A TRILOGY ON ERRORS IN THE HISTORY OF COMPUTING

by

N. Metropolis and J. Worlton*

UNIVERSITY OF CALIFORNIA

LOS ALAMOS SCIENTIFIC LABORATORY

Los Alamos, New Mexico, U. S. A.
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N. Metropolis and J. Worlton

ABSTRACT

Three studies are presented, each of which reviews published errors on, or a misunderstanding of, a particular topic in the history of computing and presents material to correct the error and to give a better understanding of the topics selected. While the studies are in a sense independent, they are tied together with the thesis of the trilogy, i.e., that those who conduct research or publish results in the history of computing should accept the responsibilities of the historian as well as those of the computer scientist. That this has not been done in the past is noted with respect to (1) claims that the originators of modern computers were unaware of the work of Charles Babbage, (2) misunderstandings about the origins of the stored program concept and its early implementations, and (3) the failure to distinguish between the IAS machine and the MANIAC. A special responsibility is noted for those now working in the field of the history of computing, since they have an opportunity--which later researchers will not--to write this history during the lifetime of its creators.

N. Metropolis and J. Worlton

1. INTRODUCTION

The critic who investigates the inadequacies of published accounts of the history of computing is at once faced with an embarrassment of riches. Computer scientists seem determined to confirm the judgment of professional historians that scientists should not be depended upon to produce the histories of their own fields.[1] Sarton, in an essay on "The Scientific Basis of the History of Science",[2] pays tribute to the "good amateurs" who work as hard in the field of history as they do in their own specialties, but complains that the amateur historian of science is more often

> "...a distinguished scientist who has become sufficiently interested in the genesis of his knowledge to wish to investigate it, but has no idea whatsoever of how such investigations should be conducted and is not even aware of his shortcomings. His very success in another domain, the fact that he has long passed the years of apprenticeship, make it difficult, if not impossible, for him to master a new technique. He generally lacks the humility of a beginner, and publishes his historical results with blind and fatuous assurance. This is amateurism at its worst."

Computer science is fortunate to have people trained in both history and computing to direct the major project on the history of computing at the Smithsonian Museum of History and Technology,[3] but there is an essential role for the "good amateur" to play in preparing this history. The field is so broad and the professional historians so few that they cannot do all of the detailed work of collecting, organizing, and documenting that is necessary; further, much of the information is known only to the computing pioneers who are, by and large, amateurs in the field of history.

Although this paper emphasizes the inadequacies and misunderstandings in published accounts of the history of computing, it is not its purpose to discourage further efforts, but to encourage them and to emphasize that the history of computing deserves to be known as well as possible, and any knowledge short of what is attainable should be treated with the same contempt as we would treat half-baked knowledge in computing itself.[2] Since the authors of this paper are amateurs in the field of history, the proposals made here for the improvement of work in this field are modest.

1. Allow no published error to go uncorrected. Only through a vigorous weeding process can we hope to stop the propagation of the seeds of error.

2. Do not publish conjectures as though they were facts. Lack of caution is one of the obvious marks of the "bad amateur."

3. Do not depend upon secondary sources. The error function for Nth-level repetition is monotonically increasing.

4. Remember that the basis of scientific history is bibliography. Start with a good bibliography and end with a better one.

Specific professional suggestions can be obtained from George Sarton's dual publication, "The Study of the History of Mathematics," and "The Study of the History of Science." The four basic suggestions noted above, however, will at least lead authors toward professional standards of history.

In the three studies which follow, we first take note of published errors or misunderstandings in the history of computing and then provide results of research intended to provide corrections.

2. BABBAGE AND THE ORIGINATORS OF MODERN COMPUTERS

2.1 A Question of Awareness

The creative genius that Charles Babbage exhibited in his design of general-purpose mechanical computing devices has surprised and delighted readers for well over a century. That the mechanical technology of his day was inadequate to bring these ideas to fruition detracts little from the honor often accorded him as the "Father of Computing." In recent articles, however, it has been claimed that those responsible for the development of modern computers were not only not influenced by the ideas of Babbage but that they were not even aware of his work.

