JOHN VINCENT ATANASOFF, INVENTOR OF THE FIRST ELECTRONIC DIGITAL COMPUTER: A CHRONOLOGY OF FACT

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This is the story of the Atanasoff/Berry Computer, an ELECTRONIC DIGITAL COMPUTER, that was invented at Iowa State College in Ames, Iowa in the 1937-1940 period. The basic principles in the Atansoff/Berry Computer are now routinely found in all modern computers.

This is not intended to be a history of the development of mechanical and analog devices. I am not unmindful of the machine of Charles Babbage who built the analytical engine in 1830, the Hollerith tabulator used in the 1880 U.S. census, the Thomson harmonic analyzer used to predict the rise and fall of tides, and the Bush differential analyzer built at MIT. Also there was the work of Zuse in Germany and Stibitz at Bell Labs in the late 1930's and 1940's who were constructing electromechanical and electromagnetic devices, respectively. NONE OF THESE MACHINES WAS AN ELECTRONIC DIGITAL MACHINE.

For over 30 years, Dr. John W. Mauchly and Dr. J. Presper Eckert were honored as the co-inventors of the electronic digital computer. They were credited with having invented the ENIAC computer for the United States Army at the Moore School of Electrical Engineering at the University of Pennsylvania. The ENIAC was unveiled in 1946.

Immediately after the unveiling, Mauchly and Eckert began applying for patents for the ENIAC. Internal feuding broke out at the Moore School when it became evident that Mauchly and Eckert were wrongfully claiming credit for inventions in the ENIAC that had been developed by eleven other individuals on the team. The team believed that since the ENIAC was built with government funds, no one should profit.

Mauchly and Eckert quickly and methodically resigned from the Moore School and set up a company for the purpose of filing for patent rights. The team at the Moore School was bitter, but did not have the resources to challenge Mauchly and Eckert. In 1950, Mauchly and Eckert sold their patent rights to Remington Rand Corporation which later became Sperry Rand.

In 1963, Bell Labs challenged the ENIAC patents in the U.S. District Court of New York, but lost as there was a legal presumption that the patents were valid.

THE EARLY YEARS, 1903 - 1936

John Vincent Atanasoff was born in 1903, the son of a Bulgarian immigrant who was a self-taught electrical engineer. When John Vincent (JV) was nine years old, his father decided that his position required a Dietzgen sliderule. Young JV read the directions, mastered it, and soon became interested in the mathematical principles behind its operation. This lead to the study of logarithm and trigonometric functions. He found a college algebra book in his father's library, and it was his mother who gave him the help he needed. In this book, he was intrigued with number bases other than ten.

He graduated from the University of Florida in 1925 with a Bachelor of Science degree in electrical engineering, and accepted a teaching fellowship position at Iowa State College where he enrolled in a Masters program in mathematics. After graduation, he married Lura Meeks and then entered the University of Wisconsin to study theoretical physics. The title of his dissertation was The Dielectric Constant of Helium. As a basis for his study of helium, JV used the complicated wave functions developed by Hylleraas, and grudgingly spent countless hours on the mechanical Monroe calculator. After graduating with a Doctor of Philosophy degree in 1930, he returned to Iowa State College as a faculty member with a joint appointment in the departments of Physics

and Mathematics. In his spare time he turned his thoughts to building a better calculating machine to help his students.

He tried all sorts of things. He gave some consideration to lining up several Monroe calculators in tandem but soon abandoned that idea. He added a device to the IBM tabulator and noted later that the Journal of the Optical Society of America had published his paper on this experiment in February, 1936. He was unaware at the time of internal memorandums at IBM expressing a highly critical view of the Iowa State College professor meddling with the IBM tabulators, and using them in ways that the corporation had not intended. He also built an analog machine called the "Laplaciometer" which was used for measuring the geometry of surfaces.

None of these devices had the speed, accuracy, or capacity to solve large systems of linear equations. At the same time, JV was examining the emerging field of electronics. He obtained one of the first textbooks on electronics written by Van Der Bije of South Africa from which he learned of vacuum tubes.

JV's mind then turned to electronics as the power medium and electric impulses as the measuring stick for a computer. He thought of abandoning base 10 and perhaps using other bases, but there was the problem of converting out of base 10 and then back again for the final solution. He came to a tentative solution that perhaps base 2 was advantageous. During the latter part of 1937, he would think he was on the brink of discovery, only to loose his train of thought in higher mathematics.

IT ALL COMES TOGETHER AFTER A LONG DRIVE, 1937 - 1938

The frustration of many months of fruitless effort built into a frenzy in the winter months of 1937-1938. In JV's words, "I went to the office to resolve some of these questions, and I was in such a mental state that no solution was possible. It was a habit of mine to go for a mind clearing drive when I was particularly baffled by a problem. Although there was no snow on the ground, the temperature was twenty degrees below zero and the wind provided an additional bite. I drove east out of Ames at a fast rate of speed, and before I realized it, I was crossing the Mississippi river. I saw the bright lights of a roadhouse on the right of the road, and while it had not been my intention to drive to Illinois for a drink (which was illegal in Iowa), I decided I might as well get a bourbon and mixer before starting the 200 mile drive back to Ames. When the waitress placed the drink before me, I suddenly realized that I was no longer nervous and tense. My thoughts turned again to the question of a computing machine. I realized that my thoughts were coming together in a positive manner."

During the evening at the roadhouse, JV made four decisions for the computer project:

1. He would use electricity and electronics as the medium
2. In spite of custom, he would use base 2 numbers (the binary system)
3. He would use condensers for memory, and would use a regenerative or "jogging" process to avoid lapses that might be caused by leakage of power
4. He would compute by direct logical action and not by enumeration as used in analog devices.

He drove slowly back to Ames, weary, but satisfied that he was finally on the right track for a revolutionary new machine using the four basic concepts he had just envisioned. He realized that his concepts at that stage were only theories, but his training as an electrical engineer, a mathematician, and a theoretical physicist gave him confidence that the testing would prove that his concepts were valid.

THE PROFESSOR AND HIS PROTÉGÉ, CLIFFORD BERRY, 1939 - 1941

JV spent the next year on some of the unsolved parts of his concepts, and, in the spring of 1939, applied to the dean of the Graduate College for funds to employ a graduate student to build a prototype model to test his theories. He received a grant of $650 which was considered a large sum of money in those depression days.

He put word out to the Electrical Engineering Department that he needed a student with outstanding mechanical ability and along came Clifford Berry. Berry was 22 years old, about to graduate in EE, and was pursuing a Masters degree in Physics. He was well grounded in electronics. At the age of eleven, he had constructed his own ham radio, and was considered somewhat of a specialist in ham radio operation by his fellow students.

