Tom Kilburn: A Pioneer of Computer Design

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Tom Kilburn was a figure of the first importance in the history of computer design, contributing to the development of five important computers over three decades. On casual acquaintance, Kilburn was a self-contained person who chose his words with care. Still, he possessed a somewhat dominating personality and was a natural team leader who inspired great loyalty and affection from those who worked closely with him. F.C. Williams summed up Kilburn in a simple sentence: "What you must always remember is that Tom is a Yorkshireman."[1]

Early Days

Tom Kilburn was born near Dewsbury in West Yorkshire, England. His father, John William Kilburn, began as a statistical clerk and rose to become a company secretary.[1]

Tom was educated at Wheelwright Grammar School from which he emerged as something of a mathematical specialist since his headmaster had not allowed him to study much else from around the age of 14. In 1940, Kilburn went up to Sidney Sussex College, Cambridge, with State, Dewsbury Major, and Minor Open Scholarships. In 1942, at the end of a shortened course, he graduated with First Class Honors in Part I of the Mathematical Tripos and in the preliminary examination for Part II.

During World War II, many Cambridge mathematics dons were absent from the university serving at Bletchley Park and elsewhere. In spite of this privation, Cambridge still boasted a lively mathematical community in which Kilburn played his part. As the Sidney Sussex college representative in the New Pythagoreans (a subgroup of the Cambridge University Mathematical Society), Kilburn almost certainly came into contact with a number of people who later went on to play a part in the development of computing. Geoff Tootill and Gordon Welchman were, like Kilburn, officers of the New Pythagoreans.[2] Speakers to the student society included future Bletchley Park code breakers M.H.A. Newman,[3,4] Ken J. Le Couteur, and William (Bill) T. Tutte. However, Kilburn would likely not have come into contact with Alan Turing, who departed for Bletchley Park in 1939, too early for them to have met. It is also unlikely that Kilburn read "On Computable Numbers" as an undergraduate because his mathematical taste was more applied than pure:

> [P]ure mathematics seemed extremely abstract. I was the sort of person who was always prepared to accept that two and two are four, whereas I'd spent the first term at

Background of Tom Kilburn

Born: 11 August 1921, Dewsbury, England.

Died: 17 January 2001, Manchester, England.

Education: Wheelwright Grammar School, 1932–1940; Sidney Sussex College, University of Cambridge, BA (mathematics) 1945; Victoria University of Manchester, MA (electro-technics) 1947, PhD (electro-technics) 1948, DSc (electro-technics) 1953.

Professional Experience: Telecommunications Research Establishment (TRE), Malvern, 1942–1947. Victoria University of Manchester, initially seconded, thereafter lecturer in electrical engineering and professor, 1946–1948; head of computer science, 1964; dean of the Faculty of Science 1970–1972, and pro vice chancellor of the university, 1976–1979. Retired, 1981.

Honors and Awards: Fellow of the Royal Society, 1965; Honorary DU (Essex), 1968; Fellow of the British Computer Society (BCS), 1970; IEEE W. Wallace McDowell Award, 1971; Commander of the Order of the British Empire, 1973; BCS John Player Award, 1973; BCS Distinguished Fellow, 1974; Founder Fellow of the Royal Academy of Engineering, 1976; Honorary DUniv (Brunel), 1977; Royal Medal of the Royal Society, 1978; Member of Council for the Royal Society, 1978–1979, Honorary DSc (Bath), 1979; Foreign Associate, US National Academy of Engineering, 1980, Honorary DTech (CNAA), 1981; IEEE Computer Society (CS) Computer Pioneer Award, 1982; ACM and IEEE CS Eckert-Mauchly Award, 1983; Howarth Medal for Enterprise and Innovation in the North West, Royal Society for the Encouragement of the Arts, Manufactures and Commerce (RSA), 1996; Mountbatten Medal, National Electronics Council (jointly with M.V. Wilkes), 1997; Honorary Member, Manchester Literary and Philosophical Society, 1998; Honorary DSc (University of Manchester), 1998; Fellow of the Computer Museum History Center, California, 2000.

