Bulletin
of the Rutherford Appleton Laboratory 4 May 1982 No.7

SERC, the Universities and the Microchip

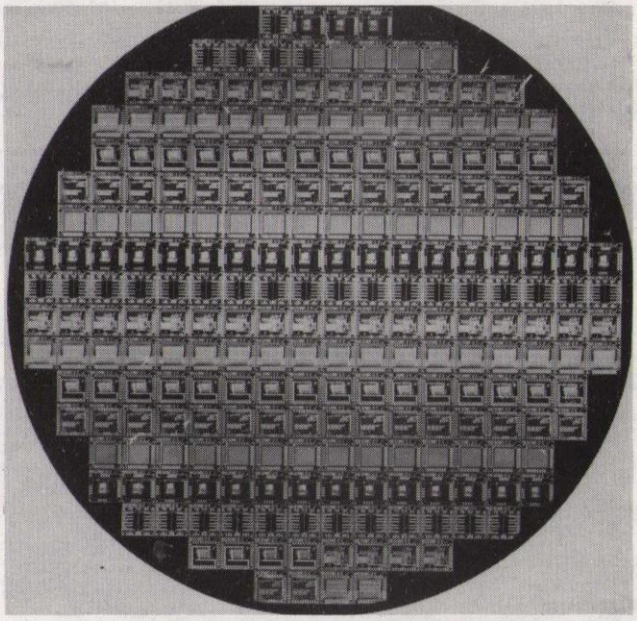
Since the invention of the transistor in 1948 the pace at which digital technology has progressed is unparalleled by any other branch of technology. Improvements in the techniques of fabricating transistors have allowed ever increasing numbers of these devices to be packed onto a single silicon chip. Large Scale Integrated (LSI) chips containing tens of thousands of transistors are currently in common use while, in development laboratories, integration levels have reached a million elements per chip. By the late 1980s it will be possible to make chips containing millions of transistors.

One result of such breathtaking evolution has been to make the world's electronic and electrical engineering industry comparable, in economic terms, with the oil, steel and automobile industries, with further growth in prospect. This is especially true in those areas - communications, computing and integrated circuits - collectively described as Information Technology, which are expected to generate economic growth for the rest of the century.

Over the last few years UK Industry has made considerable efforts to build up its expertise in micro-electronics. UK Governments, past and present, have recognised the importance of microelectronics and have sought both to promote the industry and to increase public awareness of the economic and social significance of the technology. Abroad, major programmes have been launched by, for example, France, West Germany, Japan and the US. Both here and overseas it is recognised that the contribution of the academic community is crucial.

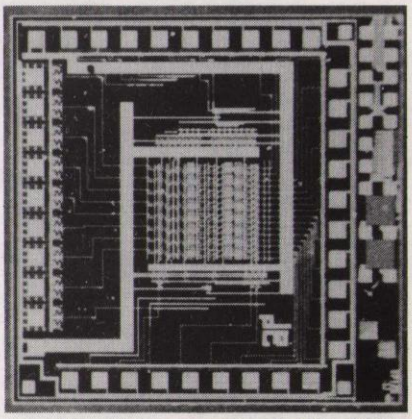
SERC Initiative

The SRC (as it then was) recognised the need for an initiative in this area 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. 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 1000 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 micro-electronics was clear as was the vital importance of the contribution to be made by the academic community.



A 3 inch wafer processed at the Edinburgh Facility from masks made at RAL. The wafer contains 7 different designs and is the work of SERC supported M.Eng. students at Durham.

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 £1.3M for this purpose.



An enlarged view of one of the chips showing an 8-bit programmable arithmetic-logic unit.

By augmenting equipment and expertise already in existence, centralised facilities for silicon processing were set up at Edinburgh and Southampton Universities, for ion implantation at Surrey University and for the growth of compound

(Continued over)

INTERNAL Events

NIMROD LECTURES
R61 CONF RM - 1400 hrs

17 May Prof A J G Hey/Southampton
"String Tensions in 2 + 1 Dimensional Lattice Gauge Theories"

LECTURE THEATRE

24 May D M Scott/Cambridge
"Gluon Effects in Z^0 Production and Decays"

REMOTE SOUNDING SEMINARS
R61 CONF. RM - 1530 hrs

8 June Dr J O Thomas/IC
"The Interpretation of Sea-sat SAR Imagery of the Ocean Surface"

HEP SEMINARS
LECTURE THEATRE - 1100 hrs

5 May Dr D A Ross/Southampton
"Does QCD Factorize?"

12 May Dr N McCubbin/RAL
"Some Topics in Large p_T from experiment R807 at the ISR"

26 May Dr F Loebinger/Manchester
"Physics from muons at JADE"

TROPOSPHERIC PROPAGATION GP SEMINAR
R61 CONF. RM. - 1500 hrs

13 May Dr R Doviak/NSSL, Oklahoma
"Weather Radar Research at the USA National Severe Storms Laboratory"

CONDENSED MATTER SCIENCE SEMINARS
R3 CONF. RM.

