Alan Mathison Turing
A Man of Machines

The world celebrates the hundredth anniversary of Alan Turing who laid the foundation for the 'intelligent machine'

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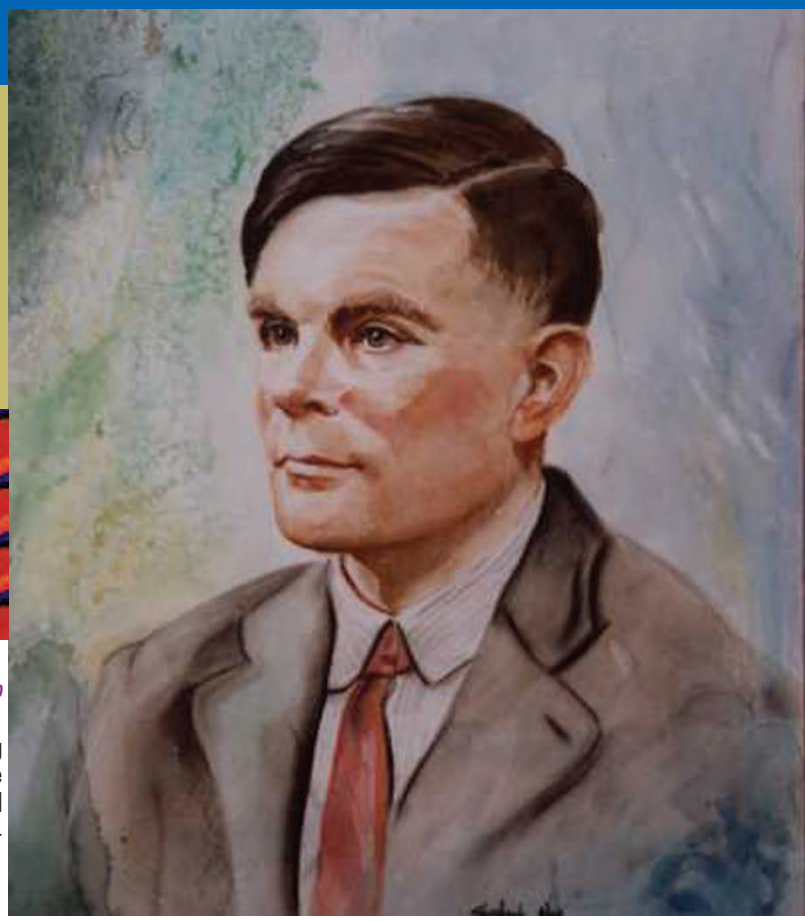


Dip the apples in the brew, Let the sleeping death seep through…

Alan Mathison Turing committed suicide on 8 June 1954. His body was discovered with an apple lying half-eaten beside his bed.

IT is extremely unlikely that Adolf Hitler knew about a British mathematician called Alan Mathison Turing but had Hitler somehow known the fellow he could have identified one more factor that led to his downfall. War historians might scoff at giving too much importance to an individual in deciding the outcome of the Second World War.

But they would be uncomfortable in ignoring the role Turing played in cracking the codes created by the mighty German Enigma machine. Surely, breaking the Enigma code is not the only contribution that Turing made in his lifetime but it was certainly the most important from the historical viewpoint.

Alan Turing returned from America to his homeland England in the fall of 1938 after having turned down an offer to work as John von Neumann's assistant at Princeton. In June of that year he had earned his PhD with a groundbreaking dissertation titled *Systems of Logic Based on Ordinals*.

Back home, he was recruited to join a course on cryptography and encipherment sponsored by the Government Code and Cipher School in London. The school's director Alastair Denniston had heard about Turing's exceptional mathematical ability and was keen on having him among his students. Turing understood the need and was willing to help.

