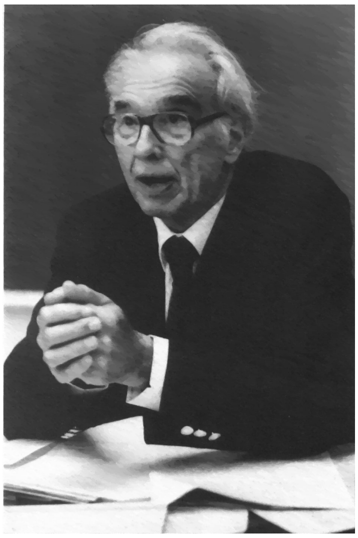
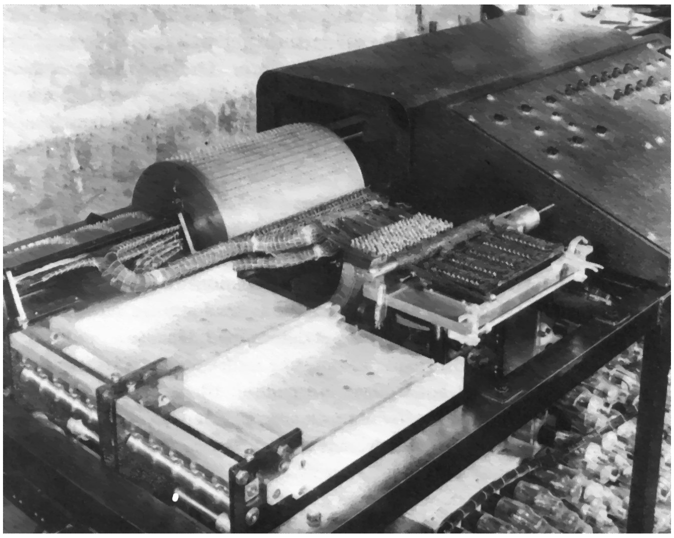
John Vincent Atanasoff: Inventor of the Digital Computer

October 3, 2006





History of Computer Science (2R930)
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Abstract

This essay is about John Vincent Atanasoff's greatest invention, the Atanasoff Berry Computer or ABC. We look into the design and construction of this computer, and also determine the effect the ABC has had on the world. While discussing this machine we cannot avoid the dispute and trial surrounding the ENIAC patents. We will try to put the ENIAC in the right context with respect to the ABC.

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Contents

1 Introduction

In 1937 a professor of mathematics and physics went for a long drive to Illinois. Forgetting his daily troubles, he conceived several ideas that in the 21st century still change the world. These ideas led Professor John Vincent Atanasoff together with his PhD assistant Clifford Edward Berry[1] to inventing and building the Atanasoff Berry Computer (ABC), the *first digital electronic computer* of the world.

This essay looks into the four ideas conceived by Atanasoff and the effect the ABC had on the world. We also examine the machine built by John W. Mauchly and J. Presper Eckert, the ENIAC, and some of its principal ideas since we cannot avoid the dispute and trial surrounding the ENIAC patents. However, we will try to put the ENIAC in the right context with respect to the ABC and hereby not disregard its tremendous contributions.

1.1 Outline

In the next section we will give some background information about John Vincent Atanasoff, the main character of this essay. His invention, the ABC, is discussed in section 3.

In section 4 we will explain what the ENIAC and EDVAC have to do with this story. The patent lawsuit that revolved around the ABC and ENIAC is briefly discussed in section 5. This lawsuit made the ABC more known and visible to the public, but still most people cannot give you the answer to the question "Do you know who invented the first computer?". Possible reasons why this is the case will be discussed in section 6. We'll finish this essay with section 7, the conclusion.

Here is a list of useful acronyms of computing machines of the years 1935–1955 used throughout this essay:

ABC Atanasoff Berry Computer

ENIAC Electronic Numerical Integrator And Computer

EDVAC Electronic Discrete Variable Automatic Computer

UNIVAC UNIVersal Automatic Computer

2 Atanasoff before the ABC

To give more insight into the knowledge and qualifications that gave John Atanasoff the basis needed to invent the first digital computer, his education and achievements before his work on the ABC are described in this section. We got the information in this section mostly from [BB88] and [Mol88].

