

REMEMBERING SOME EARLY COMPUTERS, 1948-1960¹

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¹ This brief personal memoir was prompted by an invitation to lead an EPIC Tuesday Luncheon Conversation at Columbia University on 7 March 2006.

Introduction

This memoir is not intended to be a definitive early history of computers; rather it is the personal recollections of a small player in a period of dramatic advances in the computer field, in terms of both equipment and applications.

I chose the starting date of 1948 for two reasons. First, it was the year that I first heard of an electronic computer; second, it was a time when there were only a very few experimental computers in existence and no commercially available ones. By the end date of 1960, there were approximately 1000 commercial electronic computers installed. Almost all of them still used vacuum tubes but the era of the transistor was about to begin. In other words it was the end of the beginning of the modern computer age.

In 1948, as I was completing high school in England, I went for some long walks with Louis Martin, the son of our next door neighbors, who was an engineering student at Cambridge University. In the course of our discussions, he told me that he had heard about a computer which was being built at the University. This computer was the EDSAC; but more of this machine later. I remember being interested in the information but of course I had no idea at the time that my life's work would revolve around computers. This conversation with Louis has stuck in my mind over the years.

Imperial College of Science & Technology, London

In October 1948, having been awarded a State Scholarship, I started an accelerated applied mathematics degree course at Imperial College of Science and Technology of the University of London.² About 80% of the students were WWII vets and anxious to get done with their studies so we were a reasonably serious bunch of students. Except for one course in physics, the only subjects that the 30 mathematics students in my class studied were the prescribed courses in mathematics. There were no options or elective courses. There were also no quizzes or marking of assignments; only formal examinations at the middle and end of each academic year.

Our courses included many which dealt with various aspects of computation, albeit by means other than electronic computers. Computation of mathematical tables, planetary orbits, tides, etc. had long been of great importance and considerable work had been done on how to perform such computations with appropriate accuracy and speed. The word "computer" was in fact first applied to the people, usually women, who did this work with the aid of mechanical calculators. I remember especially the large amount of labor involved in solving two dimensional partial differential equations using so-called relaxation techniques. The process was anything but relaxing for the person doing it!

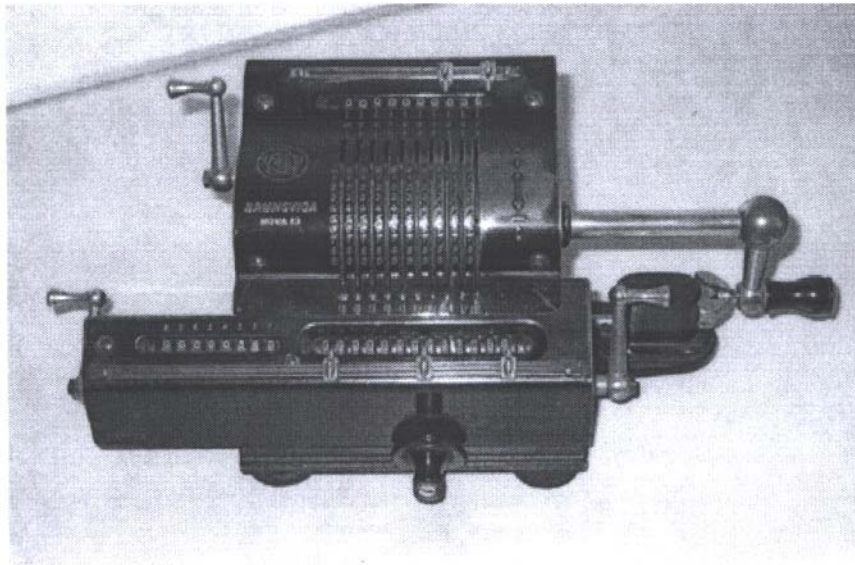
In 1950, after 2 years at Imperial College, I passed the exams for my Bachelor's degree but then had to spend a third year in residence before being actually awarded the

² Emeritus Professor Sam Devons, the founder of EPIC, was a Professor of Physics at Imperial College at that time and I met him through the student Mathematical and Physical Society of which I was president in 1951-52.

degree. Since I was interested in computation, I looked around for a department in which I could pursue this interest. I found that Dr. Eric Eady, a Reader³ in the Meteorology Department, shared this interest so I moved to that department to study the application of computational methods to weather prediction.

The idea for using computational methods in weather prediction had been pioneered by Lewis Fry Richardson. During WWI, he had made extensive hand calculations while serving as a medic in France but did not come up with anything like a correct prediction.⁴ Therefore his work was essentially forgotten until the arrival of the digital computer. Actually, the problem with his numerical forecasting technique turned out not only to be the amount of work involved but also his choice of time increment. However, that was not realized until the 1940's. Incidentally, Richardson estimated that to just keep up with worldwide weather, using his very simple model, would require some 64,000 computers, that is: human computers. He did not pursue weather prediction and went off to work on other endeavors.

Let me get back to my work at Imperial College. Since we did not have access to any form of automatic computer, Eady assigned me problems which could be tackled using hand computations. Luckily, after only a few false starts, I found a problem which, in a relatively short time, generated results which were sufficiently interesting for a Ph.D. thesis.⁵ Fortunately, my fourth year at Imperial College was funded by a grant from the U. K. Department of Scientific & Industrial Research (DSIR).



