Alan Turing (1912 – 1954) and His Contribution to the Defeat of Nazism

By Brigitte Battat

“”*During World War II, the notion of a machine imitating another machine was to be implemented in the Polish "bomba" and British "bombe." These machines simulated the operation of multiple German Enigma cipher machines and allowed British intelligence to learn of German plans in time to thwart them on land, on sea, and in the air.The British later used Colossus, a prototype of the modern computer, to break messages simultaneously enciphered and transmitted over the Lorenz SZ42 teleprinters between Hitler and his generals.The intelligence reports based upon the breaking of the German Ciphers by these machines were referred to as "Ultra intelligence."The fact that British intelligence was regularly breaking the German ciphers was termed the "Ultra secret." Ultra did not become publicly known until the 1970s,when some of the former codebreakers began to write about it.More recently, thousands of once-classified National Security Agency documents have been released. These documents reveal how machines were used to mechanize the basic intelligence functions of German cipher clerks and British codebreakers*.””

The Alan Turing Institute [AIUK]

There is a cornucopia of information written about Turing’s contribution to science and technology. Various speculations exist about his ultimate demise. The present article is an abbreviated description of Turing’s unique contribution to high tech and the world of computers.

It is said that without Alan Turing’s contribution to the war effort, the allies’ victory against Germany may have taken much longer to materialize and many more casualties would have occurred. Turing was instrumental in developing and influencing actual computing devices that shortened the War by up to two years by decoding encrypted enemy messages that were generally believed to be unbreakable.[1] As the BBC News site[2] stipulates:

“*Turing pitted machine against machine. The prototype model of his anti-Enigma "bombe", named simply Victory, was installed in the spring of 1940. His bombes turned Bletchley Park into a codebreaking factory. As early as 1943 Turing's machines were cracking a staggering total of 84,000 Enigma messages each month - two messages every minute. Turing personally*

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[1] J. P. Bowen. The Impact of Alan Turing: Formal Methods and Beyond. First Online: 14 April 2019. Part of the Lecture Notes in Computer Science book series (LNPSE,volume 11430)

[2] Copeland, B.J.: Alan Turing: The codebreaker who saved 'millions of lives'. BBC News (19 June 2012). http://www.bbc.co.uk/news/technology-18419691

broke the form of Enigma that was used by the U-boats preying on the North Atlantic merchant convoys."

Alan Turing – The Human Being

Alan Turing was a brilliant mathematician. He is considered to be the founder of computer science. During World War II, he was a member of the Bletchley Park team who broke the cipher systems used on the German Enigma machine. The result of this effort contributed to the Ultra intelligence that proved to be a key factor in Allied successes during the war.

Ultra was the designation adopted by British military intelligence in June 1941 for wartime signals intelligence obtained by breaking high-level encrypted enemy radio and teleprinter communications at the Government Code and Cypher School (GC&CS) located at Bletchley Park.[3] Ultra eventually became the standard designation among the western Allies for all such intelligence. The intelligence obtained at Bletchley Park was considered more important than that designated by the highest British security classification then used (Most Secret) and so was regarded as being *Ultra Secret*.[4]

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In their biography on Alan Turing, Hodges and Hofstadter[5] make an interesting comment on the political and technical environment at the time of Turing's birth in 1912. Their analysis may intimate that the ground became fertile for individuals like Turing to develop novel technologies that would change the world.

"Strikes, suffragettes, and near civil war in Ireland had changed political Britain. The National Insurance Act, the Official Secrets Act, and what Churchill called 'the gigantic fleets and armies which impress and oppress the civilization of our time,' all marked the death of Victorian certainties and the extended role of the state. The substance of Christian doctrine had long evaporated, and the authority of science held greater sway. Yet even science was feeling a new uncertainty. And new technology, enormously expanding the means of expression and communication, had opened up what Whitman had eulogized as the Years of the Modern, in which no one knew what might happen next – whether a 'divine general war' or a tremendous issuing forth against the idea of caste."

