Frederic Calland Williams

Born 1911; died 1977; developer of the CRT electrostatic memories that bore his name, devised for the Manchester computers.

Education: BSc, Engineering, University of Manchester, 1932; MSc, Engineering, University of Manchester, 1933.

Professional Experience: Metropolitan-Vickers, 1933-1934; Oxford University, 1934-1936; assistant lecturer, University of Manchester, 1936-1939; Telecommunications Research Establishment, Radar Research, 1939-1946; chair of Electro-Technics, University of Manchester, 1947-1977.

F.C. Williams graduated in engineering from Manchester University in 1932. A year later he received his MSc and joined Metropolitan-Vickers for a short time before moving to Oxford University in 1934 to work on circuit and valve noise. Williams stayed two years at Oxford before returning to Manchester in September 1936 as an assistant lecturer. While lecturing at Manchester, Williams gave a new course called "Electro-technics," which combined physics and electrical engineering (Kilburn and Piggott 1978). Williams also collaborated with P.M.S. Blackett, Langworthy Professor of Physics at Manchester, to design a curve follower for Hartree's differential analyzer, situated in the basement of the Physics Department (Blackett and Williams 1939). Williams later recalled that Blackett had influenced his thinking throughout his career.[1]

By 1939, Williams had established his reputation with the publication of over 20 papers and, near the beginning of the war, Williams was "channeled" by Blackett (Lovell 1975) into radar research, first at Bawdsey and later at the Telecommunications Research Establishment (TRE), which moved to Malvern in 1942. One of the first projects Williams became involved in was the IFF system (Identification Friend or Foe), which used radar pulses to distinguish Allied aircraft. The device was manufactured by Ferranti. Williams later went on to do extensive radar research at TRE, where he was "prolific, enthusiastic and unselfish" (Kilburn and Piggott 1978) and confirmed his standing as an acknowledged expert in circuit design.

Toward the end of the war, Williams became involved in producing a series of definitive works in electrical engineering. The Radiation Laboratory at the Massachusetts Institute of Technology (MIT) planned 24 volumes (published between 1947 and 1949) giving a comprehensive coverage of all aspects of electrical engineering. Williams was editor and a contributor to volumes 19 and 20, *Waveforms* and *Electrical Time Measurements*, respectively. Williams visited the Radiation Laboratory in his editorial capacity (in both November 1945 and June 1946), and learned of work being done at both the Radiation Laboratory and the Moore School (which he visited June 21 and 22, 1946) on using cathode-ray tubes as storage devices. Drath[2] quotes Williams as remarking that the end of the war "left many scientists and engineers at TRE searching for new projects to occupy themselves." Cathode-ray tube storage was such a project and, on his return from the US in July 1946, Williams began to study the problem. By October 1946 Williams was able to demonstrate that a single cathode-

[1] Lovell, B., "Patrick Maynard Stuart Blackett, Biographical Memoirs of Fellows of the Royal Society, Vol. 21, 1975, pp. 1-115.

[2] Drath, P., The Relationship Between Science and Technology: University Research and the Computer Industry, 1945-1962, unpublished doctoral dissertation, Manchester Univ., UK, 1973.

ray tube could regeneratively store a single binary digit. Tom Kilburn, a scientific officer at TRE, began to work with Williams.

As early as May 8, 1946, Womersley, superintendent of the NPL Mathematics Division, had written to TRE inquiring about the use of cathode-ray tubes as a possible alternative to delay-line storage for the ACE. When news of Williams' success in storing one binary digit reached the NPL, Sir Charles Darwin, director of the NPL, and E.S. Hiscocks, secretary of the NPL, visited TRE on October 15-17, 1946, to see the Williams tube demonstrated. This visit was followed up on November 22 with a meeting at the NPL attended by Hiscocks, Womersley, and Turing from the NPL and by R.A. Smith (director of TRE), Williams, and A.M. Uttley, also from TRE. The NPL, most notably Hiscocks and Womersley rather than Turing, pressed hard for TRE to agree to carry out much of the electronic development work needed to construct the ACE to Turing's designs. The NPL did not intend to build the machine in house, as none of the Mathematics Division staff had the relevant electronics experience.

