth of new physical phenomena manifest for example in the transport, galvanomagnetic and optical properties of the composite crystal. The term multiple quantum well (MQW) layer is used.

Research in the Department of Electronic and Electrical Engineering, Sheffield University, has been concerned with trying to capitalise on one of these new properties, namely a much enhanced change of refractive index with optical intensity as compared to GaAs alone. The effect was first noted by workers at Bell Laboratories and Arizona University using a finely focused laser beam traversing an MQW sample in a direction normal to the layers. It was sufficiently strong to generate bistable switching between a low and a high transmission state in a Fabry-Perot etalon formed by reflections at the two outer surfaces of the crystal. The Sheffield work has been concerned with non-linear optical propagation along the plane of the MQW layer rather than normal to it, with a view to investigating guided wave interactions.

In one of our experiments an MQW layer has been grown with 25 GaAs wells each 100 Å thick separated by a similar number of $Ga_{0.7}Al_{0.3}$ As barrier layers each 300 Å thick. Beneath the MQW layer is a 1 micron thick layer of $Ga_{0.7}Al_{0.3}$ As alone. Since the refractive index of GaAs is slightly greater than that of $Ga_{0.7}Al_{0.3}$ As, light is confined as a single mode within the MQW layer by total internal reflection. Lateral confinement or guiding is produced in our case by evaporating two thin gold metallic stripes on to the top surface of the layer, with a spacing of approximately 10 μm between them. Since the gold stripes contract on cooling following evaporation, they place the quantum well material beneath them in a state of compression. Both GaAs and GaAlAs are photoelastic and it may be shown that the resulting strain pattern produces a region of waveguiding close to the edges of the stripes, due to the refractive index change. Two closely coupled waveguides are present therefore within the slot region between the stripes. Light focused into one of the waveguides will be progressively coupled into the neighbouring waveguide and, if the length of the structure is chosen correctly (about 1 mm in our case), the beam will emerge from the opposite waveguide. This is the so-called 'cross over' condition and pertains at low optical intensities. As the incident light intensity is increased the coupling between the two waveguides becomes less efficient because of the strong change of refractive index with intensity. Eventually a stage is reached where no light is coupled across and the 'straight-through' condition applies.

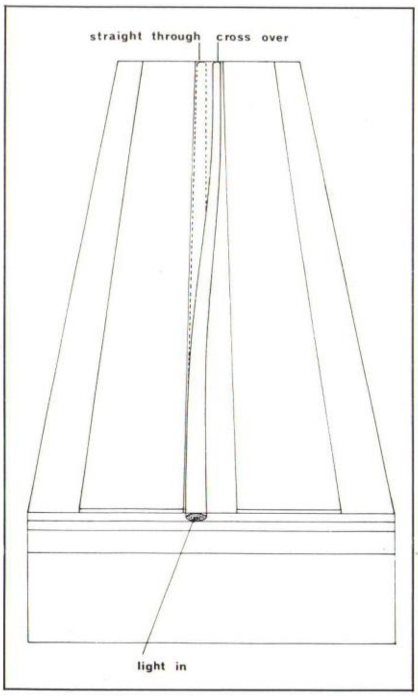
In this way we have been able to realise an all-optical waveguide switch. The power level required to produce switching is approximately 1 mW, obtained from a solid state GaAlAs heterostructure laser operating at a wavelength of about 850 nm. Operation has presently been achieved at a temperature of 180 K which was determined by the need to position the absorption edge of the quantum well waveguide at a slightly shorter wavelength than that of the source. Room temperature operation should be readily achievable by correct choice of the quantum well thickness. The mechanism for the enhanced dependence of the refractive index on intensity is not fully understood.

There are many potential applications for a non-linear optical four-port device such as described here. For example all-optical logic can be performed with AND and EXCLUSIVE OR functions being readily achievable. An input pulse to one port could be routed to one or other of the two output ports by a second signal applied to the other input port. Limiting and pulse-shaping are other possibilities. Much however will depend on the switching speed that can be obtained and this aspect is currently under investigation.

The MQW layers were grown under the direction of Dr J S Roberts in the SERC Central Facility for III-V Semiconductors at Sheffield University set up in 1978 by the Engineering Board to provide a service in custom grown III-V layers for the university community. Metal organic vapour phase epitaxy was used for the layers described in these experiments and they were notionally undoped. The devices were fabricated and the optical measurements performed by Mr Patrick Li Kam Wa with the assistance of funding from the Royal Signals and Radar Establishment, Malvern.

Professor P N Robson and Dr J H Marsh

Department of Electronic and Electrical Engineering, Sheffield University



Schematic showing optical beam in the 'cross over' condition at low intensity and in the 'straight through' condition at higher intensity.

The Energy in Buildings Specially Promoted Programme

The UK energy conservation programme is largely dependent upon reducing energy consumption in buildings, since they account for half of the UK's prime energy consumption. During the 1970s there was considerable growth in the number of research and demonstration projects in this area, and it was against this background that the Energy in Buildings Specially Promoted Programme was set up during 1979.

The area selected for special study was determined by the need for some overall theory of the dynamic interaction between climate, building fabric, environmental services and control and, not least, the users of the buildings. The objective of the programme was to increase the fundamental understanding of, and develop the methodology for, the prediction of the dynamic thermal behaviour of buildings.

The grant-awarding activities of the programme ceased in summer 1984. A total of 73 grants were awarded, totalling approximately £2 million. The research programme has established links with the building industry, and almost half of the grants awarded have involved some degree of direct collaboration with other bodies. There have been a number of Cooperative Research Grants, with collaboration between research teams and designers, component suppliers and building owners, and not least with the research programmes of the Building Research Establishment, the Energy Technology Support Unit (ETSU) and the European Community.

The core activity of the programme has been in the development of simulation models with supporting studies in a number of related areas. These are:

- Control
- Fabric performance
- Ventilation and infiltration
- Heat transfer coefficients
- Meteorological data
- Parameter extraction techniques
- Socio-economic analysis.