The question of the "influence" of one person's work on that of another is often subjective and difficult to establish; however, it is possible to establish "awareness" by documenting references in the writings of the people concerned, and it is this point which is addressed here, i.e., are there references in their writings to the work of Charles Babbage? The claims noted below imply a uniformly negative answer, but this is not the case.

2.2 Babbage and the Electromechanical Era

With respect to the origins of electromechanical computers it has been claimed:

> It is an insight of fundamental importance that the organization of a computer has to match the technology available. Babbage unwillingly provided the first example of this principle by the unsuccessful outcome of his experiment. Mechanical devices will do for desk calculators and cash registers, but not for a general-purpose computer. The realization of his idea had to wait for the appearance of electromechanical devices. Several relay computers were successfully completed in the late 1930's and early 1940's. The designers of these were unaware that they were rediscovering Babbage's concept.[4] (Emphasis supplied.)

This claim bears upon the work of Konrad Zuse in Germany in the development of the "Z3";[5] the work of Stibitz and Williams at Bell Labs in the development of the "Complex Calculator";[6] and the work of Aiken and IBM in the development of the "Automatic Sequence Controlled Calculator" or "Harvard Mark-I".[7] To this list should be added the equally successful and important work of Vannevar Bush in the development of the mechanical differential analyzer.[8]

Konrad Zuse was awarded the Harry Goode Memorial Award in 1965 by the American Federation of Information Processing Societies (AFIPS), and in his acceptance speech he stated:

> My goal was to be able to carry through, fully automatically, complete calculation sequences. I did not know anything about computers, nor had I heard about the early work of Charles Babbage. Thus--unprejudiced--I could go new ways.[9]

In private correspondence with the authors, Dr. Zuse has clarified the time when he became aware of Babbage's work:

> I, myself, was beginning with the computer-development in the year 1934. I had no knowledge of the work of Babbage. In the year 1939 I heard of his "Analytical Engine" in connection with a patent-application I made in the U. S. A. But to that time the principal ideas of my machine were already fixed. The information about Babbage had no influence on my further development, because I had already succeeded to get further ahead in the development.[10]

For George Stibitz also, the question of awareness can be answered negatively. In an interview concerning the relay computers at Bell Labs, he stated:

> I took my model into the labs to show some of the boys, and we were all more amused than impressed with some visions of a binary computer industry. I have no head for history. I did not know I was picking up where Charles Babbage in England had quit over a hundred years before.[11]

Thus, for these two men, the claim that they were unaware of the work of Babbage can be accepted, and further, there can be no question of "influence".

For Aiken and Bush, however, we find quite different answers. In August 1964, the IEEE Spectrum republished Howard Aiken's "Proposed Automatic Calculating Machine,"[12] a memorandum which, though undated itself, has a recipient's handwritten notation, "Prospectus of Howard Aiken, November 4, 1937." In this memorandum, Aiken devoted some five paragraphs to Babbage's work, although erroneously describing the Analytical Engine as "...intended to evaluate any algebraic formulae by the method of finite differences."[13] Aiken described Babbage's ideas in a paper on the Mark-I in 1946[14] and in the "Manual of Operation" for the Mark-I, also published in 1946.[7] For Aiken, then, there is no question but what he was indeed aware of Babbage's work.

In 1936, Vannevar Bush delivered the twelfth Josiah Willard Gibbs Lecture under the auspices of the American Mathematical Society, choosing for his subject, "Instrumental Analysis," by which he referred to "The use of instruments of computation and analysis..."[15] In three different paragraphs, and through three references,[16,17,18] he exhibited a rather thorough awareness of Babbage's ambitious designs. The casual way in which Bush referred to Babbage gives the impression that he expected his audience to be familiar with the man and his work, since his remarks were referential rather than explanatory.