At their first meeting, they discussed building the prototype. JV outlined his four concepts with notes and sketches of some parts he had worked out in detail, and presented rough sketches on parts that they would have to work on together. The prototype would be no larger than a "breadboard" with electrical components mounted on its surface. However, it would include all the essential components of a complete calculating machine. They would abandon the idea of attacking the solution of solving large sets of linear equations. They would make it simple....the simpler the better.

The prototype was completed in seven weeks. Almost as soon as it was completed it began to work well. Fellow professors were surprised that it was giving correct answers. JV viewed it as a great success, and it removed doubts that an electronic computer could be built. (See stylized drawing of the breadboard prototype in the Appendix.)

The war in Europe had begun. Besides the computer project (and in addition to teaching classes and directing other graduate students), JV was directing a National Defense Research Project on tracking aircraft for military gunners. The graduate student working on the defense project was Sam Legvold. Sam Legvold officed with Cliff Berry in the basement of the Physics Building where JV had been assigned space to build his machines.

In December, 1939, JV received a second grant from the Graduate College for the construction of a full-scale model computer which was to take the size of a large desk. Besides computational tasks, the purpose of this computer was to solve 29 linear equations with 29 unknowns.

In the spring of 1940, JV and Berry wrote a 35-page manuscript called "Computing Machines for the Solution of Large Systems of Linear Equations." The manuscript described in detail the principles of the machine as well as the design features.

The 35-page manuscript became the basis for a patent to protect their work. Iowa State College lawyers decided that they needed help on the patent and hired a consultant on patent law, Richard Trexler, who worked out of Chicago. The 35-page manuscript also became the basis for a grant of $5,000 which JV received from the Research Corporation of New York. The president of the College was astounded when a grant of this size was received.

The full-scale model was built in 1940. It worked well and demonstrated that it was capable of solving linear equations up to 30 unknowns. (See stylized drawing of the full-scale model in the red brochure.) JV enumerated the significant advances that the full-scale Atanasoff/Berry computer encompassed (hereafter referred to as the ABC):

- All internal operations were executed in binary arithmetic (base 2 number system)
- All computation was done in a serial manner
- Separate memory storage and computing devices
- What I (Atanasoff) called jogging, others call it regenerative memory

- Vacuum tubes were used in computing
- Electronic amplifiers were used as on and off switches
- Parallel processing circuits for logical addition and subtraction (logic circuits)
- Capacitators were used as memory elements
- A rotating drum memory contained the capacitators
- Clock control of electronic operation (While the timing mechanism was driven by a mechanical electric motor, all computing was electronic.)

There was a flaw related to the computer's method of punching holes in binary cards in the internal mechanism of changing from base 10 to base 2. They used an electric spark method that would overscorch a card maybe once in 100,000 punches. They had a sample of paper where this would not occur, but were not able to purchase a supply because of the war.

JV and Berry met several times in 1940 with the patent lawyer, Trexler, in order to furnish just what was needed to protect their work. They also spent several days at the U.S. Patent Office in Washington.

In December of each year, it was JV's practice to attend the meeting of the American Association for the Advancement of Science. In 1940, the meeting was held in Philadelphia. By chance, JV dropped into a lecture being given by a Dr. John Mauchly who had constructed an analog harmonic analyzer (copied from a previous model at MIT) which he used for tracking weather data. At the time, Mauchly was teaching Physics at Ursinus College, a small college in Pennsylvania. After the lecture, JV went to the front of the lecture hall, introduced himself, and engaged Mauchly in conversation about his harmonic analyzer, JV mentioned that he had constructed a computing machine at Iowa State College. Mauchly became immediately interested. JV responded that he could not say too much about it because the patent had not yet been filed, but if Mauchly would like to visit Ames in late spring or early summer, he would show him the machine and explain its function. In fact, he would be welcome to stay in the Atanasoff home.

In early January 1941, JV was so pleased with the state of development of his computing machine that he gave an interview to a reporter from the Des Moines Register. The headline for the nontechnical story was "MACHINE REMEMBERS". The brief story was accompanied by a large picture of Clifford Berry holding a device for the regenerative memory. (See picture in top right-hand corner, page 17, Appendix. A close look will reveal that the board contains 45 vacuum tubes.)

A VISITOR FROM THE EAST, 1941

In the spring of 1941, a letter arrived from Mauchly accepting JV's invitation. He would come in June. JV had hoped that the patent would be filed before Mauchly's visit but it was not. He had told Mauchly he would show him the machine and he felt obligated to live up to his promise. He believed Mauchly to be an honorable man who would not take advantage of a friendly colleague.

Mauchly arrived on June 17, 1941, a day earlier than expected, at dusk expecting dinner (dusk in Iowa in June is after 9 pm), and with his six-year old son, Jimmy. Lura and JV had 3 children under 5. He stayed 4 days and 5 nights. Mauchly engaged JV in what seemed to be a constant prying of questions.

According to Lura, "After breakfast, the men went off to the college, briefcase in hand. When they returned for lunch, it was computer talk to the exclusion of all else. At the evening meal. it was the same pattern. On the weekend, all four children and I accompanied JV and Mauchly to the basement of the Physics Building. At least two evenings, they went back to the college, and during the other two they talked "computer" in the den."

During the day when JV had other duties, he turned Mauchly over to Clifford Berry with instructions to show all parts of the machine, to demonstrate its operation, and to explain the philosophy of each part of the project.

Lura was deeply concerned and told her husband that he was "talking too much" and giving away the secrets of his invention. She said, "I think you should be careful." JV's response was, "Oh, this is a fine and honorable man. You do not have to worry about him. Also, he does not have a sufficient understanding of advanced electronics to build a computer."

During the visit, Mauchly was refused only one request. He asked if he could take the 35-page manuscript with him. JV explained that the patent had not yet been filed. However, Mauchly had had the manuscript in his possession during the entire visit, carried it to his room in the late evenings, and on more than one occasion asked for paper so that he could take notes.

They parted with a firm handshake and promised to stay in touch.

Two letters followed. The first was a thank-you letter expressing enthusiasm for the ABC. The second letter, dated September 30, asked if there was any objection to his building some sort of computing machine incorporating some of the ideas of the ABC machine. In the same letter, he also asked if JV would like to join him in building a larger machine at the Moore School of Electrical Engineering (U of Penn.) where he had joined the faculty just a few weeks previously.