[1] John Vincent Atanasoff, Clifford Edward Berry and John William Mauchly will often be referred to by us with Atanasoff, Berry and Mauchly respectively for abbreviation purposes. With these abbreviations we intend no disrespect.

John Vincent Atanasoff was born on October 4, 1903 in Hamilton, New York. We begin the account of Atanasoff's scientific life with his high school education.

Atanasoff started high school in 1919 and finished 2 years later with excellence in both Science and Mathematics, after which he went on to study at the University of Florida (1921). His Bachelors degree in *Electrical Engineering*, which he got in 1925, gave him the knowledge of electronics that would later aid him in creating his electronic computer.

After finishing his Bachelor, Atanasoff got his Masters degree in Mathematics from Iowa State College in 1926, where he subsequently got a job teaching physics and mathematics. While he was teaching, he also got his Doctoral degree in *Theoretical Physics* from University of Wisconsin in 1930.

In his doctoral thesis, "The Dielectric Constant of Helium", Atanasoff was required to do many complicated and time consuming computations on the Monroe mechanical calculator. This, amongst others, is what sparked his interest in developing a better and faster computing machine.

In 1930 Atanasoff returned to the staff of Iowa State College and began the work that would eventually lead to the invention of the ABC.

3 The Atanasoff Berry Computer

The computing machine that is central to this essay was conceived in 1937 by Atanasoff. The purpose of this machine was to solve up to 29 *simultaneous linear equations* with up to 29 variables. He built the machine with the help of Clifford Berry and therefor it was later named the Atanasoff Berry Computer. The core of the machine was finished in 1939, but it would take until 1942 to built the complete computer (see [RRH00, Wika]).

This section first discusses the key principles of the ABC, followed by a description of the design and workings of the computer. After this the construction of the design is treated, both of the prototype and the final implementation. We end this section with a comparison of the ABC to other computing machines of that era.

3.1 Key principles

The ABC is based on four key principles that discern it from other computing machines of that time. These principles are the separation of memory and computational units, the use of electronic switching (by means of vacuum tubes), calculations based on binary numbers and the use of a regenerative memory. We will look into each of these concepts in more detail. For a truly detailed description, see [BB88] and [Mac88].

1. **Separation of computation and memory:**
   When Atanasoff first started designing the ABC he intended to use scale-of-two electronic counters that were available at that time. However, after

months of experimenting, he discarded them due to "the inherent instability of the circuits" [BB88, chapter 2].

Discarding them however, meant that he had to replace them with a different implementation. His solution was based on an observation of the workings of the electronic counter, specifically that the counter incorporated two distinct functions: the addition of the numbers and storage of the results. By implementing these functions separately, he could greatly simplify his design and avoid using counters. He was able to do this because he had already developed a separate memory unit.

2. **Regenerative memory:**
   The memory of the ABC consisted of rotating drums, in which capacitors were mounted. There were two large memory drums for the main number storage, named the keyboard and counter drums, as well as a smaller drum used to store carry or borrow bits. These drums can be seen on the rear of the ABC as depicted in figure 1 (page 7).

   Each of the two main drums had 1600 capacitors, each of which had one contact that was connected to the ground and another that was connected to a stud penetrating surface of the the drum. A simplified version of this can be seen in the memory disk of the prototype in figure 2. The studs were arranged in 32 bands of 50 studs, of which 30 bands were used to store numbers of 50 binary places and 2 bands were used as spares. The capacitors were used in a binary mode, where a high capacitor voltage indicates a zero and a low capacitor voltage indicates a one.

   The studs in a band were placed at 6 degree intervals, occupying 300 degrees of the drums circumference. The remaining 60 degrees were left empty, to allow for time to do control actions. Each rotation of the drum took one second, meaning that of each second about 835 ms were used for calculation and 165 ms for control purposes.

