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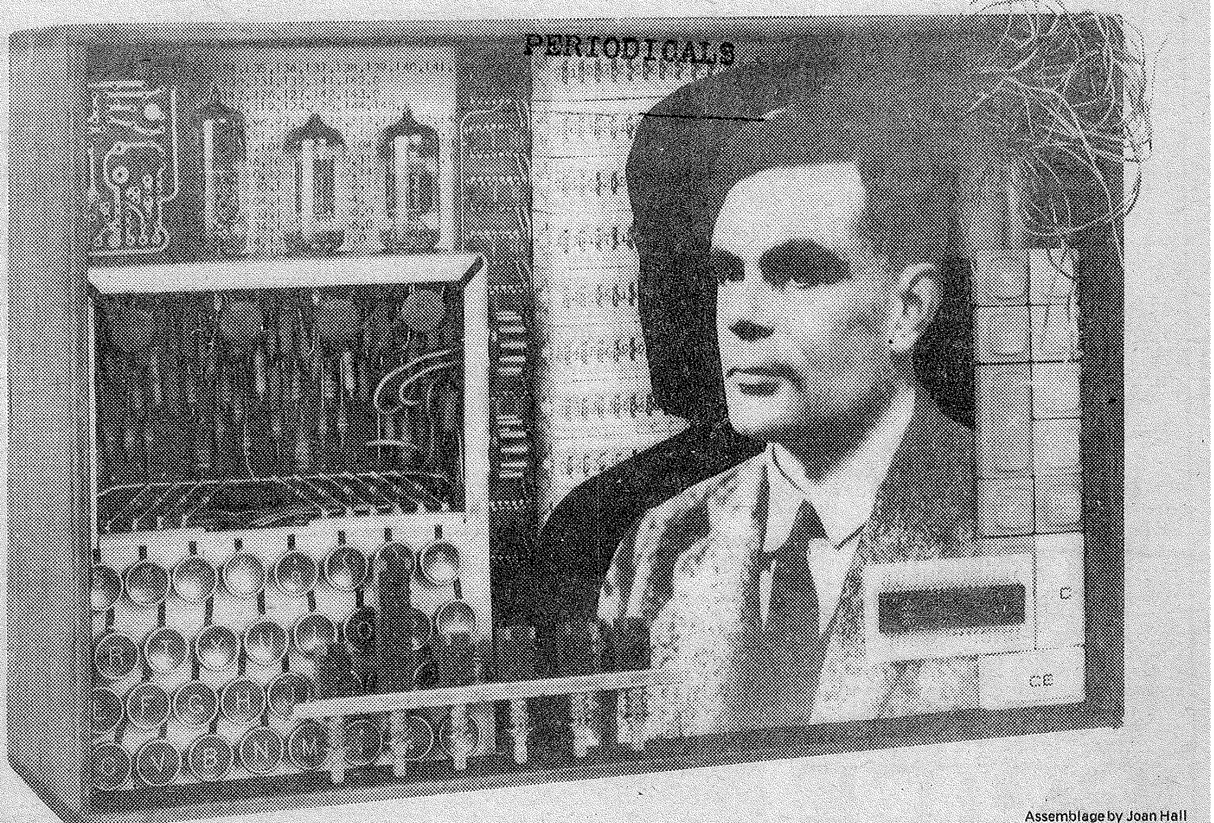
Mind, Body and Machine



Assemblage by Joan Hall

ALAN TURING
The Enigma.
By Andrew Hodges.
Illustrated. 587 pp. New York:
Simon & Schuster. $22.50.

By DOUGLAS R. HOFSTADTER

CAN true intelligence be embodied in any sort of substance — organic, electronic or otherwise? Is mind more than pattern? How can we distinguish between a genuine mind and a clever facade? Do emotions and intellects belong to separate compartments of ourselves? Could machines have emotions? Could machines be enchanted by ideas, by people, by other machines? Could machines be attracted to each other, fall in love? Could a machine destroy itself purposefully one day, planning the entire episode so as to fool its other machine into "thinking" (which, of course, machines cannot do) that it had perished by accident?

