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In this issue

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CERN exhibition at the Science Museum

Opening the CERN exhibition at the Science Museum, Mr William Shelton MP, Under Secretary of State for Education and Science (left) with Dame Margaret Weston, Director of the Science Museum, and Professor Herwig Schopper, Director-General of CERN. *Photo: Science Museum*

"Kilburn, Waterloo, Wandsworth, Hammersmith...." Opening the CERN exhibition at the Science Museum, Mr William Shelton, MP, Under Secretary of State for Education and Science, traced the periphery of the tunnel for CERN's LEP project as it would be if it were to be built in London, with its centre at South Kensington. The scale of the enterprise, and the technology involved – the tunnel had to be accurate to a centimetre or so – gave some idea of the complexity and cost. He welcomed the Exhibition, which would allow the public in Britain to see how CERN spent its money and to share in the excitement of the research.

In welcoming Professor Schopper, CERN's Director-General, Mr Shelton reminded him of the faith that British physicists had always had in CERN. The UK was one of the Organisation's founder members in 1954, and in the 1970s we had redesigned our research programmes, closing our own national accelerators, and relying wholly on CERN to keep our scientists at the forefront of research into the fundamentals of matter. This faith had not been misplaced.

Dame Margaret Weston, the Science Museum's Director, said that the Museum had had little in the way of high energy physics display till then. This exhibition would remedy that, and at the end of the year a new nuclear physics gallery would be opening, in which visitors would be able personally to repeat Rutherford's classical 'scattering' experiment by bombarding a gold foil with alpha-particles.
The CERN exhibition was open throughout October and November 1982.

Cover Picture:
Part of a microengineering structure consisting of a gold spiral on a glass substrate. The thickness of the gold is 6μm and the width 20μm. The separation between adjacent walls of the spiral is 5μm. This structure was manufactured at the Electron Beam Lithography Facility at Rutherford Appleton Laboratory, described on pages 14 and 15.

The Science and Engineering Research Council is one of five Councils funded through the Department of Education and Science. Its primary purpose is to sustain standards of education and research in the universities through the provision of grants and studentships and by the facilities which its own establishments provide for university research.
The SERC Bulletin summarises topics concerned with the policy, programmes and reports of the SERC.

All publications described are available from the appropriate department of the Council, free, except where otherwise stated. The 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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Council commentary

Estimates and Forward Look
In October, following the recommendation by the Advisory Board for the Research Councils (ABRC) that SERC should receive an additional £5 million for information technology, Council agreed estimates for 1983/84 based on earlier plans but enhanced by these funds in the Engineering Board's area (see page 11). It also agreed to reallocate some £300,000 to the ASR Board to enable preliminary studies to be undertaken into a possible UK-led space mission for the late 1980s.

As part of the 1984/85 to 1988/89 Forward Look, Boards and Committees are being encouraged to look at the long-term direction of their activities, say over a period of ten or more years ahead; and to consider the ABRC's advice on the need to be able to redeploy resources flexibly. Council's forward plans had been generally well received, but the ABRC had felt that the future level of support for nuclear structure physics should be considered. The Council therefore decided to establish a small committee, under the chairmanship of Professor E W J Mitchell, to examine this field and to report by February.

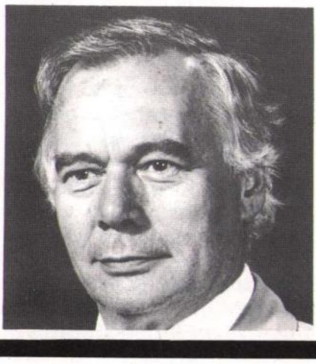
Fellowships in 1983
On the advice of its Awards Panel, Council decided that the allocation of fellowships amongst schemes should be similar to that made last year, but with a slight increase in Advanced Fellowships at the expense of Industrial Fellowships. It also discussed its policy on awards held overseas, concluding that the overriding principle in determining awards should be that the best candidates should go to the best institutions, irrespective of where these were.

New Council members

As mentioned in the last issue of the *Bulletin* (Vol 2 No 6, Autumn 1982), the Secretary of State for Education and Science has appointed the following new members of Council:

Mr Geoffrey Hall FEng has been Director of Brighton Polytechnic since 1970 following seven years as Professor of Nuclear Technology at Imperial College, London. A nuclear chemical engineer, Mr Hall is a member of SERC's Engineering Board and Chairman of its Education and Training Panel. He is a member of the Council for National Academic Awards and of the Engineering Council, of which he is Chairman of the Education and Training Steering Group. He is also Chairman of the Working Group on Engineering Education of the National Advisory Body for Local Government Higher Education. He was a Founder Fellow of the Fellowship of Engineering and has been President of the British Nuclear Energy Society and the Institute of Fuel.

Professor E W J Mitchell CBE is the Dr Lee's Professor of Experimental Philosophy at Oxford University and the Head of the Clarendon Laboratory. After gaining his PhD in 1950 from Bristol University for measurements of the work functions of metals and semiconductors, he joined Reading University in 1951 and worked on a succession of topics in solid state physics – colour centres in quartz and diamond, radiation damage, the Faraday effect for determining effective masses in semiconductors, highly disordered gallium arsenide and the development of the now widely used method of small angle neutron scattering for the study of real crystals. He is currently working on the structure and dynamics of simple molten salts using neutron and light scattering. He previously served on the Council from 1970 to 1974, was Chairman of the Physics Committee from 1967 to 1970 and the Neutron Beam Research Committee from 1967 to 1974. He was appointed CBE in 1976.



Sir Francis Tombs FEng is Chairman of the Weir Group PLC and a Director of N M Rothschild & Sons Ltd and Rolls-Royce Ltd. He is immediate Past President of the Institution of Electrical Engineers, was elected to the Fellowship of Engineering in 1977, is a Fellow of the Institution of Mechanical Engineers and the Institute of Energy and an Honorary Member of the British Nuclear Energy Society.

Knighted in the 1978 New Year's Honours List, Sir Francis is Visiting Professor at Strathclyde University and holds honorary degrees from that University, Aston, Loughborough and the Technical University of Lodz in Poland. He is a member of the Standing Commission on Energy and the Environment, Chairman of the Economic Development Committee for the machine tools industry and Vice-President of the World Energy Conference.

Professor James J Turner has held the Chairs of Inorganic Chemistry at Newcastle, 1972-79, and at Nottingham, 1979 to the present, following a lectureship at Cambridge and a Harkness Fellowship in California. His research interests are in the field of photochemical and spectroscopic studies of unstable inorganic species, particularly organometallic fragments. He and his colleagues have developed the use of the matrix isolation technique, to unravel, at low-temperature, complex photochemical pathways relevant to room-temperature behaviour. In 1978 he was Tilden Lecturer of the Royal Society of Chemistry. He is currently a Vice-President of the Dalton Division of the Royal Society of Chemistry.

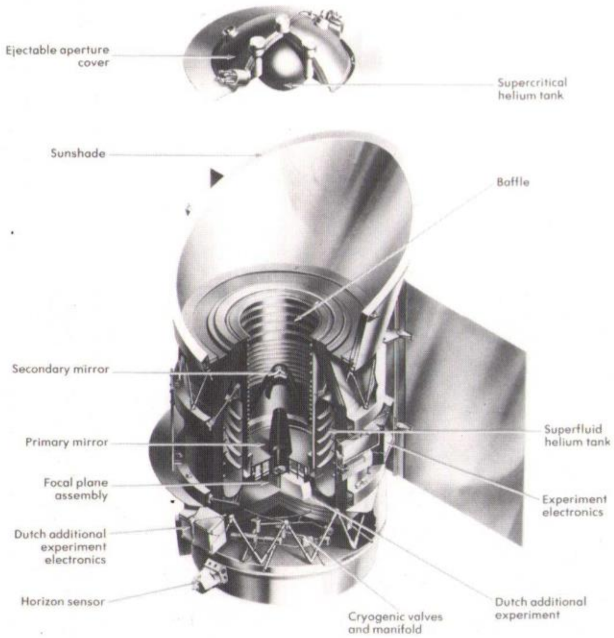
He has served on a number of SERC Committees (most recently as Chairman of the Chemistry Committee) and is currently Chairman of the Science Board's Education and Training Panel.

IRAS — a cooled telescope in space

The mission of IRAS, the Infrared Astronomical Satellite, is to perform an all-sky survey in wavebands from 8 to 120 microns and to make further special observations of selected sources. IRAS will extend greatly our knowledge in this spectral region and is expected to lead to fundamental advances in our understanding of the Universe.

The project is an international venture involving the USA (responsible for the telescope system, survey instruments and final data analysis), the Netherlands (responsible for the spacecraft, the non-survey instruments and, in part, for the control centre software) and the UK (responsible for the ground station at the Rutherford Appleton Laboratory (RAL) control centre at Chilton and software for data acquisition, engineering and preliminary science analysis). In the UK, scientists from University College London, Queen Mary College London, and Leeds University have been involved both in the international science team and in working with the project team at RAL since the beginning of the mission. After launch, now scheduled for the end of January 1983, they will continue to work at the control centre.

IRAS is composed of two major units, namely the infrared telescope and the spacecraft. Together they form a cylinder with a length of 3.5 metres and a diameter of 1.5 metres which, at launch, will weigh about 1100 kg. The experiment hardware is comprised of a cooled Cassegrain-like (Ritchey-Chrétien) telescope with a 60 cm beryllium primary mirror and (situated at the focal plane of the telescope) an array of 62 infrared detectors for the survey, a low-resolution infrared spectrometer, a mapping photometer and a star-counting instrument for statistical work. Visual star sensors provide accurate attitude checks.



In order to detect the weak infrared signal from astronomical objects, the telescope system is surrrounded and cooled by a liquid helium cryostat which, by virtue of its extremely low temperature (below 16K) emits negligible infrared radiation. The boil-off rate of the liquid helium dictates the mission lifetime of around seven months.

The spacecraft part of the satellite contains the hardware and software for controlling its attitude while in orbit and for storing the collected data and relaying it to the ground station at RAL.

The IRAS operations control centre at Chilton

The IRAS on-board tape-recorder can store up to 14 hours of observed data. Twice a day, when the satellite passes over the Chilton ground station, the recorded data are relayed to Earth and fed into the control centre, for processing by a twin PDP 11/34 computer system. During the same pass over Chilton, the satellite's next 12-hour sequence of observations is transmitted via the antenna to the IRAS on-board computer.

As well as being responsible for these 'real-time' tasks, the PDP 11s sort the various data streams (science, engineering and attitude data) and process and/or distribute them to other computers. Science and attitude data are sent to the Jet Propulsion Laboratory in California for final processing and eventual compilation of the survey catalogue. All data other than non-survey science data go to the control centre's ICL 2960 computer. Non-survey science data are processed on the PDP 11s by Dutch scientists resident at RAL.

The ICL 2960 computer is used for planning observations and analysing both engineering and science data. The observation-planning package is interactive so as to facilitate rapid changes of plans which might be required as a result of the quick-look science analysis.

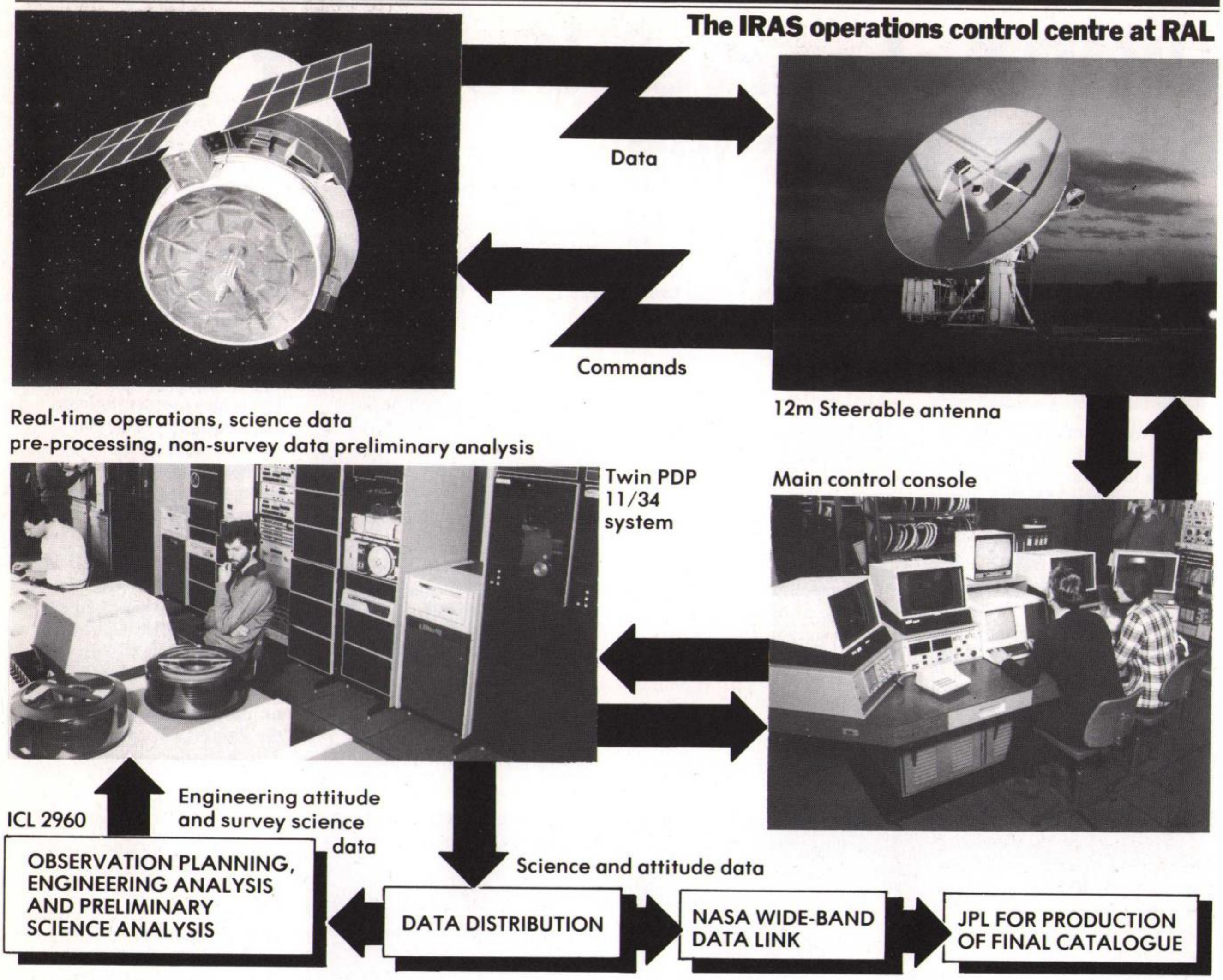
Mission operations and preliminary analysis

The Mission Operations organisation at RAL comprises a number of teams whose main functions are:

- ☐ To plan and to incorporate the observations to be performed by the satellite into a daily operations schedule.
- ☐ To implement the schedule during a satellite pass over the Chilton ground station by sending commands to the satellite and observing the telemetry data being received.
- ☐ To assess the current state of the satellite by monitoring engineering, pointing direction and scientific data during and immediately following a satellite pass.
- ☐ To assist in the long-term planning of observations by monitoring trends, ensuring that the sky is being covered and monitoring the scientific data to ensure that unusual infrared sources are adequately observed.

The tasks of the various teams broadly divide, therefore, into pre-pass planning, pass execution and post-pass analysis. To do these tasks, about 100 scientists and engineers will work at RAL during the satellite's lifetime, augmented during the critical post-launch phase by up to 50 specialist hardware and software systems engineers. The current best estimate for the launch date is 27 January 1983.