   The main problem with using capacitors as a memory unit is that they lose their charge. In the ABC calculations were always done by adding or subtracting a number on the keyboard drum to a number on the counter drum. This method meant that the capacitors on the counter drum were constantly refreshed, but that the capacitors on the keyboard drum would slowly discharge. The solution Atanasoff found for this is to "jog" the memory, meaning that the data read from the keyboard drum was not just forwarded to the counter drum but also written back to the keyboard drum, thereby regenerating the capacitor charge.

3. **Logical/electronic switching (by means of vacuum tubes):**
   Since the memory problem was taken care of, the next main part needed was a means of adding or subtracting two numbers. Atanasoff's had the insight that one could use electronic switching to do (per digit) addition and subtraction by using tables predetermining the required output for every possible combination of input digits. He described it as the result being calculated as if having "been taught by a man with a soldering iron to select the right answer" [BB88, chapter 1]. Of course, when working on a base 10 scale, these (electronic) tables become huge, making this approach highly infeasible. Atanasoff solved this by doing all his calculations on binary numbers.

4. **Binary system:**
   In order to keep the addition and subtracting tables of a manageable size, the ABC calculates on binary numbers, which means that there are only 8 possible input/output combinations [2]. Inputs to the system were given in decimal form, converted to binary for internal use and when the answer was calculated it was converted back to decimals. Since the drums could handle 50 binary places using two's complement notation, the ABC was able to handle digital numbers of up to 15 decimal places. The internal use of binary numbers meant that the machine could be much simpler and therefor cheaper than if digital counters had been used.

The principles developed in the ABC established the feasibility of electronic computing and (derivations) can still be found in modern computing machines. One specific computer that used many of the above concepts was the ENIAC, which will be treated further in section 4.

3.2 Design

In the summer of 1939, Atanasoff wrote a 35-page manuscript containing the complete design of a machine capable of electronically solving linear equations[3]. To explain the design we will distinguish four phases of a typical calculation performed by the ABC[4]: initialisation, forward elimination, backward elimination, and finalisation.

A schematic version of the system can be seen in figure 1. In the explanation we describe the functionality of the parts of the system visible in figure 1 and denote them with italics. We assume in the explanation that the system has to solve X linear equations with X variables. A linear equation is considered to be of the form: $c_1x_1 + c_2x_2 + \cdots + c_Xx_X = V$, where x_1, x_2, etc. are variables, c_1, c_2, etc. are coefficients and V a given value.

Initialisation For each of the X input equations the following steps are taken:

1. Punch the coefficients of the equation on a decimal card.
2. Feed the card to the *decimal card reader.*
3. The computer will then read the decimals and use the *decimal-to-binary conversion drum* with the *add-subtract logic circuits* to convert the decimal value to a binary one on the *counter drum.*
4. The contents of the *counter drum* are sent to the *base 2 output puncher* and written to a binary card using the *electrical card-punching circuits.*

[2] That is, 2^3, a bit from both the keyboard and counter drum and a carry/borrow bit from the carry-over drum

[3] The manuscript was called "Computing Machines for the Solution of Large Systems of Linear Algebraic Equations". It was reprinted in [Ran82].

[4] Since there are several ways to perform a calculation we will follow the steps used in chapter 1 of [BB88].

