The Inception of Electronic Digital Computing

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***Abstract*— The goal of this paper is to review the first projects for building automatic computing machines during the first half of the 20th century. The presented timeline shows that 85 years ago – in October 1939 – the first breadboard proof-of-concept prototype of an electronic digital computer became operational. The credit for this revolutionary invention goes to John Vincent Atanasoff at Iowa State College. Using fresh insights and some nearly forgotten facts, we also review the origins of the IEEE Computer Society and the role of organized professional activities, as well as the customer demand for spreading new ideas and design solutions for the fast-growing computer industry. The paper recognizes and explains the contribution of John Vincent Atanasoff to the invention and early development of electronic digital computing and the design of the modern computers that changed the world.**

Keywords*— *Invention of electronic digital computing, John Vincent Atanasoff, computer history, IEEE Computer Society

I. Introduction

Discovering and developing new ways to speed up computation, especially of the more complex and laborious mathematical problems, has occupied human thought for millennia. Among the many great minds who have worked to overcome this challenge are such geniuses as Leonardo da Vinci, Blaise Pascal, and, more recently, Charles Babbage, who conceived and tirelessly constructed his mechanical computing machines as early as the first half of the 19th century. But the design principles that would underpin modern computers were first proposed by John Vincent Atanasoff at Iowa State College, and his invention marked the beginning of the modern information revolution [1]. It is widely acknowledged that most of the contemporary computer systems and devices are constructed in accordance with the design principles and technologies that underpin electronic digital computing. This fact naturally attracts more attention to the early projects that adopted these principles in the mid-twentieth century.

This paper provides an overview of the inception of electronic digital computing as well as the origins of the IEEE Computer Society which is the successor of the first technical committees on computers. Indeed, professional activities on computers commenced approximately a decade after the revolutionary invention by John Vincent Atanasoff. In addition, the paper outlines the chronology of significant events and developments in the nascent history of electronic digital computers.

II. The Invention of Electronic Digital Computing

In the 1930s, the growing activity of scientists and inventors seeking new methods of automating computing—driven by interest from academia, industry, and government—led to a proliferation of ideas and potential solutions. In this context, the research efforts of a young associate professor of physics and mathematics at Iowa State College underwent significant development and flourished. He had long been interested in the problem of accelerating computation, and his discovery of the basic principles of electronic digital computers in December 1937 was the result of many months of diligent research [2].

Atanasoff's approach was completely different from the developments of analog computers (for example, the work of Vannevar Bush) or computers on relays (the projects of Howard Aiken, Konrad Zuse, George Stibitz, and others). Although working, these solutions did not pass the sieve of time because they were not as fast, economical, and reliable as the electronic digital computers based on Atanasoff's invention. His design principles included the use of:

- electronic technologies, initially vacuum tubes and subsequently semiconductor devices, for much faster computations, in contrast to the capabilities of mechanical or electromechanical components.
- operations, based on binary rather than decimal arithmetic, which has enabled considerably simpler computations and hardware design.
- direct logic calculations, developed specifically to achieve higher accuracy and speed, as opposed to calculations by counting.
- dynamic memory regeneration which has the dual benefit of reducing costs and increasing reliability.

III. First Electronic Digital Computers

A. The Atanasoff Berry Computer

There are three machines designed and built at the dawn of electronic digital computing and for clarity we will briefly introduce them using the timeline of those early developments as depicted in Figure 1. First, in October 1939, John Atanasoff