BRUNSVIGA CALCULATOR, circ 1920

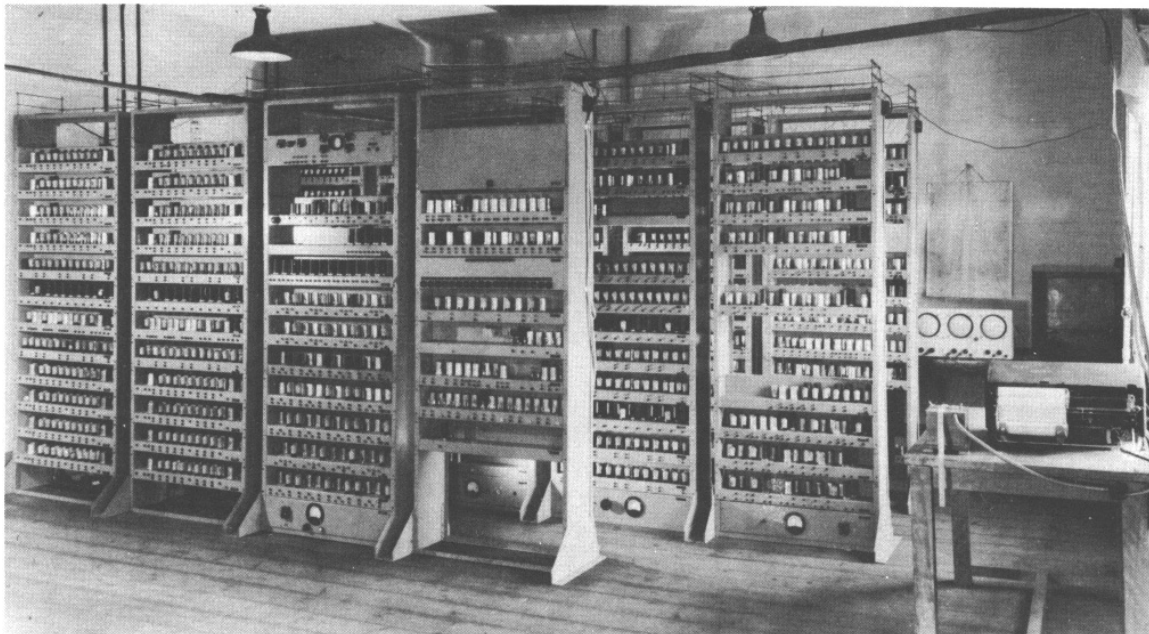
³ A Reader was a U.K. academic appointment approximately equivalent to an Associate Professor in the United States.

⁴ Richardson, Lewis F., "Weather Prediction By Numerical Process," Cambridge University Press, London, 1922 (Reprinted 1965 by Dover Publications)

⁵ Gilchrist, Bruce, "The Application Of The Equations Of Motion To The Solution Of Climatological Problems," Ph. D. Thesis, University of London, June 1952

Along the way, Eady and I kept our eyes on some of the various computer projects which were getting started around the world. Close to home, two mathematics lecturers at Imperial College, Keith Tocher and Sidney Michaelson, were constructing a relay computer but this appeared to be much too limited to be considered for the weather prediction problem. However, we did become aware that fifty miles away at Cambridge University, the EDSAC, a much more ambitious computer was nearing completion.

In 1951, I was fortunate to be able to attend a two week course at Cambridge University run by Dr. Maurice Wilkes, the developer of EDSAC. This was my first real exposure to computer programming, the problems of debugging, etc. The EDSAC was an interesting machine. It used pulses circulating in large tanks of mercury (acoustic delay lines) for high speed memory and had paper tape input and output. At this course, I received a copy of what I believe is the first book on programming.⁶



EDSAC COMPUTER, CAMBRIDGE UNIVERSITY, circ 1951

Among the students with whom I became friendly on the course was Gordon Welchman. I learned many years later when the project was declassified, that Gordon was a key member of the team at Bletchley which broke the German ENIGMA Codes in WWII using what was essentially a special purpose computer. He subsequently wrote a book describing this work.⁷ A notable special lecturer at the Cambridge course was Dr. Alan Turing, also a hero of the ENIGMA code breaking efforts, who was at the time developing a computer at Manchester University. He was later portrayed in the acclaimed Broadway play “Breaking the Code”.

⁶ Wilkes, Maurice V., Wheeler, David J. & Gill, Stanley, “The Preparation of Programs For An Electronic Digital Computer,” Addison-Wesley, Cambridge, MA, 1951

⁷ Welchman, Gordon, “The Hut Six Story – Breaking The Enigma Codes,” McGraw-Hill, New York, 1982

The program at Cambridge University certainly wetted my appetite for computers but alas I had to spend the next several months with laborious hand calculations for my thesis. But there was a glimmer of light from across the Atlantic.

