1990

The Origins of Modern Computing

Saul Rosen

Report Number:
90-1013

THE ORIGINS OF MODERN COMPUTING

Saul Rosen

CSD-TR-1013
August 1990

The Origins of Modern Computing

Saul Rosen
Department of Computer Sciences
Purdue University
West Lafayette, Indiana.

Abstract

The modern electronic computer had its origins in the work of J. Presper Eckert and John Mauchly and their colleagues at the Moore School of Electrical Engineering of the University of Pennsylvania in the years between 1942 and 1946. This article contains a brief review of that period, and of some of the publications that deal with its history. The latter part of the article reviews several recent publications that seek to detract from the importance of the work at the Moore School during those years by giving exaggerated importance to an earlier attempt to build a small special purpose electronic computer.

Introduction

I think that the most important and most productive period in the history of computing was the period from 1942 to 1946 at the Moore School of Electrical Engineering at the University of Pennsylvania. During those years the group at the Moore School designed and built the ENIAC, the first large scale general purpose electronic computer. Also during those years their design of the EDVAC introduced the revolutionary idea of the modern stored program electronic computer. This article contains a brief review of that period, and of some of the publications that deal with its history. The latter part of the article reviews several recent publications that seek to detract from the importance of the work at the Moore School during those years by giving exaggerated importance to an earlier attempt to build a small special purpose electronic computer.

The most important books that cover the history of the work at the Moore School are:

Herman H. Goldstine *The Computer from Pascal to von Neumann.* Princeton University Press 1972. 378p.

Nancy Stern *From ENIAC to UNIVAC: An appraisal of the Eckert-Mauchly Computers.* Digital Press 1981. 286p.

Brian Randell, Editor, *The Origins of Digital Computers.* Springer-Verlag 1973, 1982. 580p. This collection contains a number of documents written at the time by participants.

In the summer of 1941 Dr. John Mauchly, a 34 year old Physics professor at Ursinus College, attended an eight week summer course at the Moore School of Electrical Engineering of the University of Pennsylvania. J. Presper Eckert, aged 22, was a graduate instructor in that course. Herman Goldstine states that Eckert "was undoubtedly the best electronic engineer in the Moore School." During that summer course Eckert and Mauchly started a scientific

collaboration that was to last for many years. At the end of the course Mauchly accepted a position as a member of the faculty of the Moore School. World War II had been raging in Europe for two years and United States involvement was imminent. The Moore School had an electromechanical Differential Analyzer which was based on the one built by Vannevar Bush at MIT. The Ballistic Research Laboratory (BRL) at Aberdeen Md. (part of the United States Army Ordnance Department) was in charge of the calculation of trajectories for new weapons. They contracted with the Moore School for use of the Differential Analyzer and also for organizing and running a manual calculating group. As the war went on the need for calculating trajectories far outstripped the computing facilities that could be made available.

The ENIAC

Professor John Grist Brainerd was in charge of Moore School liaison with BRL. In August, 1942 Mauchly wrote a memo to Brainerd, *The use of high speed vacuum tube devices for calculating*. He stated that reliable electronic counters could operate at 100,000 pulses per second, and that such counters could be used as the basis for a very fast computer. He pointed out that a calculation that would take 15 to 30 minutes on a mechanical differential analyzer would be done much more accurately in about 100 seconds on an electronic calculator. Mauchly's 1942 memo is included in Randell's collection. Lt. Herman H. Goldstine, a young Mathematics Ph. D. at BRL was put in charge of the BRL operation at the Moore School. Goldstine states that "Mauchly and I had frequent and mutually interesting conversations about computational matters in the fall of 1942." At his suggestion Brainerd, Eckert, and Mauchly prepared a proposal to BRL. A contract was signed on June 5, 1943 that called for the Moore School to design and build the ENIAC (Electronic Numerical Integrator and Computer). It was to use 5000 vacuum tubes and cost $150,000. When completed it had close to 18000 tubes and cost about $750,000. It was accepted by BRL on June 30, 1946.

The ENIAC was a spectacular machine. It was the herald of the age of computers. Skeptics who argued that the ENIAC could not be finished in time to contribute to the war effort were proved to be right. But those who argued that it wouldn't work, or that it wouldn't make the older electromechanical computing technologies obsolete, were proved to be terribly wrong. The ENIAC was orders of magnitude faster and more powerful than any earlier computer. Its existence made it possible to carry out computations that could not have been considered without it. The ENIAC was a monument to the engineering genius of J. Presper Eckert, and to the imaginative thinking of John Mauchly. The early history of electronic computers has unfortunately been distorted by claims of priority based on patent litigation. However, even those who make the most outrageous claims don't deny ENIAC its place as the first operational large scale general purpose programmed electronic digital computer.

The Stored Program Computer-EDVAC

In early 1944, after the design phase of the ENIAC was complete, some members of the group at the Moore School started to work on the design of a successor machine which came to be known as the EDVAC (Electronic Discrete VAriable Computer). The principal shortcomings of the ENIAC were recognized to be inadequate storage and the difficulty of setting up new problems, i.e. the difficulty of programming. On January 29, 1944 Eckert wrote a "preliminary disclosure" in which he described a magnetic disk calculating machine in which instructions as well as data would be stored on the disk. That document is the earliest known proposal for a stored program computer. It is published as an appendix to the book *From Dits*

to Bits by Herman Lukoff. (Robotics Press, Portland Oregon. 1979. 219p.) Lukoff's book carries the subtitle *a personal history of the electronic computer*. He joined the ENIAC project when he graduated from the Moore School in 1943, and he was associated with Eckert and Mauchly, and later with Eckert through all of Lukoff's long career as a computer engineer. His book has a great deal of interest to say about many computer projects. Unfortunately, Lukoff was drafted into the navy in mid 1944 and was away from the Moore School until mid 1946, and there is a gap in his interesting informal report about the work there from the point of view of one who was then a junior engineer. Eckert's "preliminary disclosure" is also published as an addendum to a short paper on the ENIAC that was presented at the International Conference on the History of Computing at Los Alamos in 1976[1]. In that paper Eckert refers to the stored program computer as "my best computer idea." By mid 1944 Eckert had designed a mercury delay line memory that was much faster than the proposed disk storage.

Much progress had already been made toward the invention of a stored program computer based on the mercury delay line memory by the time that John von Neumann joined the Moore School group as a consultant. In his book Goldstine tells his now famous story about how he met von Neumann at the railroad station in Aberdeen during the summer of 1944. Von Neumann was a world famous mathematician who served as a consultant for major defense projects, including the very secret atomic bomb project at Los Alamos. Goldstine states that "When it became clear to von Neumann that I was concerned with the development of an electronic computer capable of 333 multiplications per second the whole atmosphere of our conversation changed." Von Neumann visited the Moore School late that summer and frequently thereafter. He was welcomed for his brilliant mind, and also for the prestige that the enthusiastic participation of a scientist of his caliber brought to the Moore School projects.