JV saw no benefit in joining with Mauchly who at best was a beginner in the field of electronics. JV's reply was, "Our attorney has emphasized the need of being careful about the dissemination of information about our device until the patent has been filed. I have no qualms about informing you about our device, but it does require that we refrain from making public any detail for the time being. It is preventing me from an invited address at the American Statistical Association."

THE WAR YEARS, 1942 - 1945

December 7, 1941 the bombs fell on Pearl Harbor. This put an end to the work on the computer. Berry graduated and took a defense related job in California. JV was summoned to the National Ordinance Laboratory (NOL) in Washington, DC. He pleaded with NOL to allow him to work out of his Ames office, but he fought a losing battle as they needed him in the Accoustics Division. When he left for Washington, as far as he knew, he had done everything required for filing for the patent.

Within a few months at NOL, JV was made chief of the Acoustics Division.

One day early in 1943, JV looked up from his desk and there stood Mauchly. JV was surprised as there had been no contact since the September letter of 1941. After the greetings, Mauchly turned the conversation to their mutual interest, computing machines, and specifically to the ABC. This was the first of many visits in 1943. There was no mention that 16 days after he had been to Ames he had enrolled in an advanced course in electronics at U Penn., 10 months after his visit he submitted a proposal to the U.S. Army for the ENIAC computer, nor did he mention that the machine was in fact being built as he stood there.

In early 1944, Mauchly appeared again and this time told JV that he was building a computer at the Moore School. He said, "It isn't anything like yours. It is much better than yours and will be completed in a few months."

JV was immediately suspicious that Mauchly had stolen his ideas, but true to his character, remained calm and cordial. However, he said, "Sit right down and tell me about it."

Mauchly declined the offer to be seated. He retorted, "It is highly classified and I can say no more."

JV replied, "I have the highest military clearance possible." To this, Mauchly stated that the policy was required by law and made a quick exit. JV thought that perhaps Lura had been right. He consoled himself with thoughts that Trexler was proceeding with the patent and any theft could be established in some later forum. In keeping with his style, he ALWAYS kept his suspicions to himself.

During the war, JV made frequent trips back to Iowa as Lura and the children had remained behind. In regard to the patent, with frequent staff changes back at Iowa State College, it was impossible to obtain satisfactory answers to the simplest of questions. After 60-hour work weeks at NOL and a long train trip, he was often too weary to pursue the matter. But he would go to the basement of the Physics Building just to lay his hands on the ABC.

THE SAD POSTWAR YEARS, 1946 - 1949

The postwar years were depressing years for JV. In 1946, the U.S. Army unveiled the ENIAC computer. It was hailed as the greatest advance in computing, and Mauchly and Eckert were hailed as co-inventors. Also, the EDVAC computer was being built. It would be years before JV would have an opportunity to examine the ENIAC patents.

Also in 1946, JV learned that his patent had not been filed. Trexler said that Iowa State College officials had lost interest. Iowa State officials said they lost track of the material in the shifting of responsibilities in the turmoil of the war.

In 1948, JV returned to Iowa State College for a visit and was surprised, shocked, and saddened to find that the ABC had been removed from the basement of the Physics Building and demolished. Dr. Fox, head of the Physics Department, had ordered a graduate student to dismantle the machine because the space was required for an office. Only a rotating capacitator memory drum was saved by Sam Legvold.

By 1949, JV and Lura had grown apart and were divorced. A few years later he married Alice Crosby.

JV decided that he would not destroy the rest of his life because of this lost opportunity and busied himself with an exciting career at NOL. His division became involved in the first atomic test after World War II at Bikini Atoll in the Pacific, as well as the explosive detonations by the British on Helgoland Island. JV personally directed the building of the seismographs and other electronic devices required for the monitoring. These successful monitoring operations laid the foundations for long-range detection of explosions, and JV received citations for his work from the Bureau of Ordnance as well as the Seismological Society of America. Later he became Director of the Navy Fuse Program at NOL, and then Chief Scientist for the Army field forces.

In 1952, he left NOL and started his own company, The Ordnance Engineering Corporation. Later, the company was sold to Aerojet Corporation and JV became vice-president of the Atlantic Division for Aerojet. In 1961, he left Aerojet and formed Cybernetics Corporation which was also very successful. He earned 32 patents during his lifetime.

THE LAWYERS COME TO CALL, 1950 - 1962

Although JV spent little time brooding over his lost opportunity, unknown to him, others were

interested. By 1953, the memory system patents had just been issued and Sperry Rand Corporation (which had purchased the patent rights from Mauchly and Eckert in 1950) was suing IBM for excessive royalties. The IBM Patent Office manager, A. Robert Noll, had run across information that a Dr. Clifford Berry, head of a research division for Consolidated Electrodynamics Corporation (CEC), had worked on a project at Iowa State College in about 1940 that involved a "capacitator drum (memory) storage device incorporating the revolving principle for storing information." Noll identified the source of his information as James B. Christie, secretary and patent counsel for CEC, and a working associate of Dr. Berry. CEC was concerned about revolving drum patents held by Sperry Rand as they planned to market commercially a digital computer having a magnetic drum storage.

In June, 1954, the IBM lawyers met with JV and opened the conversation with, "IF YOU WILL HELP US, WE WILL BREAK THE MAUCHLY/ECKERT/SPERRY RAND PATENTS. THEY WERE DERIVED FROM YOU!" (This quote is corroborated by David Beecher, JV's company vice-president, whom he invited to join the meeting as a witness.) JV was elated but did not let his inner excitement show. JV's response was, "I have never seen the ENIAC patents and do not know what they contain." The lawyers said they would send him a copy. JV mused that it would take a giant corporation like IBM to finance the litigation to break the patents.

The patents arrived and JV's suspicions were confirmed. Indeed his ideas were in the patents. They were almost identical to the concepts of the computer built at Iowa State.

Months went by; years went by. JV heard no more from IBM. He assumed they were not interested. In 1957, he learned that IBM had used the information of Clifford Berry's work at Iowa State as "prior art" to negotiate a patent sharing agreement with Sperry Rand for $10 million.

By 1959, Sperry Rand was becoming increasingly nervous about possible challenges to both the ENIAC and EDVAC patents (parts of which had not yet been issued by the U.S. Patent Office). They obtained a copy of Cliff Berry's thesis from the Iowa State Library, and, searching the library for further information on the ABC, found nothing. They searched the literature and found nothing. Finally, they took JV to dinner to cross-examine him. They wanted to know exactly what information had been publicized on the ABC. JV responded that nothing had been published. They asked him to turn over all his personal papers to Sperry Rand. JV demurred.