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> Cambridge in one of Newman's lectures proving that this was so. Whilst it was all very interesting—I mean one could appreciate the beauty of it—it left me rather cold. At the end of it, you didn't seem to be much further forward . . .[5]

War Service

Sometime during his last year at Cambridge, Kilburn attended a talk by C.P. Snow,[6] who was visiting universities recruiting people for unspecified war work. As Kilburn engagingly recounted, he had some fairly clear ideas about what he wanted to do for the war effort:

> It seems silly but if I could have joined the RAF as a pilot, I would have done that, but I was relegated to navigator or some such, and that was not quite so appealing. It sounds egotistical but I like to lead. I like to be in charge and I didn't fancy the idea of being driven and crashed by some other character. I wanted to do my own driving and crashing. It's on these sorts of whims that life is founded—it's not through any profound thought is it? You take advantage of what's there at the time.[5]

With the RAF ruled out, Kilburn's first destination was a number of short courses in electronics followed quickly by a call up and a six-week City and Guilds course on electricity, magnetism, and electronics. After about a week-long break, he was posted to the Telecommunications Research Establishment (TRE), Malvern, where he joined Group 19, led by Williams.[7] He was not greeted with unbridled enthusiasm. Williams had requested an extra person to join his team, and Kilburn was the person they sent. The other members of Williams' group were all around 30 years old with an average of 10 years experience in practical electronics. Kilburn was 21 years old and, prior to being called up, had not the least interest in electronics or electronic equipment of any kind. Williams, whose group was responsible for designing and debugging electronic circuitry and for solving problems encountered by other groups, made no attempt to hide his disappointment at being offered someone so inexperienced. Kilburn later recalled:

> [I]n effect he said "Oh God, you don't know anything?" and I said "No." That was the sort of relationship at the start. But of course by the time we left Malvern—that was four years later—the relationship was quite different.[5]

The Manchester Baby

By the end of the war Kilburn had made a great deal of progress. He was well settled domestically, having married Irene Marsden in 1943, and professionally, he had become an important member of Williams' team. Kilburn had risen to the rank of acting scientific officer. In 1946, Williams left TRE to take up the Edward Stocks Massey Chair of Electro-Technics at the Victoria University of Manchester. It was Williams' intention to continue his work on the development of the cathode ray tube (CRT) memory, and he arranged for Kilburn to work with him at Manchester on secondment from TRE. By the end of 1947, Williams and Kilburn had developed a CRT that could store patterns over long periods. But as Kilburn put it, "the only way to test whether the cathode ray tube system would work in a computer was, in fact, to build a computer."[8]

The story of precisely how the Manchester Baby was conceived, funded, and developed as well as the roles played by various actors in the project is somewhat complicated.[9,10] The dominant historical narrative has come univocally from the engineering tradition and has generally paid little attention to the contribution made by people like Patrick M.S. Blackett.[11]

What is not in doubt is that the machine itself was the first working example of a digital electronic stored program computer. However, its significance for the historian of computing is not that it was an iconic first but that it provided the foundation that Manchester used to build itself into a leading center for the emerging computer science field.

Mark I and Mercury

Kilburn had planned to return to TRE after the Manchester Baby was completed, but he was overtaken by events. Impressed by the Baby's success, the Ministry of Supply quickly awarded a contract to Ferranti to design and build a full-scale commercial computer to Williams' specification. An important preliminary step was for a prototype,[12] the Manchester Mark I, to be produced at the university. Kilburn's importance to the new project was obvious, and Williams persuaded him to remain at the university to work on it and offered Kilburn a lecturer position.

The Manchester Mark I, complete with backup drum store, was ready by the autumn of 1949 and ran continuously for almost a year. Approximately nine Ferranti Mark I machines were sold from 1951 to 1957. Over the three years since the Baby had been developed, two important shifts of responsibility had taken place. First, Newman recognized that the further computer development should be in the hands of engineers and withdrew from the area. Second, Williams, who never had much interest in computing as such, passed effective control of further developments to Kilburn.

In 1951, once again following a process of incremental development, Kilburn began working toward a Mark II computer that was known as the megacycle machine, or Meg. It replaced the Mark I valve diodes with solid-state versions and offered a tenfold increase in clock rate together with greatly improved reliability and floating-point operation. The serial CRT memory, which was already running at a near optimal rate in the Mark I, threatened to act as a performance bottleneck for the Meg. Kilburn's solution was to design a 10-bit parallel CRT memory.

Meg first operated successfully in the summer of 1954, and Ferranti developed a commercial version of Meg under the name Mercury. Clients included the Meteorological Office, the Norwegian Defense Research Establishment, and Manchester University. In all, 19 Mercury computers were sold, six of which were purchased by overseas customers (see http://www.computer50.org/mark1/kilburn.html).