The electronic digital computer flourished in the wartime environment in which computing needs were expanding and resources could be made available to try to satisfy these needs. The wartime environment also brought with it restrictions on publication and on the free interchange of information. The computer projects at the Moore School were classified Confidential. Eckert and Mauchly could not publish papers or lecture about their work. They may have welcomed the confidential nature of the project since they hoped to obtain valuable patents when it was over. Von Neumann apparently had no interest in patents and was prepared to ignore the Confidential classification.

One of the most important documents in the early history of electronic computers is the *First Draft of a Report on the EDVAC* written by John von Neumann, and dated June 30, 1945. This 118 page mimeographed document was not treated as a classified document. It was fairly widely distributed, and soon made the basic concepts of the stored program computer known in scientific circles. In recent times a large excerpt was published in Randell's book, and the document was published in full as an appendix in Nancy Stern's book. The architecture of modern computers is frequently referred to as the von Neumann architecture, based on his authorship of the *First Draft*. It might be more appropriate to call it the Eckert, Mauchly, von Neumann architecture, since the *First Draft* was a report based on discussions that took place at the meetings of the Moore School group for which von Neumann served as a consultant, and some of the major ideas about the stored program computer had been developed at the Moore

[1] *A History of Computing in the Twentieth Century.*
Edited by N. Metropolis, J. Howlett, and G.-C. Rota. Academic Press 1980. 525-539.

School before von Neumann heard of the computer activity there. Friends of von Neumann have stated that in conversations with them he always agreed that the *First Draft* was a summary of the work of the EDVAC design group, and that a more formal publication of these ideas would have included Eckert and possibly Mauchly along with von Neumann as authors.

Eckert and others have pointed out that von Neumann was asked on numerous occasions to clarify the situation as to authorship of the concepts and ideas contained in the *First Draft.* He never chose to do so. Eckert has publicly criticized von Neumann for his tendency to take credit for the ideas of others. In his book Goldstine points out that the *First Draft* was not intended as a publication, and hence von Neumann should not be blamed for attaching only his own name to it. He states that "Through no fault of von Neumann's the draft was never revised into . . . a report for publication." Goldstine emphasizes the major contributions that von Neumann made, and that the writing of the *First Draft* itself was a major contribution. Of the Moore School group he states, "Everyone there was indispensable as regards some part of the project . . . but only von Neumann was indispensable to the entire task." Goldstine was a friend and a great admirer of von Neumann, and may not be completely objective in his evaluation. It is unfortunate from the point of view of the history of computing that von Neumann showed no interest in evaluating the contributions of others to the computers in which he was involved. Thus, von Neumann knew Alan Turing when Turing was working on his Ph. D. degree at Princeton in 1938, and von Neumann must have been aware of Turing's 1937 paper on "Computable Numbers" in which Turing Machines were introduced[2]. In that paper Turing showed how, "It is possible to invent a single machine which can be used to compute any computable sequence." It would be interesting to know to what extent Turing's ideas influenced von Neumann in his perception of the stored program computer as a truly universal computer.

There exists a very interesting document entitled *Automatic High Speed Computing: A Progress Report on the EDVAC.* This progress report was submitted to Army Ordnance by Eckert and Mauchly, and is dated September 30, 1945. It is a logical successor to the *First Draft*, and might have had as great an impact, except for the fact that it was Confidential, and there was no distribution outside of Army Ordnance at the time. Concerning the *First Draft* it states, "Dr von Neumann has also written a preliminary report in which most of the results of earlier discussions are summarized. In his report the physical structures and devices proposed by Eckert and Mauchly are replaced by idealized elements to avoid raising engineering problems which might distract attention from the logical considerations under discussion." The *Progress Report* lists a proposed order code for EDVAC and states "This plan for orders is essentially that which von Neumann has proposed after trying out various coding methods on typical problems." It also states that, "von Neumann has specified that some order symbols be capable of modification by deleting a given part of the order and inserting something else in place of this part" Thus it appears that Eckert and Mauchly gave von Neumann credit for the idea of address modification during program execution. The Progress Report is 111 pages long, and is a clear and detailed discussion of the thinking about electronic digital computers in mid 1945. It is unfortunate that it was not published and distributed at the time. I have recently suggested that it should be published in the Annals of the History of Computing, and I

[2] On computable numbers with an application to the entscheidungsproblem. by A. M. Turing. Proc. London Math Soc. Ser. 2, Vol. 42, 1936-7. pp 236-265. Reprinted in "The Undecidable" edited by Martin Davis, Raven Press, Hewlett, New York 1965.

hope that it will become available there.

Both the *First Draft* and the *Progress Report* stress the idea of serial computation as an essential idea on which the stored program electronic computer is based. It is now amusing to read section 5.6 of the *First Draft* in which von Neumann points out the economy that results by avoiding any parallelism, and that the high speed of electronics would make a totally serial computer fast enough for all practical purposes. By the time the design of his IAS computer was started, about a year later, he had realized that very much higher speeds would be needed than could ever be obtained in serial computers.

Spring and Summer of 1946

In the fall of 1944 Eckert and Mauchly decided to apply for a patent on the ENIAC. The ensuing controversy concerning patents led to a great deal of bad feeling within the Moore School group, and eventually resulted in the departure of Eckert and Mauchly from the Moore School on March 31, 1946. At about the same time Goldstine and Burks (discussed below) joined von Neumann at the Institute for Advanced Study at Princeton. Goldstine and Burks have written extensively about the early development of computers. Partisans of Eckert and Mauchly have not. As a result the literature is rather one sided. Goldstine and Burks idolized von Neumann. They did not like Mauchly. One also gets the impression that they found it difficult to give full credit and recognition to the youthful genius of J. Presper Eckert, and much easier to give credit to John von Neumann whose genius had already been demonstrated in other fields.