At the end of WWII, the distinguished mathematician John von Neumann⁸ had set up a project at the Institute for Advanced Study (IAS) in Princeton, NJ, to build a stored program computer. Von Neumann looked around for a non-classified scientific project which would be ideal for early experiments using electronic computers. He chose weather prediction for the major application project and attracted Dr. Jule Charney, a gifted meteorologist/mathematician from UCLA, to lead the effort. Even before the completion of the IAS machine, Charney's work resulted in 1950 in the first reasonably accurate weather prediction being made using the ENIAC.⁹ This was a computer which had been built at the University of Pennsylvania during WWII for the Aberdeen Proving Ground

Charney visited us at Imperial College in the spring of 1952, shortly after the IAS computer had become usable, and showed Eady and I some of his early results and examples of computer coding. This was all very exciting for me, especially when Charney, finding out that I would be finishing my Ph.D. thesis that summer, invited me to spend the next academic year with his group at Princeton. I needed funding but, with the backing of von Neumann, I received support for a year's visit under the US Smith-Mundt and Fulbright programs. This is a great example of who you know being more important than what you know!

Institute for Advanced Study, Princeton, NJ

In September 1952, a new Ph.D. and \$25 in hand, I left food rationing and fuel shortages behind and boarded the Queen Mary for New York City. There I got a bus from the pier to Pennsylvania Station and then a train to Princeton. Now started what, in retrospect, were probably the most exciting four years of my life. I had access to a state-of-the-art digital computer, considerable freedom as to the problems I wanted to attack, great mentors and colleagues, and an unbeatable academic atmosphere at the Institute for Advanced Study. Although initially I had funding for only a one year visit, at the beginning of 1953 I was put on the regular on-going payroll of the electronic computer project. This enabled me to buy my first car, a Studebaker.

The two main divisions at the IAS were the schools of Mathematics and Historical Studies. The electronic computer project was the baby of John von Neumann and was the only unit at the Institute to have a laboratory.¹⁰ It also differed in that it was supported by several government contracts rather than IAS funds. At the upper echelons

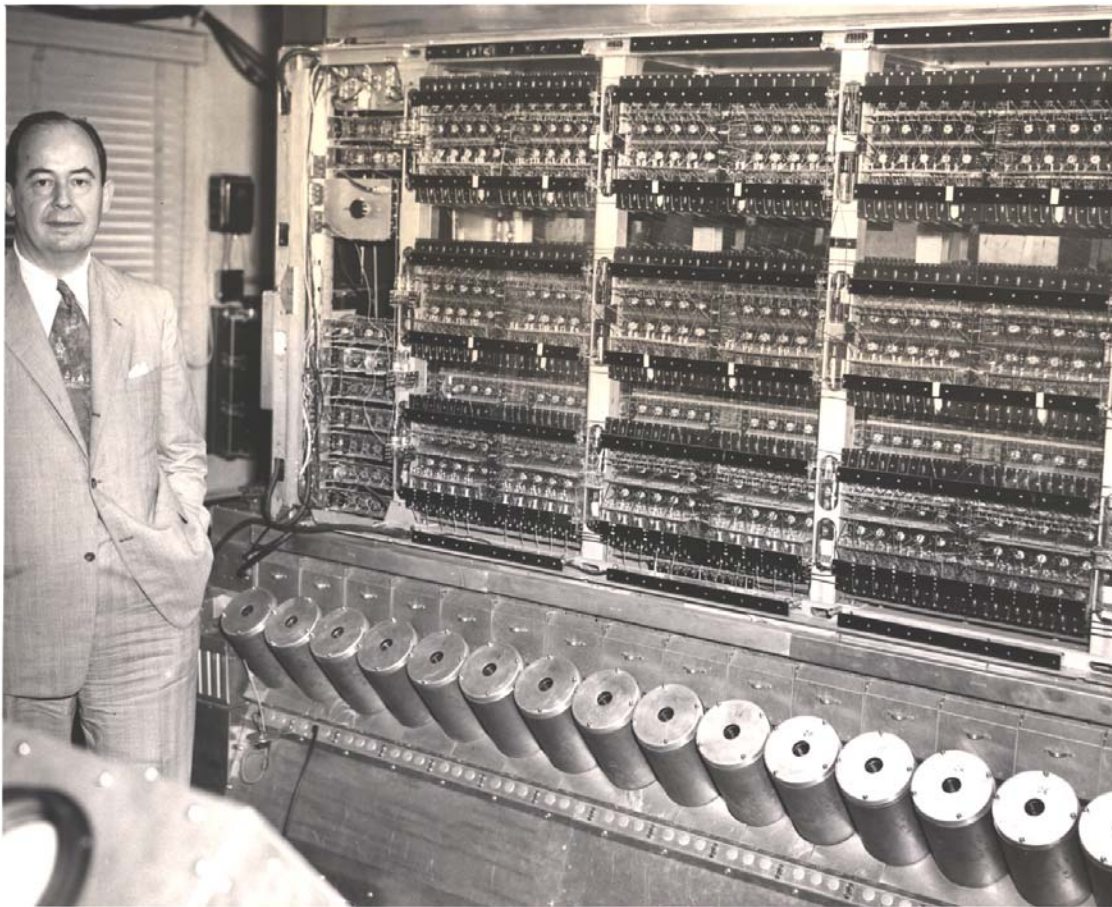
⁸ A popular saying of mathematicians of his day was that most mathematicians prove what they can; von Neumann proves what he wants. A brief summary of his work is given in the Fall 2003 issue of the IAS Newsletter. He was born in Hungary in 1903 and died in Washington, DC, in 1957.