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Alan Turing taught himself to read in about three weeks, using a book entitled "Reading without Tears."[6] He was, however, quicker with identifying figures, and had the frustrating

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[3] Hinsley, F. H.; Stripp, Alan, eds. (1993), Codebreakers: The inside story of Bletchley Park (OU Press paperback ed.), Oxford: Oxford University Press, ISBN 978-0-19-280132-6

[4] Lewin, Ronald *(2001) [1978], Ultra goes to War (Penguin Classic Military History ed.), London: Penguin Group,* ISBN 978-0-14-139042-0

[5] Alan Turing: The Enigma: The Book That Inspired the Film The Imitation Game - Updated Edition. by Andrew Hodges and Douglas Hofstadter | Nov 10, 2014.

[6] Favell Lee Mortimer. 1866. Reading without tears or, A pleasant mode of learning to read.

habit of stopping at every lamp post and trying to identify its serial number. This obsession translated later into his ability to be a codebreaker.

Good knowledge of the Latin language was a requirement for being accepted at a British public school (i.e., private school). Alan Turing, however, was not interested in Latin, and would rather create number games. His nanny made the following comment about Alan as a young child:

"The thing that stands out most in my mind was his integrity and his intelligence for a child so young as he then was, also you couldn't camouflage anything from him. I remember one day Alan and I playing together. I played so that he should win, but he spotted it. There was commotion for a few minutes…"[7]

During a holiday at Ullapool, in the far north-west corner of Scotland, Alan decided to collect honey for picnic tea. To achieve this, he established the intersection point of the paths of the bees in flight, with the view to find their nest. The retrieved honey was murky but impressed his parents.

In 1922, a benefactor gave Alan Turing a book entitled "Natural Wonders Every Child Should Know,"[8] which opened his eyes to science, and inspired him to understand the structure of machines, in particular, machines that would help him improve writing abilities:

"*April 1 (fool's day)*

Guess what I am writing with. It is an invention of my own it is a fountain pen like this: - [crude diagram] you see to fill it scweeze E ['squishy end of fountain pen filler'] and let go and the ink is sucked up and it is full. I have arranged it so that when I press a little of the ink comes down but it keeps on getting clogged."

In July of the same year, Alan described a crude idea for a typewriter. In 1924, geography and chemistry became his topics of interest.

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In its article on Alan Turing, PBS News Hour[9] provides the following information that adds to further understanding of Turing as a scientist and mathematician:

"Turing's most notable work today is as a computer scientist. In 1936, he developed the idea for the Universal Turing Machine, the basis for the first computer. And he developed a test for artificial intelligence in 1950, which is still used today.

But he also studied physics, especially as a young man. He read Einstein's theory of relativity as a teenager, and immediately filled a notebook with his own thoughts and ideas on the

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[7] Quoted in EST from a letter written to Mrs. Turing after AMT's death.

[8] Natural wonders every child should know, by Edwin Tenney Brewster. Brewster, Edwin Tenney, 1866-1960. New York, Doubleday, Doran & Co., Inc. [c1939]
http://hdl.handle.net/2027/coo.31924001126055

[9] https://www.pbs.org/newshour/science/8-things-didnt-know-alan-turing

subject. He dabbled in quantum mechanics, a new field at the time, as well as biology, chemistry and neurology after the war. Much of this work was related to creating machines that could learn and "think", but some of it came out of simple curiosity about the world."

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From February 1931 to November 1934, Turing studied at King's College, Cambridge, where he was awarded first-class honors in mathematics. His dissertation, "*On the Gaussian error function*," written during his senior year and delivered in November 1934 (with a deadline date of 6 December) proved a version of the central limit theorem[10]. It was finally accepted on 16 March 1935. By spring of that same year, Turing started his master's course (Part III)—which he completed in 1937—and, at the same time, he published his first paper, a one-page article called "*Equivalence of left and right almost periodicity*."[11]

On the strength of his dissertation, Turing was elected a Fellow of King's College. It would appear however, that unbeknownst to Turing, his version of the theorem had already been proven in 1922, by Jarl Waldemar Lindeberg. Despite this, the committee found Turing's methods original and so regarded the work worthy of consideration for the fellowship [Wikipedia].