In summary, of these four men who successfully developed electromechanical and mechanical computing devices in the 1930's and 1940's, two were not aware of the work of Babbage, but two others were aware of his work, and any references to this question should be so qualified.

2.3 Babbage and the Electronic Era

The same question of awareness might be posed with respect to the originators of electronic computers, and indeed, the same negative claim has been made:

> (Babbage) has been described as a pioneer of the modern computer, but it is safe to say that it was not until after the electronic computer had been developed in the United States during World War II that its inventors ever heard of Babbage and his works.[19]

This statement has the ring of authority, since it comes from Dr. H. R. Calvert, curator of the London Science Museum, who has had charge of Babbage's machines and drawings for many years. Authoritarianism has no role in either science or history, of course, and the question must be pursued from original sources.

As background to this question we have compiled a selected chronological bibliography of works which either refer to Babbage or review his life and ideas. The entries in Table I have been selected from a larger set, and we make no pretense to completeness. However, the Table illustrates the point that awareness of Babbage's work has suffered no long gaps, and that during the precursory decade of the 1930's there were many new publications that mentioned or reviewed Babbage, in both Great Britain and the United States, including presentations to learned societies (Bush to a joint meeting of the American Mathematical Society and the American Association for the Advancement of Science, and Buxton to the Newcomen Society). What is surprising, then, is not that some people were aware of Babbage's work, but that others were unaware of his work.

Yet the latter point seems to be true for some of the men responsible for the development of electronic computers in the United States and Great Britain. In private communications with the authors of this paper,

YEAR	GREAT BRITAIN	REFERENCE	USA	REFERENCE
1889	Babbage	(17)		
"	Ball	(20)		
1906	Fyvie	(65)	Goddard	(22)
1910	Babbage	(23)		
1914	Horsburgh	(16)		
1917	Shuster & Shipley	(24)		
1919			Macfarlane	(66)
1923			Smith	(67)
1925			Smith	(68)
1926	Baxandall	(18)		
1932	Comrie	(25)		
1933	(Nature)	(26)		
1935	Buxton	(27)	Archibald	(28)
1936			Bush	(15)
"			Sarton	(69)
1937	Gunter	(29)	Aiken	(12)
"			Bell	(70)
1942	Lilley	(30)		
1943			Archibald	(31)
1945			Archibald	(32)
1946	Comrie	(33)	Aiken & Hopper	(14)
"			(Harvard)	(7)
1947	Hartree	(49)	Babbage	(34)
"			Pledge	(71)
1948	Hartree	(35)	Mullett	(36)
"			Hacker	(37)
"			Struik	(72)

Table I. Selected chronological references to Babbage.

Mauchley, Wilkes, and Kilburn state that they do not recall being aware of Babbage's ideas. (From their extremely close association we assume that Mauchley's statement is true for Eckert.) Kilburn, for example, says:

> On your enquiry about Babbage, I can only say that speaking personally, and at a distance of more than twenty-five years, I cannot recall that I was aware of his ideas. This is not to say that others in the field at the time with whom I was in contact were not familiar with them. Computers were in the air; the subject was very exciting, and unfortunately one did not stop to record sources of information, but simply got on with the job.[38]

It is an important point that "...one did not stop to record sources of information, but simply got on with the job"; this lends emphasis to reports that appeared soon after a project was completed, not just to those that appeared before and during the project. It is noteworthy, then, that Williams, Kilburn, and Tootill began a report (submitted 16 March 1950) on their work on computer design at Manchester with a review of the work of Charles Babbage,[50] and in a more recent letter to the authors, Kilburn has advised us that Williams recalls being aware of Babbage during their early work.[47]

Most British computer scientists would have become aware of the Babbage concepts no later than 4 March 1948 through a discussion on computing machines by Hartree, Newman, Wilkes, Williams, Wilkinson, and Booth (published in the Proceedings of the Royal Society)[35]; Hartree opened the discussion with a rather extensive survey of Babbage's ideas and plans. Further, Hartree had lectured to the Manchester Branch of the Institute of Physics on 10 January 1947 on the recent developments in computing machines, and in that lecture he gave credit to Babbage for the concept of a large general-purpose calculating machine.[49]