During July and August, 1946 a very important summer course on computers was held at the Moore School. Eckert and Mauchly and Goldstine came back to serve as major lecturers in the course. Many important figures in the design and use of computers were there as visiting lecturers. Attendance at the course was by invitation, and a number of those who attended went on to do important work in the computer field. Maurice Wilkes came from Cambridge University in England. From lectures and discussions about the EDVAC he took back with him the idea of the stored program computer based on mercury delay lines, and his EDSAC computer based on these ideas was doing useful computation long before the EDVAC was completed. A large number of the lectures presented in the course are included in a set of lecture notes that were published some time after the course was completed. Some were manuscripts submitted by the lecturers, and some are based on transcriptions of wire tape recordings. They provide a very interesting record of the state of the art of computing at that time. They are unfortunately incomplete, since some important lectures are listed only by title with a minimal summary. The notes have recently been republished as Volume 9 of the *Charles Babbage Institute Reprint Series for the History of Computing* under the title *The Moore School Lectures*. (The MIT Press and Tomash Publishers. 1985. 568p.) The summer of 1946 marks the end of the period in which the Moore School was the center of the world of computers. The Computer Revolution had been launched at the Moore School, but the leaders of the next phase were at Princeton and MIT, at Manchester and Cambridge in England, and in the computer industry in which Eckert and Mauchly played an important pioneering role. The Moore School remained involved, but it never again achieved a position of preeminence in the computer field.

The ENIAC Patent

In October of 1946 Eckert and Mauchly formed a computer company which later became the Eckert-Mauchly Computer Corporation. They filed a patent application for the ENIAC on June 16, 1947, and a patent was finally granted on February 4, 1964. The 200 page patent contained 148 claims that included many basic concepts in electronic computing. By 1964 the patent had been assigned to Sperry Rand Corporation. IBM raised some objections but a cross licensing agreement was worked out. Honeywell refused to pay royalties to Sperry Rand, and in May of 1967 Sperry Rand filed a suit against Honeywell and Honeywell filed a counter suit. The combined suits came to trial before Judge Earl R. Larson in Minneapolis in June of 1971. Honeywell lawyers submitted 30,000 documents, and Sperry Rand lawyers submitted 6000 documents. The transcript of the trial was 50,000 pages long. The verdict that was handed down on October 19, 1973 was 319 pages long. The trial record has become a major source of information about the early history of electronic computing. The ENIAC patent was declared to be invalid on several grounds. One was the purely technical ground that the ENIAC had been in use and offered for sale more than a year before the patent was filed. The other was a ruling that: "Eckert and Mauchly did not themselves first invent the automatic electronic digital computer, but instead derived the subject matter from one John Vincent Atanasoff". At that time few people had heard of John Vincent Atanasoff.

Atanasoff and Mauchly

Atanasoff, while a professor of Mathematics and Physics at Iowa State College, started work on an electronic computer project in 1938. With the help of a graduate student Clifford E. Berry he undertook to design and build an electronic computer that would solve up to 29 linear algebraic equations in 29 unknowns. The computer, which has come to be known as the ABC computer, was never finished but according to Atanasoff it was able to solve small systems of equations in the spring of 1942. Because of the advent of World War II first Berry and then Atanasoff left Iowa State in 1942 and there was no further work done on the computer. It was dismantled in 1948.

The book, *Electronic Digital Systems* by R. K. Richards. (John Wiley and Sons, 1966, 637p.) was an early general introduction to electronic digital computers. On page 3 it states that, "The ancestry of all electronic digital systems appears to be traceable to . . . the Atanasoff-Berry Computer". Dr. Richards was a student at Iowa State at the time that Atanasoff was building his computer and he saw the computer at that time. On page 4 he states that, "One of the few people to study the machine in detail was Dr. John Mauchly who . . . made a visit to ISU in 1941 for the specific purpose of studying the computer." This statement was the catalyst that led Honeywell attorneys to Atanasoff in connection with their patent suit against Sperry-Rand.

Mauchly presented a paper at an AAAS meeting in Philadelphia in December, 1940. Atanasoff introduced himself and their mutual interest in computation led to an invitation to Mauchly to visit Atanasoff. It also led to correspondence which became important evidence in the ENIAC patent trial. Mauchly visited Atanasoff at Ames, Iowa for a few days in June, 1941. While there he saw the partially completed ABC computer and was shown a document that Atanasoff had prepared in 1940 as part of a proposal to the Research Corporation. Mauchly was not permitted to take away a copy of that document because Atanasoff was preparing to file for a patent on the ABC. No patent was ever filed, and there was no contemporary publication about the ABC. The 1940 document by Atanasoff, *Computing Machine for*

the solution of Large Systems of Linear Algebraic Equations, was first published in Randell's collection in 1973. It includes an interesting discussion of how Atanasoff's design decisions were made, and it presents a complete description of the design of the ABC.

The Book *From ENIAC to UNIVAC*

Nancy Stern's book was written after the ENIAC patent trial, and was the first book that made effective use of the records of the trial. I first read this book, in a preliminary form, when the Publisher sent me a copy of Stern's dissertation and asked me to review it and to comment on its suitability for publication. My response stated that "I read Nancy Stern's dissertation . . . on the day I received it, almost without putting it down. I found the material very interesting - even fascinating . . . The full story of the Eckert-Mauchly computers has not been told before. . ." I have recently reread a major portion of the book in connection with this essay, and I still think that it is fascinating. Goldstine's discussion of the Moore School computer projects is of special interest because he was active both as a liaison between BRL and the Moore School and as a participant in the technical meetings in which design considerations were discussed and decisions were made. Stern's discussion is of special interest because she provides the objective view of a non participant. Goldstine writes authoritatively and convincingly. His research was reinforced by his own memory of the people who participated. Stern's approach is more that of an interpreter. She quotes from Goldstine's book as an authoritative source, as indeed it is.

Dr. Stern is trained as a historian, not as a computer scientist or a mathematician. As a historian she brings insights into this area that represent an important contribution to the study of the period. I find it significant that her book is not quoted, and is not even listed among the references in either the Burks book or the Mollenhoff book on Atanasoff discussed below. Stern discusses the importance of Mauchly as an innovator, with innovation "defined as the application or adaptation of an idea, even an existing one, in such a manner that the resulting technology is rendered practical and useful." She takes issue with the point of view "that the *idea* is of critical import and the application or execution of that idea is of secondary significance." Even though it is not explicitly stated in the book, I think it is made clear that the part played by Eckert and Mauchly in the invention of the computer was far more significant than that of Atanasoff, and would remain so even if it could be proved that Mauchly's work made use of some ideas that he first came across in his meeting with Atanasoff.