The IRAS operations control centre at RAL



The infrared survey and additional observations

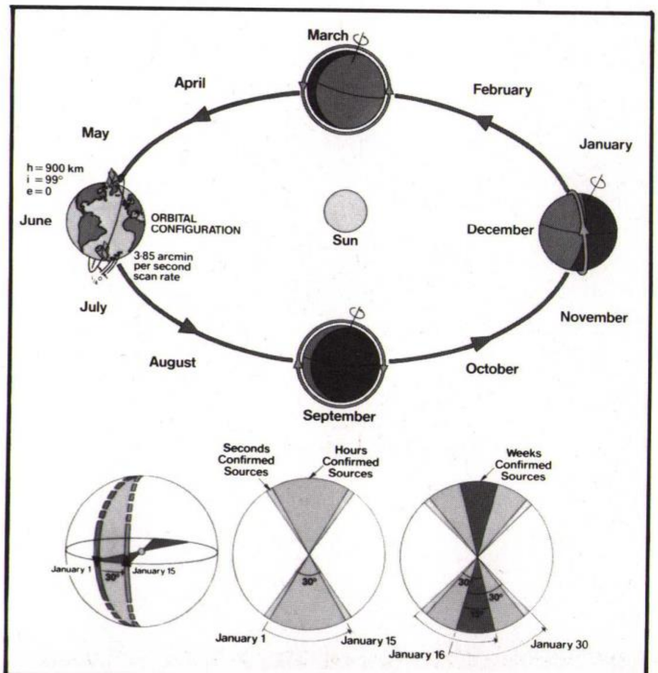
The IRAS survey strategy is based on carrying out the complete sky survey in approximately four months. This strategy makes use of the one-degree daily precession of the satellite orbit.

A major constraint on the mission is the need to avoid radiation from the Sun entering the telescope. The IRAS sunshade has been designed so that the telescope can be pointed within the range 60° to 120° from the Sun and the survey strategy has been designed so as to be well within this constraint. On the assumption that the survey commences on, say, 1 January, two 30° wide lunes are defined on the celestial sphere and these are scanned until 15 January. The design of the focal plane array permits 'seconds-confirmation' with a single traversal of a source.

Also, since the instrument's ½° wide field is overlapped ¼° on successive orbital scans, sources in the first lune may be 'hours-confirmed'.

From 16 January until 30 January two further lunes are scanned, which overlap the previous two lunes by 15°. Continuing in this way the complete celestial sphere will be scanned and all sources seconds, hours and weeks confirmed, within about four months.

For a nominal 40 percent of its mission IRAS will perform non-survey or 'additional observations' of astronomical objects of special-interest. UK astronomers must compete for some of this time just as they would for time on ground-based telescopes. Both survey and non-survey instruments may be utilized for additional observations.



UKIRT observes the most distant galaxies

A recent article in the SERC Bulletin (Vol 2 No 4, Spring 1982) described the development of the CCD spectropolarimeter at the Royal Observatory, Edinburgh. The instrument was designed as a highly versatile spectrograph–polarimeter–camera and can be used as a direct imaging camera, as a polarimetric camera, as a spectrograph and as a spectropolarimeter. The two-dimensional format of the CCD detector makes it a very efficient instrument in all these applications.

Following a commissioning run on a 60-inch telescope in Arizona last year, the CCD detector was used for the first time on a large telescope in April 1982, at the Cassegrain focus of the UK Infrared Telescope (UKIRT) in Hawaii. It may well be asked, "Why put an optical CCD camera on an infrared telescope?" The question is a good one in that UKIRT was designed as a flux collector for infrared radiation rather than as an optical telescope and, according to the original specification, UKIRT would not appear to be a suitable telescope for use with an optical CCD camera. However, with great foresight, Grubb Parsons, who provided the thin mirror, polished it to optical specification so that it is capable of providing 1 arcsec images in the optical waveband. Technical developments and a better understanding of the lightweight structure of the UKIRT mount have meant that the telescope can now track to 1 arcsec precision under autoguider control at any point in the sky that is accessible to the telescope. Thus, in principle, UKIRT had the capability of providing optical quality images for long integrations. This had not, however, been tested because of the very heavy use of the telescope for infrared observations for which much larger observing apertures than 1 arcsec are normally used.

Thus, besides the excitement of using the new instrument on a 4 metre telescope, there was the knowledge that we would be testing UKIRT as an optical telescope for the first time. The new instrument performed beautifully throughout the observing run and excellent exposures were obtained with 1.5 arcsec images in integrations of up to 30 minutes. An example of the quality of the images is shown in figure 1 which shows exposures of the field of a very distant radio galaxy 3C 352 taken in four different wavebands. The white crosses indicate the locations of the two radio components of a double radio source. The associated optical object is always found between these and it can be seen that there is a galaxy-like image right between the two radio components. To give some idea of the sensitivity of the system, the galaxy has magnitude 22.6, in the V waveband, a performance similar to that obtained with the Palomar 5 metre telescope with a similar detector.

Throughout the run, consistently high quality images were obtained, such as those shown in figure 1, proving that UKIRT has the capability of high performance as an optical or as an infrared telescope. Since these observations were made, new encoders for the main telescope drive have been installed with 0.3 arcsec

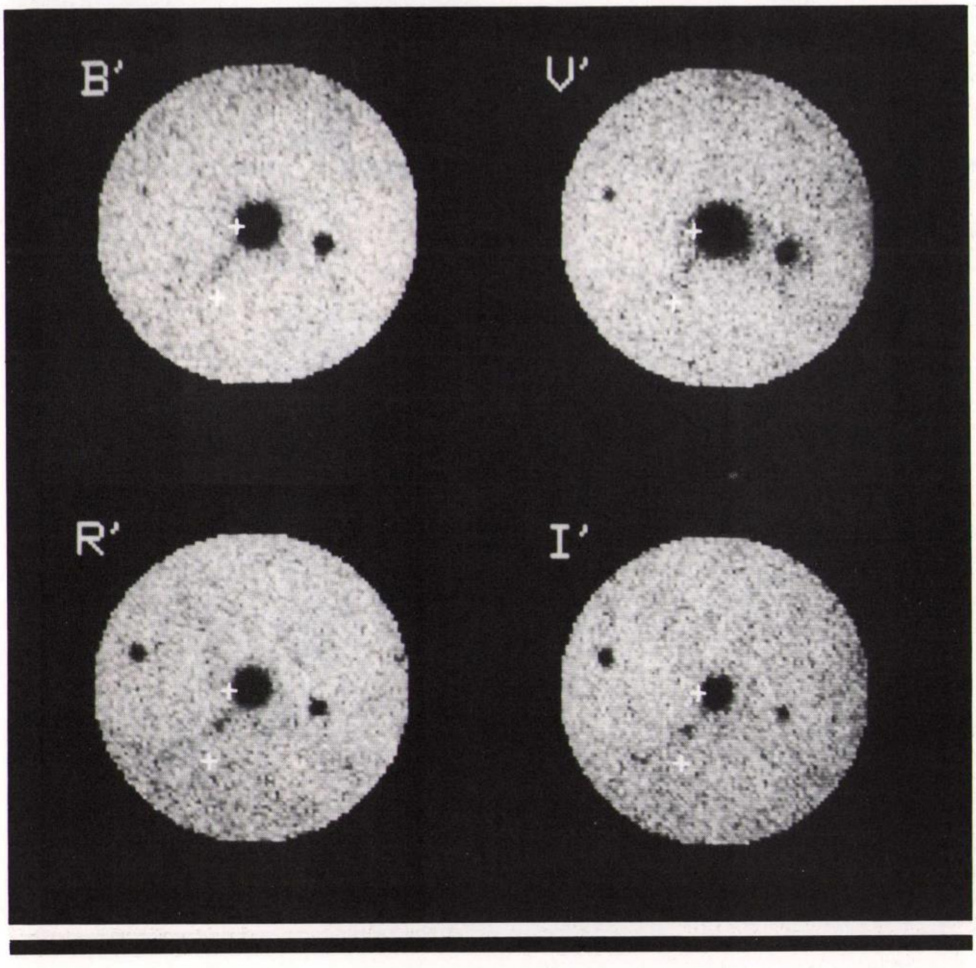


Figure 1 Images in four colours of the field of the radio source 3C 352. The white crosses mark the positions of the two lobes of a double radio source which are separated by 10 arcsec and a galaxy can be seen between these lobes in all four images. The colours correspond to blue (B'), visual (V'), red (R') and infrared (I') colours within the wavelength range 400 to 1000 nm. The compactness of the I' image is almost certainly caused by the very strong 500.7 nm line of [OIII] which originates in the nuclear region of the galaxy. The extended nature of the B' and V' images indicates that the excess short wavelength flux density does not originate in the nucleus of the galaxy.

resolution so that better than 1 arcsec tracking is now assured for all types of observations. This will be particularly important for the use of infrared arrays on UKIRT which should be possible in the next year or two.

What about the science itself? The observations of these distant radio galaxies formed part of a survey of the optical and infrared properties of the most distant galaxies known, the strong radio galaxies. It has been known for a long time that these are among the most luminous of all galaxies and hence they can be observed at very large distances once they have been located using radio telescopes. The most distant now known emitted their light when the Universe was less than half its present age and so it is possible to look for changes in their properties over cosmological time scales. Quasars are known at much greater distances but they are exotic objects and their physics is still poorly understood.

The advantage of studying radio galaxies is that they are the most distant objects known at present in which the light is the integrated light of stars.

Searches for these galaxies in the fields of bright radio sources have proved to be the most effective way of discovering galaxies at very large redshifts. Simon Lilly of the Department of Astronomy, Edinburgh University, in collaboration with the author, had already carried out a programme of infrared observations of these radio galaxies over a wide range of distances with UKIRT and discovered that there are very significant changes in their properties with cosmic epoch (see box). The most distant galaxies are brighter and bluer than would be expected if the stellar content of the galaxies had remained unchanged with cosmic epoch. The observations are consistent with a model in which the star formation rate in these galaxies has decreased exponentially over the cosmological time scales studied.

To investigate whether this phenomenon is indeed taking place throughout the body of these galaxies or whether it is concentrated at the nucleus, Lilly and the author collaborated with Ian McLean, who was responsible for the ROE CCD project, to make a special study of one of these very distant galaxies, 3C 352, using the CCD Imaging Spectropolarimeter in its direct imaging mode. Inspection of the four images of the galaxy in figure 1 gives an immediate answer. Although rather faint, the galaxy is plainly visible in all four colours. This shows that the galaxy must be much brighter in the blue (B') and visual (V') wavebands than we would expect because when galaxies are observed at large distances, their light is strongly shifted to the red end of the spectrum ie the B' and V' images should be much fainter than the red (R') and infrared (I') images. In addition, the B' and V' images are clearly extended, indicating that the evolutionary changes are occurring throughout the whole galaxy. These new observations strongly suggest that we are observing significant changes in the ordinary stellar population of very distant galaxies which indicate that they are evolving with cosmological epoch.

The importance of these results is that they make the whole question of the evolution of the stellar population of galaxies with cosmic time a practical, though difficult, observational study. Rather than being a purely theoretical study, models of galactic evolution may now be confronted with real observational data from much earlier cosmic epochs. We have gained a powerful tool for understanding how the most massive galaxies have evolved into their present state.

M S Longair
Professor Longair is Director of ROE, Astronomer Royal for Scotland and Regius Professor of Astronomy at Edinburgh University.

'Colour'/redshift for radio galaxies

Astronomers have the dreadful convention of working in magnitudes rather than intensities or flux densities. Magnitudes are negative logarithmic measures of flux density. To make matters worse, they take differences of magnitudes measured in different wavebands and call this a colour.

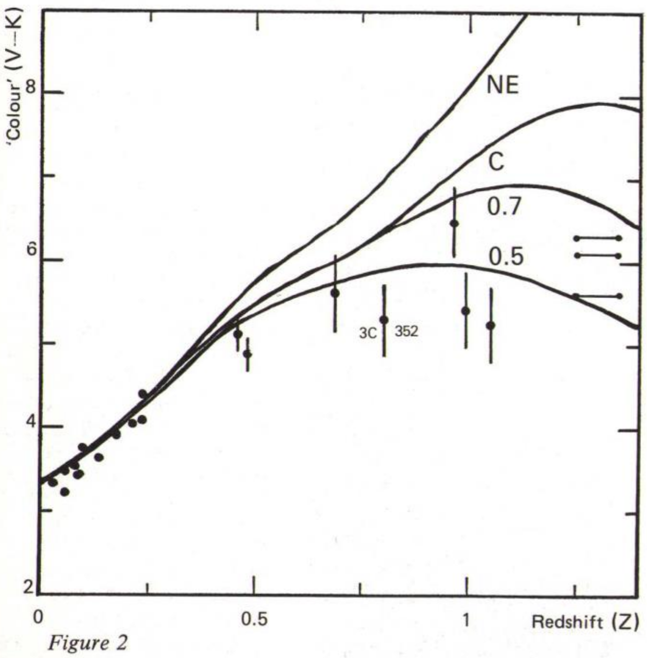


Figure 2

To compare the properties of galaxies at different distances, it is simplest to plot their colours as a function of distance and compare this with what would be expected if the galaxy remained the same but was observed at a large distance. The galaxy will not look the same at a large distance because the farther away a galaxy is, the greater its velocity of recession (Hubble's law) and hence we look at a different part of the spectrum because of the Doppler effect.

The diagram shows what we observe when we study nearby and distant radio galaxies of the same intrinsic type. The most distant radio galaxies observed are so far away that they emitted their light when the Universe was less than half its present age and so we can investigate whether or not they have changed their properties with cosmic time.

The line denoted NE shows how the optical-infrared colour (V-K) would change if the properties of the galaxy remained unchanged with distance (or redshift z). It can be seen that at small redshifts ($z < 0.4$) the agreement is good but at larger values the colours of the galaxies depart from the null prediction in the sense that the galaxies were relatively more luminous in the optical waveband.

The line marked C shows the effect of ageing on the stellar population. As stars get older they get redder, and hence, even if all the stars were formed at one time, more distant galaxies would appear bluer.

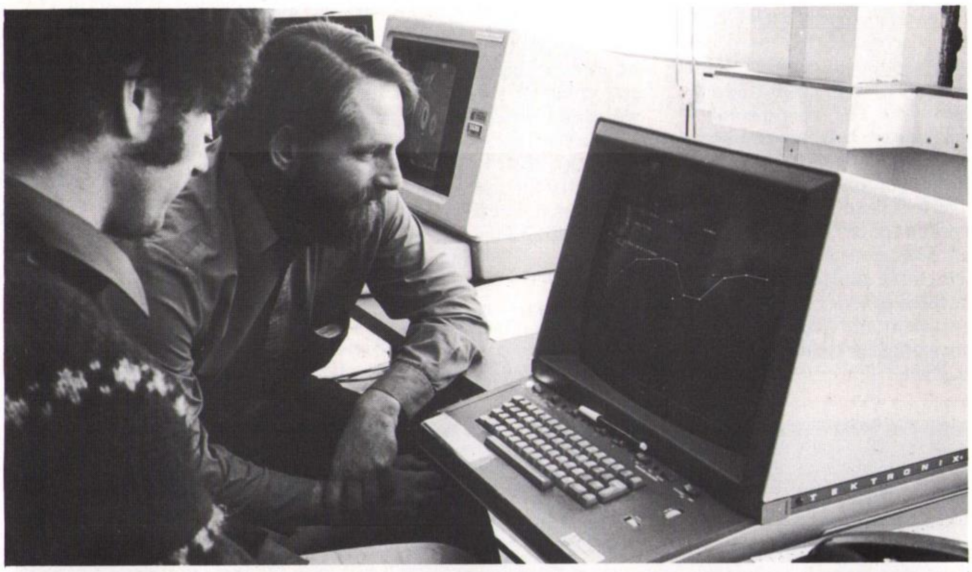
The lines labelled 0.7 and 0.5 show the additional effect of having continuous exponentially decreasing rates of star formation over the cosmic time interval over which these galaxies are observed. These data are thus consistent with reasonable models of the way in which galaxies might be expected to evolve with cosmic time.

Intercontinental remote control

Astronomers of the Royal Observatory, Edinburgh (ROE) achieved a technological 'first' in September 1982 by remotely controlling the UK Infrared Telescope (UKIRT) in Hawaii from a computer terminal in Edinburgh. The UKIRT Remote Observing Facility, under development for a year by ROE staff in Hawaii and in the UK, is expected to lead to greater flexibility in the use of major astronomical facilities and, in the long term, substantial cost savings.

The first observations to be carried out during initial tests were an infrared photometric measurement and a spectrophotometric scan of the star HR 8824, using the 3.8m UKIRT on the 4,200 m summit of Mauna Kea, Hawaii, from a computer terminal 7,000 miles away in Edinburgh.

When fully operational, the intercontinental link will allow British astronomers to use UKIRT and its standard common-user instrumentation to carry out many kinds of observations without leaving the UK. The astronomers will be able to operate from any terminal connected to the SERC computer network, including all users of SERC's astronomical STARLINK network. The remote operation also has the attraction that night-time observations in Hawaii can be carried out in normal working hours in the UK.