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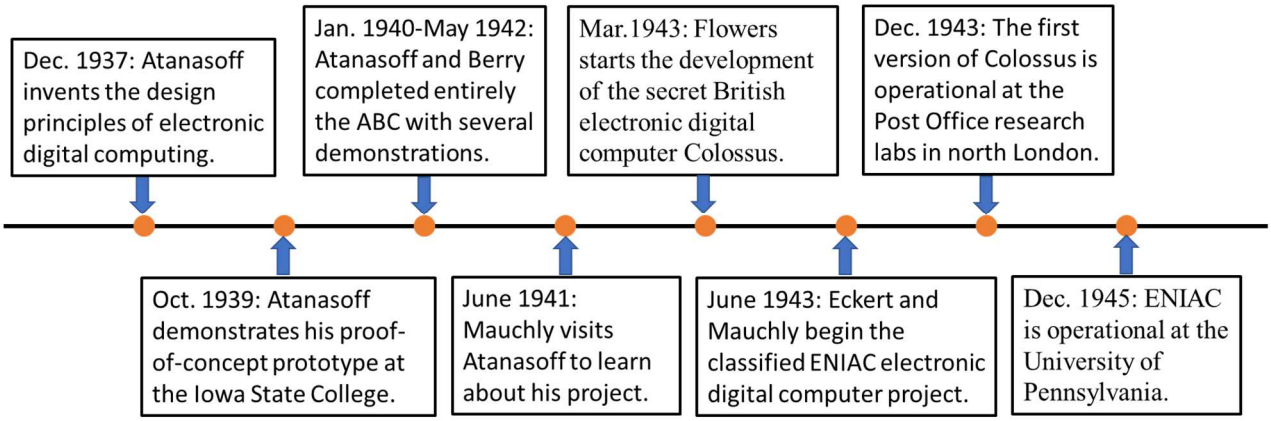

Figure 1: Milestones in the development of the first electronic digital computers between 1937 and 1945.

showed a working breadboard prototype proving the validity of his discovery. This was followed by the complete development of a computing machine for solving systems of equations using digital electronics, built by Atanasoff and his graduate assistant Clifford E. Berry, and demonstrated by them several times between 1939 and 1942. Existing published materials clearly confirm that Atanasoff and Berry worked very closely in a productive partnership on the computer's implementation.

B. The Colossus Project

Several years after Atanasoff's project, between March and December 1943, at the British Post Office Research Laboratories in Dollis Hill, London, Thomas H. (Tommy) Flowers implemented, completely independently of other ideas and developments, a second electronic digital computer, Colossus [3]. The first prototype was operational on Christmas Day, 1943. Then, in January 1944, the first Colossus was moved to Bletchley Park or “Station X” – the top-secret British code-breaking facility. Following highly positive feedback from the early production phase, the project team built another 10 improved versions of the Colossus computer, which were extensively and very successfully used to crack German secret messages encrypted with the "Tunny" cypher code, during the last two years of World War II. Ironically, the full technical details of the Colossus project remained secret for 60 years after the end of the war, except for one article and a few presentations delivered by Tommy Flowers. This not only significantly delayed the recognition of the project leader and his excellent team of engineers and mathematicians, but also prevented the use of the results in future academic developments and industrial products.

C. The ENIAC

Shortly after the construction of Colossus started in London, a third groundbreaking classified project, the ENIAC (Electronic Numerical Integrator and Computer) began at the University of Pennsylvania in June 1943. Led by J. Presper Eckert and John W. Mauchly, the ENIAC became operational in December 1945.

IV. The Intellectual Property Dispute

We should mention here some important facts that are at the heart of a long-running dispute over the intellectual property of the electronic digital computing invention. During their first encounter at a professional meeting in December 1940, John Mauchly learned from Atanasoff about his computer. In June 1941, full of interest, he visited Atanasoff’s home to study his project at Iowa State College. Archive documents confirm that by that time Atanasoff had submitted a patent application, but the college management failed to file it. In response to Mauchly's letter expressing interest in the computer, Atanasoff stated in his reply to him, dated October 7, 1941: "I have no qualms about having informed you about our device, but it does require that we refrain from making public any details for the time being." Four and a half years later, the ENIAC design and construction was completed, without acknowledging the use of Atanasoff's invention. As pointed out much later in Judge Earl R. Larson's historic decision published on October 19, 1973 [4]:

"Between 1937 and 1942, Atanasoff, then a professor of physics and mathematics at Iowa State College, Ames, Iowa, developed and built an automatic electronic digital computer. The work of Atanasoff was known to Mauchly before any effort pertinent to the ENIAC machine or patent began. Eckert and Mauchly did not themselves first invent the automatic electronic digital computer, but instead derived that subject matter from Dr. John Vincent Atanasoff."