Transistor Computers

In addition to Kilburn, the Manchester design team consisted of Dai Edwards and Tommy Thomas, who concentrated on the Meg, and Dick Grimsdale and Douglas Webb, who were simultaneously working on what was originally a research project looking into developing the smallest possible economic computer.[13] It was soon clear that a great deal of valuable experience could be gained if the machine was built using transistors. Two prototype transistor computers were commissioned, both of which made use of a pseudo two-address instruction format and permitted optimum programming. The 48-bit, November 1953 machine, which is widely acknowledged to have been the world's first operational transistor computer, had 92 point-contact transistors and 550 diodes, which STC manufactured. An enhanced version of the transistor computer was completed in April 1955, boasting some 200 point-contact transistors and 1300 diodes.[14]

In 1956, the Metropolitan Vickers Electrical Company, adapting the design of the experimental transistor computer to permit the use of junction transistors and manufactured six transistor machines, mainly for internal use, under the name Metrovick 950. For Kilburn and his team, the most important aspect of the Transistor computer was the early experience it gave them in transistor circuit techniques.[15]

Muse and Atlas

Kilburn's intention with the Muse (microsecond) project was to develop a really large fast machine that would make full use of both existing and emerging technology. By the time he had finished, Muse used "multiprogramming, job scheduling, spooling, interrupts, pipelining, interleaved storage, autonomous transfer units, virtual storage and paging—though none of these techniques had been invented when the project started in 1956."[14]

Muse was comparable in scope and ambition to the IBM Stretch and Univac LARC projects, and Kilburn was under no illusions that the Department of Electrical Engineering had sufficient resources available to complete a project of its scale and complexity without assistance. His attempts to elicit Ferranti or the government's support for the Muse proposal were initially unsuccessful, so the decision was made that Manchester should press on press on with a slimmed-down version of the original plan. However, in January 1959 Ferranti decided to participate in the project, now renamed Atlas, with £300,000 in backing from the National Research Development Corporation (NRDC).[15]

One of the innovations introduced in the Atlas was a scheme that let programmers treat both core and drum stores as if they were core storage. Drum transfers were handled behind the scenes by an innovative program called the *supervisor*. The *one-level-store concept*—the idea of a fast and a slow store appearing as a single fast store—was an important precursor to virtual memory.

Kilburn not only managed the project but was also was partly responsible for the circuit design, including work on an adder with a fast carry path.[1] In general though, he relied greatly on the experienced teams that he had established over a number of years. Three Atlas systems were eventually built and installed at the Universities of Manchester and London and at the Rutherford Laboratory.

In 1960, Kilburn was appointed a professor of computer engineering in the Department of Electrical Engineering.[x]

Department of Computer Science

Beginning in 1963, Kilburn spent two or three years establishing and organizing a new Department of Computer Science, the first of its kind in the UK. The intention was to provide a natural home for computer research, a sound base for future projects, and undergraduate courses in computer science. Kilburn, now a professor of computer science, was the first department head in 1964 and had 12 academic staff under him. Reflecting Kilburn's personal strengths, Manchester placed more emphasis on hardware than many of the other computer science departments that followed it, most of which sprang from a mathematical lineage rather from engineering. Kilburn was also the dean of the Faculty of Science from 1970 to 1972 and pro vice chancellor between 1976 and 1979.

MU5

In 1966, Kilburn embarked on what was to be his last major computing project: the MU5. The Atlas had been operational for four years, and the MU5's main focus was to provide an architecture geared to the efficient running of programs written in high-level languages. The MU5 was originally planned as a range of three machines—a small inexpensive computer, a high-spec scientific computer with 20 times the throughput of the Atlas, and a multiprocessor—but only the second was actually developed.[17] The MU5's original design proposal was laid out in 1968 at the Edinburgh International Federation for Information Processing (IFIP) conference in a paper authored jointly by Kilburn, Derrick Morris, Jeff Rohl, and Frank Sumner.[18]

An interesting technical aspect of the MU5 was the associative name store in which frequently used scalar variables would automatically reside in a fast cache store. Morris explained, "This was as a result of an analysis of the Atlas software, especially the instruction code. We learnt something about the frequency of use of operands and control structures. The order code accommodated string functions and vector functions."[17]

The university secured the cooperation of International Computers and Tabulators (ICT), which made construction facilities available at cost and provided five staff to work on the project. The university's relationship with ICT and the potential it created to benefit the company persuaded the Science Research Council (SRC) to assist the project by awarding the university a £630,000 grant over a five-year period. The MU5 ran for the first time in 1972 and, by 1974, was providing computer services for the department's staff and students.