On Blackford Hill in Edinburgh, Mr Malcolm Stewart and Dr Tim Hawarden of the UKIRT Unit of the Royal Observatory, Edinburgh operate the 3.8m UK Infrared Telescope (UKIRT) on Mauna Kea, Hawaii, to obtain the first infrared astronomical observations to be secured by means of the intercontinental Remote Observing Facility. The visual display contains an infrared spectral scan of the star HR 8824, secured a few seconds previously at the telescope 7,000 miles away.

. . . and now, pictures

A second major step in the intercontental remote control of telescopes was taken in October by astronomers at the Royal Greenwich Observatory. Working from a control desk in Sussex, they operated the 2.1 metre reflector at the Kitt Peak National Observatory in Arizona and received the first direct TV pictures of the view through the telescope. Their successful observations also produced the spectra of three objects: the star SS433 in our galaxy; a distant galaxy which is emitting radio waves as well as light; and the 'exploding galaxy' Perseus A.

This success prepares the ground for the remote control of the new British telescopes on La Palma (see page 10).

Star machines

The advance of observational astronomy depends not only on the use of various types of telescope but also on development of the sophisticated machines used to extract data from astronomical photographs.

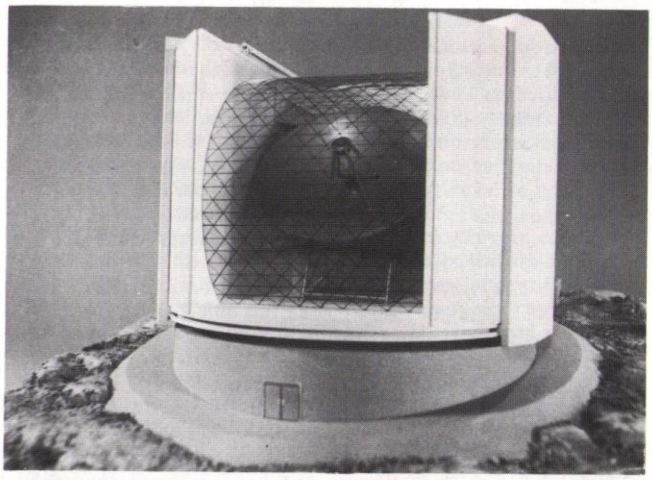
This development is proceeding simultaneously on several fronts: the hardware of the machines is being adapted and improved; the software required to handle the large volumes of data produced is becoming more sophisticated; and the astronomers concerned are devising new ways of attacking the scientific problems involved. Good communication between the astronomers and those responsible for the machines is essential to keep these varied developments under control.

Building on the experience of the first Astronomical Measuring Machines Workshop held in Cambridge in 1981, the Royal Observatory, Edinburgh, organised Workshop September 1982. Representatives from the four major measuring machines in the UK (APM at Cambridge, COSMOS at ROE, and GALAXY and PDS at RGO: see *Bulletin* Vol 2 No 5, Summer 1982) were brought together in Edinburgh with users from two dozen astronomical institutes, including ten in Europe and two in Australia. What came through clearly at the two-day Workshop was the amount of astronomy being done by these machines. Major new contributions have been made in studies of the structure of our Galaxy, in elucidation of the three-dimensional distribution of galaxies at faint magnitudes and in the discovery of unusual objects both within our Galaxy and beyond it (such as variable stars and quasars).

These astronomical measuring machines are being used for projects which previously were not feasible with manual techniques, not only because the sheer labour of handling the data would have taken a lifetime but more importantly because improved analysis techniques are possible with the machine-based data. The machines are very fast, producing large quantities of accurate information on the stellar and galaxian images.

Millimetre-wave telescope to be built in Hawaii

The 15 metre diameter radio telescope now being designed at the Rutherford Appleton Laboratory (RAL) is to be built in Hawaii. The clear skies above the 4,000 metre high observatory of Mauna Kea will allow the full potential of the instrument to be realised, enabling useful astronomical observations for wavelengths as short as 0.3 millimetre.



Model of the mm wave telescope

Interest lies in studying cool clouds of molecules and dust that are found in many parts of the Universe and these emit radiation most strongly at millimetre wavelengths. Such clouds are believed to be the birthplace of new stars and the UK Millimetre-wave Telescope (UKMT) will enable information to be obtained on how the clouds condense into stars, the rate at which this happens and the size and arrangement of the newly formed star groups, all of which is essential to our understanding of the evolution of galaxies. This spectral region, at the confluence of radio and infrared astronomy, is rich in molecular spectral lines which provide important clues to the composition of the material in space.

To be efficient at such short wavelengths the surface of the telescope must be very accurate, within 0.05 millimetre (rms) of a true paraboloid. It must also have a high pointing accuracy of a few arc seconds, comparable with some optical telescopes. The surface, made from 276 separate panels, will be supported by a backing structure of sophisticated design. This structure will maintain its paraboloidal shape despite the effect of gravitational distortion which will vary as the elevation angle is changed. Many other factors can contribute to the inaccuracy of the surface, not least of which are wind forces and thermal effects due to solar radiation. To protect from these and other environmental influences the antenna will be housed in a co-rotating enclosure. This enclosure will have a large viewing aperture, covered by a membrane transparent to radio waves which will allow operation up to wind speeds of 70 kilometres per hour. Above this velocity, doors and roof shutters will be closed to provide storm protection up to 200 kilometres per hour.

The enclosure has been designed and the antenna development programme is in its final stages. There is no evidence to suggest that the stringent specifications will not be met and much of the basic design is well advanced.

Through an agreement signed in June 1981 (*SERC Bulletin* Vol 2 No 3 Autumn 1981) between SERC and its Dutch counterpart, the Netherlands Organisation for the Advancement of Pure Science (ZWO), the Netherlands will provide 20% of the resources required to build and operate the Millimetre-wave Telescope facility, in exchange for the same proportion of the observing time. Dutch scientists and engineers are participating in the design of the facility with staff from RAL, the Mullard Radio Astronomy Observatory at Cambridge University and Queen Mary College, London. Other universities in both the United Kingdom and the Netherlands will have a major role in the development of the receiving systems.

When the project was first approved in August 1980, it was intended to build the facility on La Palma in the Canary Islands. After entering the collaboration with the Netherlands, a detailed re-assessment of the site characteristics was carried out. Of particular importance is the water vapour content of the atmosphere. Water vapour is strongly absorbing for radiation in the sub-millimetre part of the spectrum. Extensive data taken on La Palma between September 1980 and July 1981 by workers from RAL, MRAO (Cambridge) and Queen Mary College and similar data for Mauna Kea in Hawaii, published by other workers, showed a significant advantage in favour of Mauna Kea. On this basis it was agreed to seek approval to change the site to allow the full potential of the facility to be realised. Approval for this change has now been received in both the UK and the Netherlands.

The new site is at 4,000 metres on a plateau just below the summit of Mauna Kea and some 350 metres to the west of UKIRT, the 3.8 metre diameter UK Infrared Telescope which is operated by the Royal Observatory, Edinburgh. This is an important feature of the new site since, after the UKMT is complete, the two facilities will be operated jointly by ROE to provide a comprehensive and highly competitive service for astronomers in the millimetre, sub-millimetre and infrared parts of the spectrum. The already successful demonstrations of remote observing using UKIRT (see page 8) offer the prospect of ready access to both facilities for European astronomers despite the remoteness of the observatory.

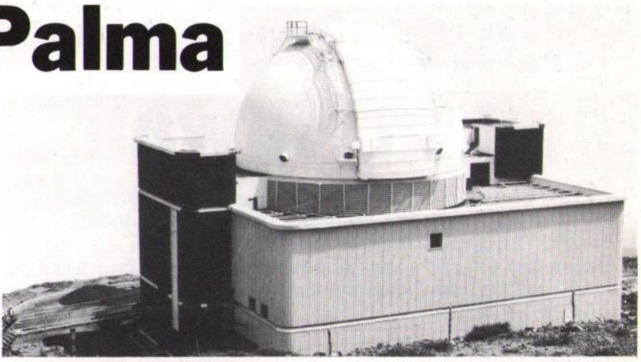
Operating staff and astronomers will use the hostel facilities at 3,000 metres which play an important role in acclimatising to working at the high altitude of the site. The headquarters of the two facilities will be at the sea level capital town of Hilo.

The Observatory on Mauna Kea is operated by the University of Hawaii at Manoa in Honolulu, some 300 miles to the west of the island of Hawaii, and is in a conservation area controlled by the State of Hawaii. Throughout 1982 negotiations have been proceeding with both the State and University authorities and the necessary agreements and approvals are expected to be achieved in time to start work on the site this Spring.

Even in the Tropics, a mountain at 4,000 metres is not a particularly hospitable place to work and the building season on Mauna Kea is restricted to about seven months each year. This naturally puts severe constraints on the planning of the civil work. Fortunately the building programme falls naturally into two parts: the site preparation and concrete work which it is hoped will be completed in 1983; and the installation of the enclosure which we hope to have weathertight before the 1984-85 winter. If this programme is achieved, the UKMT will be installed in 1985 and will be scientifically commissioned in 1986.

R W Newport

First light at La Palma observatory



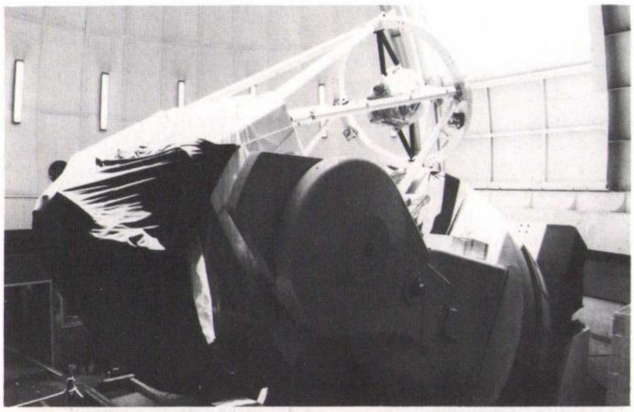
The completed dome of the INT on La Palma

British astronomers and engineers are putting the finishing touches to the country's largest optical telescope, the refurbished Isaac Newton Telescope, now re-sited on the peak of La Palma in the Canary Islands. The INT, with its 2.5 metre diameter mirror, will be one of a trio of major British telescopes at the site. The three form the core of the international Observatorio del Roque de los Muchachos. The INT will make the Observatorio one of the world's major astronomical facilities; and after the completion of the largest of the three, the 4.2 metre William Herschel Telescope in 1986, the Observatorio will be second to none.

The Royal Greenwich Observatory (RGO) is running the three British telescopes on behalf of all the astronomers who will use them. The RGO originally erected the INT in the grounds of its headquarters at Herstmonceux Castle, Sussex, in 1967. Despite its convenience for British astronomers, the weather and 'seeing' (atmospheric distortion of images) meant that the site was not suitable for such a powerful instrument. What was needed was an overseas 'Northern Hemisphere Observatory'. Site testers visited mountain peaks from Italy to Hawaii, and they eventually settled for the clear, steady, dark conditions of La Palma. The 2,400 metre peak lies above the inversion layer which traps below it most of the haze particles, and the air-flow off the sea is relatively unturbulent. The island also suffers comparatively little from scattered light from artificial sources which can brighten up the sky and make it difficult to observe the faintest objects.

May 1979 saw the signing of the international agreement: Britain, Denmark and Sweden would build telescopes on the mountain peak, the Roque de los Muchachos – the 'rock of the companions'. Spain would provide a road to the peak and accommodation for off-duty astronomers, as well as power supplies and telephone lines. In return, Spanish astronomers are guaranteed 20% of the observing time on each telescope. Other international partners have now bought a share in some of the telescopes: the Dutch 20% of the time on all three British telescopes, and the Irish 27 nights per year on the smallest, the 1 metre.

The 2.5 metre INT, refurbished by the British telescope firm of Sir Howard Grubb Parsons Ltd in Newcastle-upon-Tyne, will be the first of the British telescopes to open its eye to the sky. The telescope has seen some major changes since its Herstmonceux days. Most important, it has a new high-quality mirror, to produce sharper images and do justice to the superb seeing on La Palma. The new mirror is made of a glass-ceramic called Zerodur, which has a very low coefficient of thermal expansion (so temperature changes produce little distortion). It is also very slightly larger than the old mirror: the INT is now a '100-inch' telescope and not the '98-inch' it used to be! Grubb Parsons has also modified the telescope mounting, as this equatorial design must be tipped over more to allow for the lower latitude of La Palma.



The 2.5m Isaac Newton Telescope in polythene wrapping, awaiting completion by Grubb Parsons

In an informal ceremony on 20 October 1982, the Spanish building contractors Huarte y Cia SA handed over the key of the INT building to the RGO, allowing Grubb Parsons to begin working on the engineering and control system of the telescope on the observing floor. RGO technical personnel are being allowed into other parts of the building in a phased entry. According to the schedule, the INT will be taking its first look at the sky early this year – 'first light' in astronomers' jargon.

The smallest of the three British telescopes will also achieve first light soon. This 1 metre reflector is specifically designed to take fairly wide-angle photographs, 1½ degrees across, with very little distortion, so that positions of faint objects can be measured relative to the bright stars on the same plate. The telescope itself has been built, and is currently at the base of the old INT dome at Herstmonceux. Here its control systems have been tested, and it should be working on La Palma soon after its building is completed in mid 1983.

Other telescopes on La Palma include a Swedish solar telescope and a 0.6 metre reflector, both already operating, and a joint Anglo-Danish transit circle. This automated and computerised telescope will swing up and down the north-south line to measure accurately the positions of the brighter stars.

The biggest telescope for La Palma is Britain's 4.2 metre reflector, the William Herschel Telescope. The Spanish contractors are currently sinking piles for its foundations. Grubb Parsons has already ground and polished the huge mirror, and is constructing the frame and mounting. When completed in 1986, it will be the world's third-largest single mirror telescope. And the superb site will mean that it can outperform its larger rivals, the Soviet 6 metre and the famous Palomar 5 metre (200 inch).

In a piece of innovation which will save travel costs and make observing programmes more flexible, RGO will make provision to control all the telescopes from Herstmonceux, over two thousand kilometres away (see page 8). The 1 metre and the INT will be under remote control by the end of 1983, and the William Herschel will be the first telescope built for remote operation from the outset. It is part of the innovative organisation which, together with the first-class telescopes and the superb site, will make the La Palma observatory a world-leader.

Nigel Henbest

Information technology and SERC

1982 was designated Information Technology Year. The Government mounted a national campaign to promote a wider appreciation in industry and among the general public of the opportunities and benefits offered by information technology; the Department of Industry's Alvey Committee presented its far-reaching report and the Department of Education and Science announced major additional funds to promote Information Technology research and training through SERC.

Universities and polytechnics have played a significant role in the development of information technology both through research and the training of skilled graduate manpower. In the last five years, the Council has launched several major initiatives to encourage support and to coordinate more academic activity in microelectronics, computing and communications. Special programmes have been mounted in microelectronic fabrication and distributed computing systems and, in 1979, the Engineering Board set up an Information Engineering Committee to direct and support further research. This article highlights some aspects of the Committee's programme which relate directly to the rapid growth of information technology.

Education and training

At postgraduate level the Council has recognised the need for more integrated circuit designers and in 1980 set up three new MSc courses on IC design (see page 13). Since 1980 some 40 graduates have been trained each year and most have taken posts directly in industry. In 1981, the Council established six digital systems laboratories at Brunel, Kent, Heriot-Watt, Bradford and Salford Universities and the Polytechnic of Central London to investigate various aspects of digital systems and to provide training for both postgraduate and industrial students to gain hands-on experience of modern microelectronic techniques. The Council is also collaborating with the Open University to produce a post-experience course on computer applications.

Microelectronics

The growth in Information Technology has depended primarily on the revolution in microelectronics in the last 20 years. Council-supported device fabrication facilities are described in detail in pages 12 and 13. The facilities were established at a viable LSI level. The Council is now moving towards the VLSI capability and a recent grant of £1.78 million has been awarded to Edinburgh University which will allow much finer circuit geometries. University research is being supported not only into novel devices in such areas as integrated optics and optical signal processing but also into the exploitation of new ideas arising in semi-conductor physics including unidimensional conductors, modulation doping and metal insulator transistors. Most of this research is being carried out in direct collaboration with the leading microelectronics companies in the UK.