The range and nature of the research sponsored by the programme are illustrated by some case histories of past and current projects.

Simulation models

Development

During the early 1970s, the main problem was the calculation of the energy requirement necessary to overcome the building fabric heat losses under changing climatic conditions. As insulation standards improved, it was realised that other factors were equally important and recent efforts have been towards the inclusion of inter-zone air movement, heating, ventilation and air-conditioning (HVAC) plant and controls and occupancy effects. The building fabric is now conceived as just one component of a much more complex system.

Strathclyde University has developed the environmental simulation package (ESP) with input and output being handled with an extensive suite of interactive graphics programs. A library of plant components has recently been included with a control strategy for linking the building and plant. Their interest in computer-aided architectural design has produced a tool which has been used as an aid in energy-conscious design by several commercial organisations. ESP has been made available to the academic research community via the SERC Interactive Computing Facility network, thus enabling many new users to evaluate the program suite.

Bristol University, in conjunction with Facet, the computer services division of the Oscar Faber Partnership of consulting engineers, is currently working on a explicit finite difference model. The HVAC plant and building are a series of interconnected modules and this enables sub-models of particular components of plant to be plugged together to represent the proposed system. The programme of work, which is due to end in early 1987, is to evaluate the potential of the modular structure and extend the description of HVAC systems.

Validation

There is a need to improve the confidence in thermal models if they are to gain widespread acceptance. Following discussions within the research community, the major requirements that emerged were that validation should be made independent of those engaged in model development and avoid unnecessary duplication. As a result, a collaborative project was established between groups at Nottingham University, Leicester Polytechnic, the Building Research Establishment and Rutherford Appleton Laboratory (RAL), who embarked on a three-year programme of work in February 1984.

The study will examine the physical processes which the models incorporate, their mathematical representation and the numerical methods adopted for their solution. This will be achieved by the development of techniques of verification to examine the theoretical basis of the models combined with studies using empirical data sets to test the ability of the model to reproduce experimentally-observed behaviour.

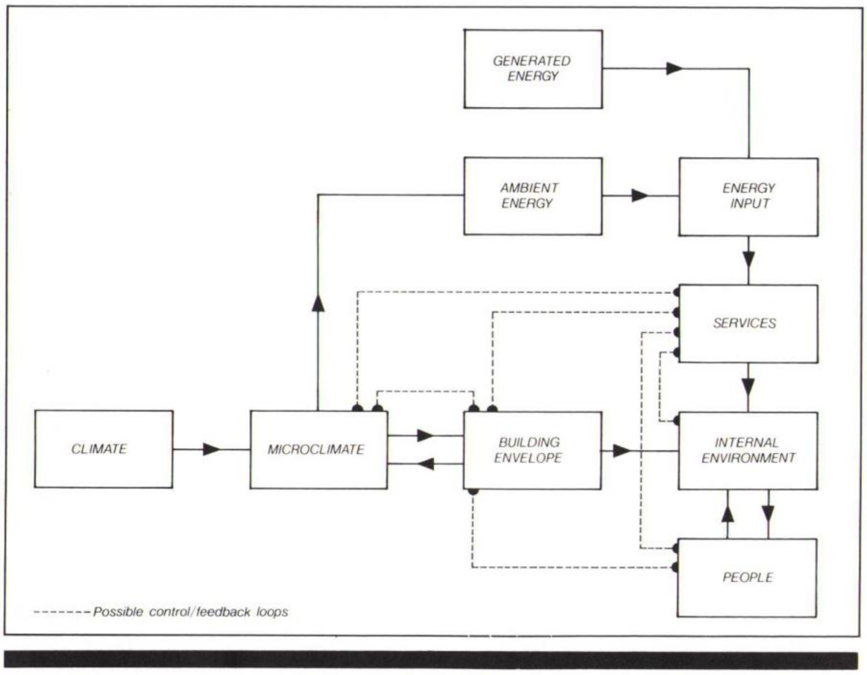


Figure 1: Simplified diagram of system for reducing energy consumption in buildings, showing possible control/feedback loops

Current plans are that at least three models – ESP (Strathclyde), HTB2 (UWIST) and an American model, SERI-RES – will be examined in some depth.

Applications

One of the central concerns of the programme has been to demonstrate the relevance of dynamic thermal models to research and practice. An early example of this type was carried out by the Cranfield Institute of Technology in collaboration with Essex County Council. The use of their 'Build' thermal model resulted in a redirection of Essex's energy conservation investment strategy and to the design appraisal of the Clacton St John Primary School. The School received the Chartered Institute of Building Services Award for low energy building design in 1982. Subsequently, the Department of Energy committed itself to a three-year programme aimed at demonstrating the energy effectiveness of a number of the school's innovative design features.

Some two years since the end of SERC funding for the model, the continuing development and application is completely financed through the use of the facility by the building industry. The design aid, known commercially as TAS, and its support team have now been established as a small but important service to the British building industry.

Control

As the programme has progressed, it has become apparent that control is a key factor in the effective and efficient use of energy. This is a complex and wide ranging area covering all aspects from automatic and manual controls of building and plant to occupant behaviour and each of these areas has to some extent been examined.

While physical factors are undoubtedly important to energy conservation, patterns of use have not received the attention they deserve even though they may sometimes be responsible for doubling energy use. This was highlighted in a study carried out by Portsmouth Polytechnic in collaboration with Hampshire County Council. Their School Design Research Group has formulated a heuristic model of energy utilisation in primary schools. From this, guidelines were developed for changes in building design which would encourage energy-conscious behaviour by school teachers who are often the main controllers of energy use. This has been acted upon by Hampshire who are currently upgrading and monitoring the two schools involved.

Fabric performance

Studies of the building fabric have ranged from the effect of combined heat and moisture transport through masonry materials to the effects of high performance, low emissivity glazing, on the overall performance of occupied dwellings.