⁹ Charney, J., Fjortoft, R. and von Neumann, J., "Numerical Integration of the Barotropic Vorticity Equation," *Tellus* (2), 1950

¹⁰ The Institute for Advanced Study, Report of the Director, 1948-1953.

there was apparently an ongoing argument as to the appropriateness of a computer project at the Institute but this did not affect me or get in the way of good relationships with other more theoretical scholars at the IAS. The IAS kept its cafeteria open in the evening so it was the place where we had lots of interdisciplinary discussions.

Including visitors, the headcount of the computer project was usually just under 50, approximately half of whom were professional engineers, mathematicians or meteorologists. The support staff included approximately 8 coders, a now extinct occupation, whose responsibility was to convert mathematical and logical instructions into machine code. There was no FORTRAN in those days! Several of these coders, all of whom had at least Bachelor's degrees in a science, were very skilled and contributed immensely. In particular, I was fortunate to have the assistance of James Cooley on several projects.¹¹



John von Neumann and the IAS Machine, 1952

The IAS computer, like all the early computers was room sized and used vacuum tubes. It was a parallel machine, i.e. it processed all 40 binary digits of a number at the same time. The high speed memory consisted of 40 CRTs which stored the information

¹¹ Cooley subsequently went back to school at Columbia University and received his Ph.D. in Applied Mathematics. He then went on to a distinguished career at IBM and election to the National Academy of Engineering for his work on algorithms for fast Fourier transforms.

as charges on the screens. This type of memory was known as “Williams Tube Memory” after its inventor, Professor F. C. Williams of Manchester University in the UK. The total memory was 1012 words each of 40 binary digits. Around 1954 a magnetic drum was added. An IBM card reader/punch was attached for input/output. Printing was done by hand carrying punched cards to an off-line IBM 402 accounting machine. When I arrived in 1952, there was only a very primitive console with little more than an on/off switch and a switch to hand-step instructions. Changing a binary bit in one of the registers involved using a clip lead to ground the appropriate pin on the base of a vacuum tube. Later, a set of 40 toggle switches was added to the console and the clip lead was retired.

There were no computer graphics per se but there was a slave CRT which could be switched to show the surface of any of the 40 CRTs used for storage. Since the bits were stored in a 36 by 36 raster on the surface of the tubes, we found that we could draw very simple pictures or maps by setting bits to one or zero.

Since high speed memory was very limited and until 1954 there was no other storage, we developed a procedure in which multiple versions of repetitive parts of a program were kept on punch cards in the card reader. Then, whenever that piece of the program was required it was read into the high speed memory. In most meteorological programs the code could be divided into two parts, A and B, which were run alternately. Thus the stack in the card reader consisted of alternating copies of the A and B programs. When resources are very limited, necessity is the mother of invention!

All programming was done in machine language although we did use alphanumeric equivalences (1, 2, ..., 9, A....F) for groups of 4 binary digits. For example we said and wrote 7 for 0111, A(ble) for 1010 and F(ox) for 1111, etc. There was no programming manual; only a one page list of instructions. I learned by doing! The great thing was that one felt very close to the computer and had what might be called a symbiotic relationship with it. One almost played it and the application you were working on like a musical instrument. Since there were no floating point instructions, it was vital that one understood the size of all the numbers which occur during a computation; otherwise one could rapidly end up with lots of leading zeroes. Since high speed memory was very limited – 1024 words shared between instructions and data – one had to be very economical. For example, whenever possible we stored four pieces of data in each 40 binary bit word. Compared with today’s computers, we had a minnow. But the remarkable thing was how much was accomplished in the early years of numerical weather prediction.

Although the IAS computer had been first used successfully for problem solving in early 1952, using the computer was far different from today’s practices. The typical routine was for the engineering group to have the machine all day for maintenance and development activities. Then the second and third shifts would, if we were lucky, be available to users like me. Needless to say, I pulled a lot of all-nighters! One of the side benefits of working in the evening was that von Neumann would frequently drop by to chat and to see how things were going.

Machine errors were frequent and we processed all our programs in small pieces, duplicating each one before proceeding with the next. Users, when errors occurred, tried to identify the source(s) so that the engineers could make the necessary fixes. To help in this, I remember writing a program to overwork the memory so as to identify weak spots on the CRTs. The engineers subsequently ran this program as part of their routine maintenance. The only user who did not appear to worry about errors was a Norwegian/Italian scientist, Nils Barricelli, who was studying genetics. He simply regarded an error as just another mutation!

Most of my time during my first year at the Institute was devoted to helping Charney develop an improved model for weather prediction. I was responsible for the programming of a so-called two and a half dimensional model.¹² In this work I was assisted by an outstanding coder Glen Lewis. The results of this and earlier work of Charney were sufficiently good to justify the US Navy, Air Force and Weather Bureau in 1954 forming a Joint Numerical Weather Prediction Unit (JNWP) in Washington to put such models into operational use.