Those are the sorts of questions that churned in Alan Turing's brain and, taken on another level, they reveal highlights of Turing's troubled life, a life that Andrew Hodges, a British writer with a doctorate in physics, has wonderfully recounted in "Alan Turing: The Enigma." This biography was painstakingly put together from innumerable sources, including conversations with scores of people who knew Turing at various stages of his life, and it provides as vivid a picture as one could hope for of a most complex and intriguing man. And it's about time, for, although Turing died almost 30 years ago, all we have had until now is a sketchy memoir his mother, Sara, wrote in the 1950's picturing him as a lovable boy of a man who was filled with the joy of ideas and driven by great curiosity about questions concerning mind, life and mechanisms.

Turing, an eccentric English mathematician, was in large part responsible not only for the concept of computers as we know them, as well as for incisive theorems about the powers of computers and a clear vision of computer intelligence, but also for cracking the German cipher code during World War II. Breaking the code was an intellectual feat that is now widely recognized as a key element in the Allies' eventual triumph over the Nazi war machine.

During Turing's life, his work on the Nazi codes was one of England's most closely guarded secrets, so he was never recognized as a national hero. In fact, at the end of his life he was a criminal, since he freely admitted he was a homosexual and homosexuality came under the criminal statutes. When in the 50's he admitted his predilections to the police, the authorities, instead of sending him to prison, committed him to medical treatment they thought might "cure" him. The effect was devastating and in 1954 he committed suicide. He was 41.

By 1939, when Turing was still in his 20's, he had already held academic appointments at Cambridge University and the Institute for Advanced Study in Princeton. When World War II began that year, he was pressed into service as a code breaker at Bletchley Park near Oxford. He and a small group of mathematicians turned their powers of analysis to furthering work done by Polish code breakers. It was known that the German high command was sending orders in a numerical code to its forces, including its vast submarine network, by means of a machine called the Enigma. The exact construction of the Enigma was known, but that knowledge was not enough; the code breakers also had to know the machine's internal state, which could be any one of an astronomical number. Any configuration of several independently-turning rings in the enciphering machine constituted a state; only when they knew that configuration could the code breakers quickly decipher a message.

Collaborating with a few colleagues, Turing analyzed strategies for using coded intercepted messages and high-speed searching machines to pinpoint the Enigma's state. The team worked feverishly as British ships were sunk by German U-boats in such numbers that it was clear the Nazis would bring Britain's war effort to an end unless the Enigma could be outwitted.

At first the members of the team were able to decipher messages only a couple of weeks after receiving them — obviously far too late. Eventually they reduced the gap to a few days, then one day, and finally

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Douglas R. Hofstadter, a visiting scientist at the Artificial Intelligence Laboratory at Massachusetts Institute of Technology, was co-editor of "The Mind's I: Fantasies & Reflections of Self & Soul."

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Mind and Machine

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they could decode messages in minutes. However, it then turned out that the Germans were referring to places by special code names and unusual coordinates so a second layer of decoding was needed. Fortunately, this could be done by watching where ships actually were sunk and correlating that information with decoded messages. Once that was done, it was as if the German fleet in the Atlantic were directly visible on a screen in front of them.

THERE was an immediate dramatic increase in the number of British ships getting through the U-boats' offensive network. To the Germans, this ought to have been a dead give-away that their code had been broken, but they were so certain of the undecipherability of the Enigma machine that they concluded the British must have very good spies, so they looked for the spies rather than inventing a new coding machine. They did occasionally alter the Enigma in various ways throughout the war, however, precipitating desperate scrambles for new theories at Bletchley Park. But Turing and his associates always came up with the theories and the British Government knew regularly, and with certainty, what the Nazi command was up to.

Alan Turing's development as a master of logic and computational theory might look natural in retrospect, but it was not obvious at first. He was born in England in 1912 of relatively well-to-do parents in the civil service in India. After his birth, his parents returned to India for a few years, leaving the boy in England. Then the family lived in France for a time, which gave Alan the opportunity to take school vacations there and learn French.

As a boy, he was inquisitive and humorously inventive but definitely not a prodigy. At 13, he was sent off to a boys' private boarding school in the west of England where he was a rather untidy pupil prone to getting ink all over himself, and one who did not distinguish himself in his classes. But he did excel at mathematics — to the exclusion of pretty much everything else. In the end, his school recognized his great talent and awarded him several science prizes.

