ALAN TURING

United Kingdom
1912-1954
Mathematician
Father of the Abstract Computer

Alan Turing was born at Paddington, London. His father was a British member of the Indian Civil Service and he was often abroad. Alan was sent to Hazlehurst Preparatory School where he seemed to be an “average to good” pupil in most subjects but was greatly taken up with following his own ideas. He became interested in chess while at this school and he also joined the debating society. He completed his Common Entrance Examination in 1926 and then went to Sherborne School. He found it very difficult to fit into what was expected at this public school, yet his mother had been so determined that he should have a public school education. Many of the most original thinkers have found conventional schooling an almost incomprehensible process and this seems to have been the case for Turing.

He was criticised for his handwriting, struggled at English, and even in mathematics he was too interested with his own ideas to produce solutions to problems using the methods taught by his teachers. Despite producing unconventional answers, Turing did win almost every possible mathematics prize while at Sherborne. Turing learnt deep mathematics while at school, although his teachers were probably not aware of the studies he was making on his own. He read Einstein's papers on relativity and he also read about quantum mechanics in Eddington's “The nature of the physical world”. Despite the difficult school years, Turing entered King's College, Cambridge, in 1931 to study mathematics. In many ways Cambridge was a much easier place for unconventional people like Turing than school had been. He was now much more able to explore his own ideas and he read Russell's “Introduction to mathematical philosophy” in 1933. At about the same time he read von Neumann's 1932 text on quantum mechanics, a subject he returned to a number of times throughout his life. Year 1933 was also the year of Hitler's rise in Germany and of an anti-war movement in Britain. Turing joined the anti-war movement but he did not drift towards Marxism, nor Pacifism, as happened to many. Turing graduated in 1934 then, in the spring of 1935, he attended Max Newman's advanced course on the foundations of mathematics. This course studied Gödel's incompleteness results and Hilbert's question on decidability.

Turing was elected a fellow of King's College, Cambridge, in 1935 for a dissertation “On the Gaussian error function”, which proved fundamental results on probability theory, namely the central limit theorem. Although the central limit theorem had recently been discovered, Turing was not aware of this and discovered it independently. In 1936 Turing was a Smith's Prizeman. Turing's achievements at Cambridge had been on account of his work in probability theory. However, he had been working on the decidability questions since attending Newman's course. In 1936 he published “On Computable Numbers, with an application to the Entscheidungsproblem”. It is in this paper that Turing introduced an abstract machine, now called a "Turing machine", which moved from one state to another using a precise finite set of rules (given by a finite table) and depending on a single symbol it read from a tape. The Turing machine could write a symbol on the tape, or delete a symbol from the tape. Turing wrote: “Some of the symbols written down will form the sequences of figures which is the
decimal of the real number which is being computed. The others are just rough notes to "assist the memory". It will only be these rough notes, which will be liable to erasure. He defined a computable number as real number whose decimal expansion could be produced by a Turing machine starting with a blank tape. He showed that was computable, but since only countably many real numbers are computable, most real numbers are not computable. He then described a number, which is not computable and remarks that this seems to be a paradox since he appears to have described in finite terms, a number which cannot be described in finite terms. However, Turing understood the source of the apparent paradox. It is impossible to decide (using another Turing machine) whether a Turing machine with a given table of instructions will output an infinite sequence of numbers. Then Turing became a graduate student at Princeton University in 1936. At Princeton, Turing undertook research under Church's supervision and he returned to England in 1938, having been back in England for the summer vacation in 1937 when he first met Wittgenstein".

Perhaps the most remarkable feature of Turing's work on Turing machines was that he was describing a modern computer before technology had reached the point where construction was a realistic proposition. He had proved in his 1936 paper that a universal Turing machine existed: "... which can be made to do the work of any special-purpose machine, that is to say to carry out any piece of computing, if a tape bearing suitable "instructions" is inserted into it. Although to Turing a "computer" was a person who carried out a computation, we must see in his description of a universal Turing machine what we today think of as a computer with the tape as the program.