In 1936, Alan Turing published "*On Computable Numbers*,"[12] which was considered his most important theoretical work. It is often said that all modern computers are Turing machines in hardware. In an article entitled "*On Computable Numbers*," Turing introduced the concept of modern computers and the mathematical study of numbers that could not be computed.

During the early stages of World War II, Turing broke the German Naval Enigma and produced the logical design of the Bombe, an electromechanical code-breaking machine. Hundreds of Bombes formed the basis of Bletchley Park's factory-style attack on Enigma.[11]

Enigma Machine and Its Originators

Arthur Scherbius, a German electrical engineer, patented Enigma in 1918 and offered it to the Imperial German Navy in the same year. Enigma was based upon the rotor principle of enciphering letters. It consisted of three rotors, each about four and a half inches in diameter with twenty-six letters arranged randomly around its circumference. There were, in turn, twenty-six corresponding electrical contacts just below the letters. Three rotors were placed inside the Enigma on a steel rod. When a

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[10] From Wikipedia, the free encyclopedia: In probability theory, the central limit theorem (CLT) states that, under appropriate conditions, the distribution of a normalized version of the sample mean converges to a standard normal distribution. This holds even if the original variables themselves are not normally distributed. There are several versions of the CLT, each applying in the context of different conditions. The theorem is a key concept in probability theory because it implies that probabilistic and statistical methods that work for normal distributions can be applicable to many problems involving other types of distributions.

[11] "AMT-B-10 | the Turing Digital Archive". (https://turingarchive.kings.cam.ac.uk/publications-lectures-and-talks-amtb/amt-b-10)

[12] A. M. Turing. On Computable Numbers, with an Application to the Entscheidungsproblem. First published: 1937. **https://doi.org/10.1112/plms/s2-42.1.230**. London Mathematical Society

typewriter key was pressed, the first rotor moved forward one notch, changing the circuit as a new contact was made and lighting up a letter on the lamp board or screen.

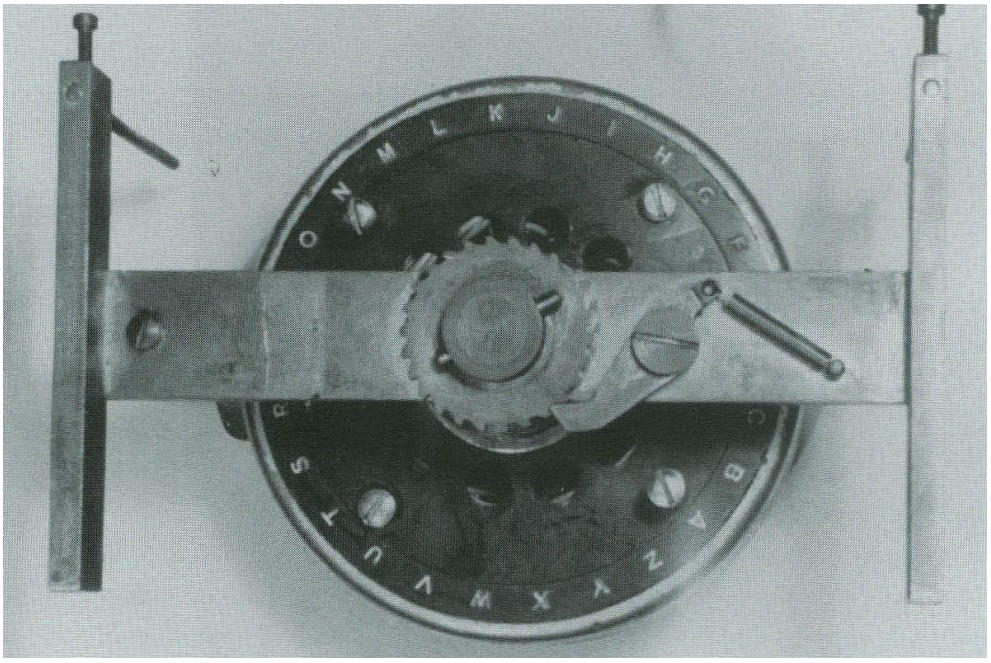

Figure 1 – Enigma rotors, 4 1/2 inch wide, had twenty-six randomly set letters and a battery connection for letter substitution in the coded message.