Computing

In 1977 the Council launched a coordinated programme in distributed computing systems. The objective of the programme was to establish the engineering principles necessary to implement such systems which offer a means of achieving very high speed and reliable processing more economically than increasing the speed of single processors. Research in the development of suitable programmable languages and the resource management of these systems was reported in Vol 2 No 5 of the *Bulletin* (Summer 1982). Significant developments have been made in the design and evaluation of new computer architectures. Cambridge University has developed a wide band digital communications ring intended to provide high speed local area networks. The Cambridge Ring is being used as the common hardware base for university researchers. An early commercial version is being exploited by Logica Ltd as a possible system for the 'office of the future'. A series of such ground-based local area networks linked by satellite forms the basis of the UNIVERSE project. This £3 million project is jointly funded by SERC, Department of Industry, GEC, British Telecom and Logica Ltd and involves the siting of seven earth stations in the industrial companies and at Cambridge and Loughborough Universities and University College London. The aim is to demonstrate and evaluate high bandwidth, high data rate transmission. UNIVERSE has great significance for UK information technology and should lead to a more widespread link between the rapidly growing number of computers in business, industry and the education system.

Under the distributed computing systems programme, Manchester University has been supported to design and construct a prototype Data Flow computer system. This system has many potential applications including weather forecasting, signal processing and intelligent systems.

In response to the Roberts Report *(Proposed new initiatives in computing and computer applications)* the Council has taken action to stimulate more industrially relevant academic research in software technology, database utilisation, systems reliability and man–machine interaction. Two consortia have been established, at East Anglia and Aberdeen Universities, in database utilisation, and a major grant has been awarded to Newcastle University to demonstrate to industry the effectiveness and practicability of reliability techniques in a command and control system.

The next phase

In 1982, the Advisory Board for Research Councils (ABRC) endorsed the Council's proposals for a major growth in SERC support for Information Technology. The proposals were made in the context of the Committee, under Mr J Alvey of British Telecom, set up to develop a national programme in IT involving industry, government departments and academic research. The Council welcomes the Alvey Committee's report.

We now know that DES has accepted the advice of the ABRC, who recommended a very significant increase in the funding of Information Technology research and training. This means that SERC can now increase research supported through grants in universities and polytechnics on a scale that will permit the support of much of the work proposed in the Alvey Committee report. In particular we expect to build up research in Software Engineering and Intelligent Knowledge Based Systems very significantly.

The number of Fellows and Research Studentships in Information Technology-related subjects will also be very considerably increased. And there will be a large increase in the number of Advanced Course studentships we can support in IT-related subjects, including a number of new courses in universities and polytechnics designed to convert graduates from other disciplines. Altogether, by 1985-86, it is hoped to increase postgraduate numbers by over 1500 a year. Together with the new posts in IT departments that are to be provided with earmarked funds from UGC, the outlook for Information Technology research and training in universities and polytechnics looks excellent.

Device fabrication facilities

The Central Microfabrication Facilities were set up under a Specially Promoted Programme in Device Fabrication which is the responsibility of the SERC's Information Engineering Committee. Current expenditure is running at about £2 million per year with further investment planned. The activities of the facilities are coordinated from Rutherford Appleton Laboratory (RAL) which is also responsible for publishing the newsletter *Microfabrication*. This is designed to keep the academic community abreast of the latest developments at the facilities and would be of interest to anyone wishing to know more about SERC's contribution to microelectronics in the UK. All of the Council's Device Fabrication Facilities are available to you. For further information, please contact Mr Bill Turner, the Programme Coordinator, at the Rutherford Appleton Laboratory (ext 5286).

SERC (then SRC) recognised the need for an initiative in microelectronic fabrication in the early 1970s. At that time semiconductor technology was capable of realising a variety of discrete devices but it was already apparent that the main application would be in integrated circuits (IC). The basic methods for the mass production of these devices had been developed at Fairchild Semiconductors, where the first IC was made in 1959, and have remained substantially unchanged. By the early 1970s, integration levels had reached about 1,000 devices per silicon chip and it could be foreseen that the IC would come to dominate the performance and cost of virtually all electronic equipment in the future. The national importance of microelectronics was clear, as was the vital importance of the contribution to be made by the academic community.

The question of how this contribution could best be mobilised was examined by an SRC panel which reported in November 1975. One conclusion was that, to support a programme to establish awareness of and expertise in microelectronics, it would be necessary to provide academic research workers with access to semiconductor processing facilities which individual universities could not afford. After extensive consultation with potential customers in the academic community it was decided that, initially, five facilities should be established and, in July 1977, Council approved the allocation of £1.3 million for this purpose.

By augmenting equipment and expertise already in existence, centralised facilities were set up at:

Edinburgh and Southampton Universities for silicon processing;
Surrey University for ion implantation;
Sheffield University for compound semiconductors; and
Rutherford Appleton Laboratory (RAL) for mask making and computer-aided design.

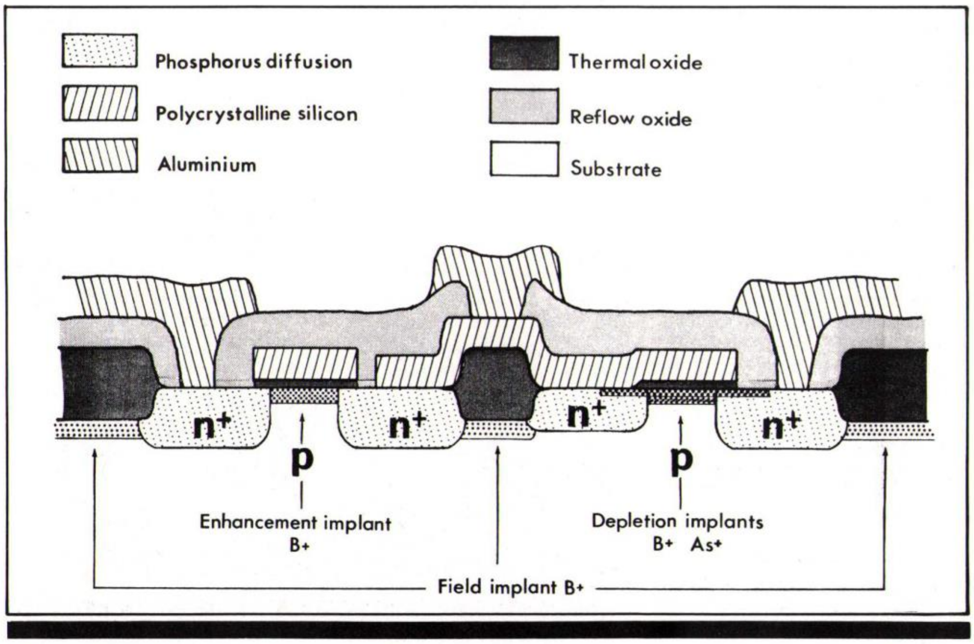
The computing needs of circuit designers would be provided via SERC's Interactive Computing Facility.

At the beginning of 1981, it was announced in the newsletter *Microfabrication* that SERC could provide, in-house, a complete up-to-date service in microcircuit fabrication.

The Central Microfabrication Facilities are available to any SERC-authorised user. Those without the computer terminals and lines necessary to gain access via the Interactive Computing Facility route may send mask descriptions coded in GAELIC language to the Electron Beam Fabrication Facility at RAL.

Thus a research worker in a university or polytechnic wishing to obtain a microcircuit made to his own design would be able to access the process most appropriate to his design needs.

The structure of an integrated circuit is complex, each element of such a device possessing a three-dimensional architecture which must be reproduced exactly in every circuit. The fabrication process begins with a thin slice, or wafer, cut from a single cylindrical crystal of silicon typically 3 inches in diameter. By a series of operations which requires access to only one surface of the silicon wafer, the device is built up in layers, some of which lie within the wafer while others are stacked on top. The configuration of each layer is defined by the appropriate mask. Each wafer will contain several hundred identical circuits each surrounded by pads by which it can be connected to the outside world. Before the individual circuits are separated each is tested automatically and defective circuits identified. Finally, the good circuits are packaged and despatched to the customer.



Silicon processing:
Cross section of typical isoplanar nmos silicon gate device.

Computer-aided design

The designer translates his electronic circuit designs into a set of mask designs each containing the pattern for one of the seven to 10 layers from which the circuit is built up. These patterns are generated by assembling simple closed shapes, usually rectangles or polygons and interconnecting tracks, into groups which can be repeated to form regular arrays as appropriate. The patterns are coded in GAELIC language – which was designed to provide a simple means of defining two dimensional geometric shapes – and stored to await transfer on to the separate masks. The GAELIC suite of programs, which includes the written GAELIC language, is mounted on the RAL PRIME C computer and may be accessed from many universities and polytechnics via SERC's Interactive Computing Facility network. It has also been marketed commercially by Compeda Ltd. Once designs are completed and checked they are launched into the process which will end with the delivery of packaged chips to the designer.

Mask making

The designs go first to the Electron Beam Lithography Facility at RAL where they are transferred to mask plates (see pages 14 and 15).

Silicon processing

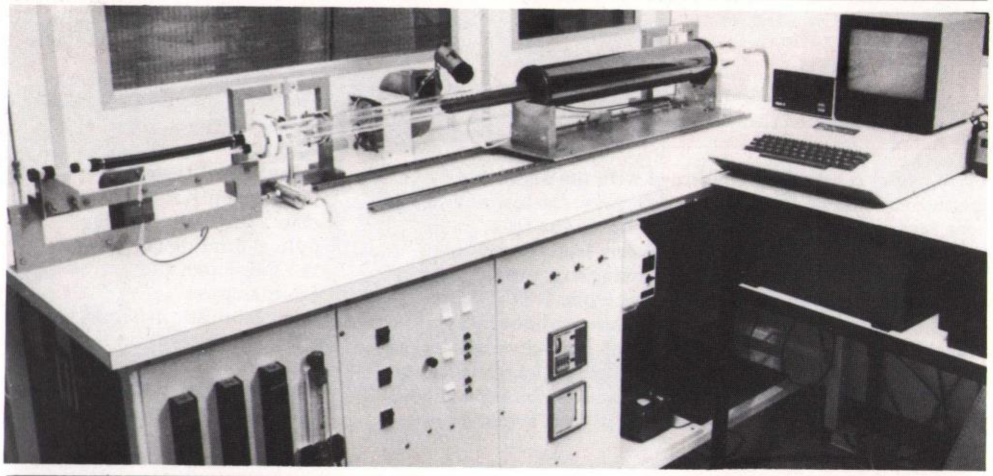
Because it offers the greatest density of circuit elements per chip, MOS (metal oxide semiconductor) technology has come to dominate the manufacture of LSI circuits. Processes to fabricate n-channel MOSFETS (field effect transistors) are available at the Edinburgh and Southampton Facilities. The other main family of transistors – the bipolar type – can also be produced at Southampton.

Plans are also well-advanced to offer gate-array services which will make it easier for non-microelectronics experts to apply microelectronics to their own disciplines.

Ion implantation

To construct active circuit elements, such as field effect and bipolar transistors, it is necessary to introduce impurities into localised areas of the silicon crystal structure – that is, to create p and n-type semiconductor regions – by adding the appropriate dopant atoms. There are two techniques for this: diffusion and ion implantation.

Ion implantation allows impurities to be introduced in a more controllable way and is thus becoming more popular. The fabrication centres at Edinburgh and Southampton have their own ion implanters for use in circuit production and specialised services in ion implantation are provided by the Central Facility at Surrey University. A wide range of dopant ions can be accelerated to energies which can be precisely controlled over a broad spectrum. Comprehensive surface analysis facilities are also available to monitor dopant profiles. Research at Surrey has concentrated mainly on implants into gallium arsenide and indium phosphide but the Facility provides a service covering all academic needs for ion implantation in microelectronics research.



Compound semi-conductors.
New fully-automated liquid phase epitaxy furnace at Sheffield University, with 'look through' gold reflector which permits observation of melts during growth.

Compound semiconductors

Compound semiconductors, the III-V compounds (so called because of the position occupied by their constituent elements in the Periodic Table) are the concern of the Central Facility at Sheffield University. III-V compound semiconductor mixed crystals find important applications in microwave amplifiers and oscillators and, more recently, in optoelectronics. The Facility provides a range of tailor-made epitaxial (ie with the same crystalline orientation as the substrate on which they are grown) single crystal layers by means of liquid phase and, latterly, vapour phase deposition techniques.

MSc courses

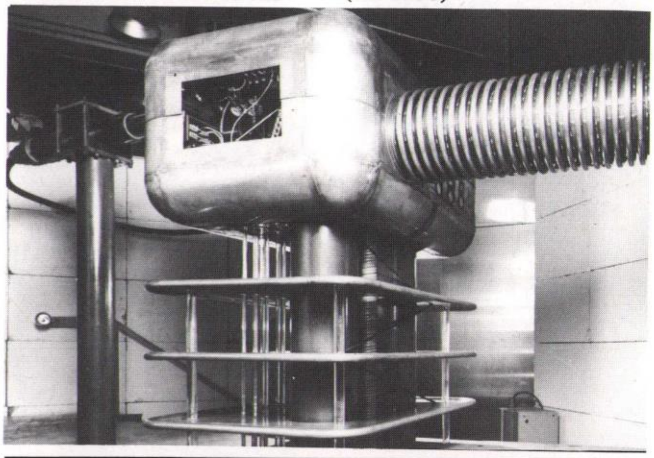
If the UK is to take full advantage of the technological revolution increasingly being brought about by the integrated circuit, the means must be provided to train the specialist engineers and scientists required in industry and elsewhere. To this end, SERC provides special support for three MSc courses in integrated circuit design – at UMIST, Edinburgh University and jointly at Brunel and Southampton Universities. The courses are run in close collaboration with the electronics industry and include substantial practical work. The staff and students have access to the SERC centralised facilities for fabricating projects entirely 'in-house'. Access to facilities has also been granted to Durham and Queen's Belfast to allow practical chip-making exercises in their Master's courses. An example of designs produced on one of these courses is shown on page 15 (figure 3).

Video cassette

Where microns matter, the 20-minute video cassette produced last year by SERC on the fabrication of a silicon integrated circuit, has been proving highly popular.

Aimed at final year undergraduate audiences, the programme demonstrates how all academic researchers can avail themselves of the latest technology and harness the great potential offered by microelectronics.

The cassette and accompanying leaflet are available on free loan from the Public Relations Unit, SERC Central Office, Swindon (ext 2256)



Ion implantation:
The high voltage terminal of the 500 keV Heavy Ion Accelerator at the University of Surrey. The ion source and associated electronics are housed in the terminal.

Electron beam lithography

Lithography is primarily concerned with the definition of geometrical shapes. Over the last few years the technology has been required to define even smaller lines. The first microprocessors were constructed (early last decade) using linewidths greater than 6 μm while today's impressive devices employ minimum linewidths of about 3 μm. It is anticipated that production devices with 1 μm minimum linewidths will be available by the mid-1980s and with 0.5 μm linewidths by the end of this decade. Many properties of microelectronic circuits improve greatly with reduction of linewidth making advanced lithography a technology that sets the pace of improvements to circuit performance.

Definition of the smallest linewidths in common use can be achieved by optical methods and such techniques are widely employed throughout the industry. The smallest linewidths that may be obtained are limited by diffraction effects to 1 μm and research into alternative methods has been in progress for the last decade. A major technology that has emerged in recent years is electron beam lithography, which uses the advantages of electron beams (no significant diffraction effects and a steerable beam) for pattern definition in an analogous manner to their use in scanning electron microscopy. Electron beam lithography machines are capable of defining 0.1-1 μm minimum linewidths with a spatial accuracy of ±0.1 μm over 100 mm (ie 1 part in a million!), using a computer-controlled electron beam of typically 0.2-0.5 μm diameter.

The EBL facility

It was decided in 1977 that the mask-making service at RAL would be based entirely on electron beam lithography and a machine was purchased from Cambridge Instruments, a well known UK commercial supplier. The machine installed in a clean room at the EBL Facility is shown in figure 1. The similarity of the machine (known as EBMF-2) to a scanning electron microscope is evident.