It is also noteworthy to mention that, while Atanasoff’s computing machine project at Iowa State College was purely academic and student-oriented, the other two projects were military-related and classified as top secret. This had a significant impact on both the primary application areas and the financial support received.

After the end of the Second World War, intensive scientific contacts in this area were quickly re-established and high priority was given to the rise of the computer industry. Since the ENIAC was already declassified, it was announced to the media in February 1946. After that, Eckert and Mauchly left the University of Pennsylvania to set up their own company and submitted patent applications for the discovery. Subsequently, an intensive and successful publicity campaign was initiated, which contributed significantly to the continued widespread recognition and acknowledgment of ENIAC within the professional community.

Due to consumer demand, the computer industry grew rapidly. Companies and corporations were formed and merged, and computers entered the market with much higher-than-expected profits. A string of coincidences led to a patent infringement lawsuit between the giant computer firms,

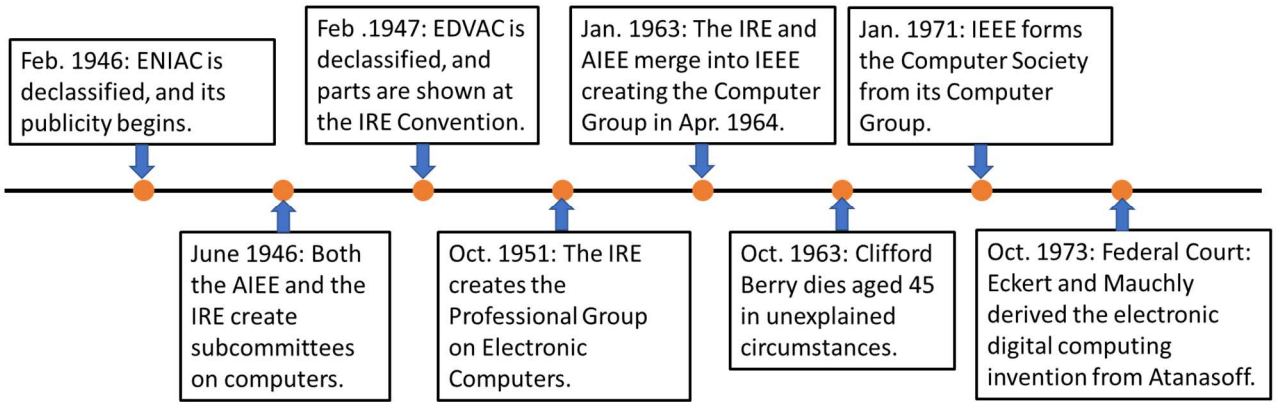

Figure 2: Dissemination and recognition of John Vincent Atanasoff's revolutionary invention.

involving liabilities in the hundreds of millions of dollars, which prompted an investigation into Atanasoff's contributions. A long and tortuous trial began, culminating in the confirmation of Atanasoff's invention.

V. Origins of the Professional Community in Computer Technologies

A. First Technical Committees

At the same time, the first efforts began towards the establishment of professional computer organizations [5]. As early as 1946, two technical committees on computer science and technology were created within the two existing engineering societies, the American Institute of Electrical Engineers (AIEE) and the Institute of Radio Engineers (IRE). The following year, another independent professional organization was formed – the Association for Computing Machinery (ACM). These professional bodies achieved a significant level of influence from the outset of their existence, mainly through their very strong membership.