4 May M Hart, FRS/King's
"Bragg Reflection X-ray Optics for Synchrotron Radiation Sources"

18 May J W White/Oxford
"Ideas for New Neutron Instruments: Ultra Cold Neutrons"

1 June E W J Mitchell/Oxford
"Structure and Dynamics of Molten Salts"

RAL LECTURE
LECTURE THEATRE - 1315 hrs

13 May Dr J H Fremlin/Birmingham
"The Risk Business"

EXTERNAL Events

NPD COLLOQUIUM
CONF RM H8 - HARWELL - 1530 hrs

6 May Dr P G Le Comber/Dundee
"Physics and Applications of Amorphous Silicon"

20 May Dr J B Farrow/Brit.Aerospace
"Scientific Space Missions in the Next Decade"

TPD SEMINARS
THEO.PHYS.DIV - HARWELL - 1400 hrs

11 May Dr R Whitehead/Glasgow
"Moments and Lanczos Algorithm"

18 May Dr R T Ackroyd/Risley
"Finite Elements in Neutron Transport"

25 May Dr D Duffy/Reading
"Line Defects and the Glass Transition"

SHEP SEMINARS
SOUTHAMPTON - 1430 hrs

7 May S Chadha/RAL
"Supersymmetry Breaking"

14 May K Stelle/IC
"Vanishing β Functions in Supersymmetric Theories"

PHYSICS COLLOQUIA
H H WILLS LAB - BRISTOL - 1700 hrs

10 May Dr C Gill/Bristol
"Charge Density Waves and Non-ohmic Conductivity in $Nb\ Se_3$"

17 May Prof E W Lee/Southampton
"Metallic Magnetism and Crystal Structures: the Invar Problem Revisited"

24 May Prof C W Kilminster/King's
"Mathematics in Physics : Stability and Strange Attractors"

7 June Prof, Sir Sam Edwards, FRS/Cambridge
"Polymer Dynamics"

HEP SEMINARS
MANCHESTER - 1430 hrs

4 May Dr Robin Tucker/Lancaster
"Some Advances in Unification with Gravity"

11 May Dr Norman Booth/Oxford
"How to Detect Solar Neutrinos"

HEP SEMINARS
CAVENDISH LAB - CAMBRIDGE - 1430 hrs

12 May Dr A K Nandi/RAL
"Preliminary Results from UA1"

19 May A R Weidberg/Cambridge
"Recent Results from UA5"

HEP SEMINARS
DAMTP - CAMBRIDGE - 1500 hrs

14 May G Ross/Oxford
"Grand Unification with Large Supersymmetry Breaking"

21 May D Capper/QMC
"Axial Gauge in Quantum Gravity and QCD"

28 May P Zizzi/King's
"Topology and Supersymmetry"

ELEM. PART. THEO. SEMINARS
NPD OXFORD - 1430 hrs

3 May R K Ellis/CERN
"Unravelling Higher Twists"

14 May D Broadbent/Open
"Can QCD Sum Rules Fix Properties of a Single Resonance?"

21 May D Ross/Southampton
"Non-factorising Terms in the Drell-Yan Cross-section in QCD"

Microelectronics *(cont. from p1)*

semiconductors at Sheffield University. The fifth central facility to make the masks which define the configuration of the devices on the surface of the silicon chip - was to be set up at the Rutherford Appleton Laboratory (RAL). The computing needs of circuit designers would be provided via the SERC's Interactive Computing Facility.

Circuit Fabrication

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

Thus a research worker in a university or polytechnic wishing to obtain a microcircuit made to his own design would first select the fabrication process most appropriate to his design needs. Because it offers the greatest density of circuit elements per chip MOS (metal oxide semiconductor) technology has come to dominate the manufacture of

Indoor Sportsday 1982

This year the task of organising the SERC Indoor Sports fell to the RAL Rec Soc and the venue chosen was the Aston Villa Sports and Leisure Centre under "Spaghetti Junction" in Birmingham. The event was held on 2 April and the combined forces of the Rutherford, Appleton and Atlas teams, with their spectators, amounted to 123 persons.