At present the major task for the EBMF-2 is to manufacture the finely patterned plates known as masks which are used by optical printing machines at the Edinburgh and Southampton microfabrication centres to copy the patterns on to silicon wafers. Each mask starts as a glass plate typically 100 mm x 100 mm x 1.5 mm coated with a 0.1 μm thick, optically opaque, layer of chromium. The required pattern is first written by the EBMF-2 into an intermediate plastic layer, known as a resist, which is spread to a thickness of about 0.5 μm over the whole surface of the chromium-coated plate. The effect of electron beam (10nA, 20kV) is such that subsequent development of the plate causes the irradiated areas of resist to dissolve, leaving windows of exposed chromium. This is seen clearly in figure 2, where the valley floor is chromium.
The resist pattern is then permanently etched into the chromium layer by irradiating the whole plate with a flood beam of 1000eV argon ions with the remaining resist areas acting as a protection for the chromium that is not to be etched. Finally, the remaining resist is stripped from the plate leaving a finished mask plate consisting of a pattern of opaque chromium with appropriate clear areas. An integrated circuit mask with six different designs is shown in figure 3, illustrating the flexibility of EBL machines to change the data written during exposure. Traditional optical methods would have great difficulty in doing this accurately and economically. A detail of a typical mask is shown in figure 4 with a minimum linewidth of 5 μm. Considerable supporting equipment is required for the EBL machine. Some 20 separate pieces of equipment are installed in the EBL Facility which occupies about 400m² of floor space. All equipment is housed in the strictest conditions of cleanliness to minimize the introduction of dust and other foreign particles. Therefore the work is always conducted in laminar flow cabinets or complete laminar flow rooms and all personnel wear suitable protective clothing. This philosophy is well illustrated in figure 4 where an operator is shown preparing a glass plate for coating with resist.

The mask-making service

The EBL Facility became operational in July 1979 and since then the demand for mask-making has doubled each year. Output of the EBMF-2 machine is now over 20 plates per week, with two-shift working. Many applications have been undertaken. The main demand has been for integrated circuit mask plates as originally planned. However,

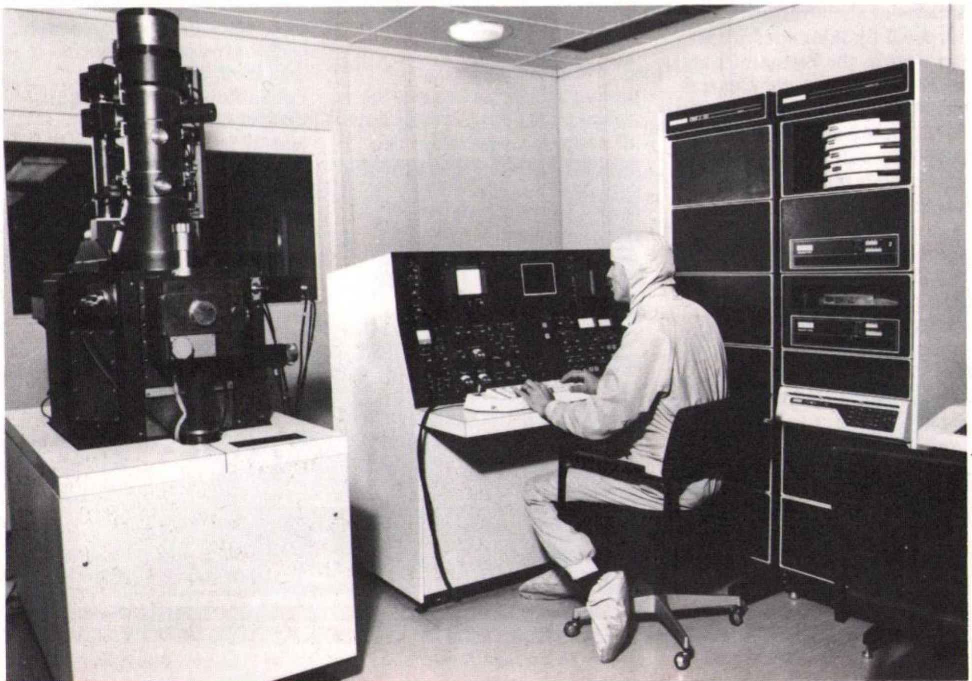


Figure 1
The EBMF-2 electron beam pattern generator installed in a clean room at the Electron Beam Lithography Facility. The electron-optical column and vacuum chamber are shown on the left. The machine is controlled by the computer shown on the right.

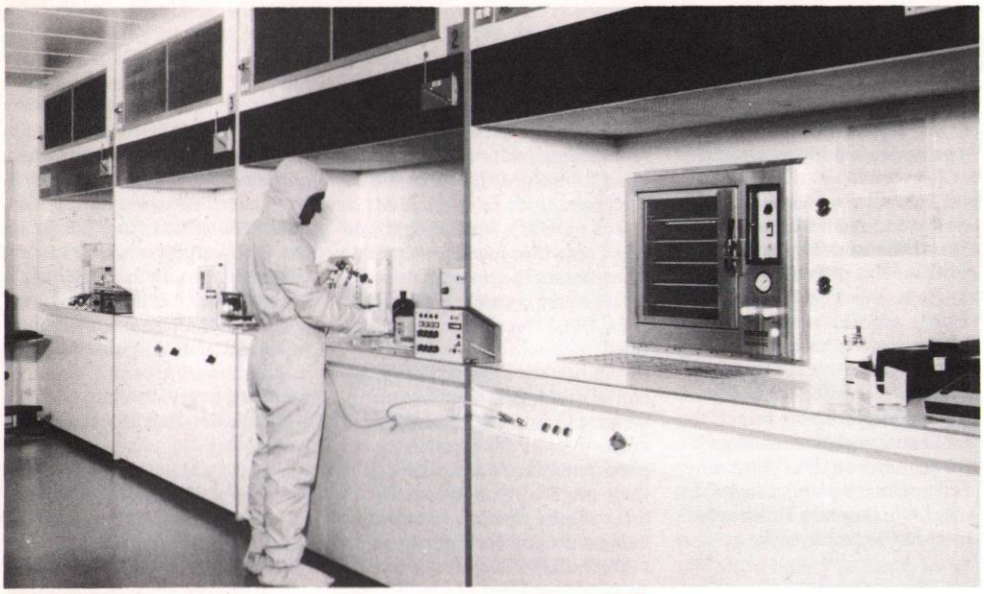


Figure 5▲
Part of the clean area of the EBL Facility. The operator protected by suitable clothing is preparing a plate for coating with resist.

there has also been a significant demand for the mask plates needed to manufacture surface-acoustic-wave devices and integrated optics devices. These latter applications are far more demanding of the EBMF-2 as there is either far more data generated or there is a requirement for curvilinear geometries (the EBMF-2 machine and CAD software is designed mainly to support rectilinear geometries, eg figure 4). A growing requirement is to use the capabilities of electron beam lithography to manufacture devices which are mask-like but are of a general micro-engineering nature. An interesting example of such work is the gold spiral shown on the cover.

Future activities

There is an urgent need for electron beam machines capable of increased throughput, higher accuracy and controlled by more flexible software. The future needs of an academic research community are unlikely to be completely met by commercial machines which tend to be developed for a production environment. Consequently, the development of a more advanced electron beam machine is in progress at the EBL Facility supported by joint DoI-SERC funding. The machine has been constructed and is now being commissioned.

R A Lawes

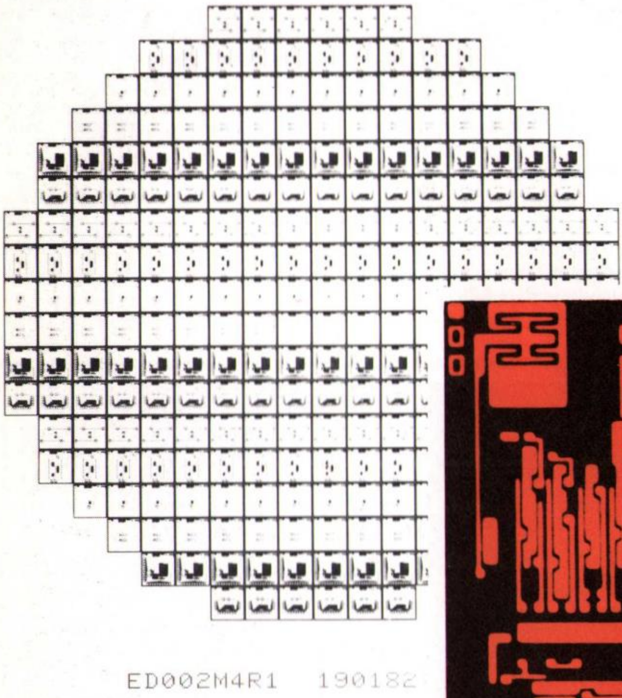


Figure 3▲
A typical integrated circuit mask designed to print on to a 3 inch diameter silicon wafer. Note the step-and-repeated array of six different designs.

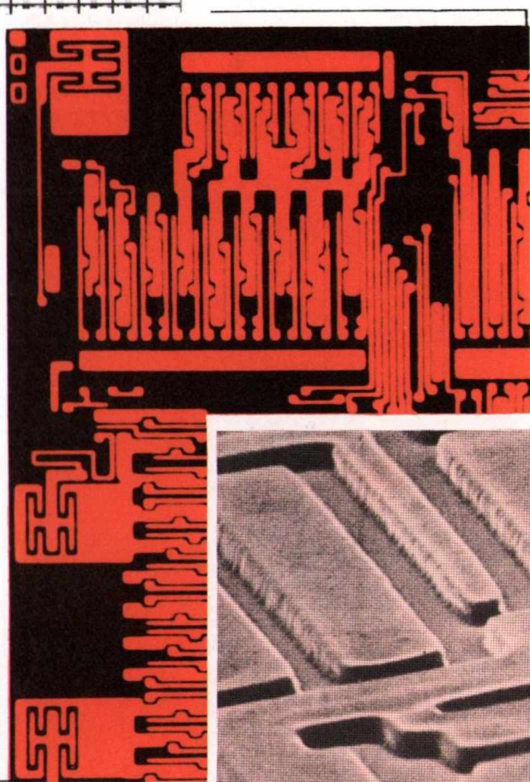
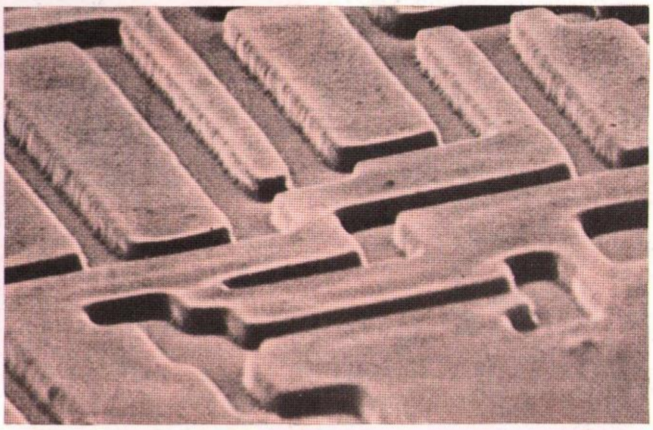


Figure 4 ▶
Detail of a mask plate manufactured at the EBL Facility. The smallest linewidth is approximately 5µm.

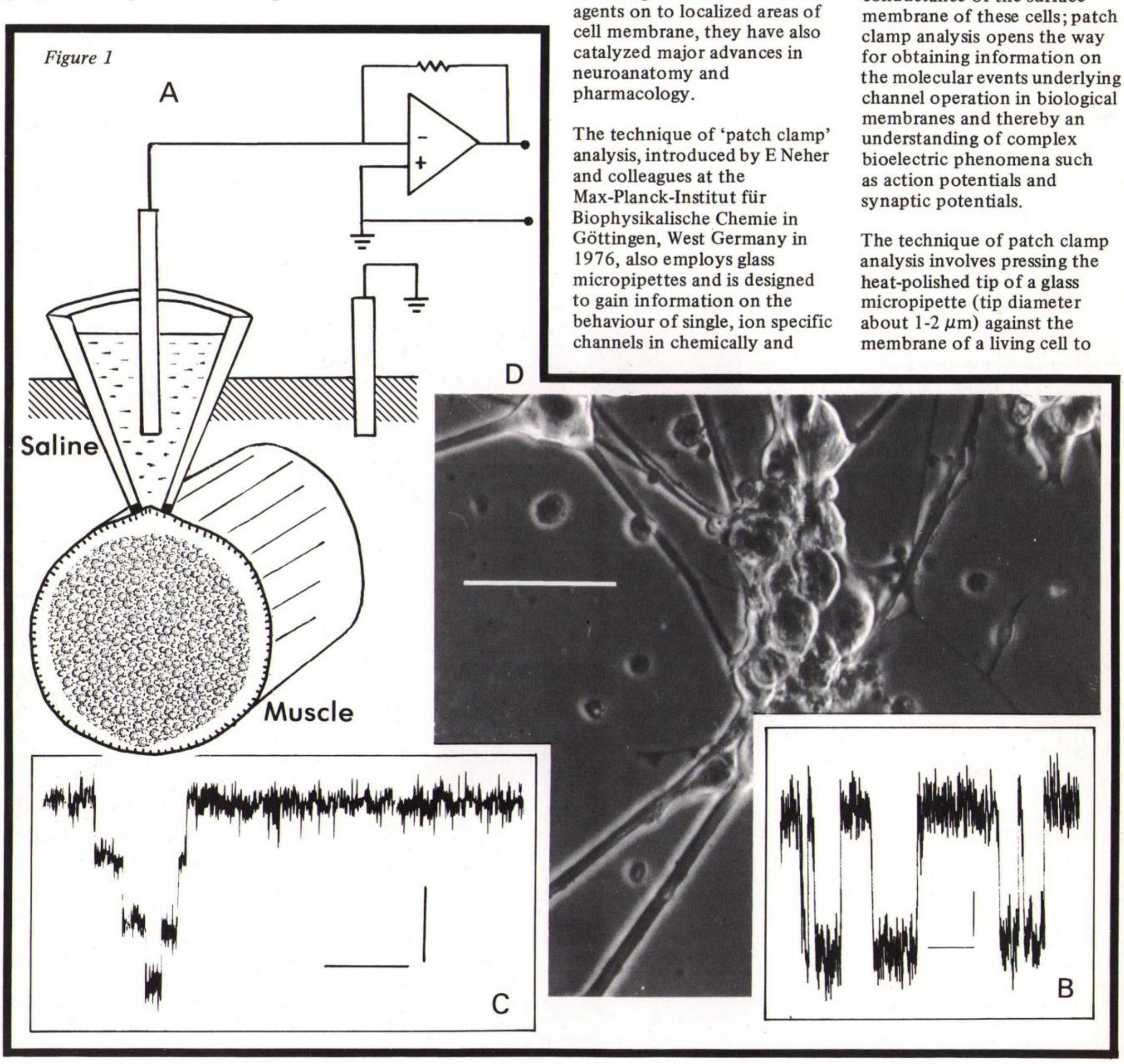
Figure 2
Images exposed by the EBMF-2 using an experimental high sensitivity resist. The minimum linewidth is 1µm. The mesa-like regions correspond to those areas not exposed by the electron beam. ▼



Patch clamp analysis

It has often been observed that major conceptual advances in biological research are preceded by technological innovation. The patch clamp technique devised in West Germany, but substantially developed in the UK, is of major significance to molecular pharmacology and membrane biophysics, and has implications for drug improvement. In the past, studies of the interaction of whole populations of membrane receptors with chemical substances have contributed significantly to our knowledge of the behaviour of excitable cells and have been of substantial benefit to the pharmaceutical industry. Now, the new technique of patch clamping will allow the extension of this research to the study of the interaction of *single* membrane receptor molecules with transmitter substances or other chemicals in living intact cells or in isolated patches of cell membrane, and is increasingly being adopted by research groups throughout the UK. This article gives some general details of this technique and reviews progress made over the last four years at Nottingham University, where the technique has been used to study locust muscle glutamate receptor-channel complexes.

Figure 1



Neurobiological research was revolutionized by the introduction of the glass microelectrode in the 1950s which enabled, for the first time, accurate measurement of transmembrane potentials in intact nerve, muscle and gland cells. Glass microelectrodes, filled with either electrolyte or ion selective agents, have contributed significantly to our understanding of the ionic basis of many bioelectric phenomena and, through their modification for intracellular dye injection into living cells and for injecting minute quantities of chemical agents on to localized areas of cell membrane, they have also catalyzed major advances in neuroanatomy and pharmacology.