The AIEE Subcommittee on Large-Scale Computing Devices (LSCD) was initially constituted as part of the Basic Sciences Committee in May/June 1946. In 1947, the group initiated the process of becoming a full committee while removing the term "Large-Scale" from its title. Subsequently, the AIEE Committee on Computing Devices was formally approved by the Board of Directors on January 29, 1948, and achieved full official standing on August 1, 1948.

The IRE's distinctive identity is rooted in its status as the most scientific of all American engineering societies during the first half of the 20th century. This spirit was reflected in the Institute's rigorous membership standards, the emphasis on creativity, its democratic elections, and the commitment to international scientific collaboration. There was a notable alignment between the values inherent to the advancement of a highly scientific field and the professional ethos established by the founders of the IRE. In accordance with these principles, the IRE Technical Committee (TC) on Electronic Computers was initially constituted in 1946 as a subcommittee, akin to the AIEE Subcommittee on LSCD.

B. IRE Technical Committee on Electronic Computers

The inaugural IRE TC on Electronic Computers has played a significant historic role. The earliest evidence of professional activities in this nascent field within the IRE can be traced back to 1946. Thus, the technical program of the highly successful 1947 IRE National Convention (March 3-6, 1947) comprised 122 papers, five of which were presented in the session entitled "Electronic Digital Computers" on March 4, 1947, at the Commodore Hotel in New York City [6]. It can be reasonably assumed that these papers were prepared and submitted in 1946 for inclusion on the technical program. The authors, J. W. Forrester (MIT), S. N. Alexander (NBS), H. H. Goldstine (IAS), J. A. Rajchman (RCA), and P. Crawford (ONR), were all inaugural members of the IRE TC on Electronic Computers.

Several interesting exhibits were also presented in special demonstration rooms, including modules of the Electronic Discrete Variable Automatic Computer (EDVAC), which had been declassified only a week before the show. EDVAC was constructed by Eckert and Mauchly, again using Atanasoff's invention without mentioning his name.

The inaugural membership of the TC on Electronic Computers includes 21 names [7] as follows:

Technical Committee on Electronic Computers

Chairman:

James R. Weiner (Raytheon Manufacturing Co.),

Vice-Chairman:

George R. Stibitz (Bell Labs),

Members:

Samuel N. Alexander (National Bureau of Standards),

John V. Atanasoff (Naval Ordnance Laboratory),

Julian H. Bigelow (Princeton University),

Perry O. Crawford, Jr. (Office of Naval Research),

Charles S. (Doc) Draper (MIT),

J. Presper Eckert Jr. (Eckert-Mauchly Computer Corp.),

Jay W. Forrester (MIT),

Herman H. Goldstine (Institute for Advanced Study),

Edwin L. Harder (Westinghouse Electric Co.),

Byron L. Havens (Columbia University),

Emory Lakatos (Bell Labs),

Gilbert D. McCann (California State Polytechnic Inst.),

Chester H. (Chet) Page (National Bureau of Standards),

Jan A. Rajchman (Radio Corporation of America),

Nathaniel Rochester (Sylvania Electric Products Inc.),

Robert Serrell (Radio Corporation of America),

Thomas K. Sharpless (University of Pennsylvania),

C. Richard Snyder (University of Pennsylvania),

Charles F. West (Raytheon Manufacturing Co.).

The founding members of the IRE TC on Electronic Computers, as listed above, represent an esteemed group of early computer pioneers, including the renowned inventor of electronic digital computing, John Vincent Atanasoff.

Then, the IRE Executive Committee approved a Bylaw amendment and appointed James R. Weiner as the inaugural Chairman of this TC at its meeting on January 6, 1948 [8]. These decisions not only confirm the elevation to full committee status but also the removal of the term "Digital" from the title, which would allow for the inclusion of analog (continuous) computers in the "Definition of Scope" document [9]. Standardization activities were also initiated, while work was being carried out to define new terminology.