Despite having the organisers on the coaches, "Spaghetti Junction" proved too much for them and for a time an amusing game of "dodgems" seemed to be taking place. The sports however proceeded smoothly, although there was a feeling that the Darts match might have to be completed next year. Fortunately all events were eventually completed and, I am glad to report that, as expected, the trophies cabinet in R1 is expected to be filled to overflowing with the achievements of the Rutherford, Appleton and Atlas teams.

It is a pity that Appleton was unable to defend their previous squash achievements. It seems that they have lost all their lady squash players during the recent merger.

I would like to thank all the various organisers for their hard efforts in making the Indoor Sports a success and an enjoyable day for all who were able to attend.

Anxious enquiries 82 RB 2257

Intense concentration 82RB 2244

and the end of a perfect day. 82 RB 2240

Badminton

The tournament was made up of two men's doubles leagues with seven pairs in each and one mixed doubles league with ten pairs (48 players playing a total of 91 games).

The men's doubles was won by R Wolfenden & D Wooton (Rutherford) who beat A Stevens & V Yeung (Appleton) in the final 15-5 15-7.

The mixed doubles was won by Mrs K Knight & T Short who beat Mrs S Merrifield & R Lawrence in an all Rutherford Lab final, 18-15 15-9.

Congratulations to Mrs K Knight who not only won this tournament after becoming a grandmother but also went on to win the Abingdon Veterans!

Thanks to Janice Knight and Karena Richens for keeping the five courts occupied throughout the tournament (6 hours) and for recording the scores.

Chess

The tournament this year attracted fewer entrants than in previous years and was further reduced by illnesses. However, each competitor was able to play six games. Philip Court (RGO) emerged as a worthy winner with 5 points. The best placed RAL player was Peter Hemmings with 3½.

Crib

Ten pairs entered for this competition and it was run on a league basis, with five teams in each league. The winners of league A played the runners up of league B and the winners of league B played the runners up of league A. The final consisted of two Rutherford teams playing against each other. The pairs were J Ackhurst and J Ball of R18 against R Lye and G Richardson of R51. The winners were R Lye and G Richardson.

A good day was had by all.

Darts

RAL won the Darts competition again this year - perhaps we have access to more dart boards! A brilliant team from R18 fought hard and beat a Daresbury team to win the finals. R Jones, S Buckle, F Roberts, P O'Connor and M Bennett were the worthy victors. Congratulations.

Squash

There was a very poor response to the tournament this year with only six teams entering, two from Rutherford, Central Office and Daresbury. The six teams were divided into two leagues of three. Rutherford 'A' won both their games in League A beating Central Office 'A' 2-1 and Daresbury 'B' 3-0. In League B Rutherford 'B' lost 3-0 to Daresbury 'A' but beat Central Office 'B' 2-1 to go through to the last four. In the semi-finals Rutherford 'A' beat Rutherford 'B' 2-1 and Daresbury 'A' beat Central Office 'A' 2-1.

The first game of the final was between Will Johnston, Rutherford and Alan Jackson, Daresbury. Will, who hadn't dropped a game throughout the tournament easily accounted for Alan 3-0 to remain unbeaten.

Next it was Jenny Coates, to renew her rivalry with Pella Machin of Daresbury. Jenny, who has been sorely missed by the Rutherford team during the past two years, had played Pella twice before and the score was one match each. The first game was very close indeed with Jenny just winning

10-8. This vital first game gave Jenny great confidence and she went on to win the next two games comfortably so giving Rutherford an unbeatable 2-0 lead. Just as well because Frank Close, still weary from a long 3-2 defeat by the 'B' teams Malcolm Edwards, never looked happy against John Helliwell and went down 3-0. So RAL had beaten Daresbury 2-1, to win the squash - the first time since 1978.

A special word for Jackie North, who although a complete novice agreed to play for Rutherford 'B' at the last moment when it looked as if we would only be able to field one team. Against players of the calibre of Jenny Coates and Pella Machin she was outclassed but bravely battled away to the last point and never gave up.

Table Tennis

This years competition was organised by the RAL Table Tennis Club. Seven teams entered - two from the Atlas Centre, three from Daresbury, one from RGO and one Rutherford team.

The teams were put into two groups and the group rounds proved to be very enjoyable with all players having plenty of matches to play.

Eventually the group winners and runners-up evolved as, Group I - Daresbury 'A' - winners, RGO - Runners-up. This was a very close result and was decided by just one extra game being won by the Daresbury side.

Group II - Atlas 'A' won this group comfortably, with the Rutherford side beating Daresbury 'B' convincingly to finish runners-up in the group.