The technique of 'patch clamp' analysis, introduced by E Neher and colleagues at the Max-Planck-Institut für Biophysikalische Chemie in Göttingen, West Germany in 1976, also employs glass micropipettes and is designed to gain information on the behaviour of single, ion specific channels in chemically and electrically excitable membranes of living cells. The conductance changes exhibited by the surface membranes of excitable cells are due to the transient appearance in these membranes of aqueous, ion specific channels gated either by the transmembrane potential or following the interaction of a specific channel agent, eg acetylcholine, with a gating molecule considered to be an intrinsic membrane protein. Most of the electrical events which characterise nerve, muscle and gland cells result from changes in the conductance of the surface membrane of these cells; patch clamp analysis opens the way for obtaining information on the molecular events underlying channel operation in biological membranes and thereby an understanding of complex bioelectric phenomena such as action potentials and synaptic potentials.

The technique of patch clamp analysis involves pressing the heat-polished tip of a glass micropipette (tip diameter about 1-2 μm) against the membrane of a living cell to form an electrical seal with a leak resistance of about 50MΩ (figure 1A). This high resistance ensures that currents flowing through the patch of membrane isolated under the tip of the electrode flow into the pipette; it also minimises the biological noise in the recording pathway and thereby enhances the resolution of single channel events. With an appropriate ligand in the pipette, receptor-gated channels are activated in the isolated patch of membrane.

The utility of this technique is limited by the conductance of the single channel, which influences the signal-to-noise ratio of recorded data and initial experiments using patch clamp analysis were directed at membrane channels with conductance of 30 ps or greater. The glutamate receptor-gated channel in locust muscle-membrane has been a particularly successful system in this respect.

Patch clamp studies of locust muscle glutamate receptor-channel complexes were initiated at Nottingham University, Department of Zoology in 1978. The conductance of the channel (cation selective, $Na^+/K^+/Ca^{2+}$) is about 130 ps so that, with a muscle-fibre transmembrane potential of -60mV, open-channel currents of about 8 pA can be recorded routinely (figure 1B). Because of their high conductance in the open state and because glutamate receptors on locust muscle are readily accessible and, under certain conditions, do not exhibit the refractoriness in the continued presence of binding agonists which characterize many other receptor systems, they are ideal subjects for patch clamp analysis.

Studies of these receptor-channel complexes have revealed information on the kinetics of the ionic channel and new insights into the pharmacology of the glutamate receptor. The single-channel conductance and life-time (average, approx 1 ms) are independent of membrane potential but histograms of frequency distributions of channel life-times suggest more complicated gating kinetics than was suspected previously from macrosystem studies. The single-channel studies have confirmed the general rule that pharmacological potency of receptor agonists depends upon the life-time of the channels when they interact with the receptor (the most potent agonists gate channels with the longest average life-times) and they have also shown that channel-gating probability is lower for weaker agonists.

Present investigations involve more detailed analysis of channel opening and closing kinetics, especially of the mobility which characterizes the patterns of activity of single glutamate receptor-gated channels in locust muscle-membrane, and testing the effects on channel kinetics of agents which interact with either the glutamate receptor, or the closed or open channel which it gates.

A recent modification of the patch-clamp technique involves adherence between the cell membrane and the micropipette glass and has greatly extended the range of phenomena that can be investigated. The membrane-glass interaction produces seal resistances in the range 10-100GΩ which reduces background noise to a level sufficient to resolve single-channel currents of 1-2 pA. Furthermore, by careful manipulation, it is possible to 'tear off' the isolated membrane patch from the cell so that it behaves like a single, 'cell-free' bilayer covering the electrode aperture. A known potential difference across the excised patch of membrane can be readily achieved by controlling the potential inside the pipette. It is possible to invert the patch so that either its cytoplasmic face or its external face is exposed to the external medium. These excised patches enable a remarkable range of studies to be undertaken. The development of 'giga seals' requires a cell or plasma membrane more or less devoid of extracellular coat or basal lamina. This requirement is met in many tissue-cultured cells, such as the neuroblastoma line (figure 1D) which has been used by the author and colleagues during the past four years to study single channels gated by receptors for acetylcholine (figure 1C) and 5-hydroxytryptamine as well as voltage-sensitive potassium channels.

Excised patches provide opportunities similar to those afforded by artificial bilayer membranes with the major advantage that channels can be studied in their native environments. Recent successes in transferring channel proteins to artificial bilayers mean that it is now possible to compare the properties of these structures in natural and artificial environments and thereby gain some insight into the role of lipids in membrane transport of ions.

Professor P N R Usherwood

Professor of Zoology, Nottingham University

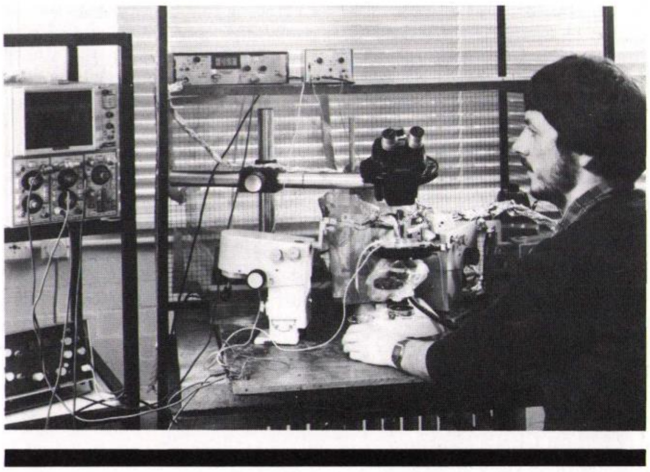
◀ *Figure 1*

Patch clamp analysis of glutamate receptor-gated channels in locust muscle membrane and acetylcholine receptor-gated channels in surface membrane of neuroblastoma cells.

A. Diagrammatic representation of single channel recording from locust muscle showing a section through a glass micropipette containing sodium L-glutamate in saline pressed against the surface of a locust muscle fibre (not drawn to scale). A silver/silver chloride electrode connects the inside of the micropipette with the recording amplifier, the saline surrounding the muscle fibre being held at earth potential by a second silver/silver chloride electrode. The potential difference across the surface membrane of the locust muscle fibre is usually about -60 mV.

B. Currents flowing inward across the membrane through a single channel are indicated by downward-going deflections with upper and lower baselines indicating closed and open positions of channels respectively. Calibration bars: 3 pA; 20 ms. Recording bandwidth 0 to 7 kHz.

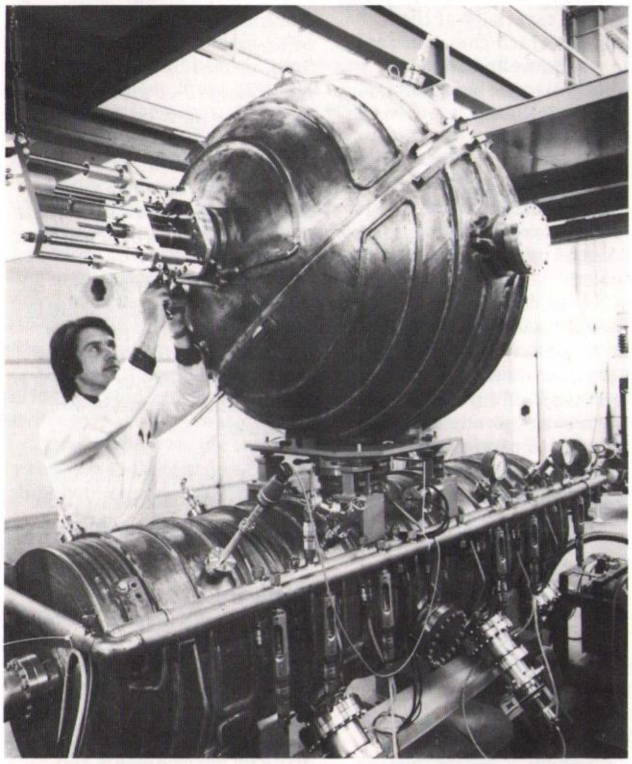
C. Acetylcholine receptor-gated channels recorded from an excised patch of membrane of a cultured neuroblastoma cell (cells illustrated in D: calibration bar 100 μm). The three channels present in this patch of membrane were open at the same time to give a summation of channel currents.



▲
Figure 2

Recording of glutamate receptor-gated channels from locust muscle at the Department of Zoology, University of Nottingham. The muscle preparation is maintained in a saline bath. Recording electrodes are positioned by an assembly of micromanipulators. Channel data are displayed on an oscilloscope and simultaneously stored on magnetic tape for subsequent computer analysis.

Energy saving at LEP



One of the foreseeable problems facing the designers of the Large Electron Positron accelerator (LEP) at CERN was its power consumption. Because of the energy loss during operation due to the phenomenon of synchrotron radiation, the most crucial components of the project are the radiofrequency accelerating cavities and their power supplies. It is in these cavities that the energy to accelerate the electrons and positrons, and to replace the energy lost by synchrotron radiation, will be transmitted to the circulating beams. Some two kilometres of space around the ring is reserved for the installation of the cavities. A large part of the radiofrequency power is dissipated as heat in the structure of conventional accelerating cavities. The LEP design uses a new idea, which is to transfer the power from these cavities for part of the operating time into others which have a special structure where much less power is dissipated. The accelerating cavities would then receive the power when each bunch of particles passes, so as to accomplish the necessary acceleration, but the power would be transferred to the low-loss cavities in the intervals between.

Initial tests of this idea have been successful, and a contract for a prototype low-loss cavity has been awarded by CERN to Morfax Limited of Mitcham.

A spherical 'low-loss' cavity being installed above the cylindrical accelerating cavity. The manufacture of the spherical cavities, which are made of high-grade copper, involves advanced jointing techniques including electron welding and vacuum brazing.

Photo: CERN

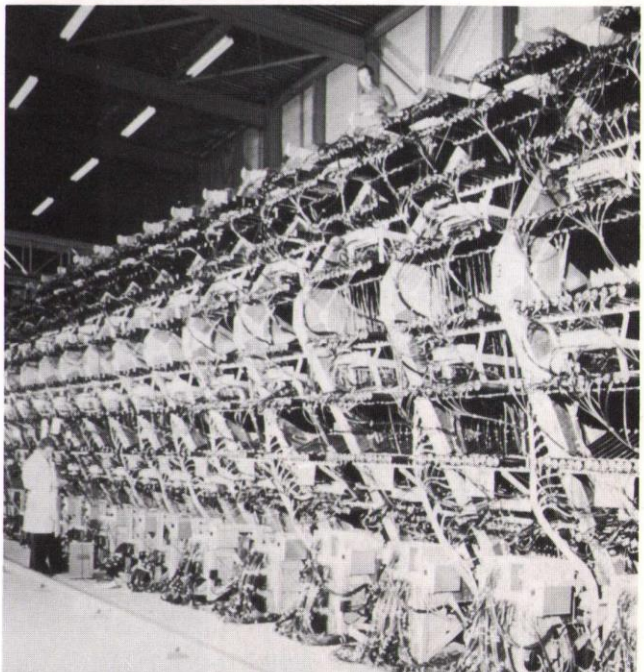
Engineering research opportunities at CERN

Although 'big science' is usually linked in the popular mind with the pure rather than the applied end of the spectrum covered by SERC, it is evident to any visitor to a large installation that the whole venture depends heavily on engineering of the highest order.

For this reason, a proportion of the awards in the CERN Fellowship scheme are reserved for research workers in applied subjects. The coverage is wide, including medical physics, electrical and mechanical engineering, instrumentation, metallurgy and computing. The opportunities available depend on CERN's programme requirements, and so vary from year to year.

The awards are intended for young postgraduates, including those working for, or having just completed, a doctorate, and for graduates up to the age of 33 at the time of application. They are for one year initially, but are normally extended for a second year.

CERN Fellowships are available twice a year by competition to applicants from the member states. Full details are available in late February and late September each year, from:
Fellows and Associates Service
CERN
1211 Geneva 23
Switzerland.



This large magnetic spectrometer, part of the detection equipment in an experiment at CERN, gives some idea of the scale of engineering involved in modern particle physics research.

Photo: CERN

Netherlands to share the SRS

Collaboration between the British and Dutch scientific research communities was further strengthened in December 1982 by the signing of an agreement covering the sharing of the synchrotron radiation facilities at SERC's Daresbury Laboratory. In a ceremony at Daresbury, the agreement was signed by Professor W F de Gaay Fortman (Chairman of the Netherlands Organisation for the Advancement of Pure Science – ZWO*) and Professor J F C Kingman FRS (Chairman of SERC), in the presence of Mr William Shelton MP, Parliamentary Under Secretary of State for Education and Science; Professor L L Green, Director of Daresbury and host for the occasion, and several senior Dutch officials.

Touring the Synchrotron Radiation Source at Daresbury Laboratory before signing the Agreement (left to right): Professor Green, Professor Kingman, Professor de Gaay Fortman and Mr Shelton, with Dr I H Munro of the Laboratory.

The Dutch participation will increase the exploitation of the Synchrotron Radiation Source (SRS), the world's first purpose-built high-energy source of synchrotron radiation. Use of the SRS is producing a rapid expansion of knowledge of the structures of all kinds of materials such as crystals, liquids and glasses, and major research fields such as surface science and catalysis, the properties of ionic solids and the structure and function of large molecules of biological importance.

The initial Dutch programme will cover studies ranging from catalysts to biological systems using x-ray absorption and scattering techniques.

*Nederlandse Organisatie voor Zuiver-Wetenschappelijk Onderzoek.

Unispace '82

Vienna was chosen to host an international 'Space Spectacular' during August 1982. For two weeks there was a United Nations Conference on the Exploration and Peaceful Uses of Outer Space, UNISPACE '82, and a large-scale Space Exhibition open to the general public.

The conference

The UN Secretary-General, Mr Perez de 'Cuella, opened the Conference, in the Hofburg Convention Centre. Delegates from more than 90 countries gathered to discuss the present and future state of space science, its technology and applications and their potential benefits to mankind.

During the plenary session Mr Kenneth Baker, UK Minister for Industry and Information Technology, stressed the requirement for international collaborative organisations for space applications systems. He said that the UK Government would encourage technological development where practical and commercial benefit to mankind could be identified. In particular, communications and direct broadcasting satellites provided examples of improving services; immediate benefits in earth resources management and world climate prediction would be brought about by remote sensing satellites. Mr Baker emphasised the increasing importance of the European Space Agency. He praised the scientific work being done nationally and in particular the work in radio astronomy and x-ray astronomy, in which the Ariel series had been pre-eminent, and the major role played by UK scientists in projects such as the International Ultraviolet Explorer and the Infra-Red Astronomical Satellite.

The conference discussed communications, remote sensing and international cooperation – reaching agreement on a final report. It was resolved to set up a UN Space Information Centre, and further discussions are to be held.

The exhibition

At Vienna's Messepalast, over 160,000 visitors enjoyed the UNISPACE '82 Exhibition – the largest ever. Western, Eastern and Third World countries presented spectacular models of satellites, rockets, space vehicles and space stations.

As part of the European pavilion, the UK stand highlighted the practical applications of British space research and technology. The companies participating in the UK display were British Aerospace, Marconi and Hunting, with RAE Farnborough, the Natural Environment Research Council and SERC. The exhibit was grouped into three areas: telecommunications, space science and remote sensing.

Members of SERC and NERC staff on the UK stand at UNISPACE '82.

Seyfert galaxy workshop at RGO

A continuing series of short workshops is being arranged at the Royal Greenwich Observatory (RGO), as part of a plan to exploit the potential offered by Herstmonceux Castle as a visitor and conference centre. The workshops present an alternative format to the traditional concept of large conferences and formal talks; instead, a small number of experts (15 to 20) sit around a table and discuss particular astronomical topics.

During September 1982, 17 astronomers from the UK, USA, Israel, France, Italy and South Africa gathered at RGO to discuss 'The intimate environment of Seyfert Nuclei'. Seyfert galaxies, which have highly energetic and dramatic events occurring in their nuclei, are scaled-down versions of the well known quasars but relatively nearby.

Much of the discussion centred on the smooth continuous radiation seen from these 'active nuclei' at all wavelengths. It varies with time but not as fast as might be expected from popular models involving accretion on to a massive black hole.

However, a 'bump' over the top of the continuum, in the optical/ultraviolet region of the spectrum, may be the expected thermal emission from a disc of gas swirling into such a massive black hole. One of the main problems of fitting data to models is that the total energy budget is unknown, because of a lack of sensitive observations in γ -rays and the far-infrared. Moreover, for a few very bright objects there is some evidence that most of the energy comes out as γ -rays.