The Cult of Atanasoff

A patent suit is an adversary process. It is not an objective investigation into the history of technology. Almost inevitably it produces a distortion of history, since the facts are filtered through depositions and cross examination by lawyers whose only goal is to strengthen their own case and to weaken that of their opponents. Thus, the ENIAC patent trial was a contest between Honeywell lawyers and lawyers for Sperry Rand in which the Honeywell lawyers won. A major part of the Honeywell lawyers' strategy was to glorify Atanasoff and to discredit Mauchly. The success of their strategy probably exceeded even their own expectations. One result has been the development of a cult of Atanasoff led by Professor Arthur W. Burks of the University of Michigan. Arthur Burks attended the 1941 summer course at the Moore School along with Mauchly, and he too joined the Moore School faculty at the end of the course. He was one of the senior members of the ENIAC design group. In connection

with the ENIAC patent trial he filed a claim that he was a co-inventor of the ENIAC. He strongly resented the claims of Eckert and Mauchly that they were the sole inventors of the ENIAC. He felt that Eckert and Mauchly were greedy and unethical for claiming exclusive rights to inventions that included the work of others, and that were carried out while they were employed by the University of Pennsylvania. He served as a consultant to Honeywell in the patent case. His wife, Alice R. Burks has collaborated with him in a number of publications.

The cult of Atanasoff has so far produced four major publications:

Arthur W. Burks and Alice R. Burks.
"The ENIAC: First General Purpose Electronic Computer" *Annals of the History of Computing.* Vol. 3, No. 4. October 1981 p. 310-389.

John Vincent Atanasoff. "Advent of Electronic Digital Computing" *Annals of the History of Computing.* Vol. 6 No. 3 July 1984 p.229-282.

Alice R. Burks and Arthur W. Burks. *The First Electronic Computer- The Atanasoff Story,* The University of Michigan Press 1988. 387p.

Clark R. Mollenhoff. *ATANASOFF Forgotten Father of the Computer.* Iowa State University Press. 1988. 275p.

The ENIAC Patent Case

The Honeywell lawyers argued that before he met Atanasoff Mauchly had had no interest in digital electronic computing. They argued that Mauchly had shown no originality in his early work in analogue computing. The implication was that a person of his limited ability could not have conceived of the ENIAC or of its electronics himself, and that all of that development must have been derived from information that Mauchly learned from Atanasoff during the few days that Mauchly spent visiting Atanasoff in Ames. They ridiculed Mauchly when Mauchly said that he could not recall how much or how carefully he had read the document that Atanasoff had shown him 30 years earlier. Honeywell lawyers were smart enough not to try to belittle Eckert's talents in electronics and in engineering. Sperry Rand lawyers don't seem to have made an adequate effort to point out that by the time of the ENIAC design Eckert had become expert in electronic engineering, far in advance of Atanasoff, and that Eckert, with the assistance of others at the Moore School, could and most probably did invent the electronics of the ENIAC and the EDVAC without needing inputs from Atanasoff by way of Mauchly. They did bring out the fact that by his own admission Atanasoff had failed in his attempts to build a flip flop after several months of effort. They also brought out the fact that Atanasoff's machine would have been terribly slow and not at all comparable to the ENIAC, since its basic pulse rate was 60 pulses per second as compared to 100,000 pulses per second for the ENIAC.

It is not surprising that Sperry Rand lost the ENIAC patent case. The arguments that the ENIAC had been in use and for sale more than a year before the patent was filed were very strong, and it is hard to see how Sperry Rand lawyers expected to overcome them. Also the claim to have invented *the* automatic electronic computer was much too broad. The Atanasoff

computer was not the only special purpose computer that might have qualified as an earlier instance of an automatic electronic computer. Thus, for example, it was brought out at the ENIAC trial that Byron E. Phelps of IBM had built and tested an electronic multiplier in 1942, and the judge ruled that several claims of the ENIAC patent were anticipated by Phelps' patent. Eckert and Mauchly were negligent in that they did not file their patent application more promptly, and within the time interval required by patent law. Also Mauchly was negligent in that he did not reveal the details of his visit and correspondence with Atanasoff to their patent attorney. Even the Burks who may be considered to be among Mauchly's worst enemies state in their book that valuable and valid patents for the ENIAC could have been filed without acknowledging any previous work by Atanasoff (page 206). Also on page 237 of Burks book there is the parenthetical remark, "(It is curious that on the very first page of the patent, Eckert and Mauchly termed the ENIAC "the first *general purpose* automatic electronic digital computing machine known to us [italics added]." If they had held to this qualification throughout, they would have had, we believe, a valid patent.)" The italics were added by Burks. The victims of their own negligence were Eckert and Mauchly, and eventually Sperry Rand corporation. A major beneficiary was Atanasoff, whose early work on computers would otherwise have remained almost totally unknown. It is ironic that partisans of Atanasoff engage in venomous attacks on Mauchly even though Atanasoff's fame is based totally and only on Mauchly's achievements as a pioneer of the computer field.

Atanasoff's Article

The Annals of the History of Computing appears to have inadvertently become a party to the cult of Atanasoff through the publication of the Burks article, and shortly thereafter through the publication of a long rambling article by Atanasoff himself. Atanasoff's article contains a great deal of interesting material, but it is poorly edited. It is a rather boastful self-serving article in which Atanasoff exaggerates the importance of his own contributions to the computer field and belittles those of John Mauchly. This article is more interesting than most of the other writings about Atanasoff, but some things in the article seem a bit extreme. Thus, for example, Mauchly had needed extra income during the war years and had obtained consulting work with the Naval Ordnance Laboratory where Atanasoff was working. On page 257 Atanasoff quotes his superior of that time as saying "He was watching you." On the same page he takes issue with an Iowa State document dated June, 1948 stating that by then Atanasoff was saying that the ABC computer was "probably largely obsolete." By then Atanasoff had already seen the ENIAC, and if he was still interested in computing he must have been aware of the EDVAC and the IAS computer projects. By then he must have known that the computer that he had tried to build at Iowa State was totally obsolete. An interesting fact, ignored in other discussions of the case, is that Atanasoff tried to intervene in the patent case, claiming that he was a co-inventor of the ENIAC. The judge ruled that it was more than 20 years too late.

Most of Atanasoff's article is a presentation of the case for Atanasoff. Atanasoff takes justifiable pride in his abilities and accomplishments. He even writes with pride about how Judge Larson complimented him for his performance as a witness at the ENIAC patent trial, and he describes how his ability to perform as a witness was enhanced by intensive coaching by the Honeywell lawyers. I don't think that Atanasoff ever claims, as Burks does, that the ABC computer was completed. He states that "in the spring of 1942 . . . we were able to solve small systems of equations, and we could *usually* get an eliminant between large

equations with accuracy" [italics added]. Atanasoff's accomplishment was very impressive. It is amazing that he and Berry accomplished as much as they did, but they did not produce a useful operational computer, and it is not obvious that they would have been able to do so even if they had remained at Iowa State.