Other lawyers came to call including lawyers from Burroughs, Control Data, Datamyte, General Electric, and National Cash Register. By this time, JV had had his fill of lawyers and was suspicious of the lot of them. In JV's words, "I did not exactly go out to the gate to welcome them."

DR. R. K. RICHARDS RESEARCHES A BOOK, 1963 - 1966

Completely unrelated to all of this, in early 1963, a Dr. R. K. Richards started in-depth research for a book on the history of the booming field of electronic data processing. Richards was an electrical engineering graduate from Iowa State, formerly employed by IBM in New York, turned author, and had written several successful books, two of which were Arithmetic Operations in Digital Computers, and Digital Computer Components and Circuils. He had returned to Ames to do his writing.

Like most electrical engineering undergraduate students in those days, Richards had been a ham radio operator. He recalled a visit to the Physics Building to see a Clifford Berry about a problem he was having with his ham radio. At the time, Berry was working on a computing machine. There had been no discussion of the machine, but Richards surmised that it was important. Now it intrigued him that he might have seen a machine of some importance in computer history.

At the Iowa State University Library, Richards drew a blank on any reference to the computing machine he had seen twenty years earlier in the Physics Building. By strange coincidence, his neighbor in Ames, Harry Burrell, recalled that he (Burrell) had actually written the press release for the January, 1941 Des Moines Register article and was able to produce a copy. A visit to the office of Professor Sam Legvold resulted in the first assurance from an eyewitness that indeed a computing machine had been constructed in the basement of the Physics Building. Legvold showed him the rotating memory drum he had salvaged when the machine was dismantled.

Richards proceeded to call JV at his home and said that he had been dismayed at the lack of records on the ABC. He said he believed it important that the ISU Library take steps to acquire and preserve any available records related to the project. JV agreed. Although JV communicated few of the details that Richards was seeking, he said that he would write to the patent lawyer, Trexler, and authorize him to release the 35-page manuscript to the ISU Library. He suggested that Richards talk to Berry, and also suggested that he might try to contact Dr. John Mauchly, one of the inventors of the ENIAC, who had been to Iowa State in 1941 to examine the ABC.

Richards related his conversation with JV to Legvold and stated that he was surprised to learn that Mauchly had studied the ABC. Legvold said he remembered Mauchly's visit and in fact had lunch with JV and Mauchly.

In his letter to Mauchly, Richards stated his purpose of authoring a book, that he understood he (Mauchly) visited Iowa State College in 1941 during the construction of the ABC, and asked for notes and drawings made at the time. He then said, "One of the professors, who at the time had his desk in the room where the computer was, also remembers you."

Mauchly did not respond. After some months, Richards was able to reach him by phone. Mauchly said that he did not wish to discuss his visit to Iowa State College, he remembered JV but did not remember Berry, he learned nothing of consequence from his visit, and that the ABC was a LITTLE PILE OF JUNK THAT WOULD NOT DO ANYTHING.

Fortunately, Richard's letter to Berry was much more productive. Berry wrote two letters giving material support on the place of the ABC in computer history. The second letter of July 12, 1963 gave a three-page detailed account of the development of the machine from the design and construction phase that started in September, 1939 through the last work in 1942. He included a sketch of the circuitry of the "memory capacitators," the "charging brushes," and the "reading brushes" that worked in the memory drum.

Richards concluded that the ABC predated every other digital computer by several years. In the preface of his book, he referred to the ABC as the FIRST ELECTRONIC DIGITAL COMPUTER. In the first chapter, he devoted three pages to the ABC, restating his conclusion with documentation from Berry's letters. He also wrote, "There was one interesting link between the Atanasoff/Berry Computer and later work. One of the few people to study the machine in detail was Dr. John Mauchly, who at the time was on the faculty of Ursinus College in Pennsylvania. According to oral reports from Dr. Atanasoff and Dr. Mauchly, the two met at an American Association for the Advancement of Science meeting. DR. MAUCHLY MADE A VISIT TO IOWA STATE COLLEGE IN 1941 FOR THE SPECIFIC PURPOSE OF STUDYING THE COMPUTER."

Richard's book was published in 1966.

THE TRIAL, 1967 - 1973

Although the general patents for the ENIAC were applied for in 1947, they were not issued by the

U.S. Patent Office until 1964. So by 1967, Sperry Rand was in one phase or another of suing all of the computer giants for excessive royalties. As a test case, Sperry Rand was suing Honeywell Corporation for $20 million.

On the other hand, Honeywell was suing Sperry Rand. Irrespective of the validity of the patents, Honeywell was charging that Sperry Rand was in violation of the Sherman Anti-trust Act for the patent sharing agreement with IBM and Bell Labs. The trio had created a virtual monopoly in the computer industry.

Honeywell lawyers, Alegretti and Call, tried to negotiate a settlement out of court. There was an IMPASSE. The very second that the impasse was reached, there was a foot-race to the repective courthouses in an attempt to file first. Honeywell was filing in Minneapolis; Sperry Rand in Washington, DC. Honeywell won the race by fifteen minutes and thus became the plaintiff.

The case was filed May 26, 1967 and ran until October 19, 1973. It was one of the longest cases in the history of the U.S. District Court System, almost six and one-half years. It was one of the most complicated cases because of the technical nature of the subject.

Three months into the case, lawyers Alegretti and Call HAD NEVER HEARD OF ATANASOFF OR THE COMPUTER BUILT IN IOWA.

Now it just so happened that the Corporate Counsel for the Honeywell Patent Law Division, Henry Hanson (now a resident of Sun City West, AZ) was an electrical engineering graduate from Iowa State College and a former electrical engineering classmate of R. K. Richards. Because of this connection, Hanson learned of the Richard's book and mentioned it to Alegretti and Call. However, Hanson did not put any particular stress on the importance of the conclusion that Iowa State University was the birthplace of the first electronic digital computer. If it was as conclusive as the Richard's book indicated, Hanson assumed that Iowa State probably would have made a big thing of it in alumni publications.

Alegretti and Call were intrigued by the description of the ABC in Richard's book and obtained a copy of Berry's thesis as well as a copy of the 35-page manuscript which by now was on file in the ISU Library. By the time Alegretti and Call decided to talk to JV, they were certain that many of the concepts in the ENIAC patents had been derived from the ABC machine. However, they knew that the strength of the Honeywell case depended upon the degree that JV would cooperate, the state of his memory (he was now 64), and the existence of records and witnesses to support the claim that Mauchly had full access to the ABC machine AND to the 35-page manuscript.

