Howard Aiken's Children: The Harvard Computation Laboratory and its Students

Gerard Salton

TR 83-583
December 1983

Department of Computer Science
Cornell University
Ithaca, NY 14853

+ Department of Computer Science, Cornell University Ithaca, New York 14853.

Howard Aiken's Children: The Harvard Computation Laboratory and its Students

Gerard Salton*

The Conventional View of Howard Aiken

The standard facts relating to Howard Aiken's contributions to the computer field are quickly told: he felt the need for automatic computational aids while working on his Ph.D. thesis at Harvard in the late nineteen thirties. In 1937 he approached Thomas Watson, Sr. of IBM with a proposal to construct a large-scale, automatic, sequence-controlled computer capable of solving a variety of numerical problems. Eventually, IBM helped design and construct the so-called Automatic Sequence Controlled Calculator, later to be renamed the Harvard Mark I. Mark I was delivered to Harvard in 1944 and it was used there for over 19 years to solve computational problems initially under contract with the U.S. Navy and later with support from the U.S. Air Force. Following the arrival of Mark I, three additional machines were built at Harvard under Aiken's direction, the Mark II, Mark III and Mark IV, which were completed in 1946, 1950, and 1952, respectively.

Aiken was the director of the Computation Laboratory for 17 years from 1944 until he retired from Harvard in 1961. After the machine-building era came to an end in 1952, the emphasis shifted toward computer applications, the development of course and instructional tools in computing, and work dealing with computer components and switching theory.

* Department of Computer Science, Cornell University, Ithaca, New York 14853.

From the beginning Aiken emphasized the construction of usable and reliable machines. The stress on applications led him to use relatively slow, reliable, largely nonelectronic components in preference to the then less reliable electronic ones. Furthermore, the Harvard machines were decimal, serial machines, even though binary, parallel machines with much faster cycle times became available at some places in the late nineteen forties.

The conventional view has it that Aiken's preeminence in computing ended in 1946 when the binary ENIAC was completed at the Moore School of Electrical Engineering in Philadelphia, and that, after 1946, the Harvard contributions were incidental and minor. The words of an eminent computer scientist, Maurice Wilkes, speaking of a visit he made in August 1950 to the Harvard Computational Laboratory, may be cited as an example of such views:

> "by then Aiken was no longer in the mainstream of development ... I don't think that it was only that he had isolated himself from these new ideas as regards machine structure, it was also that he was technologically backward ... his technological aims seemed to us very pedestrian ... these machines were the end of an era, not the beginning."

This particular judgment is somewhat questionable even if accepted in the restricted sense in which it may have been uttered, that is, applicable strictly to the machine design area, because, after all, quite a bit of novel work was done at Harvard in component technology after 1946, for example, on the application of magnetic drums and magnetic cores to computational needs; that work is not now considered to have been antiquated. But, more seriously, the initial quote covers at most the machine design era which ended early at Harvard. For over a decade after the end of the machine construction phase, Howard Aiken provided a highly challenging environment at Harvard which, as even critics admit, attracted a large number of first-class people. To quote again from the remarks by Wilkes:

"Aiken dominated the place ... but he had one redeeming feature: unlike

> other dominating men, he did not seek to surround himself with nonentities, with yes-men. He was a judge of men, and he chose for the staff of the Computation Laboratory outstandingly able men. They were not allowed much exposure: publications were from "the Staff of the Computation Laboratory" and there was a list of everybody in alphabetical order, with Aiken's name at the beginning. Moreover their work was censored ... ."

Taking the two quoted excerpts together, it seems as if something were missing: here was this technologically pedestrian person, who was evidently able to blind, or maybe cow, all these "outstanding men" into spending a large part of their best formative years in a technologically backward environment, placed in intellectual straight-jackets, with restrictions on their intellectual freedom and publication activities. This is surely not an accurate scenario for what actually happened at the Harvard Computation Laboratory under Aiken's directorship. In the remainder of this note, an attempt is made to provide a more rounded picture of the Computation Laboratory environment in the nineteen fifties, and to explain why people like myself feel fortunate to have been there.