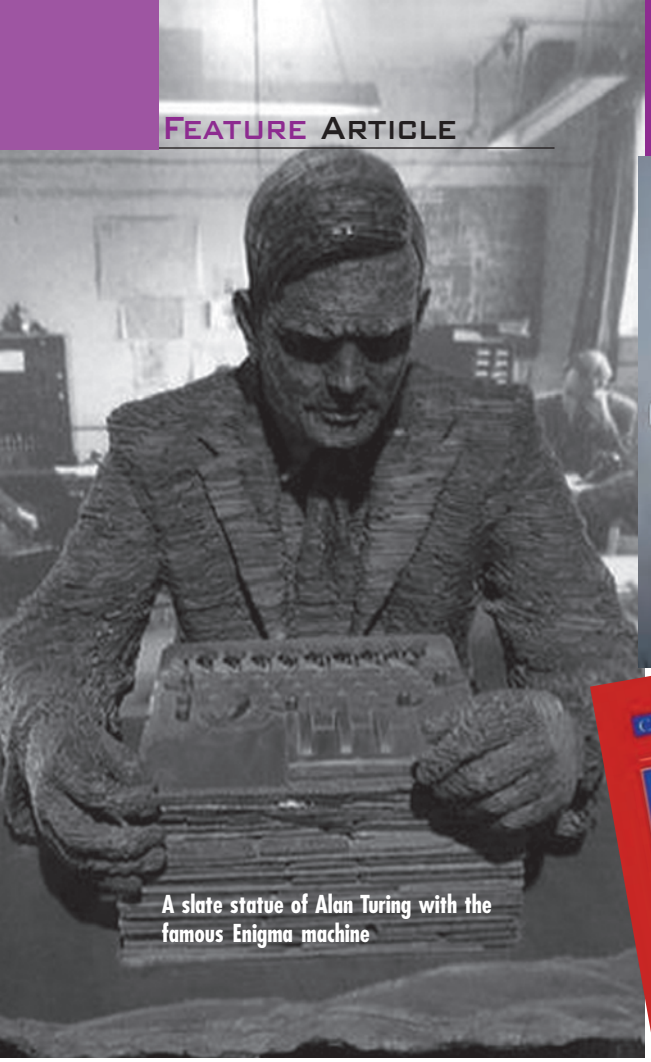
This course and the associated stream of events finally led him to Bletchley Park. Whatever it meant to lay citizens, Bletchley Park, after the autumn of 1939, had become the address of Britain's core group of codebreakers. The German *blitzkrieg* that was conquering countries at a very fast rate had to be thwarted. The Allies, of which Britain was a part, knew that their best bet lay in cracking the secret German code that was making German military progress possible.

Communicating through secret ciphers or codes had been in vogue since time immemorial. Every major user had tried to make his code more complex so that it became unbreakable. But in every age a solution had somehow sprung up. And therefore, no code had been absolutely secure. The Enigma code did succumb to this age-old rule but before that it had set superior standards in encipherment.