When he was 20, he went on to Cambridge. That was in 1933 when the scientific world was charged with the excitement of absorbing several revolutionary discoveries of the previous decade. Relativity, one of Turing's early obsessions, was now old hat, while quantum mechanics and mathematical logic were in their heyday. Quantum mechanics made a deep impression on Turing's mind. In quantum systems, such as an atom, an electron can jump from one orbit (or state) to another without occupying any intermediate position between them. It would be as if a space satellite jumped from one orbit to another in a flash without traveling between them. Equally striking to him was the mechanization of mathematical reasoning which he had read about first in a philosophical book by Bertrand Russell.

Later he studied the ambitious Hilbert program, devised by David Hilbert, whose aim was to demonstrate the possibility of capturing in a single system all the valid principles of mathematical reasoning. In that system, all possible true consequences would flow out of a small set of axioms by means of a well-defined set of rules — like automobiles from an assembly line or physical systems jumping from one state to another. The image of a machine that moved from one state to another by means of a finite set of rules, a machine whose states could be thought to "say" things about mathematics, chess strategies or lines of poetry by anyone who wished to interpret it that way, came to dominate Turing's mind. What such a machine might "mean" was of secondary interest to him; the important thing was to get it to make the jumps from state to state.

IN 1931, the Austrian logician Kurt Gödel devastated Hilbert's and Russell's hopes of creating a perfect formalization of all mathematical reasoning. Gödel had demonstrated that there were undecidable propositions in any axiomatic system of the Hilbert-Russell sort, propositions based on famous paradoxes of logic known since the time of the ancient Greeks. (The sentence, "I am lying," is a good example, as is the attempt to catch a glimpse in the mirror of what you look like with your eyes completely closed.) What Gödel left unsettled, however, was the question of whether, given an axiomatic system and an arbitrary proposition within it, one could determine mechanically whether that proposition was undecidable in that system. If that was possible, one could easily discard undecidable propositions as mere oddities.

Turing chose to work on that problem, to discover whether the undecidable questions could be lopped off the rest of mathematics, leaving the core of mathematics intact and mechanizable. To his surprise, he discovered that, for very Gödelian reasons, no machine could be built that would infallibly recognize undecidable propositions. He began by trying to specify exactly the most general possible notion of what a "machine" is. In fact, the definition he arrived at, now called a "Turing machine," was a central part of his contribution to the theory of computing. Although fundamentally all a Turing machine can do is jump from one discrete state to another by means of very simple transition rules, Turing was able to show that such machines could do anything one could reasonably expect of any machine or any human following well-defined rules.

He went further and showed that a very complex type of machine called a "universal" Turing machine would be capable of being fed a single number that encoded the structure of any other Turing machine much in the way DNA codes for the structure of an organism. The universal machine could then act indistinguishably from the machine whose number it had been fed. If Turing were alive, he might relish Woody Allen's recent character, Leonard Zelig, the "human chameleon" — a living, breathing universal Turing machine, one that can perfectly simulate any other when it is fed the right code number.

Turing's death blow to the hopes of logicians such as Russell and Hilbert was delivered in two stages. First, he supposed that a machine for recognizing undecidable propositions exists; then he showed how that assumption leads to self-contradiction. He began by showing that any such machine would closely resemble a universal Turing machine in that it could accept the description number of any machine and simulate it. Slyly, then, he proposed feeding into this hypothetical machine its own description number. This action, he showed, would instantly send it into a dizzy loop and make it perish of computational vertigo. In other words, the idea of such a machine was self-contradictory. The tantalizing upshot of this convoluted argument is that mathematics remains unmechanizable or, more precisely, incompletely mechanizable, no matter how complex the machine involved.

THOUGH on the surface this defeat for mechanism might seem to imply that human reasoning can always outwit or transcend mechanical imitations, on deeper analysis it turns out that Turing's argument can be applied to humans as well. Consider the yes-no question, "Will your answer to this particular question be 'no'?" You will find that you too go into a sort of computational vertigo in trying to answer it with a yes or a no. Though the example is simplistic, it reminds us of an essential fact of the human condition. People, though aware of their minds, cannot fully take their own complexity into account in attempting to understand themselves and, like Turing machines, baffled by their own descriptions, go into a vertigo of the psyche when they attempt to calculate their own hypothetical or future acts.