Those who followed the development of the Harvard Mark-I through either British or American publications would have become aware of Babbage, since Comrie's article in Nature on 26 October 1946 referred to the Mark-I as "Babbage's Dream Come True,"[33] and Aiken's publications with references to Babbage have already been noted above. It is possible that Lilley's article on "Mathematical Machines"[30] in 1942, with refernce to Babbage, or the review of this article in the United States[31] may have been missed by many people in the press of other work during World War II. However, these articles and the numerous prior publications noted in Table 1 above offered ample opportunity for British and American scholars to become aware of Babbage. In fact, William Phillips may be right when he argues[39] that knowledge of Babbage was so common in Great Britain during the 1930's and the 1940's that authors and speakers often assumed such knowledge on the part of their readers or audience and "...simply got on with the job" (as Kilburn remarked).

The discussion thus far leaves open the question of awareness of Babbage on the part of two of the central figures of modern computer development: Turing and von Neumann. The untimely deaths of these men have left gaps in both science and history, and in particular with respect to the present question, since they were both noted for the paucity of their documentation of sources (due partly, of course, to the originality of their thinking). Turing's paper on "Computing Machinery and Intelligence," first published in 1950,[48] does, however, refer rather frequently to both Babbage and Lady Lovelace, and it should be noted that the name of the computer developed under the initial guidance of Turing was the "ACE", an acronym taken from "Automatic Computing Engine." Huskey, who worked at NPL* during 1947, noted at the time that "In England 'engine' has been a favored term for automatic computing machines since the days of Charles Babbage and his 'analytical engine'."[40] Thus, it is clear that Turing was aware of Babbage, but the question of when he gained that awareness remains open.

For von Neumann the situation is similar--and related, since Turing and von Neumann were both at Princeton before World War II. The published works of von Neumann contain no references to Babbage, but this is "negative evidence" in the sense that it does not resolve the question. It is a reasonable conjecture that Turing and von Neumann would have discussed at least the theoretical aspect of computing machines, and it has been suggested that Turing may have contributed to von Neumann's interest in these machines, but whether or not Turing and von Neumann discussed Babbage's ideas is a speculation without a documentary foundation, as far as we are aware.

In summary, Calvert's assertion about a lack of awareness of Babbage among the inventors of the electronic computer in the United States seems indeed to be safe, but when the more general question of awareness among other early workers in this field is considered, a rather broad awareness of Babbage can be demonstrated.

3. THE STORED-PROGRAM CONCEPT AND EARLY IMPLEMENTATIONS

3.1 Control modes.

There has been some confusion in the literature concerning the origin of the stored-program concept and the early implementations thereof. Some of these errors are easy to correct, as for example, the notion that

*National Physical Laboratory, Teddington, England the Zuse Z3 was an electronic stored-program machine.[41] In fact, the Z3 was an electromechanical computer which was indeed programmgesteuerte (program controlled), but whose program control was implemented through the use of eight-bit one-address instructions punched in 32-mm cinefilm, rather than in the 64 words of relay storage.[5]

Some of the confusion concerning program control in early computers is derived from a lack of understanding of the stages through which program control in scientific computers evolved during the 1940's. Figure 1 is an idealized classification of this evolution, with the pioneering machines noted for each level; each of these levels is discussed briefly below.

1. Manual control was used on the Bell Labs' "Complex Calculator" (1940), with instructions being entered through a teletypewriter keyboard. This device was thus more nearly related to modern desk calculators than to modern computers.

2. Automatic control of a calculational sequence was achieved in the Zuse Z3 (1941) and the Harvard Mark-I (1944) through the use of external program readers for film (Z3) and paper tape (Mark-I).

3. Internal control of calculations was first implemented in the ENIAC (1946) through the use of jackplugs and switches to route control signals. "Programming" for this machine consisted of making jackplug connections and setting switches.