As an example, if the rotor was set at the letter "A" before typing in text, the text consisted solely of the letter "A" typed repeatedly. For argument's sake, the "A" key might light up first the "H" on the lamp board; on a second occasion, "Y" and on the third occasion, the "D." The rotor had to revolve through the remaining twenty-five positions (twenty-six minus the letter "A") of the wheel before returning to the letter "A" would appear as itself. Thus, "A" would occur once in twenty-six rotations. Adding another rotor that rotated once whenever the first completed its cycle increased the possible circuit combinations to 26 x 26, or 676 letters. In this case, "A" would appear as itself only after depressing the "A" key 677 times! Each new rotor added a factor of twenty-six. "*Four rotors produce a period of 456,976 letters; five rotors, a period of 11,881,376.*"[13]

Later changes increased the invincibility of Enigma. The chance of an enemy cryptanalyst deciphering the messages was one in billions. While these changes were being made and the machine adapted for use by the German armed forces (*the Luftwaffe adopted Enigma in 1935*), other versions with diverse modifications of Enigma made their way into the Bletchley Park. Historian and former Bletchley Park cryptanalyst Frances Harry Hinsley[14] made the following comment:

[13] David Kahn, Seizing the Enigma: The Race to Break the German U-Boat Codes, 1939-1943 (1991), pp. 32-33

[14] F. H. Hinsley, et. al., British Intelligence in the Second World War': Its Influence on Strategy and Operations, vol. 1 (1979), p. 487.

"*By the outbreak of war, as a result of these modifications, the Germans judged that they had rendered it safe even in the event of capture; and they had indeed made it into a cypher system that presented formidable obstacles to the cryptanalyst. Instructions for arranging and setting the wheels could be changed as frequently as every 24 hours; anyone not knowing the setting was faced with the problem of choosing from one hundred and fifty million, million, million solutions*."

Collosus and Its Originators

The British "bombe" machines simulated the operation of multiple German Enigma cipher machines and allowed British intelligence to learn of German plans in time to thwart them on land, on sea, and in the air. The British later used Colossus, a prototype of the modern computer, to break messages simultaneously enciphered and transmitted over the Lorenz SZ42 teleprinters between Hitler and his generals. These teleprinters were German rotor stream cipher machines developed by C. Lorenz AG in Berlin. The SZ stands for Schlüssel-Zusatz, meaning *cipher attachment*.

British cryptanalysts referred to encrypted German teleprinter traffic as Fish. They dubbed the machine and its traffic *Tunny* (meaning *tuna fish*) and deduced its logical structure three years before they saw such a machine.

The intelligence reports based upon the breaking of the German Ciphers by these machines were referred to as "Ultra intelligence."The fact that British intelligence was regularly breaking the German ciphers was termed the "Ultra secret." Ultra did not become publicly known until the 1970s, when some of the former codebreakers began to write about it. More recently, thousands of once-classified National Security Agency documents have been released. These documents reveal how machines were used to mechanize the basic intelligence functions of German cipher clerks and British codebreakers.

Colossus machines were used by the British to decipher the Lorenz SZ42 teleprinter codes. In his article on Collosus, Jack Copeland[15] introduces the background to this machine as follows:

"Colossus, the large-scale special-purpose electronic computer used for code breaking in the 1939–1945 war with Germany, completed its first trial runs in December 1943 (two years before the first comparable US computer, the ENIAC, was operational). From February 1944, cryptanalysts used Colossus to read the priceless German traffic code-named "Tunny" by the British. The exact timing of the D-Day landings in June 1944 was based on intelligence produced by Colossus.