A current issue in the design of new housing is the contribution that solar radiation can usefully make to supplying space heating requirements. There have been a number of theoretical analyses indicating that energy savings are possible by appropriate window design but that these savings are dependent upon the degree of overshading, orientation, etc. This issue, together with the level of insulation, is being examined by the Open University in occupied houses in Milton Keynes. ETSU was responsible for setting up the trial with SERC support directed towards the analysis of the data.

Preliminary results indicate that improving the current Building Regulation standards of thermal insulation for a typical dwelling by approximately 30% would lead to an energy saving of between 1400 and 1900 kWh per annum. The effect due to passive solar design has proved difficult to estimate, partly because any effect is small. When the results of the study are confirmed it should have a significant impact upon the priorities that designers attach to available energy conservation strategies.

Further details

A review of the Specially Promoted Programme and brief summaries of all grants issued as part of it are contained in *Energy in Building Specially Promoted Programme Report for the years 1979-84.* Copies of the report are available from the Environment Committee Secretariat, SERC Central office, Swindon, ext 2353.

Further information on the programme may be obtained from the coordinator: Dr T J Wiltshire, Building Science Section, School of Architecture, Newcastle University, Newcastle upon Tyne NE7 1RU.

Dr T J Wiltshire
Coordinator, Energy in Buildings SPP

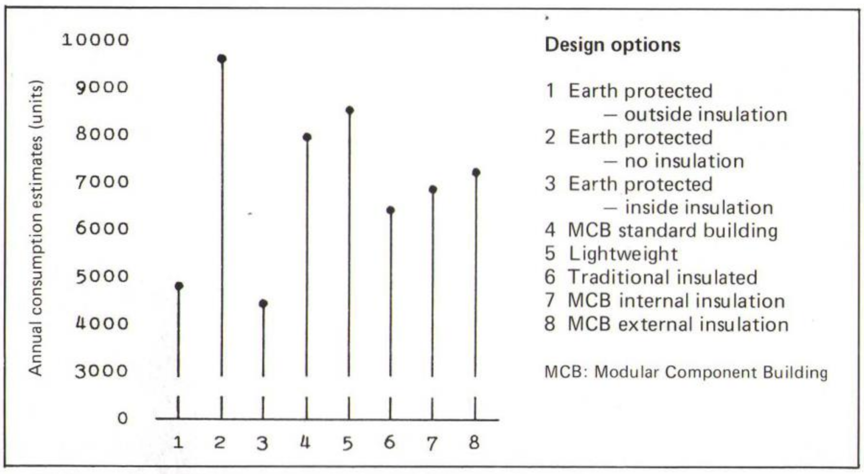


Figure 2: Comparative annual consumptions for different designs (gross values) for the Clacton St John Primary School using the BUILD program

The Clacton St John Primary School, for which Essex County Council received the Chartered Institute of Building Services Award for its contribution to low energy building design in 1982 *(Photo: David Bartram)*

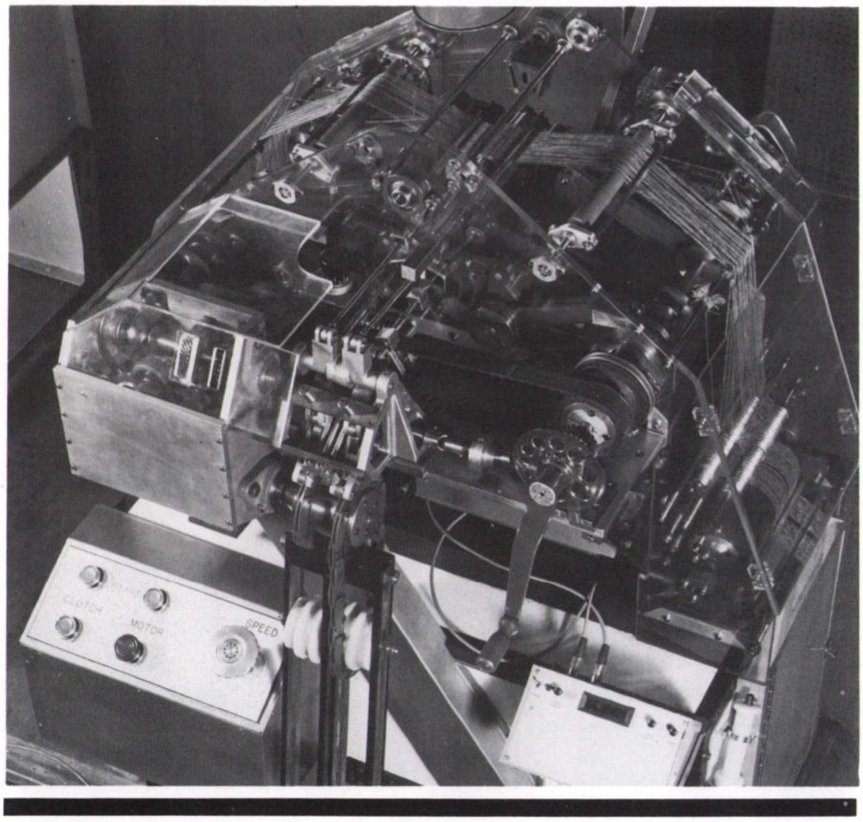
The design of high speed machinery

The Engineering Board is proceeding, through its Machines and Power Committee, with a Specially Promoted Programme (SPP) of research to improve the design and performance of high speed machinery, primarily for packaging, textile and sheet metal working plant. Funds being earmarked for this SPP are expected to rise to about £1 million p a by 1987/88.

The Applied Mechanics Subcommittee will be responsible for the programme management, in which there will be a high degree of coordination of the activities of researchers. A Coordinator, Dr G Sweeney, who has wide academic and industrial contacts, has been appointed to help in identifying areas of industrial need, in stimulating grant applications from relevant universities and polytechnics, and in coordinating the overall programme. The Coördinator will also be a contact for all individuals and organisations wishing to take part in the programme.