Almost all our work testing prediction models used data from the severe north-east storm of November 24/25, 1950. This enabled reasonably objective comparisons to be made between various models. In order to keep the computations within the capability of existing computers, these models had to be simplifications of a very complex reality. The genius of Charney was to see which simplifications made good physical sense and kept the key features necessary for prediction. Over the following 50 years, as computer capability rapidly expanded, the number of simplifications has been gradually reduced.

One of the requirements for any forecasting model is good initial data. This led Dr. George Cressman, a visitor to the project from the US Air Weather Service, and I to investigate how the computer might be used to analyze incoming weather observations, i.e. essentially to draw a weather map. We found that we could indeed do this with some success.¹³ After Cressman went back to Washington to head the JNWP, he expanded this work into an operational system.¹⁴

In 1951, IBM had started construction of what it called the Defense Calculator. It was subsequently renamed the IBM 701 and IBM offered it for sale to a few select government and commercial organizations. This machine was based on the IAS design and like the IAS machine, used CRTs for high speed memory.¹⁵ Eventually 19 of these machines were built. Since von Neumann was a consultant to IBM, he was offered time on the first 701 which was installed in the IBM showroom at 590 Madison Avenue at the end of 1952. Von Neumann turned the time over to the Meteorology Group and I was given responsibility for its use. I therefore attended an IBM 701 Programming class in

¹² This work was reported in Charney, J. G., "Numerical Prediction of Cyclogenesis," Proceedings of the National Academy of Sciences, 40 (2), February 1954.

¹³ Gilchrist, B. & Cressman, G. P., "An Experiment in Objective Analysis," Tellus 6 (4), 1954

¹⁴ Cressman himself went on to serve as Director of the National Weather Service from 1965 to 1979.

¹⁵ The IBM 701 is described in Bashe, Charles J. et al, "IBM's Early Computers," MIT Press, 1986

June 1953.¹⁶ That summer and fall, Jim Cooley and I commuted from Princeton to New York to run some improved forecasting models on the IBM 701 which had a larger memory than the IAS machine, improved I/O devices and attached tape drives. This allowed for more complicated models than had been possible with the IAS machine.¹⁷ The course and visits to New York gave me an interesting view of how various government agencies and commercial companies were getting involved with computers. I was also able to observe how IBM, a large commercial organization, operated.



IBM 701

After the completion of our work on the IBM 701, von Neumann described it to IBM as follows:

“The purpose of the IBM calculations was to establish how much greater precision could be obtained by a further increase in the number of layers [of the numerical model], with five being considered the greatest number that will still yield an increase in precision. Neither the speed nor memory capacity of the Princeton machine were deemed adequate for these computations. Calculations with the five-level model required that a number of its mathematical and physical properties be

¹⁶ One of the other attendees at this class was Morton B. Friedman of NYU; later Vice-Dean of Engineering at Columbia University.

¹⁷ Charney, J. G., Gilchrist, Bruce & Schuman, F. G., “The Prediction of General Quasi-Geostrophic Motions,” *Journal of Meteorology*, 13 (5), October 1956.

explored. This exploration, utilizing the IBM 701, extended over three separate versions of a five-layer model. It was established that one, and only one, of these three versions was suitable. Its precision was found to be higher than that of the three-level model, but a residual error remained even then. As a result of these calculations, we know how to proceed with multi-layer models of the most general type and we have established, in the shape of the residual error mentioned above, the inherent error of all geostrophic models Also, as a result of the IBM calculations, we know that it will be necessary to perform computations with both geostrophic and non-geostrophic models.”¹⁸

My knowledge of the IBM 701 also came in useful after the JNWP in Washington, DC, installed one as its first operational computer for weather prediction in March 1955. This was the nineteenth and last IBM 701 built. Jim Cooley and I made occasional use of the JNWP computer during its first year of operation.

Although the IBM 701 was a commercial machine it did not have anywhere near the reliability we find in computers today. In fact, the IBM 701 came with a crew of field engineers who performed extensive daily maintenance and “baby sat” the machine 24/7. It was the reliability of IBM support which helped IBM make many sales in competition with UNIVAC.

As our thoughts moved toward the operational use of computers in weather prediction, I gave some thought to the data transmission problems associated with getting the results of observations to the forecasting center. Remember these were the days before high speed transmission systems which we take for granted in the 21st century. Discussions with Julian Bigelow¹⁹, of the project’s engineering group, and George Cressman led to two short papers on improving the efficiency of existing transmission systems.²⁰ As it turned out, our ideas were never put into effect as data transmission systems soon improved so much that inefficient encoding of the data became of minimal importance.