The Scope of Activities at the Computation Laboratory

The Computation Laboratory started as a Navy facility, and between 1944 and 1948 Mark I was operating and the next two machines were built for the U.S. Navy, in part by Navy personnel. Howard Aiken was a Commander in the Naval Reserve during the war, which accounts for the fact that in the early years everyone spoke of him as "the Commander". (By the time, I arrived on the scene in 1952, this form of address had given way to the equally descriptive "the boss".) Many of the best known early programmers at the Computation Laboratory, such as Richard M. Block, Robert V.D. Campbell, and Grace M. Hopper, were also officers in the Naval Reserve.

During the Navy period much of the energy was spent on machine design.

However, by 1948, the first of several long-term contracts was signed with the U.S. Air Force, to be followed in 1952 by additional contracts with Bell Telephone Laboratories, and in 1955 with the American Gas Association and the Edison Electric Institute. From 1948 on, the Computation Laboratory activities became increasingly diversified. The prodigious published record documenting the work in the period for 1948 to 1960 may give a clue to the scope of the endeavors. Five different series of reports, most of them in book form, were issued during Aiken's directorship:

- A set of 60 volumes constituting Progress Reports to the Air Force (AF-1 to AF-60) issued between May 1948 and December 1960 under the title "Investigations for Design of Digital Calculating Machinery".

- A series of 123 "Problem Reports of the Computation Laboratory", supplementing the Air Force Progress Reports, and issued between April 1949 and July 1959.

- The 41 volumes of reports on the Theory of Switching addressed to Bell Telephone Laboratories (BL-1 to BL-41), issued between September 1952 and May 1966. The first 29 of these volumes were prepared under Howard Aiken's directorship, the remainder being issued after Aiken's departure under the supervision of Anthony Oettinger and Hao Wang.

- The 7 volumes of Progress Reports on Automatic Data Processing prepared between 1955 and 1958 for the Electronic Steering Committee of the American Gas Association and the Edison Electric Institute.

- The 40 volumes published between 1945 and 1956 by the Harvard University Press under the general title of "Annals of the

Computation Laboratory of Harvard University".

Not counting the problem reports which were sometimes relatively short, over 140 volumes of materials were prepared to account for the activities at the Computation Laboratory under Aiken's directorship. These volumes represent not only an unprecedented amount of output relating to computation, prepared at a time when hardly anyone was interested in automatic computers, but they cover a surprising variety of different topics in the hardware, software, and applications areas of computing. One must remember that in the nineteen forties only very limited computational facilities existed anywhere, and that there were no computer science departments and no instruction in computing. But as early as 1948, Howard Aiken signed an Air Force contract with the following provisions:

- to give instruction in Applied Mathematics with special reference to automatic calculating machinery;
- to make an investigation of the mathematical and physical techniques best adapted to the design and construction of computing circuits.

Within a few years, courses of instruction were offered at Harvard in a variety of topics including numerical analysis, switching theory, computer hardware, and automatic data processing. In the areas of computer use and instruction, Harvard seemed to be ahead of anyone else by some ten years, instead of being "technologically backward".

The work on the theory of switching undertaken for Bell Laboratories was equally broadly conceived. To be sure, much attention was paid to the development and use of magnetic switching devices of various kinds, but the Bell Laboratories work also covered the design of automatic data processing systems to use only one extraneous, somewhat random example. The work performed from 1955 on for the American Gas Association and the Edison Electric Institute demonstrates Aiken's interest in nonnumeric computer applications far in advanced of anyone else.

It is not possible in the present context to review the 140 volumes covering the Annals and the Progress Reports of the Computation Laboratory. Some very fine contributions are included, as well as more marginal ones. About one thing there is no doubt: these volumes include many "firsts" in the computer literature. The first manual of operations of a large scale computer (Mark I) appeared as Volume 1 of the Annals, and the proceedings of the first conference on large scale computers held at Harvard in 1947 are reproduced in Volume 16 of the Annals. What is likely to have been the first programming text, covering Mark IV coding, is included in Air Force Progress Report AF-23 issued in 1952. There were also many firsts among the Ph.D. dissertations published as reports from the Computation Laboratory, including, for example the first thesis on automatic language translation by Tony Oettinger, and the first on the design of automatic data processing systems by Fred Brooks.