The SPP's origins lie in the decline of the UK machinery manufacturing industry in recent years, and the need to reverse this decline. It is believed that the knowledge residing in academic engineering departments could and should be used to help industrial machinery manufacturers to meet the challenge, and improve the performance, efficiency and productivity of their designs.

Following a comprehensive survey, three main sectors of machinery manufacture were chosen initially: textiles, packaging and sheet metal forming. It was felt that these three areas offer good market potential and ample scope for the application of advanced research and development. It is envisaged that the common core of research for these machine types will involve an integration of relevant structural mechanics, manipulative dynamics of high speed processing, and developments of new materials—work that will undoubtedly be valuable for other types of high speed machinery.



New technology for textile fabric constructuion. Conventionally designed warp knitting machines are rapidly approaching their optimum productivity limits. SERC-sponsored researchers at Loughborough have combined a novel process with dynamically optimised and balanced mechanisms to reach a 100% increase in fabric manufacture. Shown here is the powered research rig, capable of exceeding 2,000 knitted courses per minute, where the design has been so effective that it has been possible to make the structural members from 10mm thick Perspex plate. (Photo: Professor G R Wray, Loughborough)

The Applied Mechanics Subcommittee wishes to see a large proportion of academic research directed towards specific industrial problems, which will entail the closest possible collaboration betwen the academic and industrial sectors.

The aims of the programme are:

to encourage universities and polytechnics to prepare applications-oriented research and development proposals for multidisciplinary projects in collaboration with industry;

to provide a flow of able engineers trained to MSc or PhD level with a systems approach, and capable of filling senior positions in design and development activities in machinery manufacturing companies;

to contribute a change in the culture of the engineering design office by setting up collaborative programmes to illustrate the great benefits resulting from integrating experimental development and computer-based analysis with the work of the drawing office;

to provide a more systematic and scientific approach to the analysis of the relevant process and to the definition of machinery performance to give rational guidance for machine and component development.

Examples of the technological problems which make the design of high speed machinery so demanding are:

☐ spindle rotational speeds up to 1,000,000 revolutions per minute with drive shaft speeds between 5,000 and 50,000 revolutions per minute;

☐ synthetic filaments 0.01 mm diameter travelling at up to 1,200 metres per minute while rotating at up to 3,000,000 revolutions per minute;

☐ accelerations up to 150 g, reversing 10,000 times per minute;

☐ components made of composite materials with surface coatings combining light weight with strength, to manufacturing tolerances of 0.1 micron;

- ☐ tribological problems under conditions of high frequency impacts and complex geometry motion trajectories with non-similar material interfaces;
- ☐ dynamic manipulation of metals, plastics and other raw materials during the processes, at extreme accelerations and velocities to produce acceptable product properties;
- ☐ fully automated manufacture of multi-component metal containers at rates up to 800 per minute.

It is intended that the majority of the research carried out under the programme should involve partnerships between academic and industrial groups. The partner firm will be expected to contribute staff effort, resources and expertise at a level commensurate with the overall value of the award. Key inputs by the collaborating company will be management skills for planning projects and defining targets, and the secondment of engineering staff to work in the university/polytechnic group. It should be noted that SERC research grants for the programme can only be made to the academic group, not the partner firm. Where appropriate, partnerships may be supported under SERC's Cooperative Research Grants Scheme.

The Coordinator is Dr G Sweeney, 8 Hall Hill, Bollington, Macclesfield, Cheshire. Telephone 0625 72623.

The SERC contact is Mr J W Reed at SERC Central Office, Swindon, ext 2478.

On-line quality monitoring of fabric production. A photo-diode camera-based system has been designed for monitoring fabric quality. The system will be mounted on the knitting machine itself close to the area of stitch formation. The system detects small fabric structural faults by a model comparison process. In the microprocessor memory a mathematical model of a correct fabric is stored. During scanning the monitored data are compared to the stored data pattern defined in the mathematical model. If there is an error, a warning is issued to the operator. The system works up to about 45 rpm on a 0.8 metre diameter knitting machine. It is hoped at a future date to build the monitoring system into a control system where process changes can be compensated for by adjustment in the controllable machine variables, cam settings, thread tensions, and in this way some of the fabric faults will be eliminated at source. (Photo: Professor G R Wray, Loughborough)

Polymer Engineering Directorate goes into industry

The Polymer Engineering Directorate (PED) became the first of SERC's Special Directorates to transfer into an industrial environment, from January this year. It is now financed jointly by SERC, the Department of Trade and Industry (DTI) and the polymer industry, through the British Plastics Federation.

This move reflects the SERC policy for its Special Directorates that, after a period of pump-priming wholly from public funds, the Directorates should move into a more industrial environment where a proportion of the running costs will be met directly by industry.

The future arrangements for PED will be that until September 1986 its running costs will be met equally by SERC, DTI and the British Plastics Federation. Research projects stimulated and monitored by the Directorate on behalf of SERC and DTI will continue to be funded directly by those bodies as at present, but the new arrangement for PED should help to improve coordination of industrially related research and development as a whole.

A Management Committee containing representatives of the sponsoring organisations and 'customers' will oversee the day-to-day administration of the Directorate and is also considering its long-term future and role.

The PED was set up in 1976 to give special impetus towards advanced technology engineering and training in polymers to meet an identified national need. Its remit was to increase substantially the contribution from academic institutions to this important industrial area, and also to involve industry more closely with research programmes in the academic world. The aim of the Directorate was to initiate and oversee a closely coordinated programme of postgraduate training and research in selected universities and polytechnics with the active cooperation and involvement of industry. Many of the original objectives have now been met and PED has more recently been concerned with ensuring that the results of its research programmes in universities and polytechnics, sponsored by SERC, are transferred into industry. The Directorate has, since December 1981, also assisted the DTI in promoting and monitoring research and development in polymer engineering sponsored through the Department's Requirements Boards.