When Honeywell called for his cooperation, JV decided that the only way to ascertain the depths of their interest was to hire himself as an EXPERT CONSULTANT. Honeywell was most pleased to oblige and an agreement was drawn.

On August 29, 1967, Alegretti and Call drove to the Atanasoff Maryland farm home to collect JV's material. There was a TWO-FOOT STACK! They realized they had hit a BONANZA!. JV had been a RECORD PACKRAT. He had all his correspondence with Mauchly, every paper related to the planning and construction of the breadboard prototype as well as the ABC full-scale model, and every paper in the attempts to get Iowa State College to patent his ideas.

The lawyers decided it would help Honeywell's case against Sperry Rand if JV could take the notes and sketches he had drawn up for Clifford Berry in 1939 and build a breadboard prototype similar to the one that he and Berry constructed in the basement of the Physics Building.

JV said, "I will go one better. Alice and I will find and order the vintage material. Then I will let two or three of the electronic technicians in my company (Cybernetics Corporation) do the

construction from my original sketches with a minimum of guidance from me. I will demonstrate that the plans we had then would construct an operational digital computer." The machine was constructed and it worked well.

There were 80 pre-trial deposition witnesses including Lura Atanasoff, Dr. R. K. Richards, and Dr. Sam Legvold. Legvold remembered the machine doing addition, subtraction, multiplication, and division, and corroborated JV's testimony in regard to the length of Mauchly's visit to Ames (4 days and 5 nights). He stated that there were no holds barred in the discussions with JV and Berry, that Mauchly was given free and open access to the machine, and that he had a sharp interest and was delighted with what he saw. He also remembered Mauchly with his coat off and shirt sleeves rolled up helping with adjustments on the machine.

Mauchly gave depositions in 1967, 1968, and 1969. On time spent in Ames in June, 1941, in the first deposition he said he spent "less than a day", in the second deposition "perhaps one day", and in the third deposition, "a couple of days". On discussions with JV, he said that he spent less than one and one-half hours discussing the machine, but did not learn anything. In regard to access to the machine, in the first deposition he said that he saw the machine in bad light with the cover on, in the second deposition he said that he was in the presence of the machine an hour or so but did not learn anything, and in the third deposition he referred to the machine as an incomplete device that would not do anything (the lawyers were tempted to ask him how he knew). Concerning access to the 35-page manuscript, he stated that he never had the manuscript in his possession.

The trial proper started June 1, 1971 and was presided over by Judge Earl R. Larson, U.S. District Judge in Minnesota. It was not a jury trial. There were 77 trial witnesses, 135 days of testimony, and over 20,000 trial transcript pages. Honeywell presented to the court 25,686 exhibits that ranged from one-page letters, to the four-drawer filing cabinet in which the ENIAC patents were stored. Both litigants spent over $5 million on the case, and these were 1970 dollars.

At the top of the trial, a motion was made by Sperry Rand that violations to the Sherman Anti-trust Act on patent sharing with IBM and Bell Labs be dropped. In addition, Sperry Rand requested that no witness be allowed in the courtroom until after testimony was given. Judge Larson granted both motions.

NOW IT CAME DOWN TO THIS. Honeywell had to establish that JV was a creditable witness. Sperry Rand had to establish that Mauchly had been thinking of the concepts involved in the ENIAC prior to 1940.

JV was on the stand 6 days in direct examination and three days in cross-examination. Honeywell lawyers were so pleased with the way JV had withstood cross-examination that they spent only a short time on redirect to clarify a few points.

When Mauchly took the stand, he was unable to name one person to whom he had communicated his ideas or produce one document in which he had recorded his ideas prior to his trip to Ames. He had a very clear memory of discussing the ENIAC machine with a number of people AFTER his trip to Ames, i.e. fall, 1941, but that was not what the Sperry Rand lawyers wanted to hear.

Honeywell trial lawyer Halladay: "Is it fair to say Dr. Mauchly that you learned the difference between an analog device and a pulse device from Dr. Atanasoff?"
Mauchly: "Heavens no! Where did you get that idea?"
Halladay: "Well, probably from reading one of your papers published in 1941 in which you stated, 'Computing machines may be conveniently classified as either analog or impulse devices.

I am indebted to Dr. John Vincent Atanasoff of Iowa State College for the classification and distinction here explained'."

Halladay: "In your depositions, you said that you learned nothing of consequence in your discussions with Dr.Atanasoff. I will read to the court part of a letter that you wrote to your friend, Helms Clayton, on June 26, 1941, eight days after your visit to Ames, 'Immediately after commencement I went out to Iowa State College to see the computing device which a friend of mine is constructing there. His machine, now nearing completion, is electronic in operation, and will solve within a very few minutes any system of linear equations involving no more than 30 variables. It can be adapted to do the job of the Bush analyzer, only more rapidly, and it costs less. My own computing devices use a DIFFERENT PRINCIPLE'."

After many days on the stand and three days of arguing semantics, Halladay finally persuaded Mauchly to confirm that 1) he spent from June 13 to June 18, 1941 in the Atanasoff home; 2) he spent uncounted hours in discussion of the theory of the ABC with JV and Berry; 3) on three if not four days, he observed the ABC in the company of JV or Berry; and 4) he was permitted to read the 35-page manuscript from cover to cover but was not permitted to take a copy along with him. He grudgingly agreed that the add/subtract mechanism did work. Also, step by step, Halladay drew from Mauchly his observing and understanding in his trip to Iowa of the vacuum tubes, the logic circuits, the regenerative memory process, and the binary add/subtract mechanism. Halladay pointed out to the court that THESE CONCEPTS WERE TAUGHT BY ATANASOFF.

In their post-trial brief, the Honeywell lawyers argued that the ABC and ENIAC machines were different, but that there was NO difference between what Mauchly learned from Atanasoff in 1941 and what Mauchly and Eckert claimed to have invented in the ENIAC and EDVAC patents.

Now it was up to Judge Larson to put together a decision that would stand against any appeal from either of the litigants. The judge distributed his decision on October 19, 1973. It was 246 pages.

Judge Larson stated that he believed Dr. Atanasoff to be a truthful witness based on his demeanor and the evidence produced to support his testimony. Uneqivocally, the judge stated that as a result of his visit to Ames, Mauchly DERIVED from the ABC the invention of the automatic digital computer claimed in the ENIAC patents. (In more stately legal terms, the judge used the term "derived" rather than stole). Excerpts from Judge Larson's decision follow.