At the end of his article Atanasoff lists a number of concepts that he claims to have "brought to computing." All of these concepts were known to the computer field long before the document he wrote in 1940 became public in connection with the ENIAC patent trial. The only way in which Atanasoff could have brought any concepts into the computer field is through the influence that he may have had on the work of John Mauchly. The basis for his claims is the document and the partially completed computer that he showed to a few people in 1941. An unpublished document and an aborted attempt at implementation do not constitute proof of invention, but with the help of the Honeywell lawyers Atanasoff built his claim on the fact that Mauchly was one of the few people who had seen the document and the partially finished computer. Modesty is certainly not a characteristic of Atanasoff. He joined in enthusiastically with the Honeywell lawyers' strategy to convince the judge that, unlike Atanasoff, Mauchly was incapable of having any original ideas, and that Mauchly's most important contribution to the Moore School computer projects was to introduce Atanasoff's ideas without acknowledging their origin. Atanasoff's claims are actually relatively modest compared to those put forward by some of his advocates who argue that most of the important advances in electronic computing at the Moore School in the years 1943-1946 were derived from Mauchly's memory of what he saw in Ames in June, 1941. My respect for Atanasoff is greatly diminished by the extent to which he supports the unreasonable claims on his behalf made by Burks, and more recently and more abrasively by Mollenhoff.

The Burks Article

In the last item of his summary Atanasoff claims that "I conceived of an electronic digital differential analyzer in early 1941. Burks showed that this idea led to the ENIAC's structure." This is a reference to the Burks article on the ENIAC in the Annals of the History of Computing. The major part of the Burks article in the Annals describes the ENIAC, and it is a scholarly presentation that is destined to remain the standard source for information about the way the ENIAC was built and how it worked. Details of the historical background of the ENIAC that a reader can find in Goldstine's book and in even more detail in Stern's book are not presented here. Instead a major introductory section of this long article introduces and elaborates on the Burks contention that the ENIAC had its origin in "an idea Atanasoff conveyed by letter to John W. Mauchly in 1941." Much of this section of the article is then devoted to a description of Atanasoff's ABC computer. The detailed discussion of an earlier attempt to build a small special purpose electronic computer seems out of place, and tends to denigrate the accomplishments of the ENIAC project. This important article on the ENIAC is seriously flawed by the inclusion of such material.

The Burks argument that the ENIAC is derived from Atanasoff is largely based on three letters. A letter from Atanasoff to Mauchly on May 31, 1941 states, "I suddenly obtained an idea as to how the computing machine we are building can be converted into an integraph." A few more sentences show that he had indeed thought of the possibility of converting his machine into a machine that would solve systems of differential equations by numerical integration. That is all there is to it. There is no evidence that he carried this idea any further. This idea, casually conceived and never pursued, is given the status of a great invention by

Atanasoff's cultists. Considering the state of the ABC at that time I wonder if they have any idea how difficult it would have been to go from there to a fully operational electronic digital differential analyzer?

The second letter is from Mauchly to a meteorologist friend, Clayton, on June 28, 1941. Mauchly mentions his visit to Iowa State. He refers to Atanasoff's machine and states that it "is electronic in operation, and will solve within a very few minutes any system of numerical equations involving no more than thirty variables. It can be adapted to do the job of the Bush differential analyzer more rapidly than the Bush machine does, and it costs a lot less." Thus in June 1941 Mauchly was impressed by Atanasoff's machine and thought that Atanasoff would be able to finish it and that he would be able to adapt it to the job of a differential analyzer. Here it is interesting to note that the Burks book has an extensive analysis of the ABC machine and concludes that it would have taken about 55 hours to solve 29 equations in 29 unknowns. They suggest that in practice, with reasonable validity checks, it would probably have taken twice that long. In the same letter Mauchly states,"My own computing devices use a different principle, more likely to fit small computing jobs." Thus Mauchly acknowledges that he was only interested in small computers in the summer of 1941. More than a year later, after the summer course and other experience at the Moore School, he proposed the construction of a very large computer, orders of magnitude larger than the ABC computer which had not been finished and which had by then been abandoned by Atanasoff.

The third letter, this from Mauchly to Atanasoff on September 30, 1941, is the most damning. Here Mauchly asks, "is there any objection, from your point of view, to my building some sort of computer which incorporates some of the features of your machine?" Mauchly makes it clear that he is thinking of a number of different approaches to electronic computing and then asks "In the event that your present design were to hold the field against all challengers, and I got the Moore School interested in having something of the sort, would the way be open for us to build an *"Atanasoff Calculator"* (à la *Bush analyzer*) here?" When the Bush analyzer was the most powerful computer available the Moore School built a copy for its own use. Here Mauchly suggests that if the "Atanasoff Calculator" is successful and becomes the most powerful computer available he might want to suggest to the Moore School that they build a copy of that for their own use.

Burks and the Honeywell lawyers used these letters to try to create the impression that the essence of the ENIAC was copied from Atanasoff. They ignore the fact that the ENIAC is about as different from the ABC computer as one computer can be from another. The Atanasoff Calculator was never finished. Mauchly soon became aware that Eckert could build reliable electronic counters that would operate at speeds in excess of 100,000 pulses per second. It is of course impossible to know how much he remembered about the details of the low speed, 60 pulse per second, electronic technology that he had seen at Ames. At the time of his visit to Atanasoff he had not even decided to attend the summer course at the Moore School. He could not have known that he would be invited to stay at the Moore School and that several years later he would be in a position to build large scale computers. It seems reasonable to believe Mauchly's testimony that he only retained general ideas of the structure of Atanasoff's machine. It seems reasonable to believe Eckert's testimony that Mauchly talked to him only very briefly about Atanasoff. Yet Burks argues that anything that was done in the ENIAC and even in the EDVAC years later that was even remotely comparable to something that existed in Atanasoff's design was done as a result of Mauchly having seen it described in the document that Atanasoff showed him in Ames in June, 1941.