Underwater technology students

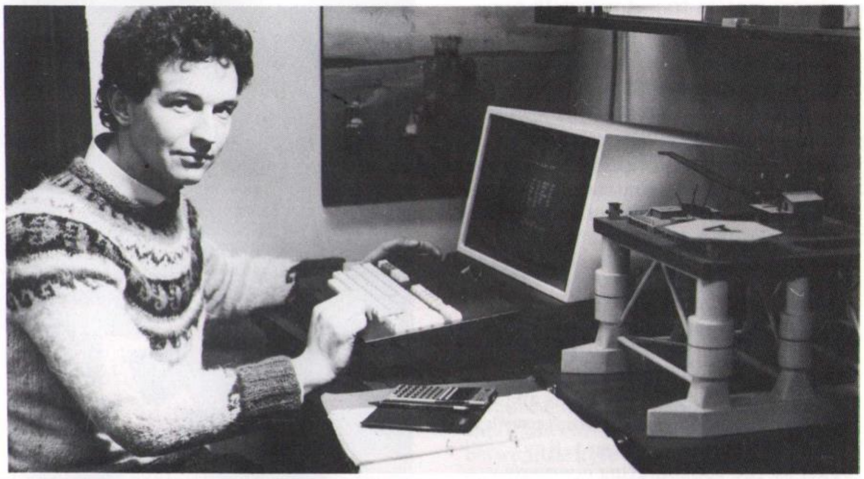
SERC's Marine Technology Directorate, in association with the Society for Underwater Technology, runs a scholarship scheme through an annual competition open to applicants to MSc (or equivalent) courses in fields of study related to the activities and interests of the Society. These embrace a wide range of subjects in science and engineering as applied to the study, exploration and exploitation of the resources of the oceans and the earth beneath them, including: the design and operation of offshore structures and submersibles; operational and biomedical aspects of diving; underwater communication; and instrumentation.

Scholarships of not less than £500 each are awarded for the best essays outlining the relevance of the proposed course of study to the career which the student foresees in offshore technology. An endowment fund was established by the Society two years ago and an Endowment Fund Management Committee of the Society, on which the Directorate has representation, is responsible for control of the fund and the review and assessment of the essays submitted. Factors taken into account in judging the essays include the demonstrated knowledge of the subject chosen; relevance to the interests of the Society; imagination and creative thinking shown about development of the student's career; and reasons for choosing a particular course and knowledge of that course.

It is hoped that in future there will be a larger entry to the competition. Prospective students to MSc courses for 1985/86 can get further details either from the Course Supervisor or from the Society for Underwater Technology, 1 Birdcage Walk, LONDON SW1H 9JJ. Entries should be submitted by 1 August 1985.

David Rodrigues de Miranda

The 1984 awards



Michael Carter

Michael Carter (£1,000) included in his essay an especially good account of the achievements he already has to his credit from working offshore for the past four years. He produced a thoughtful and sound analysis of the problems to be faced and the progress possible for offshore structures and subsea completion. He is taking a break from working offshore to study Ocean Engineering at MSc level at University College London to add depth in hydrodynamic and structural theory to his present qualifications in mechanical engineering from Cambridge; this should fulfil a need that he identified during his experience offshore.

Bruce Wilson (£1,000) had just graduated in Civil Engineering at Strathclyde University and choose to add breadth to his knowledge of maritime applications by taking the MSc course in Maritime Technology at Strathclyde before taking up full-time employment in industry. His essay was well presented, mature and firmly addressed to the theme set. He included purposeful and sensible thought about his future and how he would like to see it develop. His appreciation of the nature of marine technology and its challenge was excellent, no doubt helped by his vacation experience with Shell Expro and by his interest in sport diving.

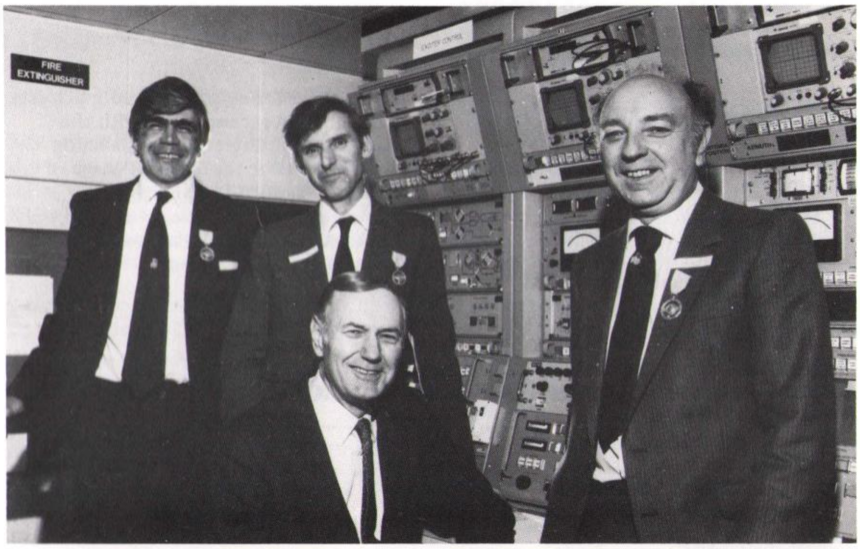
David Rodrigues de Miranda (£500), who had previous work experience on the construction of a storm-surge barrier in the 'Delta-plan', had just graduated in Civil Engineering at Birmingham University and is now taking the MSc course in Maritime Civil Engineering at Liverpool University. The especially attractive feature of his essay was the breadth of imaginative cover of what he calls 'oceanautics', which embraces the technology associated with the extraction of oil and gas and other minerals and a broad range of activities in aquaculture. He sees this as a challenge and a rich source of opportunity at the start of his career.