Traditional histories point to Alan Turing as the key figure in the design of Colossus. Yet the recently declassified official history of the attack on Tunny states: "Colossus was entirely the idea of Mr. Flowers."

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[15] B. Jack Copeland. Collosus: Its Origins and Originators. IEEE Annals of the History of Computing. Published by the IEEE Computer Society 1058-6180/04/$20.00 © 2004 IEEE

Tony Sale, curator of the Bletchley Park Museum,[16] explained how Colossus operated during a 1996 lecture at the National Archives:

"What Colossus does, in a nutshell, is to generate the key streams-that is, the sequence of symbols on the wheels of the Lorenz machine-internally in its electronic circuits. It reads the intercepted message tape at 5,000 characters a second, comparing the tape of the intercepted enciphered text with these internally represented key streams. Then, making some very sophisticated cross-correlations, it finds the start-wheel positions for the particular enciphered message."

Colossus used twenty-five hundred valves (vacuum tubes) to generate and store the key stream, which was then compared with the five-hole punched tape input. Its output was the wheel setting used by the Lorenz operator for a given message. These settings were then used on a Tunny machine to decipher the message.

Turing's Post-war Contribution

In his landmark essay "*Computing Machinery and Intelligence*" (1950),[17] Turing raised the question as to how far it is possible in principle for a computing machine to simulate human activities. In his article, Turing considered the central problem of writing a program that could play the "imitation game" and stated the program's goal as trying to imitate an adult human mind. This goal was then modified to simulate a child's brain through programming a "child machine."

""I propose to consider the question, "Can machines think?" This should begin with definitions of the meaning of the terms "machine" and "think." The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous, If the meaning of the words "machine" and "think" are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, "Can machines think? " is to be sought in a statistical survey such as a Gallup poll.

We may hope that machines will eventually compete with men in all purely intellectual fields. But which are the best ones to start with? Even this is a difficult decision. Many people think that a very abstract activity, like the playing of chess, would be best. It can also be maintained that it is best to provide the machine with the best sense organs that money can buy, and then teach it to understand and speak English. This process could follow the normal teaching of a child. Things would be pointed out and named, etc. Again I do not know what the right answer is, but I think both approaches should be tried. We can only see a short distance ahead, but we can see plenty there that needs to be done.""

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[16] Tony Sale quoted in John Cornwell, "The Secret That Beat the Nazis;" The Sunday Times Magazine (May 12, 1996), p. 41.

[17] Turing, A.M. 1950. Computing machinery and intelligence. Mind, 59, 433-460.

Alan Turing vis-a-vis Future Weapons

On December 14th 2017, The Economist magazine[18] published an article on military robots utilizing Artificial Intelligence (AI). On November 12th, 2017, professor of Artificial Intelligence Stuart Russel at the University of California, Berkeley, uploaded a video called "Slaughterbots" to YouTube. The project was funded by concerned scientists and technologists that included Elon Musk, Stephen Hawking and Martin Rees, Britain's Astronomer Royal. The video describes a near-future is set in near-future small drones fitted with face-recognition systems and shaped explosive charges that are programmed to seek out and kill known individuals or classes of individuals (those wearing a particular uniform, for example). In one scene, the drones are shown collaborating with each other to gain entrance to a building. One acts as a petard, blasting through a wall to grant access to the others.

Although the video describes a futuristic weapon, military laboratories around the planet are busy developing small, autonomous robots for use in warfare, both conventional and unconventional.[18] In America, in particular, a program called MAST (Micro Autonomous Systems and Technology), which has been run by the US Army Research Laboratory in Maryland, has been wrapping up the effort after ten successful years. MAST research has been coordinated and paid for by a consortium of established laboratories, notably at the University of Maryland, Texas A&M University and Berkeley (the work at Berkeley is unrelated to Dr Russell's). The successor to MAST entitled the Distributed and Collaborative Intelligent Systems and Technology (DCIST) program, which began earlier in the year 2017, has been getting into its stride.