In the semi-finals the Daresbury A v Rutherford tie proved to be a close encounter with good attack from both sides resulting in a draw. However, Daresbury came through on a better games average. Bad luck Rutherford.

The Atlas 'A' v RGO was also a good contest with RGO playing some very good defensive and counter hitting play. Atlas was too strong, however, and won by 4 - 2.

The finals, therefore, were between Daresbury 'A' and Atlas 'A' and by this time the test was becoming one of fitness as well as skill. Some very good play was seen coming from both sides, but the Atlas 'A' trio Peter Kent, Eric Thomas and Tim Pett, proved to be a huge task to overcome. Daresbury put up a good fight to overcome cramp etc, but were finally defeated 4 - 0.

All the table tennis participants agreed, it was an enjoyable competition.

Volley Ball

Once again there was a good turn-out with seven teams entered from Appleton (2), Atlas (1), Central Office (1), Daresbury (2) and Rutherford (1). The court facilities were reasonable but we had to supply our own timer (the controller's kitchen clock), whistles and volley balls. The general playing standard was higher than in previous years but it was apparent that some teams had not prepared sufficiently. However, as evidence of the growing popularity of this sport, all the matches were played with enthusiasm and determination. Fittingly, the two strongest teams met in the final, Appleton 'A' beating Central Office by 2 sets to love, to take the trophy for the third year in succession.

A vote of thanks is due to the Controllers of each sport, whose hard work kept the competitions going so smoothly - and for providing these reports to the "Bulletin".

Thank you, Peter Hemming, Ain Forster, Tudor Morgan, John Rice, Roger Wolfenden, John MacDougall and John Varley, and of course Mike Courthold our Rec Soc Secretary.

RecSoc AGM

The Annual General Meeting of the RAL Recreational Society will be held in the Lecture Theatre on Thursday 13 May 1982 at 1240.

Please make every effort to attend.

Cricket AGM

The Laboratory Cricket Club is holding its AGM on Wednesday 5 May in R3 Conference Room at 12.30 pm. Old and new members please attend.

Thanks

My sincerest thanks to you all for such beautiful leaving presents and for a memorably happy stay at RAL.

I'm sorry I wasn't able to say au revoir personally to everyone, but will be reminded of you all by the 160 signatures on my cards. I shall remember you all with great affection.

Pauline Gammon

Sales to Employees

The sale of scrap metal and plastics as set out in RLN 12/73 will be made on 14 May, 28 May and 11 June in the R40 scrap compound at 1230hrs.

RAL Lectures

The next lecture in this series will be held on Thursday, 13 May, at 3.15pm in the R22 Lecture Theatre.

THE RISK BUSINESS

by

Emeritus Professor J H Fremlin
University of Birmingham

In the last 50 to 100 years the chief civilised risks due to epidemic disease and air pollution have been reduced by many hundreds of times. The much smaller risks of to-day arouse far better publicised concern. Unfortunately the amount of concern displayed depends more on the perceived novelty of the hazard than on its magnitude. This will be illustrated by contrasting quantitatively the perceived and actual risks from different ways of producing power.

Library Notice

The following journal issue is missing and we have a waiting list for it. Its speedy return would be appreciated.

"Physics reports vol.74(3) Aug 1981"

The librarians would also be delighted if someone would return,

"Practical Organic Chemistry" - F G Mann.

Now - a book they have but don't want,

"Applications of Adaptive Control" ed. K S Narendra & R V Monopoli.

This one was found in one of the Laboratory's transport vans. Would the owner please collect.

From time to time we acquire the belongings of forgetful readers. We have, at present, a spectacles case and pen-knife, which can be reclaimed from the enquiry desk.

But, we await with interest the owner of a neatly rolled-up pair of socks, found under one of the tables.

Obituary

We deeply regret to announce the death of Mr K W J Humphries on Friday 2 April, after a long illness. He was aged 62.

Ken joined the Laboratory in 1966, coming to us from the cleaning contractors who had previously serviced the Atlas Centre.

A quiet, retiring, reliable, conscientious worker, Ken was well liked by all his colleagues, one of whom describes him affectionately as "a dear". He has been very much missed during his illness and we are very sad that his absence is permanent.

We offer our sincere condolences to his family and friends.

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.