Bruce Wilson

NASA awards to IRAS team

Three UK scientists have been awarded public service medals by NASA for their outstanding contributions to the joint USA/UK/Netherlands Infrared Astronomical Satellite project, IRAS. NASA's chief administrator, Mr James Beggs, presented the medals, together with group achievement certificates for the entire IRAS team, during a visit to Rutherford Appleton Laboratory (RAL) on 13 December 1984.

The Americans launched the Dutch-built spacecraft in January 1983, with enough liquid helium on board for about nine months' active service surveying infrared signals reaching our solar system from outer space. Mr Alan Rogers (RAL) was responsible for the construction of the Control Centre hardware and was Deputy Mission Operations Manager. Dr Eric Dunford (RAL) was head of the Preliminary Scientific Analysis Team, and then UK Project Manager. The third medal winner, Dr Peter Clegg from Queen Mary College, London, was the IRAS Resident Astronomer.



The three medal-winning scientists (left to right), Dr Peter Clegg, Dr Eric Dunford and Mr Alan Rogers, in the control room where they worked on the IRAS project, with NASA's chief administrator Mr James Beggs who presented the medals.

Professor Dick Jennings (UCL) accepted an award on behalf of the IRAS Joint Infrared Science Working Group for outstanding scientific and engineering contributions to all aspects of the IRAS project, and Dr Richard Holdaway and Mr Harry Bevan for the work of the RAL operations team who contributed to the success of the mission through the design, development testing and operation of the IRAS Operations Control Centre at RAL.

A NASA medal was also awarded to Richard Van Holtz, a member of the Dutch team on IRAS.

After the presentations, Mr Beggs spoke of the enormous discoveries made by IRAS. Astrophysics had undergone a revolution in the last 25 years and the IRAS mission had opened another window on to a Universe we had only just begun to understand, he said. With international collaboration of this calibre, yet another revolution was heralded for the future.

This was the second time that the UK participants in IRAS received honours from the United States for their IRAS work. In April 1984, Dr Geoff Manning, RAL's Director, received on their behalf the Nelson P Jackson Aerospace Award of the National Space Club.

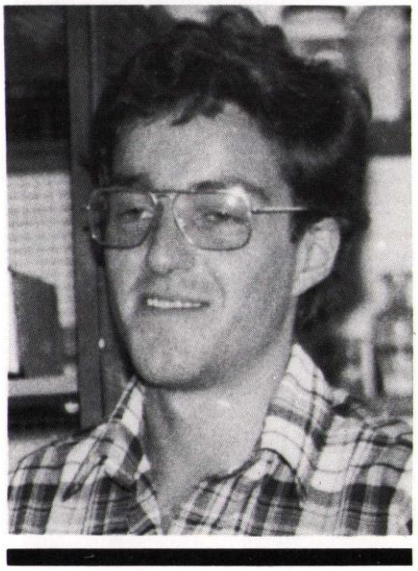
Huxley Award for zoology thesis

The Thomas Henry Huxley Award for 1984 was awarded to SERC student Dr R R Preston of the Department of Zoology, Nottingham University, for his thesis 'Studies on the responses of *Paramecium tetraurelia* to amino acids'.

The aim of the work was to characterise the responses of the ciliate protozoon *Paramecium tetraurelia* to amino acids and to place these responses within the current perspective of how this ubiquitous freshwater microorganism collects and responds to information on the chemical composition of its environment.

Dr Preston is to be congratulated on the successful completion of a difficult but biologically significant research programme, for mastering so many biological techniques and for engendering ideas for future research which will undoubtedly be pursued by other protozoologists.

The Thomas Henry Huxley Award was established in 1961, following an offer by the Granada TV Network (Sidney Bernstein) of money to set up three annual awards - the others evolved to be the Stamford Raffles Award and the Prince Philip Prize.



Dr R R Preston

Studentship numbers 1984-85

1984 report

In 1984 the Council's Boards and specialist Directorates allocated 4,596 studentships, 139 more than in the previous year. Of these 1,629 lay within the general field of information technology (IT), with 1,349 being funded by the Alvey initiative and 280 being provided by the Engineering Board's Information Engineering Committee as part of its normal on-going activities.

The CASE scheme had 875 awards allocated to it.

The demand for awards proved much less strong than in recent years, with the result that considerably more awards were available at the 'appeals' stage of awarding. In all, 714 applicants contended for 315 'appeals' awards; only four candidates with first class honours failed to obtain an award.

Reduced demand for CASE, resulting in an overall shortfall of 150, was in particularly marked contrast to the previous year, when in the Engineering Board's field the target provision was exceeded by more than 100. In the light of this low demand, the Science Board redirected unallocated CASE awards to standard research studentships at the 'appeals' stage.

Within the broad area of IT, all eligible candidates for IT advanced and conversion courses at the 'appeals' stage received offers of awards.

The overall outcome was that by October 1984, 4,340 awards had been committed against the allocation of 4,596. There remained a shortfall in the take-up of research studentships in the Engineering Board's fields (a reversal of recent trends and in contrast to other Boards) and, for the first time in recent years, a shortfall in the take-up of CASE in the major subject areas, both in science and engineering.

Table 1 compares the take-up of studentships at October 1984 with the Boards' target. (NB: Information technology embraces both Alvey-funded awards and provision by the Engineering Board's Information Engineering Committee).