"By the time, the 35-page manuscript was produced in August, 1940, construction of the ABC was already far advanced. According to expert witness, Paul Winsor, the description contained in the manuscript was adequate to enable one of ordinary skill in electronics at that time to build and use an ABC computer. Dr. Mauchly had an opportunity to read and did read the 35-page manuscript."

"Prior to his visit to Ames, Dr. Mauchly had been broadly interested in electrical analog devices, but had not conceived an electronic digital computer. .....I am inclined to the point of view that the work on the ENIAC was a group or team effort, and that inventive contributions were made by Sharpless, Burks, Shaw, Davis, Mural, Chu, Williams, Chedaker, Cummings, Gail, and Michael."

"Honeywell has shown that the subject matter of detailed patent claims, Numbers 88 and 89, of the ENIAC patent corresponds to the work of Atanasoff, which was known to Mauchly before any effort pertinent to the ENIAC machine or patent was begun."

Media headlines read: COMPUTER PATENTS RULED INVALID. HONEYWELL OWES NO ROYALTIES

There was no appeal.

RECOGNITION, 1974 - 1995

While the decision was coming too late for John Vincent Atanasoff or Clifford Berry's heirs to receive financial reward, after 25 years it was of immense personal satisfaction to JV to have formal recognition as the inventor of the electronic digital computer.

To name just a few honors, there were Honorary Doctorate degrees bestowed from the University of Wisconsin, the University of Florida, Moravian College, and Western Maryland College. At the May 16, 1987 graduation ceremony at the University of Wisconsin, Dr. Edwin Black told the assembled 2500 students who were receiving their undergraduate and graduate degrees, "Dr. Johm Vincent Atanasoff had the central insight that led to one of the most momentous inventions of the century, the electronic digital computer. His invention is transforming the world. It accelerates mathematical calculations beyond the dreams of our ancestors; it enhances our collective memory; it functions as a surrogate to human intelligence in applications so numerous that not even a computer can aggregate them all. Yet, this astonishing invention did not exhaust John Vincent Atanasoff's ingenuity. He holds 32 patents for subsequent inventions in such diverse fields as agriculture, transportation, and information science. His contributions to technology have been protean and abundant."

In Iowa, JV was installed in the Iowa Inventors Hall of Fame, was awarded the Governor's Science Medal, and at Iowa State University was given the Distinguished Achievement Citation and honored as Grand Marshall of the Veishea Celebration.

From the Institute of Electrical Engineers, he was awarded the Computer Pioneer Medal, and from the American Society of Mechanical Engineers, the Holly Medal.

In 1990, in a ceremony at the White House, President Bush awarded Dr. Atanasoff with the National Medal of Technology.

Dr. Atanasoff died in 1995 at the age of 91.

AFTERWORD

Recent historians now credit Dr. John Vincent Atanasoff as the inventor of the first SPECIAL PURPOSE electronic digital computer. Historians characterize the ENIAC computer as the first GENERAL PURPOSE computer capable of solving a variety of problems.

Professor Allan Macintosh, Professor of Physics at the University of Copenhagen, has written that it is sad that World War II terminated Dr. Atanasoff's work when he was just on the brink of triumphant success.

Dr. Mauchly and Dr. Eckert deserve great recognition for doing a brilliant job of selling the ENIAC to the United States Army. However, the construction of the ENIAC, remarkable as it may be, DOES NOT AND SHOULD NOT EXCUSE John Mauchly for his subsequent actions of denying Dr. Atanasoff credit for his achievements.

Dr. Atanasoff emerges from this saga as a TOO-TRUSTING hero, while Mauchly emerges as a TARNISHED CHARACTER. Perhaps Dr. Mauchly had never been apprised of the famous quote from the greatent of all scientists, Sir Isaac Newton, who said:

"IF I HAVE SEEN FURTHER THAN OTHER MEN, IT IS BECAUSE
I HAVE STOOD ON THE SHOULDERS OF GIANTS."

APPENDIX [1]

Atanasoff's Thoughts at the Roadhouse, Winter of 1937 - 1938

In the two or three hours that John Vincent Atanasoff was in the Illinois roadhouse, his thoughts settled first on the use of electronics as the power medium and electric impulses as the measuring stick for a computer. This turned to the need for a regenerative memory or "jogging" of the electrical system through the use of condensers that would regenerate their own state. "If the condensers were in the plus state, for instance, they would stay in the plus state; or if they were in the negative state, they would stay in the negative state. They would not blink off to zero. Or if two positive charges were used, they would retain their original identity, and would not leak across.

Quietly thinking in the roadhouse, John Vincent (JV) was able to develop the initial concept of what is called "logic circuits." He explained this as a "non-racheting approach to the interaction between two memory units, or as I called it 'the abaci'." Atanasoff visualized a black box with an internal mechanism that would be moved by electric or electronic means, and would operate on a base 2 system on the principle of the abacus. "The state of Abaci 1 would pass into the box, the state of Abaci 2 would pass into the box, and the box would yield the correct result on output terminals. I was not sure what would be in the black box besides vacuum tubes or condensers."

During the evening at the roadhouse, Atanasoff made four decisions for the computer project:

1. He would use electricity and electronics as the medium
2. In spite of custom, he would use base 2 numbers (the binary system)
3. He would use condensers for memory and would use a regenerative or "jogging" process to avoid lapses that might be caused by leakage of power
4. He would compute by logical action and not by enumeration as used in analog devices.

Atanasoff Details His Concepts, 1938 - 1939

The Regenerative Memory. The regenerative memory condenser system was solved first. "I was planning to use vacuum tubes for computer circuits, but I could not afford too many vacuum tubes. I chose small condensers for memory because they would have the required voltage to actuate the tubes, and the plates of the tubes would give enough power to charge the condensers. In the past, I had been worried about loss charges in the condensers, but now with jogging (regeneration) that worry was gone." Design and construction of the actual circuit for jogging the memory required a minimum amount of time, a week or so at most, Atanasoff explained later.

Direct Logical Action. "The decision to compute by direct logical action and not by enumeration was much more difficult," Atanasoff explained. "I had merely hypothesized a black box that would do this, but the generation of a device for putting into the black box was a more difficult problem that occupied me literally for months. None of the modern metallic theory and logic theory, of course, was available and we were attempting to devise it. If I had chosen to do the job by enumeration (analog), I would have tried to simulate by electronic means the counting processes that have always been used in computing, but here I wanted something different."

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[1] Mollenhoff, Clark R. Atanasoff, Forgotten Father of the Computer. Iowa State Press, Ames. 1988.