Computer-Aided Design

The designer translates his electronic circuit designs into a set of mask designs each containing the pattern for one of the 7 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 the SERC's Interactive Computing Facility network. 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. Typical mask plates are made of glass 1.5mm thick and 100mm square coated on one side with a thin chrome layer. The plates are first coated with a polymeric material (called a resist) which is sensitive to incident electrons. They are then scanned by a fine beam of electrons which, under computer control, traces out the pattern to expose the electron sensitive resist in the desired areas. The exposed resist is removed by developing, and the chrome etched away to provide the required pattern. By using positive and negative resists patterns of clear areas on a chrome field, or chrome patterns on a clear field may be produced as required. The mask sets are checked for accuracy and despatched to the appropriate fabrication facility.

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.

Ion Implantation

To construct active circuit elements, such as field effect and bi-polar 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. In the diffusion process the silicon is heated to a high temperature and appropriate areas exposed to an atmosphere containing the required dopant. The impurity enters the unprotected areas of the silicon and slowly diffuses into the bulk of the wafer. When enough impurity atoms have accumulated the wafer is allowed to cool and the diffusion ceases. Subsequent process steps, particularly those associated with thermal cycling, can cause further diffusion of dopants. In contrast, ion implantation allows impurities to be introduced at room temperature. Dopant atoms are ionised, accelerated to a high energy, and allowed to strike the silicon wafer. The ions embed themselves in the unprotected areas of the wafer at various depths depending on their mass and energy. The silicon is then annealed at moderate temperatures to heal the damage to the silicon crystal lattice, caused by the impacting ions. This technique allows accurate control of dopant concentration without the risk of sideways diffusion. The fabrication centres at Edinburgh and Southampton have their own ion implanters for use in circuit production.

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.

III-V Compounds

Compound semiconductors, the III-V compounds, - so called because of the positions 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 opto-electronics. 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 deposition techniques.

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.

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 the 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".

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 £2.0M per year with further investment planned. The activities of the Facilities are co-ordinated from the Rutherford Appleton Laboratory 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 wising to know more about the SERC's contribution to Microelectronics in the UK.

We are indebted to Eddie Jones for this review of the SERC's initiative in microelectronics.

Farewell and Adieu

Practising

Jack Marshall

Jack Marshall retired from RAL on Wednesday 31 March, and it was obviously a sad occasion for his friends and colleagues.

Apparently, at the time of his arrival, a merger between DSIR and NIRNS to form SRC was still viewed with suspicion by both sides. Jack as an ex-DSIR man was looked upon in the same light. It took him all of three weeks to win us over, to the extent that when they wanted to borrow him back, we were worried he might go.

Seventeen years on, Jim Valentine stood surrounded by a crowd of other wellwishers, presenting Jack with a set of crystal glasses, a gift to mark the esteem in which he is held.

Jack spent his early years as a solicitor's clerk in Newcastle and his war years in the Royal Corps of Signals. He joined DSIR in 1946 first in the accounts section of the Road Research Laboratory, then Finance Division at DSIR Headquarters and finally Establishments Division, before becoming SRC, London Office, Staff Recruitment. We were "awarded him" in 1970.

"We are delighted to have worked with you, look upon you with enormous affection and wish you a happy retirement," concluded Jim as he presented Jack with a card and the gift.

Jack remarked that he remembered 1970 well. The sun had shone all that year and he had enjoyed coming here. However it seemed to have rained ever-since and after last winter's snow, he joked, he was looking forward to retirement.

"Thank you all for your companionship, I have enjoyed my time at RAL, and though retiring I am staying in the area. I'm quite happy where I am".

Gerry Soulby

A man with a long career in accelerators, was how Gerry Soulby was described by David Gray, at a presentation ceremony held on Wednesday 7 April to mark his retirement.

Gerry came to Chilton in 1960 via Malvern-synchrotrons, linacs and klyston design and AERE-Accelerator Division, to work on Nimrod-beam diagnostics. A period on the TVIA satellite ultra-violet telescope was followed by work on a new RF system for Nimrod, a new ion-source also for Nimrod (which has since been incorporated in the design for SNS) a session with NBRU on the Harwell linac and back to beam diagnostics on SNS.

"He has always been cheerful and realistic and we are sorry to see him go", said David "but we understand why and wish him and his wife all the best in their joint retirement. Thanks for your very good work over many years". David then presented Gerry with two magnificent sun-beds on behalf of all Gerry's friends and colleagues.

"Thank you", replied Gerry. "It's been quite nice working here - at times! A question to ask when assessing if a job has been worthwhile is - Have you passed on your techniques to other people? I think we have!" A few remarks aimed at specific colleagues followed, the significance of which were lost on your editor until it was revealed that Gerry's successor was a young lady, and are therefore best glossed over. Gerry's final words of thanks and farewell were, "thank you everyone - cheerio, for now!"

Practising

Bulletin

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