In the summer of 1954, I spent a month in Stockholm at the Royal Institute of Technology visiting with Professor Carl-Gustaf Rossby and his group. Rossby was an internationally recognized meteorologist whose ideas had had a great deal of influence on Charney. Also, several Swedish meteorologists had visited the IAS project for extended periods. This visit gave me a chance of meeting with lots of interesting people and seeing the Besk computer which had been built in Stockholm using the IAS machine architecture.²¹ The Besk started with a CRT memory but in mid-1954 this was changed to

¹⁸ Enclosure in letter to Cuthbert Hurd of IBM, 11 November 1954, quoted in Aspray, William, “John Von Neumann and the Origins of Modern Computing,” MIT Press, 1990

¹⁹ Bigelow, a permanent member of the IAS, was chief engineer of the computer project from 1946 to 1951

²⁰ Gilchrist, B. & Cressman, G. P., “More Efficient Weather Coding,” Bulletin of the American Meteorological Society, 35 (3), March 1954, and Gilchrist, Bruce and Bigelow, Julian, “Data Transmission for Numerical Weather Prediction,” Bulletin of the American Meteorological Society, 36 (8), October 1955

²¹ Other close copies of the IAS machine included the AVIDAC (Argonne), ILLIAC (Illinois), JOHNNIAC (Rand), MANIAC (Los Alamos), ORACLE (Oak Ridge), ORDVAC (Aberdeen Proving Grounds), DASK (Denmark), BESM (Moscow), PERM (Munich), SILLIAC (Australia) and WEIZAC (Israel).

ferrite cores. My stay in Stockholm also allowed me to change my US visa status from exchange visitor to permanent resident.²²

Although I spent most of my time working on the meteorological application of the IAS machine, I was also able to spend some time thinking about the design of computers. In particular, I was interested in how arithmetic operations might be speeded up in asynchronous adders by reducing the time taken for carries to propagate. With me doing the theoretical part and two of my engineering colleagues, James Pomerene²³ and S. Y. Wong, providing the laboratory skills, we were able to come up with some interesting results.²⁴ Our design was actually incorporated in one computer, the S2000 produced by Philco Corporation. This was advertised as the “World’s Fastest All Transistor Data Processing System” but was not a commercial success. In practice, most computer manufacturers preferred to use synchronous adders which were easier to maintain. Also, with the advent of transistors, there was much less emphasis on minimizing the number of components in a computer’s arithmetic unit. Thus my brief sortie into machine design ended with nothing more to show than a “classic” paper.

Although the meteorology project was the major user of the IAS computer, many other applications were developed and run, mainly by short term visitors to the Institute. These included ones in astrophysics, fluid dynamics (shock waves), atomic and nuclear physics, traffic simulation, historical ephemeris, etc.²⁵ For quite a while I was responsible for scheduling computer time, so I tended to learn something of each of the applications.

Before concluding this discussion of the work at the IAS, I should mention a project about which I really knew nothing but was apparently very important to the US government. We had two mysterious visitors, Mr. and Mrs. Evans from Los Alamos, who would never discuss what they were doing and would always couch any questions they had about the machine in a way that did not reveal anything about their application. Our assumption was that they were working on highly classified bomb problems. In retrospect, I believe that the calculations were related to the development of the H-bomb.

In 1955, von Neumann left the Institute for Advanced Study to join the AEC. Without him, there was insufficient support for the building of another computer. We spent a lot of time writing final reports to our funding agencies and then, in the summer of 1956, the project broke up. The computer went first to Princeton University and then, in 1960, to the Smithsonian Institution in Washington where it is still on display. The

²² At that time the US under pressure from the UK government, due to its concern with “brain drain,” was requiring individuals to leave the US if they wished to change visa status. Using a trip to Canada for this purpose was not permitted.

²³ Pomerene was chief engineer on the IAS computer project from 1951 to 1956. He went on to a distinguished career at IBM and election to the National Academy of Engineering.

²⁴ Gilchrist, Bruce, Pomerene, J. H. & Wong, S. Y., “Fast Carry Logic for Digital Computers,” IRE Trans. Electronic Computers, EC-4, 1955 (reprinted in Benchmark Papers in Electrical Engineering and Computer Science, Vol 21, Dowden, Hutchinson & Ross, 1980) and “A Note on High-Speed Digital Multiplication,” IRE Trans. Digital Computers, EC-5, September 1956

²⁵ Many of these are described in Aspray, William, op. cit.

staff went to various places including Bell Labs, UCLA, SRI, IBM and MIT. After considering several very interesting offers, I accepted an invitation to be an assistant professor of mathematics and first director of the computer center at Syracuse University.

Before going to the next phase of my career with computers I should note that I was married in Princeton in April 1954 and my eldest son was born there in February 1956.

Syracuse University, Syracuse, NY

In the early 1950's the Endicott Laboratory of IBM started developing a computer based on using a magnetic drum for storage. This was felt to be a lot cheaper and much more reliable than the CRT storage of the IAS machine and the IBM 701. Although it was much slower, it turned out to be much less expensive. In mid-1953 IBM announced it as the IBM 650 Magnetic Drum Data Processing System.²⁶ They still did not want to use the word computer! The first delivery was made at the end of 1954 and there was a



IBM 650, 1955

steady stream of installations through 1962. In all, some 2000 of these computers were manufactured. Thanks to special pricing, the IBM 650 proved very attractive to universities. Basically, a university received a 30% discount for teaching general and scientific uses and another 30% discount for teaching business applications.