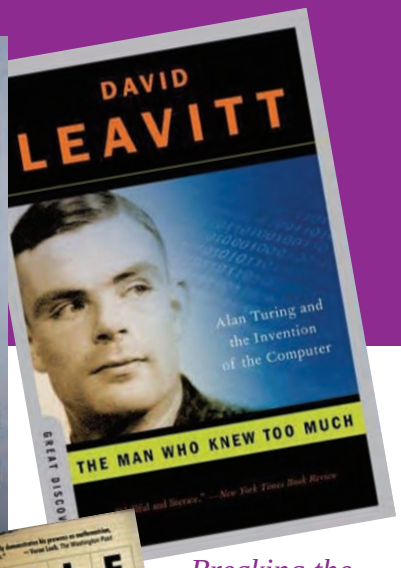
The Machine

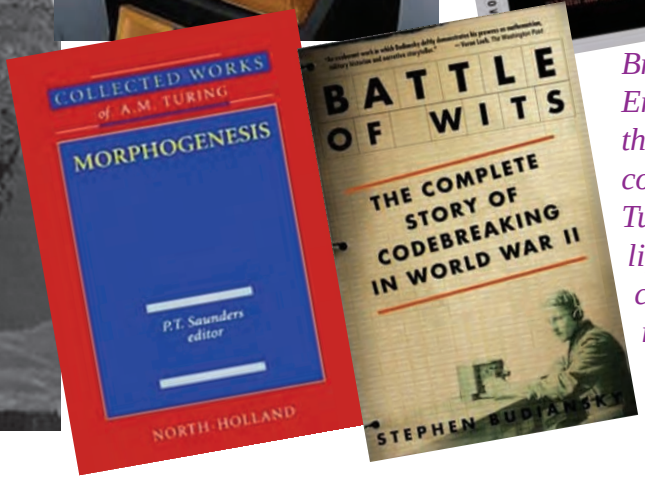
At the end of the First World War the decimation of Germany began through the Treaty of Versailles. It was an unjust and highly biased treaty where the victorious Allies put all the blame on Germany and made it pay heavily for the damages. But deep inside the German psyche there remained an anguish and zeal to avenge this injustice. The Enigma machine can be thought of as being a product of this mentality.

Electrical Engineer Arthur Scherbius designed this machine to replace the inefficient systems of cryptography used in the First World War. It will be wrong to term his effort as 'all patriotism' and 'no profit seeking' because he had made all



A slate statue of Alan Turing with the famous Enigma machine





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necessary arrangements to rake in profit through the sale of his innovation. He founded a company with his friend Richard Ritter and took out a patent for his machine.

It was a formidable cipher machine that combined electrical and mechanical parts. However, the person in charge of encrypting a plain text message for onward transmission was not required to know the structural intricacies of the machine. He could just type the text on the keyboard of the machine and receive a jumbled collection of letters in return. That was the coded message. The receiver, in turn, had to type the apparently meaningless code on the keyboard and voila, he saw the meaningful text message in front of his eyes.

Thus, from the user's point of view it was very friendly and therefore commercially successful. Once the machine was made robust and its usefulness established the German military placed heavy orders for its purchase. In 1925, Scherbius began mass production of his machine for supply to the military forces.

As Simon Singh puts it in his bestseller *The Code Book*, "Over the next two decades, the German military would buy over thirty thousand Enigma machines. Scherbius' invention provided the most secure system of cryptography in the world, and at the outbreak of the Second World War the German military's communications were protected by an unparalleled level of encryption".

Attempting A Break

Germany's neighbours and its adversaries could not sit idle and watch Germany's secret communications go from strength to strength. They had to do something in order to ensure their safety in the years preceding the Second World War. But apart from discovering a traitor in the form of Hans-Thilo Schimdt who supplied the design of the Enigma machine, the French could achieve nothing in this regard.

Poland, however, was desperate to gather information regarding Germany's communications. It had gained independence in the aftermath of the First World War but was afraid that Germany might any day lay claim to its territory. They set up a secret bureau mainly with the aim of cracking Enigma codes. The genius who led the mission was called Marian Rejewski.

Over the years Rejewski built up an elaborate system to decipher Enigma codes. His major achievement lay in discovering the method for finding the key for encipherment. The Germans changed the key everyday or even sometimes once in a few hours and it was the heart of encipherment. Rejewski kept pace with the German military as they made changes to the machine in order to make the encoding a more complex process.

By 1938, the Poles were at the peak of their code breaking success. But then a host of changes at the German end rendered their setup insufficient for the process of code breaking. It was at this point that the Poles invited the British and French cryptanalysis and sought their help. They handed over their technologies and made a fervent plea to carry on with the process. Everyone could sense that a big war was approaching and the British marshaled its strength to take up the Enigma challenge.

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Alan Turing's office at Bletchley Park

Cracking it at Bletchley

On 4 September 1939, Alan Turing reported to Bletchley Park. It was actually a massive building in Buckinghamshire, about fifty miles northwest of London. Admiral Quex Sinclair had bought the house to serve as the base for the functioning of the General Code and Cipher School. It was undoubtedly a center of military activity but the group that arrived there, Turing included, had very little respect for formal behavioural manners.