4. Storage control of a computer was later implemented on the ENIAC (1948) through the use of a decoding matrix in conjunction with the read-only function tables.

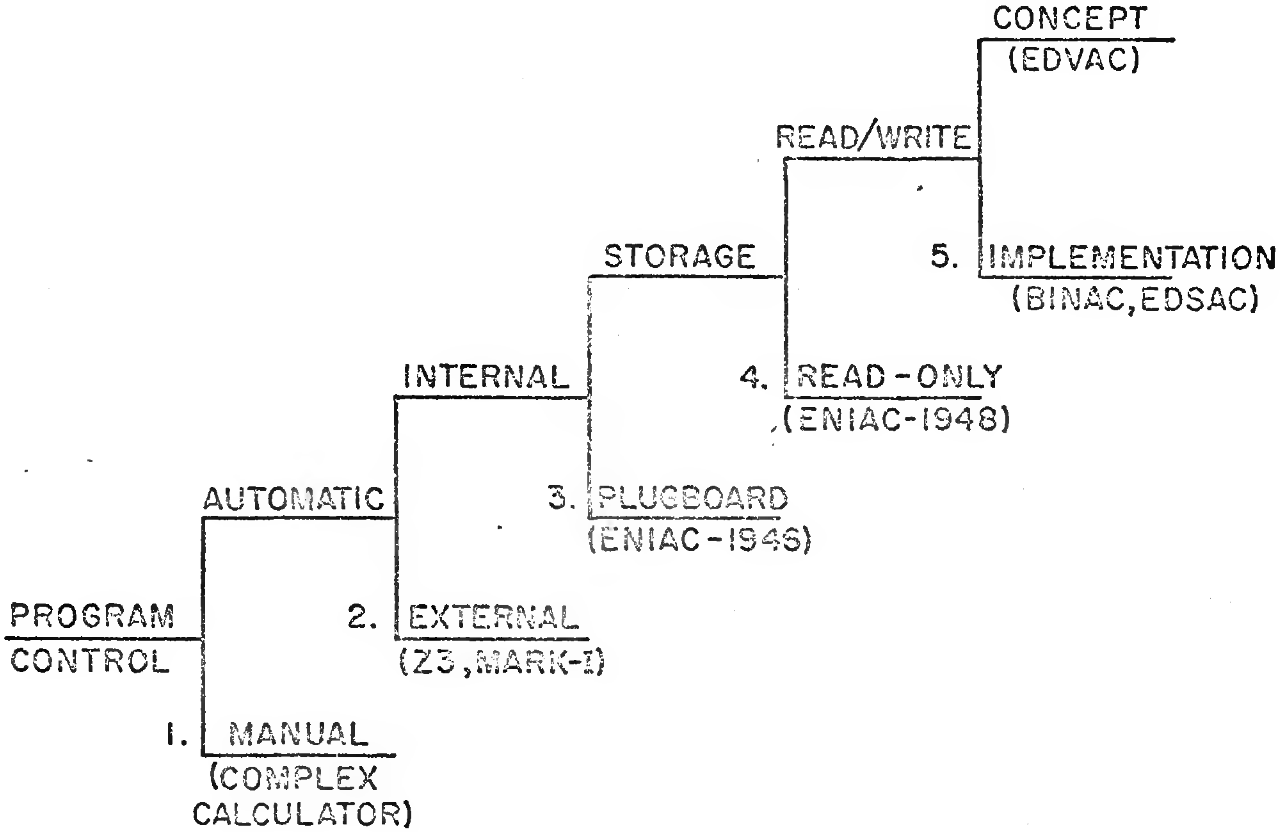

Fig. 1. Evolution of program control modes.

5. Read-write memories for stored programs were first implemented in 1949 on the BINAC in the United States and the EDSAC in Great Britain. These machines were based on the design of the EDVAC (1945).