Burks, Arthur H. and Alice R. Burks. The ENIAC: First General Purpose Electronic Computer. Annuals of the History of Computing. Vol.3, 4, pp 310-389, 1981.

Mackintosh, Allan R. The First Electronic Computer. Physics Today. Vol. 20, 3, pp 25-32, 1987.

"I considered how I might add two numbers," Atanasoff continued. "I would have them enter the black box from two separate memory devices. The black box would find their sum and would signal this to a third memory device or, what is more usual, back into one of the memories that had sent the original numbers. The box in each case would have to compute the answer to the addition or subtraction required."

Atanasoff planned to use serial addition or subtraction; that is, to operate on numbers digit by digit. The black box, which he began to call his computing device, started at the lowest power of 2 and moved to the next higher power, and at each power it received the 2 signals from the digits to be added or subtracted. The logic of the system gave the answer and the carry or borrow digit, if any, for the next step. The black box or computing device was to contain vacuum tubes to carry out this operation. "I knew the electronic theory but just couldn't convince myself that the vacuum tubes would act like a gear tooth and form an adding machine. I had to see it for myself later in the construction of the breadboard prototype."

"I called my logic circuit an add-subtract mechanism," Atanasoff continued. "The breadboard prototype would contain 13 vacuum tubes (the full-scale model 300 vacuum tubes), and in the end those were all triodes. Adjustment of the biases of the tubes would cause the circuit to add or to subtract. By arranging for the data on one of the two memory devices to be shifted, I planned for automatic division and multiplication. The mathematical method to solve sets of linear equations was that of a systematic elimination of coefficients through combinations of pairs of equations. At the end of some months, I commenced to be able to write circuits for the scale of base 2."

Memory Storage Device. The memory storage device and the device for regenerating the memory were in different parts of the machine. A capacitator drum (memory) storage device incorporated the revolving principle for storing information.

Atanasoff and Berry used 2 rotating drums in the full-scale model. The drums were 8 inches in diameter. Within each drum, 1632 capacitators were mounted in 32 tracks with 51 capacitators per track. At a rotational speed of one revolution per minute, the "clock" pulse rate was 60 cycles per second. A corresponding array of brass studs was mounted on the drum for making connection to the computer circuits as the drum rotated. A binary digit was represented by the polarity of the charge on the capacitator, with the charge being reversed, as called for in the computation, once each drum revolution. The capacitators could be charged, discharged, and recharged as often as necessary.

Punching Holes in Binary Cards by an Electric Spark Method. Atanasoff had to have a device for storing intermediate results within the machine. He had to devise a base 2 card reader system to furnish the machine a record of at least 1500 bits of information per second. There was no method in the world for doing that at the time. IBM punches could handle 20 or 30 numbers per second, but nothing beyond. Atanasoff devised a system in which the full-scale model (the ABC) burned holes in the binary cards with an electric spark. These were called electrostatic punches. Later in the computation, the computer would find out where the holes were and read the data.

The full-scale model had 30 such electrostatic punches working in unison. Getting the 30 to work in unison was no small feat. Zapping the paper without igniting it was tricky as well. The cards had worked well in preliminary tests in 1939, but as data input was increased the holes were found to scorch in error once in 10,000 or 100,000 times. Atanasoff and Berry eventually found a type of paper that worked but never documented it. It was unavailable in quantity due to the war.

Input/Output Devices. Initial input of data was by means of standard IBM cards with five 15-place numbers per card; the machine translated these numbers to binary numbers. The computed answer was read by peering into an axle to find odometer numbers rotating into place.

The Atanasoff Berry Computer (ABC) Full-Scale Model

Atanasoff enumerated the significant advances that the ABC encompassed:

- All internal operations were executed in binary arithmetic (base 2 number system)
- All computation was done in a serial manner
- Separate memory storage and computing devices
- What I (Atanasoff) called jogging, others call it regenerative memory
- Vacuum tubes were used in computing
- Electronic amplifiers were used as on and off switches
- Parallel processing circuits for logical addition and subtraction (logic circuits)
- Capacitators were used as memory elements
- A rotating drum memory contained the capacitators
- Clock control of electronic operation (While the timing mechanism was driven by a mechanical electric motor, all computing was electronic.)

The full-scale model was the size of a large desk and weighed 750 pounds. It performed 0.06 operations/sec (compared to 19 billion operations/sec today), and had a memory storage capacity of 3,000 bits (compared to 100 billion bits today).

Iowa State University Builds Replica of the Atanasoff Berry Computer

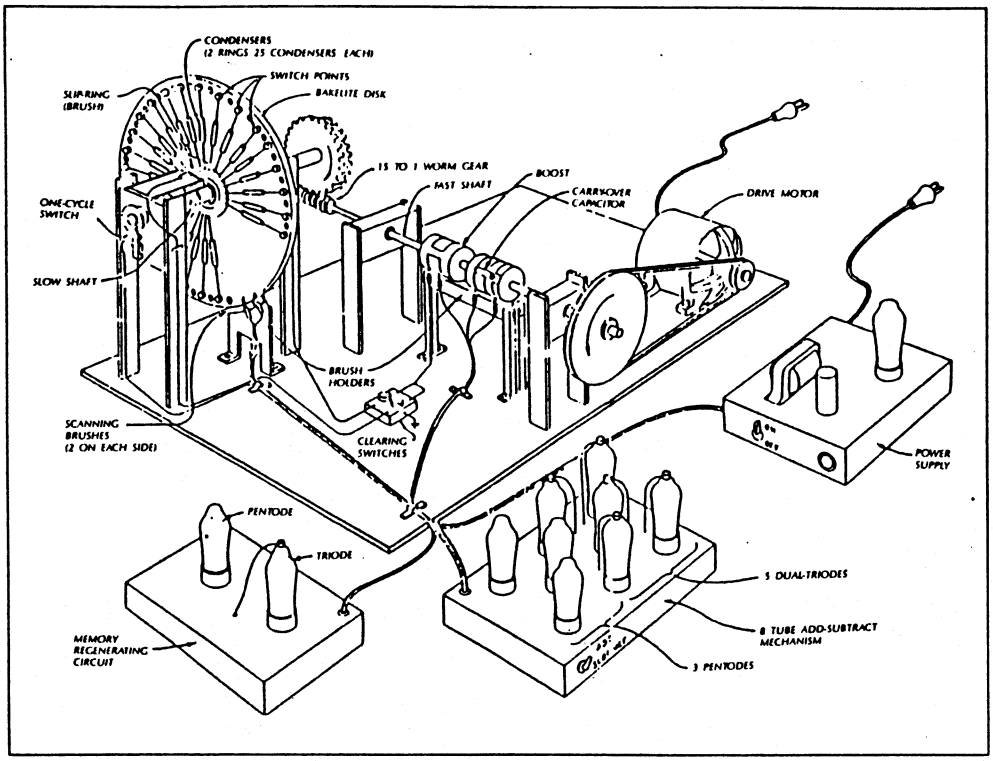
To preserve the legacy of Atanasoff and Berry, a team of Iowa State University scientists and students have built an authentic full-scale working replica of the desk-size Atanasoff Berry computer. Construction has been true to the original. This required painstaking care in using vintage computer parts, like 1940 vacuum tubes, brushes, and punch cards of the era.