These wide ranging activities attracted many people to the Computation Laboratory whose life inevitably was shaped by Howard Aiken to a major extent. Several hundred people must have passed through the Computation Laboratory over the years, and it is impossible to be exhaustive in covering their activities. However some comments are in order, especially about Aiken's interaction with his graduate students, since these may best explain his attitude and influence.

Howard Aiken and his Graduate Students

In reviewing the Computation Laboratory staff lists one is impressed by the number of well-known people who spent time at the Laboratory. These included the previously mentioned original programmers for the Navy, among them Grace M. Hopper; senior people who had received engineering degrees at Harvard before Aiken became preeminent such as An Wang and Way Dong Woo; the two long-term staff members who were Assistant Directors at the Computation Laboratory, John A. Harr and Marshall M. Kincaid; some impressively ingenious programmers such as J. Orten Gadd and Peter Strong; and a number of foreign visitors who were later instrumental in starting computer organizations in their own countries, such as Jose Santesmases from Spain and Ambrose Speiser from Switzerland. There were also some younger graduate students who had their Ph.D. theses published as Reports from the Computation Laboratory during the final years of Aiken's directorship, but did their doctoral research with some other, mostly junior, faculty members, including Ramon L. Alonso, Martin Cohn, Willard L. Eastman, Robin Esch, Derek S. Henderson, Richard M. Karp, Andrew J. Lincoln, Eugene L. Lawler, Peter G. Neumann, and others.

For many years, however, Howard Aiken was the only Professor covering the computer area at Harvard. Only he could accept graduate students in computing, and a prospective candidate for a doctoral degree necessarily had to approach Aiken. Aiken lived in the style of the European university professor who is alone and preeminent in his area, and who completely determines the university career of his advisees. The graduate students were thus dependent on Aiken's help and goodwill since there was effectively no alternative advisor short of changing one's research area. Howard Aiken had 16 graduate students who received their doctoral degrees between 1948 and 1958: Herbert F.

Mitchell, Jr. (May 1948), Miles V. Hayes (April 1950), Gerrit A. Blaauw (April 1952), Charles A. Coolidge, Jr. (April 1953), Robert C. Minnick (April 1953), Kenneth E. Iverson (January 1954), Anthony G. Oettinger (March 1954), Warren L. Semon (April 1954), Theodore Singer (May 1954), Peter Calingaert (May 1955), Leroy B. Martin, Jr. (August 1955), Robert L. Ashenhurst (May 1956), Frederick P. Brooks, Jr. (May 1956), Roderick Gould (May 1957), Albert L. Hopkins, Jr. (May 1957), and Gerard Salton (January 1958).

Although senior professors tend to attract the better students, and the quality of graduate students at Harvard may have been relatively high, still this group was not an average set of Ph.D. students. It includes a Turing Award winner, a former President of the ACM, two of the chief designers of IBM System 360, two former editors-in-chief of ACM Communications, a number of present and former chairmen of computer science departments, and many people well known in their respective areas in the computer field. Given Aiken's reputation for autocratic behavior and occasional rudeness, one wonders how such a group of people could prosper at the Computation Laboratory under his leadership.

No one answer will suffice in telling the whole story. My own feelings may however be typical of the general sentiment in this connection:

- Howard Aiken was unusually supportive, even solicitous, of the research needs of his students. The tale has been told many times of how Aiken would appear almost daily in the graduate student offices, peeking over every one's shoulder, asking for a progress report, and throwing out suggestions of various kinds. Whereas most graduate students feel lucky if they can see their advisor once a month, we sometimes wished that we could see our advisor a little less frequently. In any case I cannot remember a single occasion where a request for help or advice was ignored.

- Aiken liked to feel that he was also taking care of the material needs of his people. If I may be permitted to inject a personal note which may provide an illustration, I would cite the occasion in 1953 when I suggested to Aiken that my weekly salary of $70 as a Mark IV programmer was scarcely adequate to support my family, which at the time included a wife and a baby. Without any argument at all, I saw my salary nearly double as a result of this one short intervention.