At the meeting, Smith outlined the difficulties that TRE had concerning availability of staff with electronics experience. Williams, one of the TRE's most valuable assets as far as the NPL was concerned, was about to leave TRE to go to Manchester University. The majority of TRE's circuit technicians had been transferred to the United Kingdom Atomic Energy Authority, and any remaining staff with computing machine knowledge (but not valve experience) were already committed to a project for the Ministry of Supply concerning computers for military use. The amount of assistance TRE could give to the NPL was, therefore, very limited.

The NPL did not, however, give up trying to persuade Williams to tailor his work on cathode-ray tube storage systems to the needs of the ACE project. In January 1947 the NPL prepared a draft contract under which Williams was to:

1. "develop an electronic storage tube for A.C.E. machine" and
2. "develop components of the arithmetical organ of the machine, e.g., adding circuit and multiplying circuit."[1]

Williams turned down the offer of such a binding contract, preferring to work within the relative freedom of TRE and Manchester University sponsorship. It was also obvious that the ACE as designed by Turing was very dependent on delay-line storage, and a major design change would have been necessary to use cathode-ray tube storage as an alternative.

In early October 1946, Williams was offered the chair of electro-technics at Manchester University. Blackett and Max Newman both sat on the committee that appointed Williams. Blackett, through his familiarity with Williams' prewar work at Manchester and his wartime contributions to radar research from his position as director of Naval Operational Research, is credited (Lovell 1975) with influencing the appointment. Newman, too, when he learned of Williams' work with cathode-ray tubes, was keen to secure Williams for Manchester. Williams moved to Manchester (on January 14, 1947) and continued to work on his cathode-ray tube storage system.

[1] National Physical Laboratory, Draft Contract for Discussion between NPL, and Manchester University, Nat'l Archive for the History of Computing, NAHC/MUC/Series I/Bla/(iii), Manchester, UK, 1973.

Williams was appointed to the Edward Stocks Massey Chair of Electro-Technics at Manchester University in January 1947. Kilburn joined him from TRE. TRE was willing to continue to support Williams' work on cathode-ray tube storage systems not only by seconding Kilburn but also by supplying Williams with the components necessary for him to carry out his research. In postwar Britain, such components were not readily available. Newman was pleased that Williams had been appointed and decided to wait for Williams' work to come to fruition rather than rely on buying components from the US whenever they became available. Newman did not anticipate that Williams would produce a working memory unit in such a short time.

Williams and Kilburn spent 1947 perfecting the CRT memory unit and were joined on the project by A.A. Robertson and G.C. Tootill. While the work in the Electro-Technics Department went on independently of the Royal Society Computing Machine Laboratory, the engineers did seek advice from Newman and his staff. By autumn 1947, the Williams tube was able to store 2,048 bits, and the next step was to develop a computer around it. It was at this stage that Newman was able to offer explanations as to what kind of machine Williams and Kilburn needed to build. Williams recalls that:

> They took us by the hand and explained how numbers could live in houses with addresses and how if they did they could be kept track of during a calculation. (Williams 1975)

IJ. Good also worked with Kilburn making suggestions for the design of the computer. For example, in May 1947 Good suggested 12 basic instructions that a prototype machine would need to include. He also pushed for two accumulators to be built into the machine. Good claims to have suggested microprogramming (which he called machine building) as early as February 1947.[1] The liaison between the Mathematics Department and the Electro-Technics Department was established.

The Royal Society Computing Machine Laboratory housed Williams' and Kilburn's work on a prototype computer being built around the Williams tube store. In reality, the Royal Society Computing Machine Laboratory was a 20 x 20-foot room in the Engineering Department, labeled “Magnetism.” The laboratory had no staff paid for by the Royal Society. Newman, Good (who left Manchester in April 1948), and Rees were based in, and employed by, the Mathematics Department. Williams, Robertson, and Tootill were on the staff of the Electro-Technics Department. Kilburn was still a senior scientific officer with the Ministry of Supply. The equipment needed to carry out the research continued to be supplied through TRE. Consequently, the Royal Society grant remained almost untouched.