In a 2017 article, The Guardian[19] newspaper provides the following analysis:

""Because AI-powered machines are relatively cheap to manufacture, critics fear that autonomous weapons could be mass produced and fall into the hands of rogue nations or terrorists who could use them to suppress populations and wreak havoc, as the movie portrays.

A treaty banning autonomous weapons would prevent large-scale manufacturing of the technology. It would also provide a framework to police nations working on the technology, and the spread of dual-use devices and software such as quadcopters and target recognition algorithms. "Professional codes of ethics should also disallow the development of machines that can decide to kill a human," Russell said.""

An article published by the Popular Mechanics magazine on December 8, 2021, describes a Turkish-made Kargu-2 drone. In March 2020, the drone conducted the first autonomous attack on human targets in history, attacking Libyan troops without the control of a human

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[18] The Economist. Science and Technology/Miniature Robotics. 14 December 2017. Military robots are getting smaller and more capable. https://www.economist.com/science-and-technology/2017/12/14/military-robots-are-getting-smaller-and-more-capable

[19] The Guardian. Science. Ban on killer robots urgently needed, say scientists. 13th November 2017. https://www.theguardian.com/science/2017/nov/13/ban-on-killer-robots-urgently-needed-say-scientists

operator. In 2020, Ghost Robotics showed off a rifle-armed quadruped drone (Figure 2), at the annual Association of the U. S. Army convention.

Figure 2 – A quadruped robot with a sniper rifle [20]

Thus, Alan Turing's brilliant abilities to decipher the Enigma and shorten the duration of the war, may also have contributed to the twenty-first century weapons capable of indiscriminate killings.

Conclusion – Alan Turing's Tragic Ending

In 1952, at the age of 39, Alan Turing started a relationship with a 19-year-old unemployed man, Arnold Murray, at a time when homosexuals were convicted for indecency in Great Britain. In an incident, Turing reported to the police a robbery committed at his house. During the investigation, he acknowledged his sexual relationship with Arnold Murray, and was consequently charged with "gross indecency" under Section 11 of the Criminal Law Amendment Act 1885.[21]

Alan Turing was found dead by his housekeeper on June 8, 1954. A postmortem determined that the cause of his death had been a fatal dose of Cyanide.

In his article, David Leavitt[22] writes:

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[20] Popular Mechanics, October 15, 2021. Welp, Now We Have Robo-Dogs with Sniper Rifles. https://www.popularmechanics.com/military/weapons/a37939706/us-army-robot-dog-ghost-robotics-vision-60/

[21] Hodges, Andrew *(2012)*. Alan Turing: The Enigma. *Princeton University Press*. *p*. 471. ISBN 978-0-691-15564-7.

[22] Leavitt, David *(2007). The man who knew too much: Alan Turing and the invention of the computer*. *Phoenix*. ISBN 978-0-7538-2200-5.

"*Did Turing commit suicide, his life rendered untenable by constant hounding due to his homosexuality? The verdict seems pretty clear in retrospect, but it was a conclusion resisted for many years, especially by those very close to him, such as his mother, trying to find all kinds of rationales for alternate interpretations. No matter what, his untimely death only adds to the intriguing character of his life*."

David Leavitt[22] summarizes Alan Turing's contribution to humanity, in a succinct and positive style:

"Turing is a man rescued from obscurity in recent decades, seen as one of the theoretical pioneers of the computer along with von Neumann. More precisely championing the position that computers should be universal machines, thus making a fundamental distinction between hardware and software, in particular understanding that they should not be architectured to the specific problems, as old analog machines necessarily were.

And finally, Turing is a pivotal figure in Artificial Intelligence, making popular the view that machines could think, a view which, to say the least, is highly controversial and disturbing."