- Aiken saw to it that his students broadened the scope of their activities by continually suggesting new endeavors and new areas of activity that he felt might become profitable. Thus Ken Iverson found himself teaching courses in "Automatic Data Processing" after having written a dissertation in numerical analysis. Indeed Fred Brooks and Ken Iverson wrote the first data processing textbook at the Computation Laboratory.

- The Laboratory provided superb training in a general professional sense quite apart from the instruction in the technical aspects of computing, and the professional training far exceeded in quality what is currently offered to graduate students in most places. What may be called the "writing workshop" is a typical case in point. To produce the laboratory progress reports mentioned earlier, it was necessary for all of us to spend substantial time in writing papers and commentaries about our work. However, not just any piece of writing was accepted; the papers had to be well-written and well thought-out. We had to follow a particular Computation Laboratory style and Aiken insisted on literate English. In the early years, I am told that Aiken would read every line personally, and would repeatedly throw back onto people's desks products which he judged to be inferior. By the time I arrived on the scene, junior people were assigned as apprentices to more senior ones and criticism would come from one's senior colleagues. (My own tutors were Warren Semon and Ted Singer; I mention this fact to enable the reader to assess the blame where it belongs should this note be found to be stylistically or otherwise inferior.)

- As already mentioned the Laboratory provided technical instruction in many areas of computing far in advance of any other computer science organization.

- Finally, the Laboratory environment provided contact with many people of unusual competence and alertness, in addition, of course, to the interactions with Howard Aiken himself. In that sense the Laboratory shaped all of our professional lives long after most of us had left the Cambridge area.

At the Computation Laboratory no one would be accepted as a long-term staff member without Howard Aiken's personal approval. Many prospective graduate students and staff people tried, and for one reason or another did not make it. The challenging environment at the Harvard Computation Laboratory in the nineteen fifties was thus a monument to Howard Aiken's abilities as a senior professor and leader of people.

The Last Years (1958-1961)

I was the "baby" among all of Aiken's Ph.D. students; however I stayed at the Laboratory for over 13 years from 1952 to 1965. This period included the years leading up to Aiken's retirement. Aiken had no Ph.D. students after 1958 and he took early retirement from Harvard in 1961 at age 61. At a time when other senior professors would relax and enjoy the fruits of their labors, Aiken decided to start his own business. Just why did he leave early, more or less in his prime, when he was intellectually and physically fit as ever?

The official story is that he saw ways to make a great deal of money as a consultant and builder of computer components. And as it turned out, he was very successful in the business enterprises which were started after 1961. But as is well known, professors find a way to join business ventures and to make outside money even while remaining affiliated with their universities. Obviously a number of things must have come together in the later nineteen fifties which rendered the Harvard environment less palatable than it had been earlier.

Of course, there had always been a built-in conflict between the Harvard administration, and Howard Aiken's position as the single professor in his area who allowed no interference in running the affairs of the Computation Laboratory. The Laboratory was placed administratively under the Harvard Division of Engineering and Applied Physics, which included many other laboratories in addition to the Computation Laboratory. It takes no great imagination to understand that many problems arose in these circumstances between Aiken and the Deans in charge of the Engineering Division. Indeed the Associate Dean of Engineering was also "Director of Laboratories", a position which he certainly was not in position to exercise very actively with respect to the

Computation Laboratory.

The administrative and personal problems extended also to other people and organizations at Harvard, and in particular to the central administration under President Nathan Pusey and Dean of the Faculty McGeorge Bundy. It may well be that as he grew older, Howard Aiken had less zest for battle than in earlier years, and eventually decided that he had had enough.

More disturbing still for Aiken must have been the slow change of relationship which took place in the late nineteen fifties between him and some of the former graduate students who had recently become junior professors in computing. There had never been any dirert censorship of activities at the Computation Laboratory; indeed as has been pointed out, the younger people were encouraged to branch out and do their thing in new areas of computing, and most of us managed to publish articles and conference papers on our own when we had something to say. There was also no obviously directed insulation of Computation Laboratory activities from the outside: general conferences in large-scale computation which included many outsiders were held at the Laboratory as early as 1947 and 1949.