The bright 'emission lines' in Seyfert galaxy spectra are caused by clouds of gas surrounding the central source of continuum radiation. Recently a rich variety of information has come from studies of the line profiles and time variations. Lines caused by various ionic species almost certainly come from different regions, with different physical conditions and kinematics. A long and detailed study of the nearby Seyfert NGC 4151 has resolved at least three distinct sub-regions within the so-called 'broad line region'.

Watching the way emission lines change in response to a brightening of the central continuum reveals the cloud kinematics; they are moving in a mixture of turbulence and radial outflow.

The workshop was organised by Dr Michael Penston and Dr Andy Lawrence.

Designers of the future

PERQ computers are being introduced by SERC into universities and polytechnics, where they are important aids in research projects.

The PERQ shown here, however, was being used by one of 30,000 visitors to the Science Museum, Wroughton. This North Wiltshire outpost of the London Science Museum at present opens its doors to the public one day a year and on this occasion (12 September 1982) SERC provided one of the displays.

The design on the PERQ screen might have been inspired by two of the other SERC exhibits. A 1949 Morris Minor gave a reminder of one of the most successful British cars ever and an MG Metro indicated the way forward, highlighting some of the benefits that current SERC research is bringing to manufacturers such as BL.

Biotech '83

The role of the new Biotechnology Directorate will be featured in SERC's display at BIOTECH '83 in May. This is an industrial exhibition being held in conjunction with a major international conference and is the first forum to be held for researchers, engineers, users and suppliers involved in biotechnology.

Biotech '83 will be at the Wembley Conference Centre, May 4-6.

Robotics — the Cranfield approach

A ten minute video cassettc about robots has been produced by SERC. *Robotics – the Cranfield approach* outlines some of the problems of industrial automation and how researchers are tackling them at one centre, Cranfield Institute of Technology, with major support from SERC's industrial robotics initiative. To an operator in a factory, many tasks are highly repetitive. Yet for a robot, these same tasks pose problems of grasping, joining and orientation. The video programme looks at several solutions being investigated, including different designs of robot hands and an error-correcting wrist.
Also shown is the programming of a robot to polish curved surfaces, and current work into the creation of low cost vision systems – robots which can 'see' components and guide them to selected positions. The video concludes by showing that the work of the Cranfield Research and Automation Group (CRAG) is leading to the creation of a complete, flexible assembly system where robots work together as an automatic production 'cell'.
The cassette is available on free loan from the Public Relations Unit, SERC Central Office, Swindon (ext 2256). Please specify which video format you require.

RAL's new UV laser facility

In response to the increasing demand from university research groups for access to the most up-to-date ultraviolet laser and diagnostic systems, a high power Ultraviolet Radiation Facility (UVRF) was established at RAL during 1982. A discharge-excited pulsed excimer laser operating at a number of wavelengths in the 157-351 nm spectral range is the main radiation source for this facility. As an example of its capabilities the laser system can produce 1 J, 20 ns pulses at 249 nm, the wavelength of the krypton fluoride (KrF) excimer, with a pulse repetition frequency of 25 Hz. In addition to the laser system, other diagnostic equipment available includes an optical multichannel analyzer and a Raman spectrometer.

Already this facility has created a great deal of interest among university researchers. Experiments currently in progress, and planned in the near future, involve groups from seven universities including two chemistry departments and five physics departments. Of the latter, one is supported by the Engineering Board and one by a CASE award in collaboration with GEC.

The existing facilities are already substantial and new additions are planned for this spring that will considerably enhance the capability of the UVRF. The high repetition rate excimer laser will be modified to emit tunable radiation, over a limited spectral range, with a linewidth < 0.2 cm^{-1}. In addition, by means of stimulated Raman scattering (SRS), the output from this laser will be frequency-shifted to generate almost any wavelength in the ultraviolet with powers of up to 50 MW in pulses lasting 20 ns. Shorter pulse durations, down to 1 ns, could be generated using electro-optic shutters.

A completely new laser system will also be added to the facilities. This is a narrow-line, continuously tunable, pulsed dye laser which can operate over the wavelength range 325-970 nm and can be synchronised with the pulsed excimer laser to within 1 ns. This will be an important addition to the facilities as it will enable users to perform 'pump-and-probe' type experiments. As an example the excimer laser could be used to generate some transient photochemical species which would be diagnosed later by the dye laser, at a time determined to an accuracy of 1 ns.

With the addition of these new facilities it is expected that the university user-community will keep the UVRF busy for the foreseeable future.

Major new computers at RAL

Although the Central Computing Complex at RAL is in the middle of its most major upheaval for many years, the user population should see little other than an improvement in the service.

The report of the *Computing Review Working Party,* in December 1980, recommended an outline plan to replace the existing IBM 360/195s – then almost ten years old. Council, acting on the working party's advice, allocated capital to carry the replacement programme through.

In May 1982, Council approved two major computer purchases for RAL: the IBM 308ID, and the ICL Atlas 10 (see *Bulletin* Vol 2 No 6, Autumn 1982).

The 308ID, one of IBM's new series of machines, has almost as much power as both the 360/195s together. The system was delivered on 7 July 1982 and installed within a day. After checkouts, operator training etc it entered service on the 19 July 1982, replacing one of the 360/195s. It was configured to take on the 'front-end' role (supporting the interactive and communications work as well as batch) on 12 August 1982, two weeks ahead of the initial schedule. There have been no problems apart from one early fault involving the replacement of a processor component.

The second 360/195 was removed from service in October, and then both the 360s were physically removed from the building – a major exercise in itself. Fortunately the cost of this was amply compensated for by the scrap value which, since there is gold in many of the circuits of these old computers, was considerable.

The ICL Atlas 10, manufactured in Japan by Fujitsu, is one of the most powerful IBM compatible computers in the world: its single processor has about the power of three 360/195s. The Atlas is expected in mid 1983 but since it will be the first of its kind in the UK, RAL and ICL will take a few months subjecting it to various tests before it enters full service in October.

This will complete the major processor replacements and enable RAL to concentrate on plans for other hardware and on a software programme which will bring the facilities once more up to the standard demanded by our scientific users in universities and polytechnics and at RAL.

Back left: the 3081 processor (with two sliding doors) and behind it part of the processor controller. In the foreground is a row of 3350 disc drives, and back right is part of the IBM 3032.

Expansion of Teaching Company Scheme

By 1986, the Teaching Company Scheme could have doubled the number of programmes in its traditional area of batch manufacture in mechanical engineering, as well as experimenting in new areas such as chemical and civil engineering, information technology and robotics. This is the result of extra funding made available by the Engineering Board and by Council in order to implement the recommendations of a major review of the Scheme in April 1981 (see *Bulletin* Vol 2 No 4, Spring 1982).

The expansion has been even more rapid than planned. At the time of the review, there were 46 current programmes. This had risen to 65 by April 1982, and by the autumn of 1982 the total stood at more than 90 compared with the review target of about 75. Expenditure is now running at about £1.9 million pa, half of which is provided by the Department of Industry who, with SERC, are joint sponsors of the Scheme.

Two features of the present phase of expansion are particularly noteworthy. Many partnerships have asked for grants for renewed support of continuing programmes. In such cases the Directorate seeks a 50% contribution from the company to the direct costs of the programmes (Associates' salaries, equipment etc). Additionally, in many 'new' programmes, companies have made substantial contributions, usually as part-payment of Associates' salaries. Total commitment of this nature represents an income to the Scheme of about £225,000 a year.

A second feature has been the movement into new areas: two of the programmes announced during the academic session 1981/2 were in Civil Engineering and one in Chemical Engineering/Biotechnology.

The Directorate hopes to collaborate more closely with several Specially Promoted Programmes to develop the new areas in a selective and controlled way. The Teaching Company mechanism is seen as well-suited for helping to transfer the results of SERC-supported research downstream to practical and profitable implementation in manufacturing.

This has been a busy year for the Directorate staff; the announcement of 37 new Programmes has required perhaps 100 meetings 'on site' with company and academic representatives to iron out difficulties and reach agreement on programmes of work, timescales and so on.

A slightly less rapid rate of growth is now foreseen, but there is still plenty of work to do, particularly in 'selling' the Scheme to those institutions with engineering departments which do not yet have a single programme.

For further information, contact:
Mr Brian Gannaway, SERC Central Office, Swindon (ext 2335).

Leicester Biocentre opened

An important development in academic/industrial collaboration has taken place with the formation of the Leicester Biocentre. Leicester University, together with four leading British companies, have joined together to support research and training in biotechnology. The Centre was opened formally on 24 September 1982 and at the ceremony Mrs Peggy Fenner MP, Parliamentary Secretary, Ministry of Agriculture, Fisheries and Food, warmly welcomed this development on behalf of the Government. SERC's Director for Biotechnology, Dr Geoff Potter, who was also at the ceremony, said that the Council was giving its fullest support to the Biocentre. During the initial phase of setting up the Centre, a special Cooperative Grant of £182,653 over four years was awarded by the Council's Biotechnology Directorate to provide specialised equipment for the laboratories at the University. The four companies, John Brown Engineers and Constructors Ltd, Dalgety-Spillers Ltd, Gallaher Ltd and Whitbread and Company PLC, all have diverse interests in biotechnology and are investing £1 million in equal partnerships in a joint, five-year research programme. The three University staff chiefly involved with the Biocentre are Professor Barry Holland (Department of Genetics), Professor Bill Brammar (Department of Biochemistry), and Professor Harry Smith (Department of Botany).

The aim of the new Centre will be to use a team of research scientists of the highest calibre to study a range of fundamental and applied biological problems whose solution can be most readily achieved through the use of genetic manipulation technology. The core programme will have three main aims: the detailed analysis of plasmid replication and its control in yeast; the isolation and characterisation of some genes coding for secreted proteins in yeast and an analysis of the mechanism of protein secretion; and the isolation and characterisation of some plant genes and their control regions and a study of their expression in *E. coli* and *S. cerevisiae*.

The industrial sponsors hope for rapid growth of the Biocentre with support from other companies, enabling the core research programme to be extended.

Brain drain of biotechnologists

The Biotechnology Directorate has awarded a contract to the Institute of Manpower Studies to carry out a pilot study into the scale of the brain drain of biotechnologists leaving the UK. The Institute is an independent international centre, based at Sussex University, concerned with key manpower issues. There have been several key British biotechnologists leaving the UK over the last few years to take up employment overseas, but it is not known how many. This pilot study will attempt not only to quantify the outflow, but also to establish the impact of this loss to biotechnology and the UK economy.
The Biotechnology Directorate would be interested to hear from individuals and organisations if they know of biotechnologists who are leaving or who have left the country in order that they can be included in the study. Please contact Dr K J Coleman at SERC Central Office, Swindon (ext 2279) or Mr R Pearson at the Institute of Manpower Studies, telephone Brighton (0273) 686751.

Lindsay G Dawson

The Council regrets to record the death on 27 November 1982 of Mr Lindsay G Dawson, coordinator of the Combustion Engines Specially Promoted Programme. Mr Dawson, a consulting engineer, was appointed in August 1981.

First director for marine technology group

Mr Mike Turner has been appointed the first Director of the North Western Universities Consortium for Marine Technology.

The consortium members are: the Universities of Liverpool, Manchester and Salford, University College of North Wales and the University of Manchester Institute of Science and Technology. The consortium forms one of the six centres for marine technology set up by SERC's Marine Technology Directorate to develop an integrated approach to marine research relevant to industry's current and future needs.

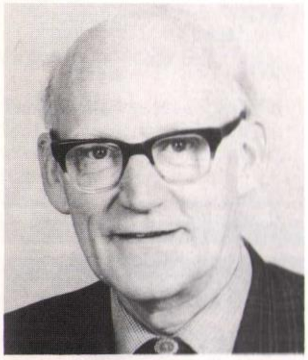
As Director, Mr Turner will coordinate marine technology activities within the five universities to ensure development of a balanced research programme. He will be responsible to a steering committee, composed of two representatives from each of the universities, and will establish links with industry to gain support for and make the best use of the consortium's wide range of research activities. Its current programme includes work on:

Mr Mike Turner

- ☐ wave and environmental loading
- ☐ sediment transport and coastal problems
- ☐ materials and structures
- ☐ economic appraisal and management studies
- ☐ instrumentation
- ☐ seabed studies
- ☐ marine biology related to pollution and fouling.

Mr Turner is a Chartered Engineer, a Fellow of the Institution of Metallurgists and a member of the Welding Institute. He has held a variety of senior executive posts in major UK companies including three years as a Principal Scientific Officer at the Welding Institute. He has served as a member of Council and Professional Board of that Institute, and will be well known to many people in the welding and metal fabricating industry.

Coal technology coordinator



Mr Jack Launder

Mr Jack Launder has recently been appointed Coordinator of the Coal Technology Specially Promoted Programme (SPP). He was previously Chief Scientist, the Coal Products Division of the National Coal Board.

Mr Launder is currently visiting investigators who hold current grants made under the Coal Technology SPP but would welcome enquiries from anyone interested in participating in the programme. He can be contacted at 15 Church Close, Horsell, Woking, Surrey GU21 4QZ (telephone 048-62-62450). For administrative matters associated with the programme advice can be obtained from Mr G D Richards, Secretary to the Coal Technology Subcommittee at SERC Central Office (ext 2300).

Particulate technology coordinator

A coordinator has been appointed for the Specially Promoted Programme in Particulate Technology which was launched by the Engineering Processes Committee. The Coordinator, **Mr L J Ford** from ICI, Runcorn, will be spending two days a week on SPP work while continuing to be employed by ICI. He is already in contact with grant applicants, and he will be arranging frequent meetings with research workers and industrialists.

Mr Ford will be monitoring the overall development of the programme and, through discussions with academics and industry, facilitating the introduction of research results into industrial practice. Research within the SPP will therefore be directed towards the needs of industry and active industrial collaboration will be encouraged.

Mr L J Ford

The main emphasis of the SPP will be on particle formation, separation and handling, but it is expected that new priorities will emerge as the programme develops.

Mr Ford can be contacted at the following address:

Mr L J Ford
ICI New Science Group
PO Box 11
The Heath
Runcorn
Cheshire WA7 4QE
Tel: Runcorn (0928) 511364.

British director for ILL

Dr Brian Fender, of the Department of Inorganic Chemistry at Oxford University and a Fellow of St Catherine's College, has been appointed from 1 October 1982 as Director of the Institut Laue-Langevin, the research establishment in Grenoble.

Dr Fender is on secondment to the Institut and has been there since April 1980 as an Associate Director. He takes over as Director from Professor T Springer.

Dr Fender is active in university circles, on SERC committees and was a member of SERC's Science Board until 1977. He worked on the planning of the new UK Spallation Neutron Source at Rutherford Appleton Laboratory and has extensive experience of the Institut Laue-Langevin, being a member of the Steering Committee from 1974-77 and a member of the Scientific Council from 1977. His scientific interests are in solid state chemistry with particular reference to the structure and properties of grossly defect inorganic solids.

Marine Technology Directorate short courses for 1983

Arranged in conjunction with the School of Industrial Science, Cranfield Institute of Technology

Oil and gas production systems	RGIT	March September
Introduction to oil well drilling fluids	RGIT	September
Response and design of offshore structures	Glasgow	Easter
Fracture mechanics	CIT	February
Corrosion prevention offshore	CIT	February
Safety and structural integrity offshore	CIT	May
Materials selection offshore	CIT	October
Probability and spectral techniques	Newcastle	April
Operating semi-submersible craft	Newcastle	April
Maintenance and repair offshore	CIT	December
Seabed mechanics	Newcastle	September
Corrosion control	UMIST	Easter
Control of hydrogen-induced cracking	UMIST	Spring
The synthesis of ocean waves for engineering design	Liverpool	Easter
Managing underwater inspection	Strathclyde	February
Electronic instrumentation for the offshore industry	Strathclyde	June

Geophysical signal processing	Strathclyde	August
The benefit of environmental satellites for offshore industries	Dundee	Easter
Laboratory testing of marine soils	Sheffield	April
Vibration and noise offshore	RGIT	April Summer
Diving and underwater engineering	RGIT	Spring
Mechanics of subsea equipment under the action of environmental forces	RGIT	Easter
Non-Newtonian fluid mechanics	RGIT	May September
Materials and corrosion engineering	RGIT	March September
Offshore drilling operations	RGIT	September
Introduction to underwater video systems	RGIT	April
Marine mineral resources	ICST	February

For further information contact: Dr K D Crosbie Marine Technology Directorate 3/5 Charing Cross Road London WC2 0HW

Short course on non-crystalline materials

The Physics Committee is sponsoring a short course on Non-Crystalline Materials, to be held at the University of Leicester from 20-31 March 1983. The Course Director is Professor E A Davis, Department of Physics, University of Leicester.