3.2 Concept vs. implementation.

A natural source of error concerning the history of the stored program is the failure to distinguish between the origins of the concept and its first implementation. The design group working at the Moore School of Electrical Engineering of the University of Pennsylvania produced the functional design of the EDVAC,[42] which included acoustical delay lines to hold both programs and data, even prior to the completion of the ENIAC, so it is correct to credit the EDVAC design as being the first to employ the stored-program concept. However, construction of the EDVAC was delayed because of the departure of key personnel from the project after the war, and the machine was not completed until 1952.[43] In 1948 an instruction decoder was added to the ENIAC at the Ballistics Research Laboratory[46] which allowed the 312 words of read-only storage on the portable function tables to be used to hold instructions, and ENIAC became the first computer to operate with a read-only stored program. In 1949 both the BINAC in the United States[44] and the EDSAC in Great Britain[45] were successfully tested; these designs were based on that of EDVAC, with a dynamically modifiable stored program being executed out of the delay-line storage. Thus, it is correct to:

(a) credit the EDVAC design as the first to include the stored-program concept;

(b) credit the ENIAC as the first computer to be run with a read-only stored program; and

(c) credit the BINAC and the EDSAC as being the first computers to be run with a dynamically modifiable stored program.

Because item (b) is so little known, we have provided the basic information in the next section.

3.2 The Read-only stored-program control on the ENIAC.

Each preparation of the ENIAC for a new problem was a time-consuming affair; the control consisted of a very large, distributed plug-board and manually-set switches. One part of the read-only memory--so-called function tables--could store 312 numbers of twelve decimal digits effected by 10-position, manually-set switches. In 1948 R. F. Clippinger (not von Neumann as stated in reference 46) suggested that the function tables might be used to store sequences of decimal digit pairs, each pair corresponding to one of a possible hundred instructions, and that the control might be implemented (once-and-for-all) to interpret and execute such pairs. To change problems, a new sequence would be introduced--a much simpler procedure than the jackplug and switch method.

A provisional plan by A. Goldstine for a control program exceeded the capacity of the ENIAC. A second approach by N. Metropolis and K. von Neumann was successful, but only because of a curious coincidence. On a preliminary visit to the Aberdeen Proving Ground in Maryland whence the ENIAC has been moved from Philadelphia*, Metropolis noticed a complete many-to-one decoder network nearing completion; it was intended to increase

*A heroic achievement, watched by many, all named Thomas!

the capability of executing iterative loops in a program. It was also just what was needed to simplify considerably the decoding of digit pairs representing an instruction, and in fact, the new mode of control could be contained. The local authorities agreed to the change and the campaign was launched; after at least the expected number of program errors had been committed and eventually removed, the ENIAC achieved a read-only stored program. The time scale to change problem setups was reduced from hours to minutes. Moreover, maintenance procedures were simplified.

In the original ENIAC form of control a limited amount of parallel operation was possible; this was sacrificed in converting to strictly sequential execution. All the remaining flexibilities were available in the new modus operandi, however.

After some thorough testing, Metropolis and K. von Neumann put the first problem--the original Monte Carlo--to the ENIAC in its new form in early 1948.

3.4 Originators.

Another point concerning the stored-program history which needs clarification is the unwarranted assumption that J. von Neumann alone deserves the credit for the stored-program concept. In his Turing lecture in 1967, Maurice Wilkes (who was at the Moore School in 1946) gave the following description of the roles played by Eckert and Mauchly on the one hand, and von Neumann on the other:

> Eckert and Mauchly appreciated that the main problem was one of storage, and they proposed for future machines the use of ultrasonic delay lines. Instructions and numbers would be mixed in

> the same memory...von Neumann was, at that time, associated with the Moore School group in a consultative capacity... The computing field owes a very great debt to von Neumann. He appreciated at once...the potentialities implicit in the stored program principle. That von Neumann should bring his great prestige and influence to bear was important, since the new ideas were too revolutionary for some, and powerful voices were being raised to say that the ultrasonic memory would not be reliable enough, and that to mix instructions and numbers in the same memory was going against nature...Subsequent developments have provided a decisive vindication of the principles taught by Eckert and Mauchly...[51]

That von Neumann is often given sole credit for this fundamental concept is likely due to the fact that he wrote, on behalf of the project, the first draft for the design of the EDVAC.[52] Von Neumann should be given his share of the credit, but to ignore the contributions of Eckert and Mauchly is both an injustice and a major historical error.