In early 1956 Syracuse University had ordered an IBM 650 and it was delivered a few months after I arrived there that summer. Other universities installing IBM 650s

²⁶ The genesis of the IBM 650 is described in Bashe, Charles J. et al, op cit.

about the same time included Cornell, Rochester, Michigan, Carnegie, Pittsburgh, Houston, UCLA, etc. We at Syracuse quickly started exchanging visits and ideas with Cornell and Rochester since they were the closest to Syracuse. We also made contact with several commercial installations in the area such as at GE Heavy Military Systems, Niagara Mohawk and Carrier Corporation. In April 1957, IBM hosted a week-long meeting at Endicott for some 50 IBM 650 users. Thus there was lots of cooperation between users as we all learned how to get the most out of our systems. It was a time when software was freely exchanged to the considerable benefit of all involved.

We ran both training and academic courses on computing being careful to satisfy the conditions of the IBM discount. We also introduced a programming language as an alternate to a foreign language for appropriate Ph.D. candidates. Much of my time and that of two graduate assistants was spent working with faculty members as they slowly introduced computing into their research and teaching.

In addition to other IBM 650's in the Syracuse area, there was a UNIVAC installation at Sylvania Electric in nearby Camillus, NY, used entirely for commercial purposes, and a SAGE (Semi-Automatic Ground Environment) installation at Syracuse Airport. The latter was part of the North American air defense system and was my first exposure to a large multi-display duplexed system. It was located in a hardened building with extensive security and a general officer in constant attendance. I was fortunate to get a tour of the installation before the Air Force severely restricted access.²⁷ Interaction between computer users was helped by the establishment of a local chapter of the Association for Computing Machinery (ACM).

I became quite involved with the ACM at this time and was elected to its national Council in 1958.²⁸ This volunteer work brought me into contact with many computer users across the US.

During my period at Syracuse, my interest moved away from meteorological applications and toward the operational and management problems associated with computer systems. I did however continue as a consultant to the US Weather Bureau and made occasional visits to the JNWP unit in Washington, DC.

One such consulting visit was in connection with the evaluation of two computers being considered as a replacement for the IBM 701. I remember that IBM sent a team of technical people to describe its proposed system whereas the competitor sent one person who arrived over 30 minutes late for his presentation. It was not hard to understand why IBM won so much business.

In the spring of 1959, I was asked by Dr. Herman H. Goldstine²⁹, to join him at IBM Research as manager of the computing facility. Although I was far from unhappy at

²⁷ The SAGE system and its computers are described in Bashe, Charles J. et al, op cit.

²⁸ I served on the ACM Council for 10 years including two-year terms as secretary and as vice-president.

²⁹ Herman H. Goldstine was an Assistant Professor of Mathematics at the University of Michigan at the start of WWII. After being commissioned in the US Army he was assigned to the Aberdeen Proving

Syracuse, this sounded an interesting and challenging opportunity. It paid well and was in a location with a somewhat better climate than Syracuse so I accepted.

Again, before moving on to the next phase of my career with computers, I should make a personal note that my second son was born in Syracuse in 1957 and I became a naturalized US citizen there in late 1957.

IBM Research

At the time I joined in the summer of 1959, IBM Research was in the process of building the Yorktown facility which it still occupies. As a result I had an office at the Lamb Estate in Ossining where my technical staff was located and the computer center, for which I was responsible, was in Poughkeepsie, NY, an hour's drive away. The initial equipment was an IBM 709, a vacuum tube machine upgrade of the IBM 701 and 704, and lots of peripherals. In short order, this was upgraded to the transistorized 7090.

Serving the needs of a large research organization was a significant challenge but the resources available were much greater than I had had at Syracuse. I also had the opportunity to meet with many distinguished scientists and engineers and to discuss their computational problems. It was a time of affluence for IBM and there was adequate funding for travel to other IBM locations and technical conferences. Again, I was fortunate to be in a good place at a good time to satisfy my intellectual needs.

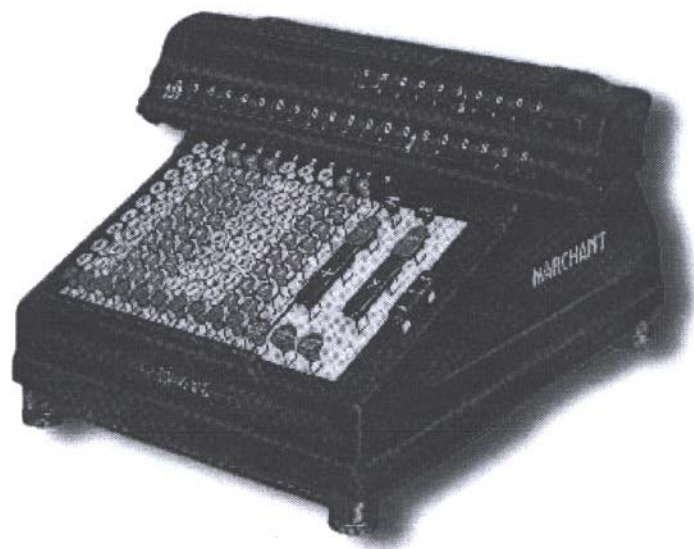
But here this memoir must end. It has taken me from a time when all computers were experimental to one where a major industry had been firmly established which was building computers by the thousands. It was a fantastic change in little over a decade. Of course, there would still be lots of changes in the following years but that is for the next memoir.