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[1] J. P. Bowen. The Impact of Alan Turing: Formal Methods and Beyond. First Online: 14 April 2019. Part of the Lecture Notes in Computer Science book series (LNPSE, volume 11430)

[2] Copeland, B.J.: Alan Turing: The codebreaker who saved 'millions of lives'. BBC News (19 June 2012). http://www.bbc.co.uk/news/technology-18419691

[3] Hinsley, F. H.; Stripp, Alan, eds. (1993), Codebreakers: The inside story of Bletchley Park (OU Press paperback ed.), Oxford: Oxford University Press, ISBN 978-0-19-280132-6

[4] Lewin, Ronald *(2001) [1978], Ultra goes to War (Penguin Classic Military History ed.), London: Penguin Group,* ISBN 978-0-14-139042-0

[5] Alan Turing: The Enigma: The Book That Inspired the Film The Imitation Game - Updated Edition. by Andrew Hodges and Douglas Hofstadter | Nov 10, 2014.

[6] Favell Lee Mortimer. 1866. Reading without tears or, A pleasant mode of learning to read.

[7] Quoted in EST from a letter written to Mrs. Turing after AMT's death.

[8] Natural wonders every child should know, by Edwin Tenney Brewster. Brewster, Edwin Tenney, 1866-1960. New York, Doubleday, Doran & Co., Inc. [c1939] http://hdl.handle.net/2027/coo.31924001126055

[9] https://www.pbs.org/newshour/science/8-things-didnt-know-alan-turing

[10] From Wikipedia, the free encyclopedia: In probability theory, the central limit theorem (CLT) states that, under appropriate conditions, the distribution of a normalized version of the sample mean converges to a standard normal distribution. This holds even if the original variables themselves are not normally distributed. There are several versions of the CLT, each applying in the context of different conditions. The theorem is a key concept in probability theory because it implies that probabilistic and statistical methods that work for normal distributions can be applicable to many problems involving other types of distributions.

[11] "AMT-B-10 | the Turing Digital Archive". (https://turingarchive.kings.cam.ac.uk/publications-lectures-and-talks-amtb/amt-b-10)

[12] A. M. Turing. On Computable Numbers, with an Application to the Entscheidungsproblem. First published: 1937. **https://doi.org/10.1112/plms/s2-42.1.230**. London Mathematical Society

[13] David Kahn, Seizing the Enigma: The Race to Break the German U-Boat Codes, 1939-1943 (1991), pp. 32-33

[14] F. H. Hinsley, et. al., British Intelligence in the Second World War': Its Influence on Strategy and Operations, vol. 1 (1979), p. 487.

[15] B. Jack Copeland. Collosus: Its Origins and Originators. IEEE Annals of the History of Computing. Published by the IEEE Computer Society 1058-6180/04/$20.00 © 2004 IEEE

[16] Tony Sale quoted in John Cornwell, "The Secret That Beat the Nazis;" The Sunday Times Magazine (May 12, 1996), p. 41.

[17] Turing, A.M. 1950. Computing machinery and intelligence. Mind, 59, 433-460.

[18] The Economist. Science and Technology/Miniature Robotics. 14 December 2017. Military robots are getting smaller and more capable. https://www.economist.com/science-and-technology/2017/12/14/military-robots-are-getting-smaller-and-more-capable

[19] The Guardian. Science. Ban on killer robots urgently needed, say scientists. 13th November 2017. https://www.theguardian.com/science/2017/nov/13/ban-on-killer-robots-urgently-needed-say-scientists

[20] Popular Mechanics, October 15, 2021. Welp, Now We Have Robo-Dogs with Sniper Rifles. https://www.popularmechanics.com/military/weapons/a37939706/us-army-robot-dog-ghost-robotics-vision-60/

[21] Hodges, Andrew *(2012)*. Alan Turing: The Enigma. *Princeton University Press*. *p*. 471. ISBN 978-0-691-15564-7.

[22] Leavitt, David *(2007)*. *The man who knew too much: Alan Turing and the invention of the computer*. *Phoenix*. ISBN 978-0-7538-2200-5.