4. RECOGNIZING THE MANIAC

4.1 The seeds of error.

In one of the early glossaries of computing terms the following definition occurs:

> Maniac. The name which has been given unofficially to the high-speed machine which is now being built in the Institute for Advanced Studies (sic) at Princeton. Alternatively, anyone who has been making or using a digital computer for more than a few years.[53]

While the alternative definition is obviously correct, the association of the name "MANIAC" with the computer built at the Institute for Advanced Study (IAS) is a historical error. In fact, the MANIAC computer was built at Los Alamos Scientific Laboratory between 1949 and 1952 under the direction of Metropolis, in parallel with the development of the IAS computer at Princeton under the direction of von Neumann.

This error has been repeated so frequently in the literature that it may now be impervious to eradication, and the example might serve as a warning to the computing profession that it is imperative to correct published errors at the earliest possible moment to prevent their being repeated by the next generations of writers and becoming permanent. In Table II we have collected a chronological bibliography of erroneous references to MAINIAC, all but the last of which make the erroneous association of MANIAC with the Princeton machine, and the latest has MANIAC

YEAR	AUTHOR	REFERENCE
1948	Tumleson	(54)
1953	Bowden	(53)
1955	Kemeny	(55)
1958	Jungk	(56)
1964	Ulam	(57)
1969	Hewlett & Duncan	(58)
1970	Dyson	(59)
1971	Major	(60)
1971	Bell & Newell	(61)

Table II. A chronological bibliography of MANIAC errors.

being built at the University of Chicago. Errors do not improve with age! It is also worthy of note that two of these references come from professional historians,[58,60] one having both an incorrect and a correct reference to MANIAC's origin in the same book.[58] The reliance on secondary sources is largely the cause of the spread of this error, and this violation of careful research practices is obviously not limited to amateur historians.

Correct descriptions of the origins of the IAS machine and the MANIAC are found in references 62 and 63. Further, since there exists no comparative description of the relationship of IAS and MANIAC, the following sections are included for additional clarification.

4.2 Some early history of the MANIAC.

In the summer of 1945, von Neumann arranged for Frankel and Metropolis from Los Alamos to visit the Moore School of the University of Pennsylvania, in order for them to learn about the ENIAC--then nearing completion of construction--so they could prepare its first computational task.[73] Over a period of many months and by the very nature of the debugging process on ENIAC, they learned both the logical design and electronic circuitry of the machine. Since the EDVAC was then being designed at the Moore School, daily conversations with the design group, including Eckert, Mauchly, Burks, Chu, and Huskey, brought the Los Alamos people familiarity with this new design.

With the war over, the group at the Moore School broke up and provided stimuli for the development of computer projects at other locations: Eckert and Mauchly formed an industrial concern in Philadelphia; von Neumann organized a group at Princeton; Frankel and Metropolis joined the faculty at Chicago; and Wilkes returned to Cambridge to begin the development of the EDSAC. Groups independent of the ENIAC-EDVAC stimulus included Aiken's at Harvard, Turing and Wilkinson at Teddington, and Williams and Kilburn at Manchester.

The wartime pace was not to be maintained in a peacetime university environment, however. Plans were delayed for a building to provide space for a laboratory in which to build a computer at Chicago, and Frankel and Metropolis revisited the ENIAC to study the liquid drop model of fission.[74] Further delays at Chicago led to Frankel's return to California in 1947, and Metropolis' return to Los Alamos in 1948. Work on the Monte Carlo method and the modification of the ENIAC to allow use of a read-only stored program delayed the start of the computer project at Los Alamos until the end of 1948.