Because the original ABC was demolished, replica team members had to rely on fragmentary data, grainy photographs, and the fading memory of those who were part of the original project or close to it. This included trips to retrieve information from the Atanasoff family, getting on loan from the Smithsonian Museum one of the few remaining authentic parts - - a memory drum - - and subjecting it to MRI and X-ray analysis at a local hospital. After struggling to find authentic binary cards, the team turned to Jean Berry (Clifford Berry's wife and Atanasoff's secretary). John Gustafson, a replica team member said, "She knew the name of the paper and where we could buy it right off the top of her head."

The machine was unveiled October 8, 1997 at the National Press Club in Washington D.C. and is now on tour to major centers of the USA.

While slow and cumbersome compared to today's computers, the ABC did demonstrate several principles that are the basis of modern computing. Common computing ideas like the use of the binary system of arithmetic, separate memory and computing functions, regenerative memory, and the use of circuits for logical addition and subtraction, were all employed in the ABC. "Except for color monitor, a mouse pad, and greater speed, he figured out how to do all the basics way back then," said Gary Sleege, another replica team member. "And Atanasoff's vision resonates today," said Gustafson. "He visualized a society in which everything was done in binary by a machine. This is just now happening. Everything - - our telephones, our TV's, our CD - ROM's - - are just now going digital."

THE BREADBOARD PROTOTYPE COMPUTER



Dr. CLIFFORD BERRY, 1918 - 1963

As noted in the text, Clifford Berry's second letter to Dr. R. K. Richards arrived July 12, 1963. October 1, 1963, Berry resigned his position as director of the Engineering Analytical Control Division of Consolidated Electrodynamics Corporation in California and started a comparable job at Vacuum Electronics Corporation in Huntington, New York. His wife, Jean, had stayed behind to pack up the house which they had just sold.

In his daily telephone calls, Berry was very enthusiastic about his new job. He was upbeat about buying a new car, and had picked out two houses in Huntington that he reported to be even nicer than the house they had just sold. Jean was to join him November 7 to choose one of them.

On November 1, 1963, Clifford Berry was found dead in his rooming house, with his hands by his side, covers pulled neatly up to his neck, and with a plastic bag over his head. Jean Berry did not relate to anyone that the death was listed as "possible suicide" by suffocation. She did not understand how the death could be suicide, as her husband had been in the best of spirits in his telephone calls.

Atanasoff learned of the details of Berry's death during the trial. Accompanied by his lawyers, he went to Huntington to reopen the case. The Chief of Police refused. Atanasoff always wondered if the mysterious death of Clifford Berry was related to Berry's renewed interest in 1963 in digging into links between the ABC and ENIAC computing machines.

ABC —The first electronic digital computer

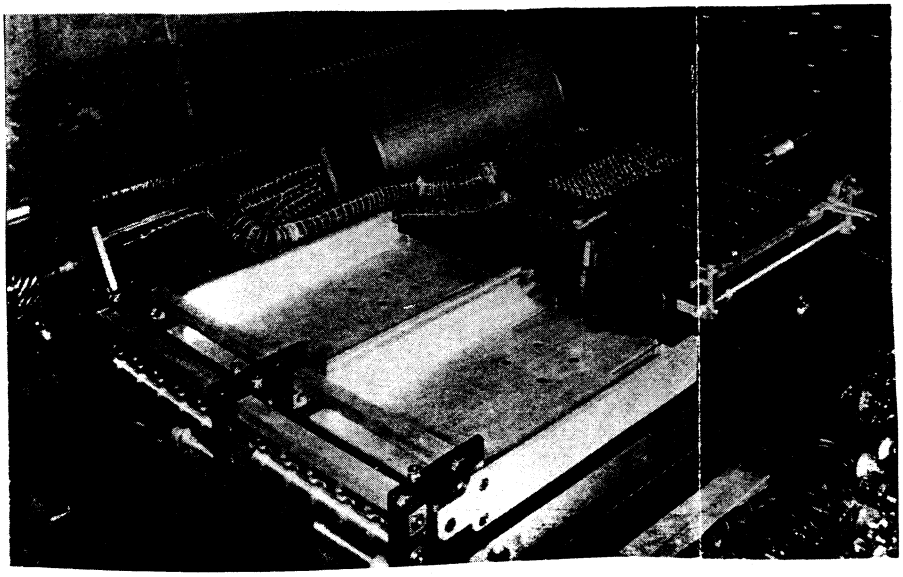
John V. Atanasoff

John V. Atanasoff received a B.S. from the University of Florida in 1925, an M.S. from Iowa State in 1926 and a Ph.D. from the University of Wisconsin in 1930. As an Iowa State faculty member in the late 1930s, Atanasoff pursued the idea of a computing machine to shorten the tedious process of solving simultaneous equations. With the help of graduate student Clifford Berry, Atanasoff assembled and demonstrated the first electronic digital computer. During World War II, Atanasoff went to work for the Naval Ordnance Laboratory in Washington, D.C. He eventually became a successful engineer and businessman. In recognition of his pioneering work in computing, Atanasoff was given the National Medal of Technology in 1990 by President George Bush and the Computer Pioneer Medal in 1984 by IEEE. Atanasoff died in 1995 at the age of 91.

Clifford Berry

Clifford Berry received a B.S. in electrical engineering (1939), his M.S. (1941) and Ph.D. (1948) degrees in physics from Iowa State. Berry was a graduate student at Iowa State when he helped John Atanasoff develop the ABC. Berry played an instrumental role in the design and construction of the original computer. After graduation, Berry went on to a successful scientific career in the field of mass spectrometry. He eventually earned 43 patents in mass spectrometry and related areas of vacuum and electronic technology. He died in 1963 at the age of 45.

ORIGINAL GRAINY PHOTOGRAPHS



CLIFFORD BERRY AND THE ORIGINAL ABC