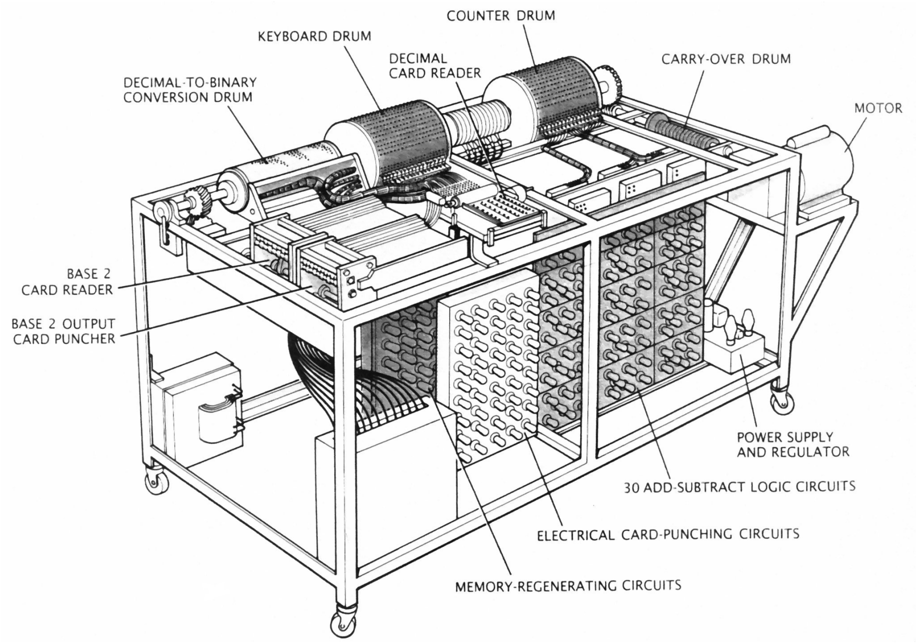

Figure 1: Schematic view of the complete ABC [Mac88]

Forward elimination The purpose of forward elimination is to systematically apply Gaussian elimination on the input equations and subsequently on derived equations to find an equation of the form $c_k x_x = V$, thus establishing a value for one variable. By finding this equation, the set of simplified equations that is used for backward elimination has automatically been found as well.

First, or each sequential pair of equations (equation (1) with (2), (2) with (3), etc.) the computer will:

1. Read the first equation of the pair via the *base 2 card reader* to the *counter drum.*
2. Read the second equation of the pair to the *keyboard drum.*
3. Perform Gaussian elimination[5] on the two equations using the *add-subtract logic circuits*, storing the end result on the *counter drum.*
4. Write the contents of the *counter drum* to a binary card.

When all $X - 1$ pairs have been processed there is one less variable to consider. The procedure is repeated for $X - 2$ pairs, $X - 3$ pairs, etc. until there are no pairs left.

[5] Atanasoff had derived his own version of Gaussian elimination of a variable in two linear equations to avoid multiplication and division. This algorithm is explained in detail in section "Atanasoff's Elimination Algorithm" of [BB88].

Backward elimination After the forward elimination, there is one equation that establishes the value of one of the X variables. This value can be substituted in all other equations to decrease the number of unknown variables.

The following actions are performed given i known variables counting from 1 up to X:

1. Read one of the equations with $i + 1$ variables (of which i are known automatically) to the *counter drum*.
2. Perform Gaussian elimination i times (for each known variable) which results in a new equation establishing the value of the $(i + 1)^{\text{th}}$ variable on the *counter drum*.
3. Write the contents of the *counter drum* to a binary card.

The result of the backward elimination is a set of X binary cards containing a value for each variable.

Finalisation The last step is to take each binary card of the solution set and convert it to a decimal card via the *counter drum* and the *binary-to-decimal conversion drum*.

Note that this is a somewhat simplified explanation of the inner workings of the ABC. For a more detailed explanation of the design, see [Mac88] and chapter 1 of [BB88].

3.3 Construction

John Atanasoff started the construction of the ABC together with Clifford Berry in September, 1939. Berry had been involved as an assistant since the spring of 1939 and his insights into electrical engineering turned out to be of great assistance throughout the entire project.

They begun by building a prototype, which was used to test and demonstrate two ideas: electronic logic circuit switching and the regenerative binary memory. This effectively implemented all four key principles. A schematic view of the prototype can be seen in figure 2. A description from [Mac88]: "It had two memory abaci, mounted on the opposite sides of a plastic (Bakelite) disk. Each abacus consisted of 25 capacitors and hence was able to hold a 25-digit binary number [...]."

The prototype was finished in October, 1939. Although it was hardly faster than a person calculating with pen and paper, it did show that the principles were viable for a computing machine. The demonstration of the prototype to Iowa State College officials showed them that the ABC project should get a $850 grant, which they eventually received in December, 1939. This money allowed Atanasoff to start buying components for the full-scale computer.