By this time, Bigelow at Princeton had completed the design of the arithmetic processor of the IAS machine and was well into the construction phase, so arrangements were made with von Neumann for the Los Alamos computer development efforts to follow those at Princeton. This plan had the virtue of providing for the training of computer electronic engineers, then in very short supply. Since duplication is straightforward, Los Alamos soon caught up with Princeton, where a delay had been incurred awaiting an independent development of an electrostatic storage system.

At this point Bigelow at Princeton decided to pursue the Williams approach with five-inch oscilloscope tubes; concurrently and independently, J. H. Richardson at Los Alamos, who had recently arrived from Toronto with some experience with Williams' tubes, designed and developed a system based on two-inch tubes, with parallel, discrete scan in contrast to the original serial analog scanning mode. An independent storage control system was designed for the MANIAC, and its input-output system was also unique, including: (1) a Ferranti paper-tape reader in which all electromechanical parts were replaced with equivalent electronic circuitry; (2) a standard, single-channel audio tape recorder from Ampex, which was modified to permit digital recording; (3) the first printer produced by Ampex; and (4) an ERA 10,000-word drum.[63] Although based on similar processor designs, the IAS machine and the MANIAC were not program compatible. Both machines became operational in early 1952.

The name "MANIAC" was proposed by Metropolis in an attempt to put an end to all such baptismal practices, but it seems to have had the opposite effect....

> His mind is engaged in rapt contemplation
>   Of the thought, of the thought, of the thought of his name:
>   His ineffable effable
>   Effanineaffable
> Deep and inscrutable singular name.
>
> -- T. S. Eliot, The Naming of Cats.

4.3 Later history and successors.

After several years of experience in engineering, programming, and a wide variety of applications, the Los Alamos group started the design and construction of a successor machine to MANIAC, labeled MANIAC-II, completed in early 1957. The original machine was then phased out and transferred to the Electrical Engineering department at the University of New Mexico (UNM), despite certain misgivings about MANIAC's transportability. Largely because of considerable faculty abilities, MANIAC continued to serve for nearly another decade as a training ground for students at UNM. MANIAC-II, a tube machine in its original form, has been modified almost continually, eventually becoming a completely solid-state machine and providing a base for the development of the MADCAP programming language.[82]

Late in 1957, Metropolis went to the University of Chicago to start the development of MANIAC III, along with a program in computer science. It is this development which likely is the basis of the most recent error concerning the origins of the original MANIAC, now said to have been in Chicago.[61]

4.4 Some early students and programmers.

No history of MANIAC, however short, would be complete without taking note of the stellar array of "student" who received their early experiences with modern computing on this machine.

First and foremost was Enrico Fermi, who spent the summer of 1952 at Los Alamos in this endeavor.[75] He was interested in every detail of problem preparation and computer operation, including writing programs and personally punching paper tape, and his questions and remarks were both penetrating and stimulating. His fellow students included Hans Bethe,[76] Frederic de Hoffmann,[76] Edward Teller,[77] Anthony Turkevich,[78] Robert Richtmyer,[79] and George Gamow.[80] In some sense it is appropriate to close this part with John von Neumann, who contributed so much to a hydrodynamical study beginning in the summer of 1953.[81]

5. CONCLUSION

A history is by its nature an approximation to the reality that was. And the historian's purpose is not to document events of the past in their entirety, but to select the important and illuminating and to pass by the incidental and confusing. The computer scientist brings considerable, perhaps essential, qualifications to the role of making this selection for the history of computing, but he is not automatically qualified thereby to write history. For no computer scientist knows all of the events which have occurred in this history, in spite of its relative brevity, and must therefore learn to use the tools of the historian. At times these tools have been badly handled, as noted in this trilogy, and the history of computing is already littered with the results of careless research.

Unlike computing itself, the history of computing has no automatic error-checking and correcting devices. Only through careful research which need not be corrected, and through correcting errors when they are detected, can our unique opportunity of writing the history of computing during the lifetimes of its creators be properly exploited.

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