Table 1: Distribution of 1984 awards taken up at October 1984

(1984 targets agreed by Boards in brackets)

	ASR	Engineering	IT	NP	Science	ESRC-SERC	Biotechnology	Total
Research studentships								
Standard	69(67)	289(312)	251(274)	59(58)	860(814)	27(27)	30(29)	1585(1581)
CASE	6(8)	205(246)	112(135)	4(4)	392(453)	5(4)	25(25)	749(875)
Instant	3(3)	13(20)	7(-)	1(2)	67(70)	- (-)	- (-)	91(95)
Total RS	**78**(78)	**507**(578)	**370**(409)	**64**(64)	**1319**(1337)	**32**(31)	**55**(54)	**2425**(2551)
Advanced course studentships								
Standard	21(21)	330(302)	210(300)		307(306)	62(58)	31(33)	961(1020)
Instant	1(1)	42(50)	3(-)		19(21)	11(13)		76(85)
Conversion			867(920)					867(920)
Total ACS	**22**(22)	**372**(352)	**1080**(1220)		**326**(327)	**73**(71)	**31**(33)	**1904**(2025)
Awards tenable overseas		4(-)	1(-)		6(-)			11(20)
Total	**100**(100)	**883**(930)	**1451**(1629)	**64**(64)	**1651**(1664)	**105**(102)	**86**(87)	**4340**(4596)

Notes: Targets for awards tenable overseas were not broken down between Boards.
Engineering Board figures exclude awards made by the Information Engineering Committee, which have been shown under Information Technology

Plans for 1985

A target has been set for 1985 of 4,713 awards of which 1,560 are in the area of information technology. This is an overall increase on the previous year of 117 studentships.

The Engineering Board allocation has been increased by 106 awards (about 10%) partly to cover provision for the Council's recently formed Directorate in the Application of Computers to Manufacturing Engineering (ACME) and partly as increased provision for CASE.

The Science Board provision has also increased, by 79 awards, to strengthen the universities' research base.

Offsetting these increases, provision for advanced course awards (including conversion courses) in the information technology area have been reduced by about 4% in the light of the demand for these awards in 1984.

Readers are asked to note that, as already announced, the closing date for applications for research studentship quotas has been brought forward one month to 30 November.

Table 2 sets out the distribution of studentships to be made in 1985.

Table 2: Allocations decided by Boards for 1985

	ASR	Engineering	IT	NP	Science	Biotechnology	Total
Research studentships							
Standard	67	353	275	55	859	29	1638
CASE	8	260	125	7	480	28	908
Instant	3	20	10	2	70		105
Advanced course studentships							
Standard	21	393	220		313	30	977
Instant	1	100	30		21		152
Conversion courses (IT only)			900				900
Awards tenable overseas	3	20			6		33[b]
Totals	**103**	**1146**[a]	**1560**	**64**	**1749**	**87**	**4713**[c]

a. Includes provision of the joint ESRC-SERC Committee but excludes awards formerly made by the Information Engineering Committee, now absorbed into Information Technology
b. Includes four overseas awards for provision outside the Council's field in consequence of SERC's responsibilities to NATO
c. Includes awards specifically directed towards polytechnics

PhD submission rates

Studentship awards beginning in 1980

The Council views the writing up of results within a reasonable timescale of a PhD thesis to be an effective measure of whether this aspect of the student's training has been satisfactorily completed.

In July 1984 the Secretary to the Council wrote to Vice-Chancellors and Principals to underline the importance which the Council attaches to the need for improvement in the submission rates. Data on submission rates are now sent to Subject Committees to be taken into account when allocating research studentships to departments.

The tables below set out the results of the latest annual survey – the fifth in the series – showing the submission rates for PhDs by 1 October 1984 for those SERC-funded research students whose awards began in 1980, and the numbers of students who still remain registered for a PhD by that date.

The information is set out by institution in Table 1 and by subject area in Table2.

Table 1: PhD submission rates etc by institution

Institutions	Number of students registered	Number submitting by 1.10.84	Number still registered at 1.10.84
Universities of England:			
Aston	48	25	13
Bath	40	20	15
Birmingham	68	33	23
Bradford	31	10	18
Bristol	58	38	15
Brunel	14	5	5
Cambridge	161	94	45
City	14	9	3
Cranfield Inst. of Tech.	17	7	5
Durham	27	13	9
East Anglia	24	11	10
Essex	12	4	7
Exeter	18	10	6
Hull	19	9	9
Keele	7	4	3
Kent	27	13	9
Lancaster	22	12	6
Leeds	81	33	42
Leicester	25	11	13
Liverpool	70	32	31
London Colleges			
Bedford	5	2	3
Birkbeck	8	5	3
Chelsea	20	9	9
Imperial	143	76	57
King's	26	12	10
Queen Elizabeth	18	11	7
Queen Mary	37	13	24
Royal Holloway	9	1	8
University	48	19	1
Westfield	7	2	3
Other institutions	30	19	9
Loughborough	19	6	9
Manchester	94	50	29
UMIST	66	32	25
Newcastle	43	19	19
Nottingham	75	41	32
Open	8	2	5
Oxford	138	95	29
Reading	30	15	12
Salford	23	7	14
Sheffield	57	24	28
Southampton	59	34	20
Surrey	15	7	8
Sussex	37	16	16
Warwick	30	15	13
York	29	17	11
University of Wales:			
Aberystwyth	21	8	9
Bangor	19	7	10
Cardiff	30	12	15
Swansea	22	11	9
UWIST	15	9	4
Universities of Scotland:			
Aberdeen	23	13	8
Dundee	10	4	4
Edinburgh	46	33	8
Glasgow	46	27	0
Heriot-Watt	28	15	9
St. Andrews	14	9	3
Stirling	5	4	1
Strathclyde	41	17	20
Total universities	2177	1111	791
Total polytechnics*	71	22	37
Other institutions*	23	12	10
Grand total	2271	1145	838

No students were registered for SERC-funded PhDs in the universities of Northern Ireland, most of whose awards are provided by the Department of Education for Northern Ireland.

* The numbers of students at polytechnics and other institutions were generally too low to make individual details useful.