Using all the time they could spare and even using some students during practical assignments, Atanasoff and Berry finished the computer (see figure 1) in

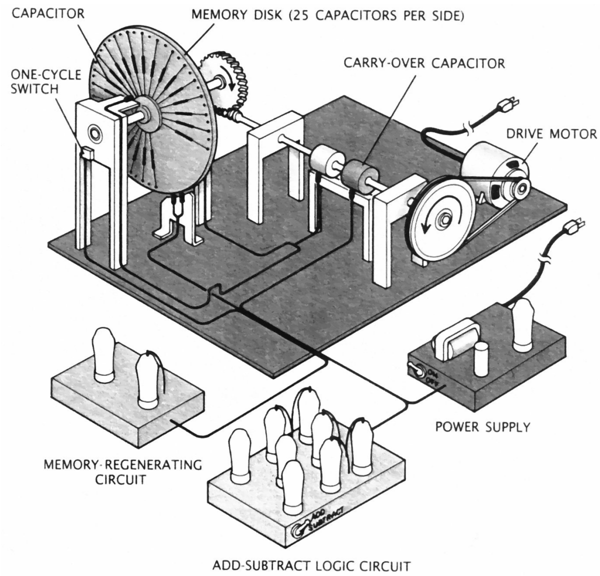

Figure 2: Schematic view of the prototype [Mac88]

May, 1942. Except for the base 2 output card puncher everything in the machine worked perfectly.

In chapter 3 of [Bur03] Atanasoff explains the problem with the input-output system. The system was used to temporarily store values by sparking (or charring) certain points on punch-cards of high quality paper. However, nearing completion of the machine, industrial supply of quality grade paper was getting scarce due to the war. This led to the machine making errors while reading and writing these intermediate values once every 10,000 times. The end result was that the machine couldn't handle a large number of equations without making errors.

Unfortunately, Atanasoff did not know that IBM already had card punching machines at that time that could have solved this problem. If he had known then he would most likely have been able to create a fully working computer.

3.4 Comparisons

Though the ABC is an impressive machine all by itself, its true significance can best be understood by comparing it to other machines of its era. The main computers at the time of the ABC were mechanical calculators and analog integrators, which were both used frequently by Atanasoff during his graduate and promotion work. To cite Atanasoff's definition of an analog computer, taken from [Mol88]:

> "The analog computer is a machine in which a number is represented by a physical quantity as measured by some system of units [...] If we desire to determine the number more exactly, we have to measure the quantity more exactly [...]."

According to Atanasoff "analogue" devices were contrasted by "computing machine proper" (the term "digital" was not in use yet). Atanasoff's terminology already indicated that he was conscious of the notion that computing could be done in a better, more proper way. He probably had concluded this from his experience with the Monroe calculator which was very tiresome to use. He also investigated if the Differential Analyser, invented by James Thomson and built in 1927 by Vannevar Bush, could be modified to solve algebraic equations which he encountered a lot in his field of work. However, he concluded that it was not within the capacity of this machine.

Computer	Nation	Year	Digital	Binary	Electronic	Programmable
ABC	USA	1937–42	Yes	Yes	Yes	No
Zuse Z3	Germany	1941	Yes	Yes	No	Fully
Colossus	UK	1944	Yes	Yes	Yes	Partially
Mark I	USA	1944	Yes	No	No	Yes
ENIAC	USA	1946	Yes	No	Yes	Partially

Table 1: Comparison first digital computers (derived from [Wikb])

To compare the ABC with some of the digital computers of that time (1935–1950), see table 1. The machines listed in the table are considered to be the first five operative digital computers. The link to the ENIAC, the differences and similarities, will be discussed in the next section.

4 What about the ENIAC and EDVAC?

In this section we look into the relation between the ENIAC/EDVAC and the ABC. First the history of the ENIAC is described, after which the information that Mauchly learned from Atanasoff is examined. Finally the ENIAC and EDVAC concepts that were derived from the ABC are described as well as the innovations and changes that were specific to the ENIAC and EDVAC.

4.1 History of the ENIAC

The ENIAC, or Electronic Numerical Integrator And Computer, is a computer that was build by J. Presper Eckert and John W. Mauchly at the Moore School of Electrical Engineering. It was sponsored by the US Army, for use with the creation of ballistic firing tables. Building began on May 31, 1943 and two and a half years later, in December, 1945, it solved its first problem. Shortly after that, in February of 1946 it was presented to the general public for the first time. The Electronic Numerical Integrator And Computer (ENIAC) is seen as the worlds first general-purpose electronic computer.

