JOHNNIAC EULOGY

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JOHNNIAC, as you know, comes from an illustrious ancestor--the so-called von Neumann machine developed at Princeton's Institute for Advanced Study. I thought you might find it interesting today to hear a little of its history, and to relive some of the highlights of its career.

In 1949-50 RAND rented from IBM and operated a pair of Card Programmed Calculators and some 604s. In 1950 a need for more computing power was felt, and the issue of larger and faster equipment arose. Should RAND attempt to build a machine for its needs, or buy and if so, buy what? The team of John Williams, George Brown, and Bill Gunning set out on a tour of the country to see what might be possible. They visited IBM at Poughkeepsie, the University of Illinois, the Moore School, and Eckert Mauchly now Sperry Rand; what they found was discouraging. Bill sums it up: "They were doing all kinds of tweaky

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things to circuits to make them work. It was all too whimsical." The only bright spot was the Princeton development, and thus it was that a working alliance between RAND and Princeton came into being. RAND was to build a machine patterned in the likeness of the Princeton one. As part of his preparation for the trial to come, Bill spent three days a week working at UCLA on the SWAC machine being built there by the National Bureau of Standards.

It is interesting to review a document of October 1950--from the same team of Brown, Gunning, and Williams to Frank Collbohm:

> It is difficult at this stage to make sharp estimates of the sums that will be needed during the fiscal years 1951 and 1952: . . . . The following, therefore, are deliberately conservative:
>
> | | FY 1951 | FY 1952 |
> |---|---|---|
> | . . . . | | |
> | Total [estimated cost] | 54,000 | 63,000 |
>
> . . . In addition, the technicians, engineers, and programmers who will be required for the project are currently available, with one exception: we shall require a first-rate mechanical engineer for about 1 man-year.
>
> The personnel have been acquired and trained over the past three years with this end in view. They have been occupied till now in training activity . . . and in design and construction work on other RAND equipment, such as the random digit generator, the coverage machines, the REAC, etc.
>
> So far as operating personnel is concerned, we now have approximately the planned number. The actual total number needed to operate the machines of

> Numerical Analysis may increase, say by two or three, because of the recent improvements made in the REAC, which will be much more voracious of problems than whan originally obtained.

There is reported to be another document which I have not been able to locate that estimated the total construction cost of the unnamed machine to be $150,000, and a construction period of 2 years.

Several of the decisions about JOHNNIAC were noteworthy for the 1950 period:

- The design goal was to improve markedly the reliability of the Princeton machine. A minimum increase in reliability by a factor of 10 was to be achieved;
- The input and output media of the JOHNNIAC was to be punched cards . . . not the teletypewriters of other machines of the day;
- The machine was to be designed as an operational equipment, not a laboratory experiment . . . it was intended to be used and to be maintained;
- The main store of the machine was to be the special electrostatic tube developed by RCA under the name "selective electrostatic storage tube."

And so work commenced.

In 1952, Cecil Hastings reports as follows:

> Discussions are in progress with regard to the console. Several schemes and methods for entering numbers into the machine are being considered. Probably there will be an operator's console presenting to him only as much as he needs to play the machine, and a maintenance console which reveals the deepest secrets of the whole JOHNNIAC. No other machine can make this statement: Our console is human engineered.
>
> JOHNNIAC will definitely be the most completely protected machine ever devised. The present plans for supervisory control will take care of the machine in event of voltage failure, refrigeration

> failure, fuse burnout, and all else. In addition to shutting down the machine, an alarm will be sounded and a tell-tale light will tell who do-ed it. The precise nature of this alarm is not yet settled; many diabolical devices, all directed toward the best interests of the operator, are being considered.