More scientific conferences with papers, discussions and deliberations followed this very successful start. For example, at the 1948 IRE National Convention (March 22-25, 1948), a committee meeting and two regular sessions with nine papers, entitled "Computers I – Systems" and "Computers II – Components," were organized by this TC [10]. It is also noteworthy that the distinguished speakers invited to present their insights on "Advances Significant to Electronics" at the same event included Norbert Wiener of MIT, who delivered a discourse on "Cybernetics"; Claude Shannon of Bell Labs, who presented a lecture on "Information Theory"; and John von Neumann of the IAS, who shared his perspectives on "Computer Theory."

C. *Merger of IRE and AIEE*

Later, in 1963, IRE and AIEE merged into the Institute of Electrical and Electronics Engineers (IEEE), and, as shown in Figure 2, their computer committees merged into the Computer Society, which has grown significantly, numbering over 375,000 members worldwide by the end of 2023. Through the activities of the professional organizations, the design principles of Atanasoff's machine applied in the declassified ENIAC and EDVAC projects spread to the first commercial computers and continue to be the foundations of electronic digital technology today.

VI. The Recognition of Atanasoff's Invention

Meanwhile, after the end of the Second World War, Clifford Berry rapidly established himself as one of the most visionary and esteemed computer designers of his generation [11]. Applying experience gained during the development of Atanasoff's computing machine to his work for CEC (Consolidated Engineering Corporation), he led the design of the CEC 30-103 electronic analog computer for solving up to 12 linear equations with applications in spectrometry [12]. He then initiated the development of electronic digital computers at CEC. In the fall of 1963, Berry left the company to start a new job in Huntington, Long Island. Shortly after his arrival, while in the process of seeking housing for his family, he was found dead in his rented accommodation. Shaken by Clifford Berry's sudden and unexplained demise, which remained shrouded in mystery, Atanasoff introduced the acronym ABC (Atanasoff Berry Computer) in 1968 for his testimony before the court to acknowledge Berry's invaluable contributions to the project [2]. Previously, Atanasoff had referred to it as a "computing machine" [13]. The only other source that uses the term "Atanasoff-Berry Computer" is a two-page description in Richard K. Richards' book [14], published in 1966.

The federal court ruling confirming John Atanasoff's invention was published on October 19, 1973, but the news was overshadowed by the Watergate scandal which was reaching a turning point [4]. This stole the media headlines and took away from Atanasoff the unique opportunity to be on the front pages of the newspapers. However, the Watergate scandal was not the only reason for the silence of the press. The complex scientific and technical matter of the federal court decision was of interest mainly to experts in the field, rather than the public at large. Indeed, the trial occupied the court for the better part of 135 days with the full transcript available on 20,667 pages. In addition, Mauchly and Eckert went on to capitalize on this media vacuum and continued their aggressive publicity campaign, creating a lot of confusion by ignoring the judgment and the merits of Atanasoff's invention [15]. The main advocate for his recognition in the USA became Iowa State University, who were among several institutions awarding Atanasoff with scientific and academic honors. He was allocated a place in the Iowa Inventors Hall of Fame and a plaque on the Iowa State University Physics Building, where the ABC was originally built. He also received the IEEE Computer Pioneer Medal, as well as five honorary doctorates from institutions, including Iowa State University. In 1990 John Atanasoff received the Medal of Technology from the US President George H.W. Bush "for his invention of the electronic digital computer" – most certainly his highest award.

Although Atanasoff's invention is undisputed and held in respect by the professional community, its validity is still being challenged via various unjustified claims and devaluing statements [16]. Therefore, the publication of Jane Smiley's book [17] is very important, especially in Bulgaria, where Atanasoff's work, and achievements have been received with much love and appreciation. He has visited twice his father's homeland. The first time was in 1970, on the initiative of Blagovest Sendov. Here he was awarded the Order of Cyril and Methodius (1st class) and gave several lectures at the Bulgarian Academy of Sciences on the invention of the computer. His second visit to Bulgaria was in May-June 1985 after the historic litigation had ended in his favor. He was then awarded the Order of the People's Republic of Bulgaria (1st class). He also visited his father's birthplace – the village Boyadzhik in Yambol region, where he was warmly welcomed and became an "Honorary Citizen of Yambol". In addition, Atanasoff received the highest scientific recognition of Bulgaria – in 1983 he was elected a Foreign Member of the Bulgarian Academy of Sciences.