4.2 Meetings and letters between Mauchly and Atanasoff

This section describes the meetings and information exchanged between Atanasoff and Mauchly in 1940 and 1941, two years before the start of the ENIAC project. The information comes from the Honeywell vs. Sperry Rand patent court case, further described in section 5.

Atanasoff and Mauchly first met in December, 1940 at the American Institute for the Advancement of Science in Philadelphia. At this meeting Atanasoff told Mauchly that he was building a computer that used vacuum tubes, was digital and could be built at $2 per digit[6]. When Mauchly showed great interest in this computer and wanted to know more, Atanasoff told him that he would have to come visit him in Iowa, since he would not disclose any more information at that time.

Between this first meeting and the trip Mauchly made to Iowa in June 1941, there were a number of letters sent back and forth. The most important points conveyed in these letter were the interest Mauchly showed in the ABC and Atanasoff's indication of willingness to tell all about the ABC at the visit.

One important thing to note is that Atanasoff told Mauchly that he had thought of a way to easily adapt the ABC to do differential equations digitally by using numerical integration. This is one of the main techniques later used in the ENIAC.

The Iowa visit

On June 13, 1941 John Mauchly and his six year old son paid a four day visit to John Vincent Atanasoff and his family in Ames Iowa. During this visit Mauchly got demonstrations of the ABC by Atanasoff and Clifford Berry, though the machine was not yet fully operational. More specifically, all different components were operational, but not all components were integrated. Therefor automation of the complete calculating task did not work and tests involving multiple components were done using temporary control devices [BB88, chapter 3][Mol88, chapter 6].

According to Atanasoff, the exposure of Mauchly to the ABC consisted of two three hour sessions[7]. During these sessions he had demonstrations of and discussions about the computer, as well as hands on experience when he helped Berry do some minor assembly jobs. Besides the direct contact to the ABC, Mauchly also read the 35-page design manuscript (see also section 3.2), though he was not allowed to take it home [BB88, chapter 3][Mol88, chapter 6].

Correspondence after the visit

During the rest of the year after the visit to Iowa there were several letters written by Mauchly and Atanasoff. These letters give a better insight into the effect that the exposure to ABC had on Mauchly[8].

[6]Extending the ABC to handle numbers with more than 29 binary digits would cost about $2 per digit.

[7]Corroborated by Sam Legvold [BB88, chapter 3].

[8]The most important letters are bundled in appendix A of [Mol88].

In these letters Mauchly wrote that he had become enthusiastic about the possibility of building an electronic computer. Though he did not yet have any solid plans for a computer design of his own, he felt the need to learn more about electronics to help him to possibly create one in the future. Therefor he had become a student again.

Mauchly also wrote a letter to meteorologist H. Helm Clayton in which he describes his perception of the ABC [BB88, chapter 3]. He saw it as a very fast electronic computer, which was nearly completed. He also believed that the ABC could be adapted to solve systems of differential equations more rapidly than the Bush's Differential Analyser and at less cost.

On September 30, 1941, Mauchly wrote a letter to Atanasoff in which he discussed his plans to build an electronic computer [BB88, chapter 3] and asked to incorporate some of the features of the ABC. Atanasoff replied that the patent on the ABC was still pending and that therefor he could not give Mauchly permission to freely use his ideas at that time.

The next section will show that despite Atanasoff's refusal to allow Mauchly to use the ideas of the ABC, a number of key concepts still made their way into the ENIAC and Electronic Discrete Variable Automatic Computer (EDVAC).

4.3 ENIAC and EDVAC concepts derived from the ABC

As described in the preceding text, a number of key concepts of the ENIAC were already invented by Atanasoff and implemented in the ABC. There were also a number of concepts that we have not described but can be found in [BB88, chapter 5].

- The binary use of vacuum tubes.
- Vacuum tube switching, i.e. the combination of these tubes into complex switching circuits for computation and control.
- Timing and sequential control of the computer's operations.
- The use of modular units.
- Doing differential equations digitally by using numerical integration[9].