Later in 1952, Cecil wrote:

> As is fairly evident to anyone who goes by the zoo* . . . the main frame for the JOHNNIAC is ready to receive registers. Bob Rumsey, who has been working with Mike Stobin to wire the filament transformers which supply power to heat vacuum tubes, has formed a private operation outside where he is holding down floor space vacated by IBM files. We promise to have this auxiliary activity (you might call it Rumsey's Rump Session) replaced by bona fide JOHNNIAC ventilation.
>
> Gan Baker has been given the awesome responsibility of Chief Inspector. What this means in essence--we know where to point the finger--anything that goes wrong is, of course, Gan's fault. Under Gan's direction the shop has produced all of the chasses of the adder, the digit resolver, the accumulator and the MQ. Two memory registers are completed; two more will be completed in two weeks. Two clear and gate drivers have been completed.
>
> What all this adds up to is, that if Mike Stobin and Willis Ware who have been dealing with the ventilation engineers can come through with the ventilating equipment in time, it is very likely that we can have a smoke test of the arithmetic unit . . . in the JOHNNIAC main frame in October [of 1952]. The goal of the test will be to connect the A and MQ for end-around shifting (7.5 order) and let the

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*Zoo needs explanation: It was a special part of the basement in RAND's former building at 4th and Broadway in Santa Monica. It was set off from the rest of the building by chicken wire. The arrangement had something to do with security clearance, and the necessity of keeping people separated.

> machine shift a set of digits all day while we hammer on the frame and wiggle wires. Applications for wire wigglers are now open.

What Cecil didn't report nor did we know at the time was that we nearly built the proverbial "boat in a basement." Not until we had to move JOHNNIAC's main frame assembly from the old building to this one did we appreciate that it wouldn't go onto the elevator. We finally nudged it up the elevator shaft, but without use of the elevator.

Concurrently with construction of the large machine, we were also building the so-called Junior version, a precise copy of one fourth of the large one.

Early in 1953 all action moved into this building, and shortly thereafter Junior was in operation as the engineering prototype to prove our designs. As John Williams proudly boasted in 1954: "During the time it was tested, something over a billion operations were carried out without a single error."

Concurrently with the hardware activity, regular seminars were conducted by programmers-to-be. Sample problems were coded and analyzed, and gradually the difference between stored-program electronic computers and the previous card and plugboard programmed machines came to be appreciated. Among the important people at these seminars were:

Gene Jacobs	Cecil Hastings	Bill Orchard-Hays
John Matousek	Paul Armer	Jean Hall
Dave Langfield	Bob Bosak	Jack van Paddenberg
Bob Rumsey	Irwin Greenwald	Bob Bremer
Wes Melahn	Arnold Mengel	Ellis Myer
Don Madden	Cliff Shaw	

All during JOHNNIAC construction, George Brown spent much of his time worrying about skiers (e.g., Bill Gunning) and airplane pilots (e.g., Roy Fry). George had visions of a large part of his project knowhow winding up in the hospital.

Eventually JOHNNIAC became operational during the first half of 1953, and it computed its first prime number. Needless to say, during its earliest days of shakedown and operation, there was much maintenance and trouble-shooting, and thereby unfolds another tale.

It had early been decided that the machine was to have a closed cycle air conditioning system. Cool, really cold, air was to be pumped up the center of the frame, returned along the outside of the frame, and recooled in the basement. The air conditioning installation designed for JOHNNIAC may never have an equal--lots of cold water to make cold air, duplication of equipment to give reliability, and a temperature control system to end all. Most equipment items in the cooling system had a corresponding neighbor with which they could exchange jobs, and thus it was that there evolved a maze of plumbing and valves second to none. We also wanted to keep the machine clean, so we installed a double set of filters. Going all out, we decided on a filter called the Cambridge filter, guaranteed to take everything but everything out of the air. However, to this day, these filters have never been installed. Somehow we lost sight of their necessity.

When it came time to service the machine, someone had to open a door. It was like standing in the deep freeze, and we quickly bought ski jackets--with hoods--for everyone.

The machine also acquired one of its early names--the Pneumoniac.

There is another noteworthy aspect of JOHNNIAC's early life having to do with the selectron tube. This tube, which was the machine's store at the time, was regarded by RCA as experimental, and hence it was not covered by guarantee. However, at $800 each, it is a little hard not to argue with RCA about defective tubes. Many will remember, especially Keith Uncapher, the long almost daily arguments about bad selectrons; generally Keith won his agreement to return the defective tube.