There were mathematicians other than Turing. Two of them were fellow Cambridge mathematicians namely Gordon Welchman and John Jeffreys. There was another called Peter Twinn. Apart from mathematicians the team had experts from other areas of knowledge also. Hugh Alexander, the British chess champion was there alongwith the writer Malcom Muggeridge. The military establishment had also ensured the services of winners in a competition to solve the *Daily Telegraph* crossword puzzle as fast as possible.

The mathematicians staying at a low building called the Cottage first concentrated on the techniques of code breaking invented by the Poles. Rejewski and his team had built machines to aid their effort. Those were called *bombes*. Several explanations existed as to why it was so named with no particular one claiming to be the correct one. The British establishment retained the name but decided that more developed machines had to be built to crack the Enigma codes.

Turing was the one who designed a new generation of *bombes*. Back in Princeton he had built an electronic multiplier that could encipher messages by multiplying large binary numbers together. So he was the really experienced one in this regard and the responsibility fell on his shoulders.

In fact, Turing had been in love with machines all his life. In 1937, about a couple of years after he was elected a fellow at King's College in Cambridge, Turing saw his revolutionary paper come out in the *Proceedings of the London Mathematical Society*. It was titled "On Computable Numbers, with an Application to the *Entscheidungsproblem*". In it Turing proposed to build a machine that would determine the solvability of the classical *Entscheidungsproblem* or the decision problem. To propose such a step needed sheer courage and radical thinking.

As David Leavitt explains in his book *The Man Who Knew Too Much*, "To speak of a hypothetical computing 'machine', especially in a mathematics paper in the 1930s, was to break the rules of a fairly rigid orthodoxy. No such machines existed at the time, only calculating devices too crude to undertake any complex mathematics, and certainly not programmable." Leavitt is only correct when he writes in such a manner.

G.H. Hardy, the famous number theorist, had earlier summarily dismissed the proposition of mathematicians making their discoveries by turning the handle of a miraculous machine. Hardy simply represented the views of his peers. But Turing was a different breed altogether and thus he could say at one place in his paper: "According to my definition, a number is computable if its decimal can be written down by a machine."

Turing's *bombes* kept the British armed forces informed about all the German measures. As Turing and his colleagues built on their successes the British could anticipate every attack from the German end. When Turing eventually cracked the naval Enigma code of the Germans it spelt doom for Hitler's war efforts. Immediately there was a sharp decrease in the number of Allied ships sunk by German U boats.

One might question the correctness of awarding all the credit of these successes to Turing alone. However, historian Stephen Budiansky puts all such doubts to rest by stating that "the fundamental mathematical insight behind the British *bombe* was wholly Turing's". In his book *Battle of Wits: The Complete Story of Codebreaking in World War II* he gives a neat and vivid description of Turing's

Commemorative stamps on Turing

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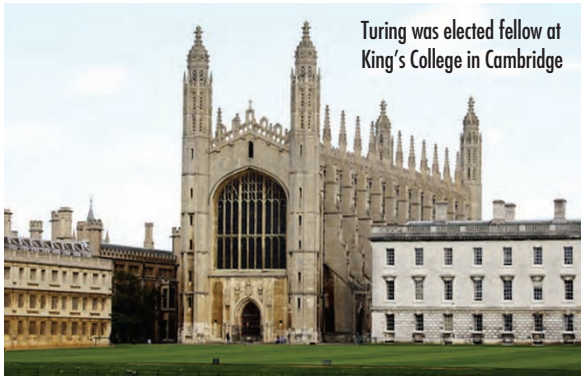
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Turing in 1927

method that later came to be known as Banburismus or more generally as Turingismus.

Andrew Hodges, the biographer of Alan Turing, underlines his prominence at Bletchley Park with these words: "By 1942, Alan Turing was the *genius loci* at Bletchley Park, famous as 'Prof'. There could be no

debate over his contribution to the victory of the Allied Forces in the greatest battle fought on this planet."

However, Turing and all other inmates at the Bletchley Park received no official recognition after the end of the War because cryptanalysis has always been a clandestine activity and thus Bletchley's achievement remained a closely guarded secret even after 1945. It was not until 1974 when Captain F.W. Winterbotham obtained permission from the intelligence services to write a book on the codebreakers that the deserved recognition finally came through.