The course, for up to 50 participants, will deal with the fundamental physics of, and current status of work on, liquids, glasses and amorphous solids including technologically important materials such as amorphous semiconductors. The course is intended to cater primarily for first or second year research students, but will also be open to more senior academic or industrial research personnel. Priority will be given to SERC students and UK self-supporting students, for whom SERC will pay the full cost of attendance.

Further details and application forms to attend the course may be obtained from the course secretary, Dr R A Howe, Physics Department, University of Leicester, University Road, Leicester, LE1 7RH; telephone Leicester (0533) 554455 (ext 174).

Polymer engineering summer school 1983

The ninth national summer school in polymer engineering will be held at the Institute of Polymer Technology, Loughborough University in September.

The course is designed to cater for the needs of first and second year students who wish to gain an understanding of engineering with polymers and to see how their own research work relates to the needs of industry. Students in chemistry, engineering, physics, metallurgy and materials departments should find this course both interesting and relevant to their current studies.

As in previous years the emphasis will be on the practical side of processing, and a number of industrial visits will also be included.

Priority will be given to SERC students, whose full attendance costs will be borne by the Council. Any surplus places may be allocated to non-SERC supported students on a first come, first served basis, but will not be funded in any way by SERC.

Nominations for students to attend this course should be made as early as possible.

Dates: 4-9 September 1983
Contact: Mrs H E Lennon, PED, Garrick House, 3/5 Charing Cross Road, London WC2 0HW; tel: 01-930 9162.

Teaching polymers

Following up the recommendations of the Powell report on the needs for education and training in the UK polymer and polymer using industries, the PED, in association with the Rubber and Plastics Processing Industry Training Board, sponsored the first advanced summer school for lecturers in engineering departments in September 1982.

The aim of the school, held at Manchester Polytechnic, was to identify and discuss the problems of teaching polymers to engineers, provide a range of proven solutions for teaching material, give practical experience in well-equipped laboratories and provide contact with industry.

The school involved 31 lecturers from 12 universities and 18 polytechnics. Most were from engineering departments with a pronounced mechanical engineering flavour. A further 18 other applicants could not be accommodated this time.

The school was made up of four sessions: mornings given over to technical discussions; afternoons to laboratory demonstrations or industrial visits; evenings to films and video recordings on a range of various aspects of rubber and plastics engineering and after-dinner lectures on the needs of industry, the expectations from academic institutions, and the value of documented case studies as teaching material. The day sessions included a talk by Dr Lewis of the Open University on the problems of distance teaching.

The various sessions were supplemented by course notes, display of books on engineering with polymers, information handouts and exhibition demonstration materials provided by a wide range of companies.

It is hoped to repeat this experimental venture this year. A report on the school is available from PED.

Dr Phil Marshall of Manchester Polytechnic explaining the mechanics of pressure testing of plastic pipe. He is showing the characteristic 'parrot's beak' in a pipe that has failed under pressure; this is seen particularly clearly in the larger pipe which he is holding.

PED summer school

The eighth national polymer engineering summer school was held at the Institute of Polymer Technology, Loughborough University, on 6-11 September 1982, attended by 26 students from a variety of disciplines including chemistry engineering, metallurgy and materials science and physics. The school gives students the opportunity to understand polymer processing and technology and an awareness of how industrial problems are related to their own work. It is hoped that those engineering students not currently engaged in polymer research work will use the summer school as the base for extending their knowledge into engineering with polymers.

The PED will be sponsoring a further Summer School in 1983 (see opposite).

Students at the Summer School – left: measuring the melt flow index of low density polyethylene; and, right: determining polymer density using a flotation test.

Collaborative Training Awards and the smaller company

Collaborative Training Awards enable both small and medium-sized firms to benefit from access to the extensive research facilities and expertise which exist in UK university and polytechnic research departments. It is an experimental scheme, the future of which is currently under review.

The scheme supports postgraduate students on short-term projects (of 12 to 15 months) covering design and manufacturing problems as well as research. Each project is devised jointly by an academic institution and a company in industry or commerce.

Here are some of the 'success stories' that have resulted from the 87 awards that have been taken up since the scheme was set up in 1979.

Microprocessor application
Micro Control Systems Ltd of Woking, Surrey, is a small, high-technology company which specialises in the application of microprocessors to industrial products.

The company has collaborated with the Electrical and Electronic Engineering Department at Bradford University in developing one such application. Mr Stephen Greenroyd obtained a CTA to work on an Ambulatory Performance and Activity Log, known as APAL. This unit is a microcomputer-controlled device which can monitor the performance of various activities (on the shop floor, in the office or in a medical environment) and maintain a diary of the results. It is an easily portable, battery-powered unit which records the data and can store the results for several years. The unit retails at about £1,000 and six have already been sold. Stephen Greenroyd presented this work for his MPhil degree and has now started working for his PhD.

Stephen has subsequently assisted Micro Control Systems Ltd in the development of a number of projects that are now being successfully marketed.

Portable gas chromatograph
Lion Laboratories Ltd in South Glamorgan is a small company which specialises in the manufacture of breath and blood alcohol analysers and gas detection equipment. The company was aware of the commercial importance of developing a portable gas chromatograph to sample gas environments. Lion Laboratories Ltd approached the Department of Applied Chemistry at the University of Wales Institute of Science and Technology in Cardiff with a view to establishing collaborative research in this area.

Mr David Carter took up a CTA to work on the new gas chromatograph. He designed and built a lightweight gas chromatograph oven which maintained uniform temperatures up to 100°C. Its performance was optimised for the resolution of environmental gases. For this work, David Carter was awarded an MSc degree. The company is delighted with the tested design of the prototype gas chromatograph which has commercial potential and has warranted the employment of a further scientist for its exploitation. A useful relationship has also been developed between the company and the university which has led to further collaborations.

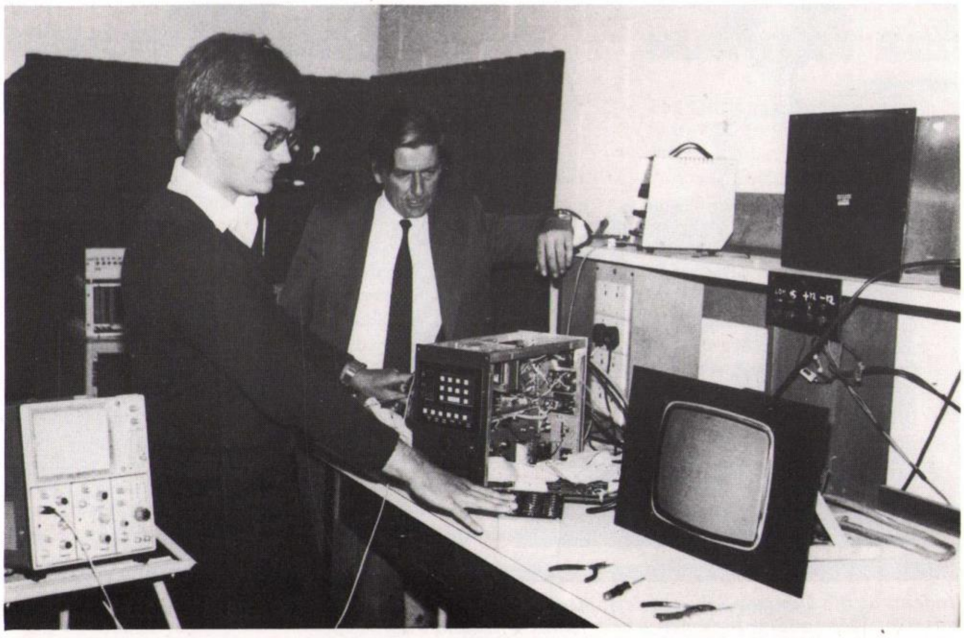
Study of fluids
BHRA Fluid Engineering in Cranfield is an independent contract research organisation supplying rapid information, consultation, design and development services for the mechanical, civil and chemical engineering industries. The company made contact with the Fluid Engineering Unit at the Cranfield Institute of Technology in order to collaborate on some specific research topics.

Twin brothers Paul and Mark Fairhurst received CTAs to work on separate research topics. Paul Fairhurst's project was to develop an understanding of two-phase flow phenomena. Using a computer-based collection system, he performed extensive measurements on the flow and pressure losses for an air/water flow through standard components such as orifice plates and valves. He also developed a flow regime technique based on the frequency spectra of fluid pressure fluctuations. The experimental results are now leading to improvements in the design of these components and analysis methods.

Mark Fairhurst worked on the factors affecting the performance of water jets carrying abrasives. Abrasive jets are widely used in offshore applications and in mining operations for cutting and cleaning. Mark designed and built a test rig and carried out an experimental study of the effects of different abrasives and jet parameters.

Both projects provided useful data of interest to both industry and the academic world. Paul and Mark were awarded MSc degrees for their work and are now employed full-time by BHRA.

For futher information on the Collaborative Training Awards scheme contact Mr S D Greig, SERC Central Office, Swindon (ext 2216).



Mr Stephen Greenroyd (left) with a microprocessor-based industrial controller he is developing at Micro Control Systems Ltd, and the company's Managing Director, Mr D F H Bent.

Some new publications from SERC

Council's annual report

The *Report of the Science and Engineering Research Council for the year 1981-82* has been produced in a new, fully-illustrated larger format. Copies are available from HM Stationery Office bookshops price £4.00 (ISBN 0 901660 50 7; ISSN 0261-7005).

Introduction to studentships

A leaflet giving a brief introduction to the way SERC's studentship system works, and the different types of awards that are available, has been widely circulated to universities and polytechnics. Further copies are available from SERC Central Office, Swindon (ext 2121).

Fellowships, studentships and research grants

New editions of the booklets setting out the terms and conditions of all SERC's awards and grant schemes are now available from SERC Central Office, Swindon: *SERC Fellowships 1982* (ext 2172); *SERC Studentships 1982* (ext 2137) and *SERC Research grants 1982* (ext 2405).

Videotapes and films

A catalogue of *Videotapes and films* available from, and for the most part produced by, SERC can be obtained from Public Relations Unit, SERC Central Office, Swindon (ext 2256).

Engineering processes

Copies of the Engineering Processes Committee's *Annual report 1980-81* are available from the Committee Secretariat at SERC Central Office, Swindon (ext 2100).

Environment Committee

The Environment Committee Secretariat has copies of its *Annual Report 1980-81* available from SERC Central Office, Swindon (ext 2165).

Information engineering

Copies of the Information Engineering Committee's *Annual report 1980-81* and its *Distributed Computing Systems annual report September 1980 to September 1981* are available from the Committee Secretariat, SERC Central Office, Swindon (ext 2203).

Water and waste

The proceedings of a seminar sponsored by the Engineering Board's Environment Committee have been published under the title, *Water and waste research: the way ahead.* Subjects covered at the seminar included improving water and waste treatment; reclamation, reuse and energy recovery; and applications to developing countries. Copies may be obtained from the Committee Secretariat at SERC Central Office, Swindon (ext 2353).

Pattern recognition

A report commissioned by the Computing and Communications Sub-Committee of the Information Engineering Committee, *Pattern recognition and image processing review,* has been prepared by members of the Committee Secretariat and the Technology Division at Rutherford Appleton Laboratory. Copies are available from the Committee Secretariat, SERC Central Office, Swindon (ext 2235).

Marine Technology report

Copies of the *Marine Technology Directorate Annual Report 1981* are available from the MTD, 3-5 Charing Cross Road, London WC2H 0HW; telephone 01-930 9162.

PED Newsletter

A regular (three times a year) newsletter on the work of the Polymer Engineering Directorate, including examples of current projects. Copies available from PED in London, telephone 01-930 9162.

Advanced Summer School for Lecturers

Report of the first Advanced Summer School for lecturers organised by PED and RPPITB (see page 25). Copies available from PED in London, telephone 01-930 9162.

Survey of polymer processors

Manufacturing management and control systems in the polymer processing industry: report of a survey of UK processors identifying current strengths and weaknesses in UK polymer processing companies. Copies are available from PED in London, telephone 01-930 9162.

Mathematics review

Mathematics Committee review of activities: 1982 issue includes details of the new procedures for small research grant applications. Copies are available from the Committee Secretariat, SERC Central Office, Swindon (ext 2312).

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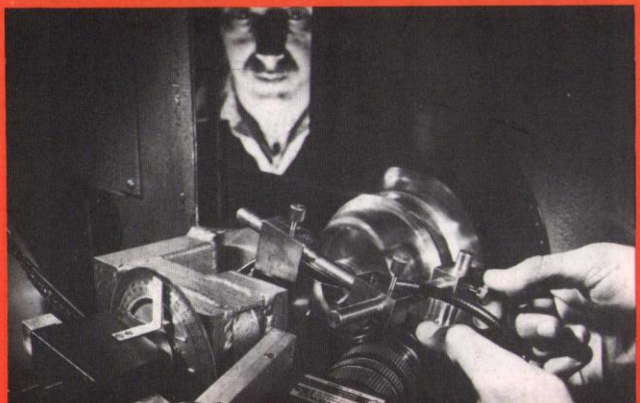
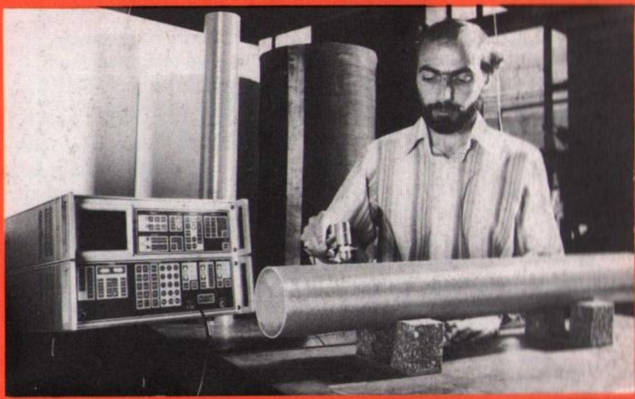
Research and innovation in polymer engineering

The Polymer Engineering Directorate (PED) has developed a comprehensive programme of research projects at universities and polytechnics, in collaboration with industry. The projects cover a wide range within the polymer fabrication field, as these examples show.

Above: Removal of a thick-section thermoplastic moulding (40 x 50 x 360 mm) – in this case, medium-density polyethylene produced by a combination of flow moulding and oscillating hold pressure.
Techniques have been developed at Brunel University by Professor Mike Bevis and (seen here) Dr Peter Allan to produce void-free mouldings with good control over dimensions and residual stresses, as well as relatively large shot-weight thick-section parts.

Below: A research team at Bradford University is undertaking experimental and theoretical studies of the contact between a V-belt and grooved pulley, the consequent stresses in the mechanical response of the belt-to-belt construction and the effects of tension level and belt and groove geometry. The knowledge gained should enable improved belt design and, through this, better efficiency and longer belt life.
An instrumental belt-testing dynamometer (capable of speeds up to 18,000 rpm and a torque at the pulley of up to 15 MN) and video record facilities are used in this work. This project is in collaboration with TBA Industrial Products and BL Technology.





Above: At Bristol University a research team is investigating the application of vibration techniques for the non-destructive evaluation of structures made from composite materials. Two tests are currently being used: frequency changes and the 'coin-tap' test. The aim of the research is to develop a system of non-destructive testing techniques which can be used for the initial inspection of composite structures and the detection of damage during service, and when the behaviour of the material can be fully characterised.
Seen here is Research Assistant Dr Hamid Al-Agha applying the 'coin-tap' test to a Kevlar cylinder; the structure is tapped with a dynamic force transducer and the acoustic response is recorded and analysed by the on-line real-time data captive unit with Fast Fourier Transform capabilities.

Below: Dr Jeremy Bowman of Brunel University prepares thermoplastic polyolefin pipe systems for fatigue testing at elevated temperatures. Shown are pipes being immersed into temperature-controlled test tanks, where they will be subjected to cyclic internal pressure changes. A range of pipe systems is being investigated which provide for variables such as: misalignment, grade of polymer, processing variables, design of fittings and the nature and dimensions of fatigue and stress-rupture crack initiation.