The Burks Book

The book by Alice and Arthur Burks is the most important of the publications that support the cult of Atanasoff. The Burks are driven by a sense of urgency that is proclaimed in the introduction. It is hard to understand why they are so driven. One gets the feeling that at least in part it has to do with hatred of Mauchly, and a desire to see him put to shame. In his review in *Computing Reviews*, (Vol. 30, No. 4, April, 1989), Eric Weiss calls it an "angry and often vicious book," and refers to "an unnecessarily fierce and vindictive antagonism and hatred for Mauchly." The book is very long, but the most important information in it had already been presented in the articles discussed above. The point of the book is interpretation rather than information. The essential argument of the book, repeated over and over again, states that Atanasoff invented electronic switching and the use of electronics for logical and arithmetic functions, and showed his inventions to Mauchly. Every time the electronics of the ENIAC or even the EDVAC are mentioned it is repeated almost as a ritual that the circuits and logic used are Atanasoff's logic and Atanasoff's circuits. The Burks assert that if not for Atanasoff there would not have been an ENIAC. It is hard to see why anyone would believe this. Even if Mauchly's competence in electronics is suspect, Eckert's talent, perhaps even genius in this area is widely recognized. Atanasoff was certainly not the only one working on electronic switching in the late 1930s and early 1940s. There were many electronic computer projects, including work at MIT and IBM and NCR and RCA. There were electronic computer projects in Germany and in England. T.H. Flowers, in his article *The Design of Colossus.* (Annals of the History of Computing, Vol. 5 No. 3, (July 1983) p239-252.) points out that electronic counters were first used by C. E. Wynn-Williams in 1929, and states that, "From 1935 onward I was exploring the uses of Electronics in telephone exchanges. By 1939 I felt able to prove . . . that an electronic equivalent could be made of any electromechanical switching or data-processing machine." This seems to be a reasonable statement in view of the spectacular Colossus system that he and his coworkers were able to build just a few years later. Colossus was a very secret special purpose electronic computer used at Bletchley Park in England during World War II. It was built to help a group of cryptanalysts under Maxwell H. A. Newman who were trying to break a high level German machine cipher. The details of their work is still considered secret, but the existence of the Colossus and some technical papers about it were finally declassified in the 1970s and 1980s. The first Colossus had 1500 vacuum tubes, and it was operational in December, 1943. That was just about the time the group at the Moore School was starting to build the ENIAC. It is not my purpose to argue here that Colossus was the first electronic computer. It was not a general purpose computer in the same sense as ENIAC. I mention it here merely to give one example of the extent to which principles of electronic technology and concepts of electronic switching were known and used in various parts of the world in the early 1940s.

Mauchly's Interest in Electronics

The story told by Honeywell lawyers was that Mauchly had no interest in electronic computers until he learned about them from Atanasoff. Mauchly claimed that this was not true, that he had started to work with digital electronics and that he was planning to build an electronic calculator before he met Atanasoff. No proof was presented on Mauchly's behalf and judge Larson's decision states that "Prior to his visit to Ames, Iowa, Mauchly had been broadly interested in electrical analog calculating devices, but had neither conceived nor built any electronic digital calculating device."

With more diligence on the part of Mauchly and his Sperry Rand attorneys evidence could have been presented to help support Mauchly's claim, since such evidence was discovered and made public after the ENIAC trial. A letter to H. Helm Clayton written by Mauchly in November, 1940 states, "we are now considering the construction of an electrical computing machine to obtain sums of squares and cross products as rapidly as the numbers can be punched into the machine. The machine would perform operations in about 1/200 second, using vacuum tube relays, and yielding mathematically exact, not approximate results." In another letter dated Dec 4, 1940 to John DeWire, a former student, Mauchly states, "For your own private information, I expect to have, in a year or so, when I get the stuff and put it together, an electronic computing machine, which will have the answer as fast as the buttons can be depressed. The secret lies in "scaling circuits," of course. . . "

These quotations appear on page 100 of the Burks book. Both of these letters were written by Mauchly before he had met Atanasoff, and before he was even aware of his existence. These letters show that Mauchly was indeed thinking in terms of electronic computing, at least on the level of an electronic desk calculator, before he met Atanasoff. They make Mauchly's testimony that he suggested the use of scaling circuits to Atanasoff seem plausible. At the time flip-flops were often called vacuum tube relays, and scaling circuits were electronic counters. The Burks do not question the authenticity of these letters, or of their dates. Thus, on page 100 they state, "We do believe . . . that his designs of neon circuits in 1941, with vacuum tubes interspersed for switching, were efforts toward this digital calculator. At the same time we continue to believe, with the Honeywell side, that he was inspired at least in part by his meeting Atanasoff and learning that electronic computing was indeed feasible." It is hard to understand how the Burks can reconcile this moderate statement with their unreasonable claims about the derivation of ENIAC and EDVAC from Atanasoff that they make in other parts of the book.

Samuel Caldwell

At the time the ENIAC was first proposed there was considerable doubt among scientists and engineers about the practicality of large scale electronic computing. It was already pretty generally recognized that electronics could and would eventually be used for computation, but serious questions were raised about whether the technology was far enough advanced to permit the successful implementation of large scale electronic computing. Stern's book contains an interesting discussion of the reaction of established scientists to the proposal to build the ENIAC. In October, 1943 Samuel Caldwell, then an Associate Professor at MIT and a member of the National Defense Research Council wrote a letter in which he stated, "It would appear that the specifications of the equipment under development by the Ordnance Department [i.e. the ENIAC] substantially duplicate the specifications of the Rapid Arithmetical Machine Program[3] . . . As far back as 1939 we realized that we could build a machine for electronic computation. But though it was possible to build such a machine and possible to make it work, we did not consider it practical. The reliability of electronic equipment required great improvement. . . "

[3] RAMP was an electronic computer project that was started at MIT in 1937. An article about RAMP is included in the 1982 edition of Randell's collection.

Caldwell was mentioned in the Atanasoff-Mauchly correspondence. Caldwell visited Atanasoff at Iowa State a number of times in connection with a federally sponsored project which was not related to the ABC computer. According to Burks his "first visit, on January 6, 1941, had the further purpose of evaluating the computer and advising Research Corporation as to its funding. Caldwell did very shortly recommend that it be supported on the bases both of this inspection and of an earlier reading of the August, 1940, description." Note that Caldwell, who had been convinced of the feasibility of electronic computation since 1939, remained skeptical about its practicality in the Fall of 1943. Caldwell had read Atanasoff's description of the ABC and had seen the ABC in January, 1941, and several times after that. Yet Caldwell did not consider the work of Atanasoff to be proof that electronic computing was practical. Caldwell was not the only one who read Atanasoff's manuscript and saw a demonstration of the partially complete ABC computer while Atanasoff was seeking financial support. In his own article Atanasoff wrote about extensive correspondence with "organizations that supported research in the sciences, and also with several corporations", and states that he submitted proposals to three foundations. In places Burks gives the impression that Atanasoff tried to keep information about the design of his machine secret, and that Mauchly violated his confidence. On the contrary, Atanasoff seems to have sought publicity and to have welcomed expressions of interest in his computer. A press release led to an article about the computer in the Des Moines Tribune in January, 1941, and another brief article later that year. He certainly welcomed Mauchly's visit, and by his own evidence he went out of his way to explain the ABC to him in detail. He must have been equally forthcoming to Caldwell and to others. Burks on page 122 refers to "how he demonstrated his computer, in its early 1941 state to Caldwell and others who visited him in some official capacity." Caldwell was an important figure in the early history of computing. He was one of the organizers of the first major post war conference on computing devices in October, 1945. It is clear that neither he nor anyone else who had seen Atanasoff's computer considered it to be important enough to be included.