There are also a number of concepts from the ABC that were not used in the ENIAC, but were used in the EDVAC:

- An arithmetic unit using a logical binary serial adder.
- A separate memory using regeneration by vacuum-tube circuits.
- Binary number system.
- Clock timing.

[9]This was not implemented in the ABC but thought of by Atanasoff as mentioned in section 4.2.

4.4 Innovations in the ENIAC and EDVAC

Of course, the ENIAC and EDVAC were not solely based on the ABC, they made some very important innovations for themselves. The most important improvement of the ENIAC was that its internal operations were entirely electronic, which resulted in a major speed improvement over the ABC. Another major improvement was that the ENIAC was programmable using a plug-board. Two other differences between the ENIAC and the ABC were that the ENIAC had accumulators based on counters and a distributive architecture. However, these differences were reverted in the EDVAC.

The EDVAC brought another number of major improvements. First of all, the mercury-delay-line store. Though it was regenerated in the same way as the memory in the ABC it was a lot faster and had much more capacity. Another one of the great inventions used in the EDVAC was Von Neumann's self-modifying program language, which made the EDVAC much more versatile than any of its predecessors. The EDVAC also introduced the notion of centralised control.

4.5 Conclusion

Based on the preceding section, we think we can safely conclude that the ABC has had an important influence on the development of both the ENIAC and the EDVAC. This was also established by the court ruling discussed in section 5.2. We can however not ignore the major improvements both the ENIAC and the EDVAC have made over the ABC. These computers brought computing to the general public.

5 Proof, court & patents

In the years after the war (1950–1970), Atanasoff became more suspicious that Mauchly had used some of his ideas in the ENIAC without telling him or giving him credit for it. This led eventually to a court case in 1971 (filed in 1967). But a lot happened before that. We discuss the precursors of the court case and the case itself in this section.

Note that in that time, court material was not yet digitised and thus is not available to us. So most information in this section concerning the trial was found in transcriptions of the trial records made by several authors ([Mol88, Bur03]).

5.1 The IBM settlement

In 1954–1955, Atanasoff was approached by IBM patent lawyers to break two ENIAC patents[10] held at that time by Sperry Rand Corporation. Atanasoff cooperated by recollecting papers and memories about the time of Mauchly's visit to Iowa State College in 1941 (see section 4.2).

[10] The Mauchly-Eckert patents in question were 2,629,827 (delay line memory) and 3,120,606 (the ENIAC itself).

In 1956 there was a long silence from IBM's side and Atanasoff assumed the lawyers had concluded that the case wasn't worth pursuing (see also chapter 9 of [Mol88]). However, in 1957 he discovered that IBM had entered a patent-sharing agreement with Sperry Rand Corp. This encouraged Atanasoff's distrust of patent lawyers which resulted in a long period of no counter-action against Sperry Rand Corp.

5.2 Patent war and the court case

As Allan R. Mackintosh writes in [Mac88], the recognition of Atanasoff's achievement was not the product of research and investigation but a result of a lawsuit. Actually, two lawsuits were involved: Sperry Rand Corp. was suing Honeywell, Inc. because the company infringed the *the ENIAC patents* and Honeywell was counter-suing Sperry for violating antitrust regulations and enforcing an invalid patent. Both cases were filed in 1967 and led to the case *Honeywell, Inc. v. Sperry Rand Corp. et al*[11] that started in 1971 and was closed in October 1973.

The heart of the case revolved around determining what Mauchly actually had learned during his visit to Iowa State College (see also section 4.2). This was a tedious task for the presiding judge Earl R. Larson, because many parts of the accounts made by Atanasoff and Mauchly were contradictory. The chapters 1–3 of [Bur03] capture the essence of these accounts very well (see also chapter 17–20 of [Mol88]).

We will not repeat the contents of the trial here, since we already devoted section 4 to the main findings, namely that important parts of the ENIAC and EDVAC were based on the ABC. We will instead skip straight to the conclusion of the trial.

