From: Derry Jones (University of Bradford, UK) 1928 – 2017

Visiting University scientists at AERE Harwell in the 1960s – Romans, Runways, Reactors and Research Renaissance

Neutron diffraction may have been demonstrated in 1936 but it began in the UK in the 1940s at AERE Harwell, which became part of UKAEA from 1957. James Thewlis (head of Diffraction Branch), George Bacon (GEB) and RD Lowde established guide lines, including absorption and extinction, for the neutron diffraction (ND) analysis of crystals and powders. During World War II, Thewlis (1905-1991) had led an Operational Research Unit improving the navigation of night bombers before working on atomic energy in Canada. Bacon's collaborations led to entertaining menu-type authorships such as Bacon and Pease and Bacon and Curry. With RS Pease, GEB in 1955 initiated studies of the ferro-electric transition in KH_2PO_4 (KDP). The first Harwell Director was the Nobel prizewinner (1952) Sir John Cockroft and during 1966-73 the charismatic neutron scatterer Walter Marshall became Deputy and then Director, following F Arthur Vick and Robert Spence.

The Harwell site, near the intersection of the ancient Ridgeway Path and the Roman Straight Street, was one of several World War II RAF stations considered. Built as part of the Re-armament Programme in 1935 for open-cockpit biplanes, RAF Harwell trained hundreds of bomber crews and in June 1944 troop-carrying Horsa gliders were towed off to initiate the D-Day invasion of continental Europe. Many of the AERE facilities, including the early reactors GLEEP and the more powerful BEPO, used aircraft hangars; commissioned in 1947 and shut down only in 1990, Graphite Low-Energy Experimental Pile (GLEEP) was said to be the first reactor built in Europe. The former RAF Officers' A Mess provided accommodation for visitors. In 1956, one could get a single room for a week in Ridgeway House (A Mess) for £4, while one could share a 5-bedded room in Cosenor's House, Abingdon for £2-50 per week. At its peak, AERE employed over 5000, a number which declined in the late 20th century, but the Harwell-Chilton campus has now metamorphosed into a flourishing and growing international science park employing several thousands and incorporating the RAL ISIS neutron pulsed source and the Diamond flying-saucer shaped Synchrotron X-ray source [1].

My introduction to ND arose by asking Norman Curry (NAC) around 1961 to give a talk at Bradford Institute of Technology (Bradford University from 1966) in a one-day Symposium on X-ray and Related Structural Techniques. I had been studying Hydrogen nmr in a single crystal of calcium hydrogen phosphate dihydrate, of which the X-ray structure had been determined. Collection of ND single-crystal intensity data in the 1960s and 70s, in collaboration with NAC, on early diffractometers, like the Ferranti and Mk VI, for hydrogen location in this and other related minerals and polycyclic hydrocarbons took many months each; this required a series of ten-day AERE attachments, with accommodation at a variety of hostels, pubs and hotels around Abingdon and Harwell. Beam time came from successful applications to the then SRC with some NIRNS financial support from 1957. Diffractometers were only gradually replacing Weissenberg goniometers as the usual way of collecting photographic X-ray intensity measurements as the precursor to structure-solving. The spallation pulsed neutron source was not due to be operational until the mid-80s. Dr JB Speakman, a hydrogen bond specialist at Glasgow University, held a vacation consultancy in ND arranged by GEB. Before he left Solid State Physics for Sheffield University, GEB arranged one for me. Consequently, for some summers I was able to bring my young family to stay in either our caravan or one of the pre-fabricated (and rather well-equipped for the times) single-storey houses on the Harwell site (but outside the wire fence guarded by MoD police). Assembled in 1940 with an expected lifetime of ten years, most prefabs lasted until around 1990.