Ground and then to coordinate the development of the ENIAC whose development the Army was funding at the University of Pennsylvania. At the end of WWII he moved to the IAS to join von Neumann as assistant director of the electronic computer project. We continued to be friends until his death in 2005.

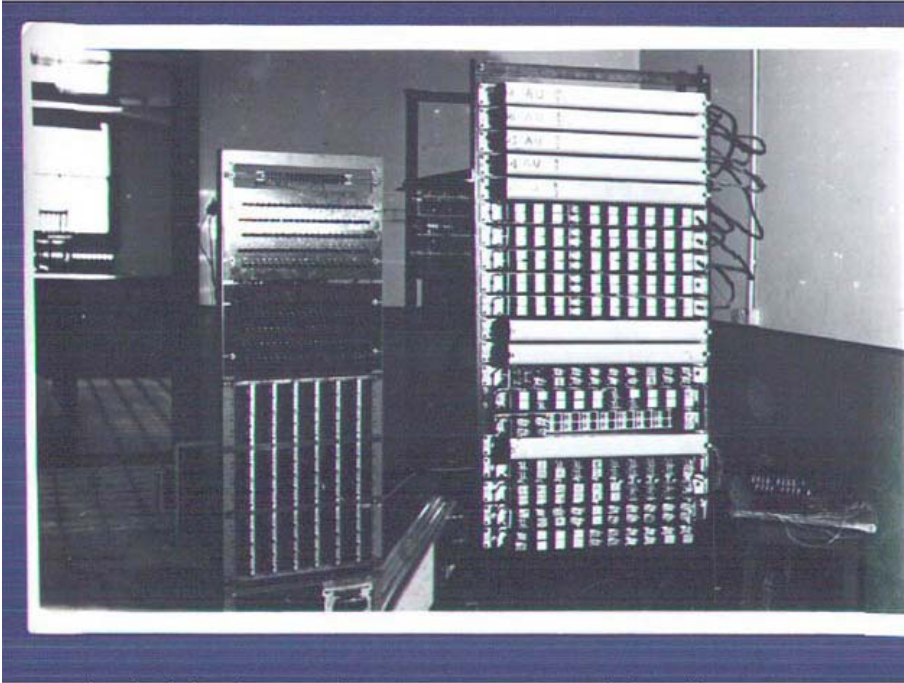
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CURTA CALCULATOR



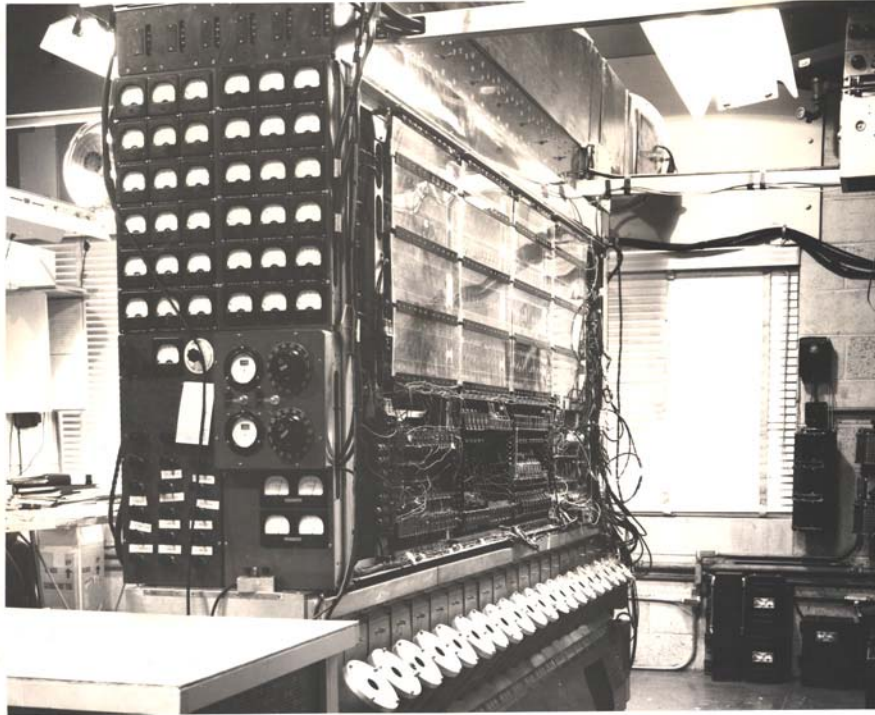
MARCHANT CALCULATOR, circ 1950



Tocher/Michaelson Relay Computer, Imperial College, 1952



Gilchrist & Devons, Imperial College, 1951



IAS Machine, 1952



Julian Bigelow, Herman Goldstine, Robert Oppenheimer and John von Neumann with the IAS Computer, 1952



COMPUTER STUDY STARTS. Dr. Bruce Gilchrist, director of Syracuse University's new \$300,000 Computer Center, makes final adjustments before the start of the first major study on the computer. Dial settings for the study, sponsored by the New York State Department of Banking, are double-checked by Richard D. Wilkins, a student assistant at the center, in Hinds Hall.