While at Princeton Turing had played with the idea of constructing a computer. Once back at Cambridge in 1938 he starting to build an analogue mechanical device to investigate the Riemann hypothesis, which many consider today the biggest unsolved problem in mathematics. However, his work would soon take on a new aspect for he was contacted, soon after his return, by the Government Code and Cypher School who asked him to help them in their work on breaking the German Enigma codes. When war was declared in 1939 Turing immediately moved to work full-time at the Government Code and Cypher School at Bletchley Park. Turing's brilliant ideas in solving codes, and developing computers to assist break them, may have saved more lives of military personnel in the course of the war than any other. It was also a happy time for him: "... perhaps the happiest of his life, with full scope for his inventiveness, a mild routine to shape the day, and a congenial set of fellow-workers. Together with another mathematician W. Welchman, Turing developed the Bombe, a machine based on earlier work by Polish mathematicians, which from late 1940 was decoding all messages sent by the Enigma machines of the Luftwaffe. The Enigma machines of the German navy were much harder to break but this was the type of challenge, which Turing enjoyed. By the middle of 1941 Turing's statistical approach, together with captured information, had led to the German navy signals being decoded at Bletchley. His ideas proved of the greatest importance in this work and he was awarded the O.B.E. (1945) for his vital contribution to the war effort.

At the end of the war Turing was invited by the National Physical Laboratory in London to design a computer. His report proposing the Automatic Computing Engine (ACE) was submitted in March 1946. Turing's design was at that point an original detailed design and prospectus for a computer in the modern sense. The size of storage he planned for the ACE was regarded by most who considered the report as hopelessly over-ambitious and there were delays in the project being approved. Turing returned to Cambridge for the academic year 1947-48 where his interests ranged over many topics far removed from computers or mathematics; in particular he studied neurology and physiology. He did not forget about computers
during this period, however, and he wrote code for programming computers. He had interests outside the academic world too, having taken up athletics seriously after the end of the war.

By 1948 Newman was the professor of mathematics at the University of Manchester and he offered Turing a readership there. Turing resigned from the National Physical Laboratory to take up the post in Manchester. Newman writes that in Manchester: “... work was beginning on the construction of a computing machine by F. Williams and T. Kilburn. The expectation was that Turing would lead the mathematical side of the work, and for a few years he continued to work, first on the design of the subroutines out of which the larger programs for such a machine are built, and then, as this kind of work became standardised, on more general problems of numerical analysis. In 1950 Turing published Computing machinery and intelligence in Mind. It is another remarkable work from his brilliantly inventive mind, which seemed to foresee the questions, which would arise as computers developed. He studied problems, which today lie at the heart of artificial intelligence. It was in this 1950 paper that he proposed the Turing Test which is still today the test people apply in attempting to answer whether a computer can be intelligent: “... he became involved in discussions on the contrasts and similarities between machines and brains. Turing's view, expressed with great force and wit, was that it was for those who saw an unbridgeable gap between the two to say just where the difference lay.

Turing was elected a Fellow of the Royal Society of London in 1951, mainly for his work on Turing machines in 1936. By 1951 he was working on the application of mathematical theory to biological forms. In 1952 he published the first part of his theoretical study of morphogenesis, the development of pattern and form in living organisms.

Turing was arrested for violation of British homosexuality statutes in 1952 when he reported to the police details of a homosexual affair. He had gone to the police because he had been threatened with blackmail. He was tried as a homosexual on 31 March 1952, offering no defence other than that he saw nothing wrong in his actions. Found guilty he was given the alternatives of prison or oestrogen injections for a year. He accepted the latter and returned to a wide range of academic pursuits. Although he was completely open about his sexuality, he had a further unhappiness, which he was forbidden to talk about due to the Official Secrets Act. The decoding operation at Bletchley Park became the basis for the new decoding and intelligence work at GCHQ. With the cold war this became an important operation and Turing continued to work for GCHQ, although his Manchester colleagues were totally unaware of this. After his conviction, his security clearance was withdrawn. Worse than that, security officers were now extremely worried that someone with complete knowledge of the work going on at GCHQ was now labelled a security risk. He had many foreign colleagues, as any academic would, but the police began to investigate his foreign visitors. A holiday, which Turing took in Greece in 1953 caused consternation among the security officers.

Turing died of potassium cyanide poisoning while conducting electrolysis experiments. The cyanide was found on a half eaten apple beside him. An inquest concluded that it was self-administered but his mother always maintained that it was an accident.

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