The Real Turing

Turing started to remove himself from the intense activities at Bletchley Park by the middle of 1942. There was no dearth of work, of course. Max Newman, his mentor at Cambridge, had arrived to take care of the Fish traffic, which was a stream of codes enciphered on a teleprinter. He contributed, even if in a small way, to the building of the Colossus that would effectively decipher the Fish traffic flowing from the German end. But his heart was yearning for more.

Alan Turing wanted to build a machine that would be more general in nature, not like the ones he had dedicated to cryptanalysis. His travel to the United States in November 1942 as part of the decipherment programme helped him a lot. The Bell Labs nourished him with fresh ideas and Claude Shannon of MIT shared his own romanticism of building a machine that would understand the recital of poetry.

In June 1945, Turing joined the National Physics Laboratory at Teddington, which is a suburb of North London. As one of the premier institutes of Britain it was engaged in the task of catching up with America's progress in computing. In that very year two large computing machines, ENIAC and EDVAC from America had set the trail blazing. Now Turing had a real challenge in hand.

He presented his plans to the authorities of the institute of building a machine that would be called ACE, short for Automatic Computing Engine. He insisted that his machine would be a digital one and it would 'learn' by experience. Unfortunately it ran into competition with another machine proposed to be developed by his former classmate Maurice V. Wilkes. As history would have it, the soft-spoken Turing was finally nudged out of the programme though the Pilot ACE was finally built after a fashion.

In 1948, Turing moved to Manchester University at the invitation of Max Newman. There, as Leavitt says, "The machine on which Turing went on to work was a preliminary model intended for small-scale experiments, and thus christened (in keeping with Turing's educational program) the Baby."

Though it became operational in June 1948 it was an extremely difficult machine to handle. It ran into more difficulty when the media riding on a lecture by Sir Geoffrey Jefferson of the Department for Neurosurgery at the Manchester University started attacking the Manchester computer. In fact Jefferson had drawn his ideas from the American Norbert Wiener who is called the Father of Cybernetics. His book *Cybernetics* released in 1948 had stirred the whole world and introduced new thoughts about intelligence of machines.

Wiener was fond of Turing and paid a visit to him in the spring of 1947. Having learnt this Jefferson concluded that Newman and his colleagues at Manchester were actually up to building machines that would compete with human beings. He painted this effort in a light that suited the gibberish of a popular media and the *Times* was very quick to take advantage. It aroused public sentiment against Newman's machine. But Jefferson failed to realize that Newman's team was far from building a robust computing machine, let alone enriched with human intelligence.

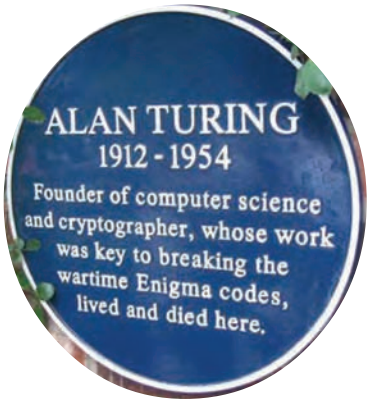
However, not all was in vain as far as the Baby or Manchester Mark 1, as it was later called, was concerned. Thirty-four patents resulted from the machine's development, and many of the ideas behind its design were incorporated in subsequent commercial products such as the IBM 701 and 702 as well as the Ferranti Mark 1. The Manchester Mark 1 continued to do useful mathematical work between 1949 and 1950, including an investigation of the Riemann hypothesis and calculations in optics.

But Turing was inextricably engrossed in his idea of building intelligent machines. In October 1950, his paper titled 'Computing Machinery and Intelligence' appeared in *Mind*. While Wikipedia like many others calls it a 'seminal paper' Leavitt had termed it as Turing's 'most perverse paper'.

In it Turing counters every objection to an intelligent machine in his own inimitable style. He even takes on the theological challenge saying that he is 'unable to accept' the theory that "Thinking is a function of man's immortal soul. God has given an immortal soul to every man and woman, but not to any other animal or to machines. Hence no animal or machine can think."