It was a fruitful collaboration. However, an initial failure by International Computers Limited (ICL) (which by then had merged with ICT) to acknowledge the extent to which the MU5 had influenced their 2900 series concerned the SRC, outraged Kilburn, and led to a long-running dispute that was not fully settled until after Kilburn's retirement in 1981.

Retirement

In order to spend more time with his wife, Kilburn retired early at age 60. Unfortunately, Irene Kilburn died just two weeks before his planned retirement.[19] After that, he continued to spend one day each month in his old department, but the majority of his time was spent with his son and daughter, gardening, playing the piano, and following the Manchester United Football Club. He died in Manchester on 17 January 2001.

Acknowledgments

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References and notes

1. M. Wilkes and H.J. Kahn, "Tom Kilburn CBE FREng. 11 August 1921–17 January 2001," *Biographical Memoirs of the Fellows of the Royal Society,* The Royal Soc. London, 2003, pp. 283-297.
2. Geoff Tootill was Christ's College representative for the New Pythagoreans and president of the Archimedeans, and Gordon Welchman was a student at Sydney Sussex College and honorary vice president of the New Pythagoreans.
3. D.P. Anderson, "Newman: Topologist, Codebreaker and Pioneer of Computing," *IEEE Annals of the History of Computing,* vol. 29, no. 3, 2007, pp. 76-81.
4. Kilburn and Tootill were also students in some of Newman's classes.
5. G. Bowker and R. Giordano, "Interview with Tom Kilburn," *IEEE Annals of the History of Computing,* vol. 15, no. 5, 1993, pp. 17-32.
6. Originally trained as a chemist at Leicester and a physicist at Cambridge, Charles Percy Snow

(Baron Snow of Leicester) was mid-way through his four years of service as technical director of the Ministry of Labor at the time of this talk.

7. D.P. Anderson, ''Frederic Calland Williams: The Manchester Baby's Chief Engineer,'' *IEEE Annals of the History of Computing,* vol. 29, no. 4, 2007, pp. 90-102.
8. T. Kilburn, ''From Cathode Ray Tube to Ferranti Mark I Resurrection,'' *Resurrection: The Bulletin of the Computer Conservation Society,* vol. 1, no. 2, 1990, pp. 16-20.
9. D.P. Anderson, ''Was the Manchester Baby Conceived at Bletchley Park?'' *Proc. Electronic Workshops Computing,* British Computer Soc., 2007; http://www.bcs.org/upload/pdf/ewic_tur04_paper3.pdf.
10. D.P. Anderson, ''The Contribution of M.H.A. Newman and his Mathematicians to the Creation of the Manchester 'Baby,''' *The British Society for the History of Mathematics Bulletin,* vol. 24, no. 1, 2009, pp. 27-39.
11. D.P. Anderson, ''Patrick Blackett: Physicist, Radical, and Chief Architect of the Manchester Computing Phenomenon,'' *IEEE Annals of the History of Computing,* vol. 29, no. 3, 2007, pp. 82-85.
12. Actually, the process involved developing a series of successively more complex prototype machines.
13. E.M. Dunstan also joined in 1954 and worked on drum storage.
14. S.H. Lavington, *A History of Manchester Computers,* 2nd ed., British Computer Soc., 1998.
15. S.H. Lavington, ''The Manchester Mark I and Atlas: A Historical Perspective,'' *Comm. ACM,* vol. 21, no. 1, 1978, pp. 4-12.
16. The University Council changed the department's title from electro-technics to electrical engineering on 19 March 1948.
17. D. Morris, ''Early Computers at Manchester University,'' *Computer Resurrection,* vol. 1, no. 4, 1992.
18. T. Kilburn et al., ''A System Design Proposal,'' *IFIP Congress,* vol. 2, 1968, pp. 806-811. See also R.N. Ibbett, ''The University of Manchester MU5 Project,'' IEEE Annals of the History of Computing, vol. 21, no. 1, 1999, pp. 24-33.
19. Sir Maurice Wilkes, interview by D.P. Anderson, Feb. 2009. An edited version of this conversation will appear shortly in the *Communications of the ACM.*

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