On October 19, 1973 the case came to a close with judge Larson's ruling. This is an excerpt from the ruling that effectively attributed the invention of the digital computer to John V. Atanasoff:

> "3.1.2 Eckert and Mauchly did not themselves first invent the automatic electronic digital computer, but instead derived that subject matter from one Dr. John Vincent Atanasoff." [Mol88, appendix C][Wikc]

The ruling also invalidated the ENIAC patents and put the invention of the electronic digital computer in the public domain.

6 Why nobody knows the ABC

One might wonder why, if the ABC has been such an influential invention, so little is known about the Atanasoff Berry Computer. Certainly, the lawsuit in 1971 must have attracted attention? This section discusses possible reasons why the ABC is still quite unknown and also how honours and credits were eventually restored.

[11] See `http://www.cbi.umn.edu/collections/inv/cbi00001.html` for an overview of the trial records.

6.1 Reasons

Studying the literature we have been able to find several reasons for the fact that the ABC isn't know:

- Both Atanasoff and Berry left Iowa State Collage in 1942 to do research for war efforts. At that time, nobody else was involved in the project which meant that it was abandoned.
- The ABC was disassembled in 1948, a few years after Atanasoff and Berry had left Iowa State College (see chapter 8 of [Mol88]). This returned the computer in a state of just being an idea. The fact that the ABC was destroyed without anyone from the department objecting indicates that it was no longer or never had been a really visible project.
- The process of applying for several patents was set in motion but wasn't pursued very well and in the end didn't lead to any patents being assigned to Atanasoff and Berry nor Iowa State College. Allan R. Mackintosh asserts in [Mac88] that these patents would have been one of the most important patents ever issued.
- Although the machine was finished in 1942, it still had a few unsolved issues. This made the machine sometimes look "incomplete". Allan R. Mackintosh explains in [Mac88] that

  > "Today the computer they left behind [the ABC] is frequently described as an uncompleted machine. It would be more accurate to characterise it as a functioning but fallible computer, in which the electronic-computing part—the logic circuitry—was a brilliant success."

  See also section 3.3 about the construction.
- As Alice R. Burks observes in [Bur03] the ABC project had no real financial backing from companies or the government like future projects as the ENIAC, EDVAC or UNIVAC.
- While the lawsuit could have been drawing a lot of attention in the news, this didn't happen, since exactly at the same time the Watergate scandal was developing which effectively overshadowed any other news.

6.2 Honour restored

In the last two decades people have started to recognise the influence of the ideas (see section 3.1) that led Atanasoff and Berry to design and construct their computer. Chapter 22 of [Mol88] described the honour restoration of Atanasoff's accomplishment: a guest of honour at the Iowa State University yearly parade, a Doctor of Science degree at the University of Florida, recognition by IEEE as Computer Pioneer, the National Medal of Technology, and several articles and books elaborating on his contributions written by Allan R. Mackintosh, Alice

R. Burks, Arthur W. Burks ([BB81, BB88, Mac87, Mac88, Bur03]) and many others.

Given these honours and recognition it is still surprising that Atanasoff's accomplishment is often pushed aside or isn't mentioned. The exact reasons for this are hard to find. One reason could be that in the years after the lawsuit, Eckert, Mauchly and his wife kept claiming until their death that the ENIAC design had no derivations from the ABC ([Bur03, Mol88]).

7 Conclusion

Considering the facts and opinions presented in the previous sections, we can conclude that John Vincent Atanasoff, assisted by Clifford Edward Berry, was the *inventor* of the first digital electronic computer, the ABC. The key principles driving his machine's design have a tremendous influence on the design of computer and the computer science world as a whole. These principles can be found in the designs of the computers of the same era such as the ENIAC and EDVAC but also still in contemporary computers.

The ABC had always been designed as a *special-purpose* computer, namely to solve sets of algebraic equations. The ENIAC however was a programmable general-purpose machine. A number of the key ideas that were first developed by Atanasoff for the ABC were later also used in the more popular ENIAC, only put to a more general use. This made the ENIAC the first of a long lineage of *general-purpose* computers. Since the ABC was never patented and long remained unknown to the world, the greatest impact made by it was through the ENIAC. While this may be the case, we think that Atanasoff should receive much more credit for his accomplishment.

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