Just as people can be surprised by their own complexity, so can machines, in that they can't predict their own behavior. People attribute this feature of themselves to free will and speak of making choices. Turing's observation that machines will go into loops if they try to predict their own behavior suggests they might suffer from a similar delusion. A mechanical approach to the mysteries of consciousness was Alan Turing's dream and by the late 1930's he was a thorough believer in the possibility of a properly organized machine that could be intelligent and conscious and could have free will — at least to the extent that we or any physical object can do so.

The war interrupted Turing's research, of course, but his war work helped his ideas about how machines could imitate the mind to nature considerably. But after the war, in the absence of life-and-death needs to solve the kinds of problems he could handle, his ideas did not seem crucial to people in Government or out of it who might have financed work on them. He tried to find funding to build his universal Turing machine, but his awkwardness in dealing with people and his tendency to advocate long-term philosophical goals along with near-term practical ones seemed to put people off. Rather than gaining respect, he became known as something of an oddball. His powerful vision of the best way to go about creating a universal machine based on his deep preference that all flexibility comes from internal programs rather than hardware was gradually circumnavigated and he found himself left out in the cold. Eventually, a British computer was built at Manchester University in the late 40's but not along the lines Turing had advocated.

FORTUNATELY, while Turing was out of favor in the "proper" intellectual circles, he was able to concentrate on philosophical issues of mechanical thought and in 1950, when he was 38, he put his reflections into a classic article, "Computing Machinery and Intelligence." In it, he proposed what has come to be known as the "Turing test." In effect, he said, "You want to know if that machine can think? Put it behind a curtain and see if it can fool people into thinking it is human by what it types to them."

The test — or "imitation game," as Turing called it — involved communication between a human interrogator and a hidden, language-using "being." Turing took pains to point out the amazing generality of the probing allowed by his test by giving a couple of short sample dialogues in which the human interrogator could elicit odd and recondite knowledge, emotional responses and subtle judgments from the unknown "being." But most people are skeptical because they fear they might easily be take in by the wiles of a superficial machine, not appreciating how deeply and broadly the Turing test allows them to probe. I believe the Turing test's profundity as an examination of an alleged "thinking machine" will only gradually seep into the culture as we absorb the many-layered complexities of computers.

In the early 1950's, Turing's interest turned somewhat away from computers and mathematics and toward biology, and he might have looked forward to a long life pursuing his intellectual dreams. But, as he got older, he also became increasingly vocal about his sexual preferences, often ignoring the advice of friends to be more cautious. Turing's house was burglarized in 1952, and it was quickly clear to him that one of his occasional lovers was involved. In the course of making depositions to the police, Turing revealed his homosexuality. Instantly, the course of his life was irrevocably changed.

At that time in Britain there was a movement to look upon homosexuality as a disease caused by hormone imbalances and physicians had proposed various "cures." Turing was found guilty of homosexuality and was sentenced to "treatment" rather than jail. Regular injections of female sex hormones were given to him to quell his sex drive. Turing did not want to try to use any of his connections in government or the academic world to mitigate his sentence and he simply endured it, growing breasts and being rendered impotent by the time the treatment ended in a year.

The torment he endured, Mr. Hodges says, left permanent scars. For the next couple of years Turing appeared for the most part quite happy to his friends. But one day in 1954, he prepared a cyanide-coated apple, just as he had once seen the wicked witch do in Walt Disney's "Snow White and the Seven Dwarfs." Unlike her, he bit into his own apple, and he was found dead the next day. He planned it in such a way that his mother would interpret it as an "accident with chemicals," but others knew better. Although today all evidence strongly suggests that the machine known as Alan Mathison Turing halted itself of its own free will, the ultimate reason remains an enigma to us, an undecidable question.

ANDREW HODGES has painted in his book a portrait of a multifaceted man whose honesty was too much for his times and who brought about his own downfall. Beyond the sympathy Mr. Hodges evidently feels for Turing, there is another level of depth and understanding, one that makes all the difference in a biography of a scientific figure — scientific accuracy. Mr. Hodges is obviously intrigued by all of Turing's ideas, and he has done an admirable job of presenting them in detail to the lay reader. This book is a first-rate presentation of the life of a first-rate scientific mind and, because this particular mind was attached to a body that had a mind of its own, the book raises some very important social questions as well. Turing would have shuddered if he had ever known that his life story would be made public, but he is in good hands; it is hard to imagine a more thoughtful and warm biography than this one. ■