On page 276-277 of the Burks Book there is a rather strained argument that leads up to the claim that "Atanasoff conceived a magnetic drum memory. . ." This is followed by the statement that this idea was "conceived independently by Perry Crawford . .. in his MIT master's thesis of 1942." At MIT Crawford was "a graduate student and research associate under Caldwell and Vannevar Bush."[4] I am surprised that Burks misses the opportunity to argue that Crawford must have gotten his idea from Atanasoff by way of Caldwell.

Irven Travis

A section of the Burks book deals with the influence of Irven Travis on the ENIAC. Travis had been a member of the Moore School faculty until just about the time that Mauchly got there. He had known Mauchly since 1938. Eckert, who was then a student at the Moore School also knew Travis as a teacher. In connection with his work as a consultant for G. E. in 1939 and 1940 Travis wrote a report in which he proposed a differential analyzer that would use electronic calculators to perform numerical integration. Partially as a result of this work the Moore School submitted a proposal in the fall of 1940 to the National Defense Research Council offering to develop electronic fire-control equipment.

---

[4] Kent C Redmond & Thomas M. Smith *WHIRLWIND The History of a Pioneer Computer* Digital Press 1980. 280p.

It is interesting to read this section of Burks concerning Travis. The Burks seem to be saying that Mauchly stole all of his ideas about electronic computers from Atanasoff, but if he didn't steal them from Atanasoff then he must have stolen them from Travis. The Burks make a big issue of the fact that Atanasoff told Mauchly about his idea of using electronic adders as integrators. But in this section it is pointed out that Travis had this in mind before Atanasoff, and it also becomes clear that Travis had given much more thought to the actual implementation of the idea. Mauchly's plan for an electronic calculator predates his meeting with Atanasoff. If he had never met Atanasoff he would still have been exposed to the idea of building an electronic integraph at the Moore School. The letter from Atanasoff to Mauchly in which he mentioned the possibility that his computer could be coverted into an integraph was in response to a letter from Mauchly in which Mauchly mentioned Travis' high estimate of the cost of building an electronic digital integraph. Note that the $500,000 estimate turned out to be a reasonable estimate of the actual cost of the ENIAC.

Travis testified at the ENIAC patent trial, and he was asked if he thought that the ENIAC ended up being in effect the electronic differential analyzer that he had discussed in his report to GE. The question was put by the Honeywell lawyer, and Travis' reply was, "I don't think I could honestly give you a conjecture on that." This topic was not pursued any further. Honeywell lawyers had built their case on Atanasoff, and it would not help their case to establish the fact that the ENIAC was like something envisioned by Travis, and not at all like Atanasoff's ABC. Sperry Rand lawyers had no interest at all in pursuing the possibility that some of the ideas that were implemented in the ENIAC design might have been anticipated by Travis or by anyone else.

Mollenhoff's Book

It is indeed impressive that the cult of Atanasoff has produced two books in the course of a single year. The dust jacket of the Mollenhoff book points out that Mollenhoff is a graduate of Drake University Law school who "has received more than twenty five major awards as an investigative reporter, author and lecturer on fraud and corruption . . ." The editor's foreword starts,"This is a fast-moving account of a triumph of justice over fraud . . . " The book is indeed a well written, fast-moving story that tells about how Atanasoff designed and built an electronic computer, how the villainous Mauchly stole his computer ideas and claimed they were his own, and how the gallant Honeywell attorneys brought Mauchly to justice.

When I first became aware of this book I thought that here was another disciple of Arthur Burks who would get all of his information from the Burks article and the Burks book. I was quite wrong. This is an independent work by a professional writer, a reporter who obviously spent a great deal of time and effort on this book. It is unfortunate that his viewpoint is so extremely biased, and that so much of his effort was devoted to producing a morality tale of the struggle of good versus evil. As a journalist Mollenhoff tends toward sensationalism. In places the book seems like the kind of exposé that is often seen on syndicated television. Thus the word Piracy appears in the title of chapters 9 and 11. The Search for Truth (That is really a chapter title) becomes an effort to damn Mauchly and to glorify Atanasoff. There is no sense of proportion in this. Even if Mauchly was a villain, perhaps it should be mentioned that the ENIAC that he and Eckert and others built went so far beyond Atanasoff's conception as to make the Atanasoff-Berry Computer seem insignificant by comparison. Even Judge Larson in his decision that is praised so highly by Mollenhoff states that, "Mauchly may in good faith have believed that the monstrous machine he helped create had no relationship to the ABC or

Atanasoff." Mollenhoff is a professional writer, not a computer scientist or a historian. I don't think he understands the magnitude of what Eckert and Mauchly accomplished.

On page 168 Mollenhoff has Atanasoff reflecting as to how he "should have been sharper and more direct in his warnings to Mauchly not to attempt to steal his ideas . . ." Of course this makes no sense at all. If Atanasoff could foretell the future he would have urged Mauchly to do exactly what Mollenhoff accuses Mauchly of doing. Atanasoff's fame rests on what Mauchly accomplished. Atanasoff's work in the computer field ended in 1942, and if not for Mauchly his work could have had no influence at all in the later development of computers. Mollenhoff states that Atanasoff "could not believe that at the time Mauchly had intended to engage in the theft of the electronic digital computer concepts." This is more nonsense. Mauchly could not have known at that time that Atanasoff would abandon his computer without a patent application and without any attempt at publication. Mauchly could not have known then that he would meet Eckert, that they would collaborate so well, that he would be asked to join the Moore School faculty, and that he would, several years later, be in a position to build large scale digital computers.

I find it a shame that the author's position is so extreme because there is much in this book that is interesting and readable. Much of the book is devoted to a discussion of the ENIAC patent trial and the legal activities that preceded it. The author's background in law and in journalism combine to make for an excellent presentation of the way in which the case developed, from the time lawyers first found out about and then approached Atanasoff, through to the final decision. I have been interested in this area for a long time and have read much about it. This book is not a rehash of material that has been published before. It contains a good deal of information that was new to me, and is clearly the work of a professional reporter using original sources. Thus Mollenhoff quotes from a 1967 memorandum by a Honeywell attorney, "It is quite clear that the modification which Atanasoff proposed for his existing machine would yield a device which could quite accurately be called an "Electronic Numerical Integrator and Computer"-an ENIAC." It is easy to see why Eckert and some of his colleagues become angry and incoherent in the face of this kind of argument.