However, everyone's work was necessarily performed within some general framework of activities at the Computation Laboratory. Thus there was no great encouragement to go out and mingle with the competition, nor, I assume, would it have been completely proper for the junior staff to start new, individual activities without at least checking with the boss. These somewhat invisible boundaries were eventually crossed by some former graduate students who were, naturally enough, anxious to look out for themselves. Thus, some of the junior faculty found friends outside the Computation Laboratory in other departments of the university, and activities were started at the Laboratory with which Aiken had nothing to do. Furthermore, as additional professors became available as thesis advisors, many new graduate students chose to seek help from someone more easily approachable than Aiken. As a result, new students no longer flocked to Aiken's door.

In short, the realization that the Computation Laboratory, as it took shape in the early sixties, was no longer quite the same place that he had created 15 years earlier, must have been painful for Howard Aiken. And so he quit. He did make a lot of money over the next 12 years, and he remained active until he died in 1973.

How should one summarize Aiken's contributions? There is certainly no single piece of writing nearly as influential as the famous papers by Burks, Goldstine, and von Neumann, and Aiken's influence on the design of modern computing machines is now considered to have been small. Furthermore, Aiken's feuds with other major figures in the computing world, with IBM after the construction of Mark I, and with certain colleagues at Harvard as well as with the Harvard administration, almost guaranteed that his "empire" would be dismantled in short order following his departure from the scene.

However, for 15 years Aiken provided for all of us at Harvard an exciting and productive environment in which to work. Many subsequent activities and contributions of the Computation Laboratory staff are surely due to the training and incentives provided by Aiken. In that sense the Harvard legacy has endured long beyond Aiken's time.

I myself think back to Howard Aiken and to my Harvard years with fondness and appreciation. I believe that most, if not all, of Aiken's former students feel the same way.

References

[1] M.V. Wilkes, Remarks made in a special Pioneer Day session at the National Computer Conference in Anaheim, CA, May 1983.

[2] Reports and Theses from the Harvard Computation Laboratory referred to in the text:

A Manual of Operation for the Automatic Sequence Controlled Calculator, Annals of the Computation Laboratory of Harvard University, Vol. 1, G.M. Hopper, editor, Harvard University Press, Cambridge, MA, 1946.

Proceedings of a Symposium on Large-Scale Digital Calculating Machinery, Annals of the Computation Laboratory of Harvard University, Vol. 16, Harvard University Press, Cambridge, MA, 1947.

K.E. Iverson, Mark IV Coding, in Progress Report No. AF-23 to the U.S. Air Force, Harvard Computation Laboratory, Cambridge, MA, 1952.

A.G. Oettinger, A Study for the Design of an Automatic Dictionary, Progress Report No. AF-31 to the U.S. Air Force, Harvard Computation Laboratory, Cambridge, MA, March 1954.

F.P. Brooks, Jr., The Analytic Design of Automatic Data Processing Systems, Report BL-15 on The Theory of Switching to Bell Telephone Laboratories, Harvard Computation Laboratory, Cambridge, MA, May 1956.

[3] R.L. Ashenhurst, Howard Hathaway Aiken 1900-1973, Communications of the ACM, Vol. 16, No. 5, May 1973, p. 274.

[4] H.S. Tropp, Howard Aiken, in Encyclopedia of Computer Science and Engineering, Second Edition, A. Ralston and E.D. Reilly, Jr., editors, Van Nostrand Reinhold Co., New York, NY, 1983, p. 40-41.

[5] F.P. Brooks Jr. and K.E. Iverson, Automatic Data Processing, John Wiley and Sons, New York, NY, 1963.

[6] A.W. Burks, H.H. Goldstine, and J. von Neumann. Preliminary Discussion of the Logical Design of an Electronic Computing Instrument, Part 1, Vol. 1, Institute for Advanced Study, Princeton (28 June 1946, 2nd edition, 2 September 1947).