GEB (1917-2011), educated at Derby and Cambridge, spent all World War II at TRE, Malvern, and its successors on radar research with special attention to height estimation of raiding German bombers. In 1946,

when he became a DCSO at AERE, GEB began initially secret work on graphite and later was a ND pioneer as described above. From 1955, when the first edition of *Neutron Diffraction* appeared, to 1987, Bacon was author of several books on ND and neutron scattering. He left AERE in 1963 to take up a Physics Chair at Sheffield University, where one of his concerns became apatite structure in bones. I attended the *50 years of ND* celebration of his 80 th birthday at the Cosenor's House, Abingdon, in1980. Appreciations of the Father of ND in Europe by Alan Hewat, Philip Bacon and others appeared in BCA *Cryst News* No 118, pp 27 & 28 (Sept, 2011) while GEB has reviewed more generally the first half-century of applying neutron beams to the study of condensed matter [2].

Valuable advice and assistance at the instruments in the reactors PLUTO and DIDO (fluxes 5 x 10^6 /cm^2/s, only shut down in 1990) was provided by DHC (Rusty) Harris, KD Rouse and Nick Hance. I have a copy of Hance's 1973 *Users Guide for the Operation the Badger Diffractometers* in DIDO; he wrote a similar one for the Curran. These powder diffractometers were for aligning large single crystals and for collecting spectra from powders and liquids. Hance, later involved in Harwell publicity, has published (2006) a much more general story of Harwell [1], although, oddly, it has no mention of any neutron scattering. I also have a copy of CG Windsor's 1975 Material Physics Division *Background Survey on the Neutron Beam Spectrometers in DIDO and PLUTO*. The survey followed the 1974 Domestic Reactors Review Panel, which envisaged appreciable expenditure; the greatest danger appeared to be because of inadequate fast neutron shielding. By this time Research Reactors Division was offering to industry irradiation facilities on the two heavy water reactors, the beginning of the commercial side to Harwell with neutron radiography extending to non-destructive testing. In the 1960's, AERE's nuclear power remit was being broadened to embrace non-nuclear activities and, in 1989, AEA Technology became a consultancy and scientific services business.

Aside from theoreticians like W Marshall and SW Lovesey, full-time neutron staff in Solid State Physics and Materials and Metallurgical Physics included Stuart Wilson (soon off to ILL), P Jane Brown and J Bruce Forsyth (co-authors in 1973 of *The Crystal Structure of Solids* and both later at ILL), Bill Stirling (to become Director of ILL much later), Graham Lowe (a future Director of AERE), Ron F (powder) Dyer, Colin G Windsor FRS, and B Terry M Willis. BTMW was author of much fundamental work in the field but was widely known as the initiator of Summer Schools on Neutron Scattering; like GEB and organist NAC (who had married another physicist from the site), he was one of Harwell's quiet, gentle but determined and effective ND physicists. Among the many UK and overseas crystallographers who carried out ND experiments at AERE, we had, from Bradford for example, a series of crystallography Research Fellows and students, including (later Prof) Giovanni Ferraris (who contrived to stretch his NATO Fellowship to cover several visits over two years), Ron W Wardle, Jack Yerkess, Bill A Denne, GYM Al-Shahery and John M Sowden. This group presented ND structural studies begun at Harwell at many conferences; some indication of the influence of AERE ND is shown by the breadth of publications in a wide variety of journals: Bull Soc Chim de France, 1968; Z Kryst, 1969, 1971, 1972, 1987 (this article by NAC and DW Jones contained a rare application of the BTMW extinction corrections); J Cryst Spec Res, 1971; J Cryst Molec Struct, 1971, 1977; Acta Cryst 1971, 1972, 1988, 1990; J Chem Soc A 1971; JCS D (Chem Comm); JCS Dalton, 1973; Inorg Nucl Chem letters, 1973; Atti Acc Sci Torino, 1974; J Less Common Metals, 1982 ; J Solid State Chem, 1991; J Chem Cryst, 1997.

References

[1] Nick Hance, *Harwell: the Enigma Revealed* (Oxford, Enhance Publications, 2006)
[2] GE Bacon, *Contemp Phys* 23 [6] 541-552 (1982)