Throughout early 1948, work was done, principally by Kilburn,[2] on building a prototype (or baby machine) around the Williams tube to demonstrate the feasibility of building a much larger machine. Meanwhile, information about the Williams tube was disseminated. In December 1947, Kilburn produced a progress report[3] describing the storage system and included a description of a hypothetical computer.

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[1] Good, 1. J., “Early Computers at Manchester University,” Nat'l Archive for the History of Computing, NAHC/MUC/Series 2/A4, Manchester, UK, Apr. 7,1976.

[2] Manchester University, Arrangements for Royal Society Computing Machine Laboratory, Nat'l Archive for the History ofComputing, NAHC/MUC/Series 2/C2, Manchester, U& Oct. 15,1948.

[3] Kilburn, T., “A Storage System for Use with Binary Digital Computing Machines,” Dept. of Electro-Technics, Univ. of Manchester, UK, Dec. 1, 1947.

Fifty copies were made of this report (which was later published without the description of the hypothetical computer in 1949) and distributed to interested parties worldwide. On March 4, 1948, Williams described his store to the Royal Society during a “Discussion on Computing Machines.”[1] Other contributors to this discussion were D. R. Hartree, M.V. Wilkes from the Cambridge Mathematical Laboratory, J.H. Wilkinson from the NPL, and A.D. Booth from Birkbeck College, London. Williams later recalled (Williams 1975) that during the discussion (which took place in March 1948) Newman stressed that the major question concerning the large computing machines being built in the US and in Britain was “if they work at all.” This remark clearly illustrates the continued element of doubt about the feasibility of building stored-program computers.

However, by summer 1948 Williams, Kilburn, and Tootill had built a very small prototype computer-which has become known as the Manchester baby-using only 32 words of 32 bits each stored on a single Williams tube. Cathode-ray tubes were also used for the accumulator and the logical control, which stored the current instruction and its address. The only input mechanism was a series of switches. Output was read directly from the Williams tube. On June 21, 1948, the machine correctly ran its first program, which found the highest factor of an integer. It was the first program to run on an electronic stored-program computer. Simon Lavington states that Manchester folklore has it that Williams never wrote a program during his career and Kilburn “wrote just one-the world's first!”[2]

The baby machine served one purpose-to prove that a stored-program computer could be built around a Williams tube storage system. The machine carried out this function very well indeed. When Blackett saw the machine working, he suggested to Williams that it was an invention from which industry could benefit. Williams demurred, feeling that the project was still too immature to involve industry. Nevertheless, Blackett contacted Sir Ben Lockspeiser (chief scientist, Ministry of Supply), who came unannounced to visit Williams and see the machine for himself. The Ministry of Supply was interested in supporting computer development (which they were already doing through TRE's continuing supply of components to Williams) for three reasons: first, to promote scientific research; second, to open up further possibilities in defense research; and third, to support industry, which was suffering from lack of orders and lack of investment in the postwar era. Lockspeiser felt that Ferranti, which was close to Manchester and had electronic experience, would be an ideal industrial partner for a joint computer venture. Although Williams had to be persuaded on this point (Drath 1973), Lockspeiser continued the negotiations with Ferranti and was able to commit £100,000 from the Treasury to support Ferranti in constructing “an electronic calculating machine to the instructions of Professor F.C. Williams” (Williams 1975).

A contract with Ferranti was not signed until February 19, 1949, but cooperation began in November 1948. D.G.B. Edwards and G.E. Thomas joined the computing effort at Manchester in October 1948, and in November Kilburn was officially appointed to the staff of Manchester University as lecturer in the Royal Society Computing Machine Laboratory. Turing moved to Manchester from the NPL in September 1948 as deputy director of the Royal Society Computing Machine Laboratory. Thus, by autumn 1948, work had started on building a larger prototype computer, the Manchester Mark I, the result of which was to be manufactured by Ferranti. The future of computers at Manchester was assured.[3]

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[1] Hartree, D.R., et al., “A Discussion on Computing Machines,” Proc. Royal Soc. A., Vol. 195, pp. 265-287.

[2] Lavington, S.H., A History of Manchester Computers, NCC Publications, Manchester, UK, 1975.

[3] Extracted from Croarken 1993.

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UPDATES

Portrait changed (MRW, 2013)