Mollenhoff obviously admires the case that was developed by the Honeywell lawyers, and he seems to enjoy and even amplify their attacks on Mauchly. He doesn't even try to be objective in his approach. He has nothing but admiration for Atanasoff, and he hates and despises Mauchly. In this book the cult of Atanasoff is carried to a ridiculous extreme. Mollenhoff recommends a Nobel Prize for Atanasoff and writes of "the overwhelming evidence establishing that John W. Mauchly derived the basic concepts of ENIAC, EDVAC, and UNIVAC from John V. Atanasoff." I find it disturbing and hard to believe that reviewers take this book seriously as a contribution to the history of computing.

Allan R. Mackintosh

Mollenhoff's book contains a three page "Afterword" by Allan R. Mackintosh, a physicist from Denmark who spent six years at Iowa State in the early 1960's. During that time he knew nothing of Atanasoff, but in the 1980's, after reading about the ENIAC patent case in the writings of Burks and Atanasoff, he became an ardent publicist engaged in the aggrandizement of Atanasoff and in the vilification of Mauchly. His expository articles about the ABC computer that appeared in Physics Today (March 1987 p25-32) and in Scientific American (August 1988 p90-96) have almost certainly been read by far more people than any of the other publications about this subject. In these articles Mackintosh goes much further than Burks or

Atanasoff in claiming that the ABC computer had been completed. He calls it a "functioning but fallible machine." In the Physics Today article he states that "it is reasonable to assume that the problem with the binary card system would have been solved within a few months" (i.e. from the time the ABC computer project was abandoned in the spring of 1942.) Atanasoff's own paper is not nearly that optimistic about the card system. My comment on Mackintosh's article in the Scientific American and his reply to that comment appeared in the December 1988 issue of the Scientific American.

In his afterword in the Mollenhoff book Mackintosh states that "The natural, sensible, and honorable course of action [i.e. for Mauchly] would have been to invite Atanasoff to join the ENIAC project. . . With his help the ENIAC might have been the first operating large-scale computer. Instead the British Colossus enjoys this distinction, . . ." It is hard to know what to say about this combination of fantasy and misinformation. Atanasoff left Iowa State and abandoned his unfinished computer project to take a defense job in Washington. He certainly must have thought that the work he was doing in Washington was more important than trying to finish his own computer. Why does Mackintosh think that he would have deserted that job to help Eckert and Mauchly build their proposed computer? Also, the Colossus was finished about the time the ENIAC was started.

The cult of Atanasoff feeds on itself and grows. Mackintosh, a disciple of Burks, who considers the extreme views of Mollenhoff to be written "with the clarity, balance, and respect for the truth which characterize journalism at its best" (this quote is from the afterword to Mollenhoff's book) was invited to review the Burks book for the Annals of the History of Computing. The review in Volume 10 No. 3 (1988) of the Annals finds the book totally convincing and strongly seconds its condemnation of Mauchly and its adulation of Atanasoff. In my own comments about that review in Vol. 11 No. 2 (1989) of the Annals of the History of Computing I stated that "many of us whose interest in the history of computing predates that of Mackintosh by many years are not at all convinced by Burks." The reader may find it interesting to compare the Mackintosh review with the more critical, though generally favorable, review of the Burks book by Eric Weiss which has been cited earlier (Computing Reviews, April 1989). Weiss was an associate of Atanasoff at the Naval Ordnance Laboratory during World War II. He refers to himself as a long-time acquaintance of both John Mauchly and John Atanasoff, and states that "both Johns deserve great credit for their accomplishments and some discredit for their errors of judgement, but neither deserves the halo or forked tail pinned on by this book."

Conclusion

The stored program electronic computer is one of the most important inventions of the twentieth century. It emerged from a surge of inventive activity at the Moore School in the years 1943 to 1946. The books by Goldstine and by Stern provide interesting insights into this activity from two quite different points of view. They are a good place to start for a reader who wants to know more about that period.

There were many who made inventive contributions to the ENIAC, the first programmed general purpose electronic computer, and to the design of the EDVAC, in which the modern stored program concepts were introduced. By far the most important inventors were John Mauchly and J. Presper Eckert. They deserve to be recognized as **the** inventors of the modern

electronic computer. The invention of the stored program computer is often attributed to John von Neumann who wrote the first detailed description of the logical design of the proposed EDVAC. Von Neumann made major contributions to the design of the EDVAC, and he may very well have considered himself the inventor. He ranks with Eckert and Mauchly as one of the most important figures in the early history of electronic computing. The rapid growth and worldwide spread of computer technology owes much to his document on the EDVAC and to the IAS computer project that he started in 1946.

The work at the Moore School did not occur in intellectual isolation from the rest of the scientific world. There were many prior and contemporary ideas and projects that were known to one or more of the Moore School group and that had some influence on the work there. Thus Mauchly was aware of the work of Travis and of Atanasoff. Eckert was aware of the work of Wynn-Williams and others on electronic counters. He was aware of work on delay lines at Bell Laboratories and at MIT, and of Perry Crawford's MIT thesis that introduced the idea of a magnetic drum memory. Von Neumann was almost certainly aware of the idealized computing machines of Alan Turing, and he and others may have known something of the much earlier work of Charles Babbage. The work of Howard Aiken at Harvard, of George Stibitz at Bell Labs, of Jan Rajchman at RCA, all contributed conceptually, and in some cases directly, to the design of the computers at the Moore School.

The ENIAC patent case and its 1973 decision have stimulated the publication of books and articles about Atanasoff, claiming for him the invention of the electronic computer, and claiming that his ideas led to the design of the ENIAC and even the EDVAC. The sheer volume of such writing tends to overwhelm logic and obscures the fact that many of the claims made by and for Atanasoff are spurious. Atanasoff is a brilliant and impressive man, but he is a minor figure in the history of computing. The claims made on his behalf, that the most important inventions at the Moore School were based on his ideas, were not put forward until almost 20 years after his own partially completed computer had been scrapped. They were part of a strategy conceived in 1967 by the lawyers for Honeywell who were trying to invalidate the ENIAC patent. Atanasoff helped their case by producing an unpublished document that he had written in 1940 and had shown to a few people in 1941. The exaggerated claims made for Atanasoff are based only on the fact that during a period of four or five days in June, 1941 Mauchly saw that document, and saw Atanasoff's partially built computer. The importance of the possibility that Mauchly "was inspired at least in part by his meeting Atanasoff" (the quotation is from the Burks book) has been blown up out of all proportion.