He puts forth his conviction in the concluding paragraph in these words, "We may hope that machines will eventually compete with men in all purely intellectual fields." In this very paper he introduced the *Turing Test* that determines a machine's ability to exhibit intelligent behaviour. This single paper can explain why Wiener was so fond of Turing and why Alan Turing shares the honour of being the father of Artificial Intelligence with Norbert Wiener.

That he would go ahead to work on mathematical biology especially morphogenesis for the last two years of his



Turing took an intense liking to the film 'Snow White...' and would keep reciting lines from it.

life is no wonder when we consider his zealous attempt at integrating man and the machine.

Snow White and the Seven Dwarfs

The 1937 animated version of the *Snow White and the Seven Dwarfs* produced by Walt Disney was released in America in 1937 but its British premiere took place in the following year. Turing took an intense liking to the film and would keep reciting lines from it. While it might be overtly melodramatic to mention his chanting of two particular lines from the film as he walked through the corridor of King's at Cambridge, it is difficult to resist the temptation. The lines are:

Dip the apples in the brew,
Let the sleeping death seep through…

Alan Mathison Turing committed suicide on 8 June 1954. His body was discovered with an apple lying half-eaten beside his bed, and although the apple was not tested for cyanide, it is speculated that this was the means by which a fatal dose was delivered. Turing had taken the two ominous lines to his end.

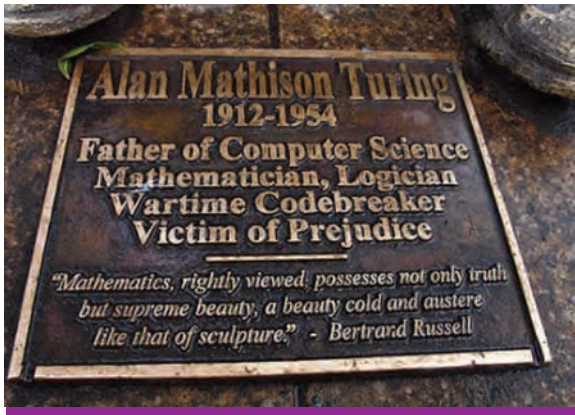
It was not a sudden suicide. Without going into the details that have been written many times since his death it is enough to say that he was charged with homosexuality under the Criminal Law Amendment Act 1885. Homosexual acts were illegal in the United Kingdom at that time and so he was charged with gross indecency. Turing was frank about his sexual behaviour but he had to accept the consequences.

He was given a choice between imprisonment or probation conditional on his agreement to undergo hormonal treatment designed to reduce libido. He accepted chemical castration via oestrogen hormone injections. As Hodges writes, "Once arrested, Turing was turned into a class traitor and cold-war risk in the moral panics and national security crisis of 1952. Amidst this, for him the issues of truth and trust were paramount. *Turing believes machines think, Turing lies with men, Therefore machines do not think,* he wrote, camp humour combined with mathematical camp, but with truth at the centre."

On His Centenary…

Though Alan Turing was born in Maida Vale, London on 23 June 1912 he was actually conceived in Chhatrapur of Orissa in India. His parents moved to England, as they wanted their child to be educated in their homeland. We can vaguely be proud of this Indian connection during his centenary celebrations.

As ordinary world citizens we might also ponder over what he could have achieved if left to grow normally into a mathematician like G.H. Hardy. He was different from Hardy in the sense that he wanted to make mathematics 'useful' which Hardy abhorred. To him reality mattered as he had curtly told the Austrian philosopher Ludwig Wittgenstein who was totally against creating an interface between pure logic and real circumstances.



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He was extraordinary in tackling the decision problem or *Entscheidungsproblem* with a Turing machine. A point may come when all his extraordinary attributes along with his truthfulness and romanticism might gel into a surreal mix in our minds. That is the perfect time to remember his epitaph where is written:

Hyperboloids of wondrous Light
Rolling for aye through Space and Time
Harbour those Waves
which somehow Might
Play out God's holy Pantomime

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