Table 2: PhD submission rates etc by SERC Board

Science Board:			
Biological sciences	520	270	196
Chemistry	503	328	137
Mathematics	132	62	40
Physics, neutron beam and SBA*	174	93	65
Engineering Board (including eng/maths)	750	305	328
Astronomy, Space and Radio Board	77	34	30
Nuclear Physics Board	63	43	12
ESRC-SERC Committee	41	6	25
Energy Committee	11	4	5
Grand total	2271	1145	838

*SBA – Science-based archaeology

Some new publications from SERC

Needs of engineering

The report of the Engineering Board Working Party chaired by Professor Geoffrey Sims on *The needs of engineering* has been published as a consultative document. Comments are being sought from the engineering community and should be sent to Mr A Spurway at SERC Central Office, Swindon, from whom copies are available (ext 2102).

Energy annual report

Copies of the Energy Committee annual report 1983-84 are available from Mrs J Broughton, Engineering Division, at SERC Central Office, Swindon, ext 2238.

Joint ESRC-SERC Committee

Copies of the *Joint ESRC-SERC Committee annual report 1983-84* are available from Mrs D Tunnicliffe, Engineering Division at SERC Central Office, Swindon, ext 2429.

Chemistry grants

Copies of the complete listing, *Current grants in chemistry*, 1 October 1984, are available from the Chemistry Committee Secretariat, SERC Central Office, Swindon, ext 2126.

Marine technology pack

The Marine Technology Directorate has produced a comprehensive information pack including details of its Centres, the 1985 to 1987 research programme and profiles of many MTD-supported research projects. Copies are available from the Directorate at Garrick House, 3-5 Charing Cross Road, London WC2H OHW. Telephone 01-930 9162.

PED review meeting

Copies of the proceedings of the Polymer Engineering Directorate's Review Meeting held at Loughborough University of Technology, 15-17 April 1985, are available from PED, 11 Hobart Place, London SW1W OHL. Telephone 01-235 7286.

The RAL Ocean Surface Current Radar Facility

During the past year, the Ocean Surface Current Radar (OSCR) system, developed at Rutherford Appleton Laboratory (RAL) for the measurement of surface currents, has undergone a series of trials at nine coastal sites throughout the UK. The trials have demonstrated that the system can yield values of surface current which are remarkably consistent in both time and space, out to a maximum range of about 40 km.

The system consists of two high frequency radars, spaced approximately 20 km apart, each having a beam-forming receive antenna which enables the radar signals, back-scattered from the sea surface, to be acquired from 16 different directions by each radar. The radial component of the surface current can be measured at 32 points, spaced at 1.2 km intervals, along each beam. By combining the measurements made by each radar, it is possible to calculate the vector current at the points where the beams intersect. There is a variety of different processes by which radio waves can be back-scattered from the sea surface, but the one which enables the surface current to be measured is the Bragg resonance process. When radio waves are reflected from sea waves, having exactly half the radio wavelength and travelling either directly away from or directly towards the radar site, the radio waves constructively interface to produce a large signal. Two 'Bragg lines' appear in the Doppler frequency spectrum of the radio echoes which, in the absence of a current, are symmetrical about zero Doppler shift. The magnitude of the current, ie the speed of the water surface over which the sea waves are travelling, is derived simply by measuring the displacement of the Bragg lines from their normal positions.

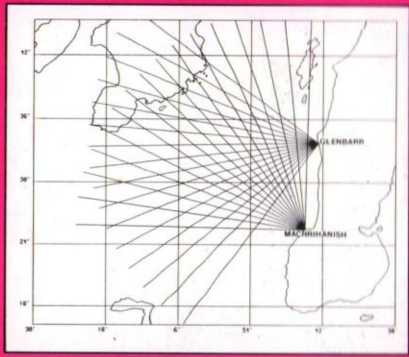
The radars are computer-controlled, and can be programmed to collect and process the signals received automatically to produce radial current information from any six of the 16 available beams, each half hour, for periods lasting up to several days. Thus at the present time the equivalent of 36 surface current meter deployments can be made anywhere within the range of the radars, at the touch of a computer button, irrespective of the prevailing weather or sea conditions. During a campaign, coarse surveys of an area can be made, interesting features focused upon, and the results displayed within hours of the measurements being made. As an oceanographer involved in the trials pointed out, it would be impossible to match this capability using conventional techniques.

In April and May 1984 an important experiment was carried out in Merseyside by the Institute of Oceanographic Sciences, Bidston, to study Liverpool Bay. A single OSCR unit was installed at Crosby, then moved a month later to Hoylake to simulate the vector system (see the Natural Environment Research Council Newsjournal vol 3 No 4). The results obtained were encouraging and showed for the first time that the fine detail of the spatial structure of surface currents could be measured. It was concluded that such data would improve the theoretical understanding of the circulation within bays, around headlands and sandbanks, and would be of direct benefit in studies of sediment transport and the dispersal of pollutants.

A few months later in October, the Challenger Space Shuttle flight provided another opportunity to demonstrate OSCR. Two units were available and, in collaboration with the Oceanography Department of Swansea University, the first true vector trial took place. Sea-truth information was collected to support the sea imaging experiment being flown on the Space Shuttle by the Royal Aircraft Establishment, Farnborough. Immediately following this exercise the system was transported to the Peninsula of Kintyre, Scotland, where, in an experiment funded by the Department of Energy, comparisons were made with surface meters deployed by the Scottish Marine Biology Association.

From comparisons made with current meters, and also from the fact that the data obtained are so consistent, it is concluded that the OSCR system is capable of measuring surface currents to an accuracy of one or two cm/sec. The trials have proved that the system can be operated from a variety of sites, and can be used to obtain detailed information about the flow of water in regions where the influence of coastal topography on the current pattern is pronounced.

David Eccles
RAL



Map showing the area covered by the OSCR system during the trials conducted from the Peninsula of Kintyre (55°N, 6°W). The lines show the centres of the beams used, the length of each line shows the maximum range of the radars (40 km) and, where the lines cross, the points at which vector currents can be calculated.

The OSCR system overlooking Macrihanish Bay, showing the 16 beam-forming receive antenna support poles aligned parallel to the beach, and the caravans housing the equipment.