VII. Recent Developments

A fully operational reconstruction of ABC was completed [18] and demonstrated [19] in 1997, by a team led by John L. Gustafson. Since 2010, when it was moved from Iowa State University to the Computer History Museum in Mountain View, California, this reconstruction has been the subject of increasing public interest [20]. The launch of Jane Smiley's

then-published book [17] was part of the grand opening of the museum's new exhibit in January 2011. I had the unique opportunity to attend this event, which included an hour-long interview with the author, conducted by the museum's director in the presence of some two hundred guests, including a large group from the inventor's family and members of the International John Vincent Atanasoff Initiative Committee.

The recognition of John Atanasoff's invention continues to grow around the world. His name is well known, and it is widely believed that he is the "father of the computer". Here is an interesting example. In January 2016, while I was attending an international committee meeting in Tokyo, I happened to sit next to a Japanese colleague, a university professor. We struck up a lively and interesting conversation, as it turned out that we had common professional interests. When I mentioned that I was working on the International John Vincent Atanasoff Initiative Committee, his eyes lit up and he exclaimed, "I'm teaching about the first electronic digital computer in my computer architecture course!" When I asked him how he knew about the ABC, he promptly replied, "From various publications but I have also heard about the John Atanasoff IEEE medal proposal from the Bulgarian ambassador in Tokyo, Blagovest Sendov!" Since then, my new friend, Hironori Kasahara, continues to be active in the International John Vincent Atanasoff Initiative Committee. And he is not alone – many other colleagues from different parts of the world join in and spread the knowledge about Atanasoff's historic invention.

In July 2023, I had the honor and pleasure to chair an International Scientific Symposium in Chicago to commemorate the 120th anniversary of John Atanasoff's birth. Among the scientists and guests from around the world who attended and participated, were the inventor's son, John Atanasoff II; Gordon Bell, the architect of the first minicomputers, who had invited Atanasoff to lecture on his discovery at the Marlboro Computer Museum in 1980; Kiril Boyanov, whose contribution, together with Blagovest Sendov, was crucial for the recognition and popularization of John Atanasoff in Bulgaria; John L. Gustafson – project manager of the ABC reconstruction; Charles Kohl, one of the lawyers who represented John Atanasoff during the patents validity trial; and Carl Chang, long-standing chair of the Computer Science Department at Iowa State University [21].

VIII. Conclusions

Of all the esteemed scientists who have contributed to the early development of electronic computing, Atanasoff was the first to utilize digital electronics for implementing arithmetic operations [22]. Approximately ten years after his revolutionary invention, organized professional activities in the field commenced and quickly reached critical mass. The first technical committees included as founding members many computer pioneers such as John Atanasoff, Presper Eckert, George Stibitz, James Winer, Nathaniel Rochester, Herman Goldstein, John Mauchly, Samuel Alexander, and others. Atanasoff's design principles were disseminated via ENIAC and EDVAC (both declassified in 1946–1947) to most of the modern computers. They remain firmly at the core of electronic digital computing technologies nowadays.

Acknowledgments

This article presents the personal views of the author. Numerous discussions with colleagues and friends, including John V. Atanasoff II, Carl Chang, John Gustafson, Blagovest Sendov, Gordon Bell, Kiril Boyanov, Mike Williams, Anne Marie Kelly, and Dick Gowen, have been instrumental in the collection of crucial data, the transcription of oral stories, and the accurate interpretation of the fascinating sequence of events that shaped the infancy of modern computer history.

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