Later in 1953, a contract was let with the International Telemeter Corporation to produce a magnetic core store for JOHNNIAC. This company was a venture into electronics by Paramount Pictures. At that time, core stores had been built only on an experimental basis at MIT. In order that we could maintain the reliability that had been designed into the rest of the machine, an extraordinarily detailed and tight specification was written for the work. It described a new level of design philosophy and required reliability, something at that time quite unfamiliar to the industrial world. For the next two years, the engineers at Telemeter found themselves boxed between RAND's engineering group with its everpresent specification, and profit-minded Paramount Pictures.

Early in 1955, the Telemeter magnetic core store was installed on JOHNNIAC. It was the first commercially available magnetic core store, and for a short while, it was the largest one in operation. It met its specifications, and to this day remains operational and reliable.

JOHNNIAC now settled into its computing load. In 1955 a 12,000 word magnetic drum was added. Inadvertently we did some of the earliest research in running magnetic drums with the heads in contact with the surface, where they weren't supposed to be. In 1954 an on-line printer had been added and in 1958 it was replaced by an improved model; the on-line plotter was also added in 1958. Finally in 1963 a special piece of hardware nicknamed MTCS was added for the JOSS work.

During JOHNNIAC's operational life things occasionally happened to enliven the daily routine. For instance, in 1958 we had a small fire in one of the room air-conditioning units. Damage was minor, but the highspots of the incident are best described in a memo from Keith Uncapher:

> There were no open flames and the damage was localized to the extent that the RAND people on hand could easily cope with the situation. . . .
>
> So far this incident sounds almost uneventful; however, the entire incident was plagued with unusual happenings which border on the humorous, ... For instance, while Frank McGee was operating a 10-lb. CO_2 bottle, the flexible hose from the supply tank to the nozzle on the unit burst, disabling the unit. Another 5-lb. . . . unit normally stored near the $\$1.2x10^6$ 738 unit failed to operate, since it had lost its charge (or never had one!). By this time another 10-lb. unit was pressed into service until its hose also blew open. In parallel, Matt Miller was operating a 50-lb. CO_2 cart unit from a

ladder. It turns out that the nozzle of such a large unit builds up a large static electrical charge which accidentally was discharged through Matt Miller. This unbalanced Matt enough to tip the step-ladder on which he was standing, and Matt found himself on the floor. A replacement then took the large nozzle in hand and proceeded to the top of the same stepladder. Upon reaching the next-to-the-top step the ladder broke in two pieces and once again, the nozzle and operator were airborne temporarily.

By this time it was discovered that the 50-lb. CO^2 unit had developed a leak at the supply end of the hose. The tank valve was closed immediately and the unit was removed from the service. A more severe leak could have resulted in injury, since the entire tank probably would have discharged in seconds.

In light of the ever present possibility of fire, I should like to suggest that an immediate and extensive investigation of the CO_2 units be made. One only need consider that 4 of 6 CO_2 units failed during the incident reported herein, to realize the importance of the situation.

For much of its life, JOHNNIAC operated more than one shift. Its nighttime operations were under the control of the same people who operated the other computers we had. On lengthy computations, the operator would start the machine, switch off the room light, and go away--to come back later for the completed work. On many such occasions it was noticed that machine errors were made, and eventually, the story got around that "JOHNNIAC was afraid of the dark." So it turned out to be. Upon investigation, we found that certain small neon tubes in the machine were sensitive to light, and did require the presence of light for reliable operation. So it is that we have a row of fluorescent lights just inside the doors.

JOHNNIAC spanned an important period in the development of the computing field. During its 13 years and 50,000 hours of operation perhaps 25-30,000 other computers have been built and installed; the industry has grown from nothing to $2-3 billion. For the time at which JOHNNIAC was built, it had many important features:

- A wonderfully complete instruction set with several innovations such as the Display and the Hoot;
- A new order of reliability in performance--in early 1956, for example it was consistently better than the IBM 701;
- A sophisticated operating console with the ability to monitor every toggle in the machine, to execute instructions one by one, or step by step;
- Complete marginal checking;
- Wired-in test routines for the store;
- Punched card input-output;
- The capability to measure from one central place, the heater-cathode leakage of groups of tubes;
- The only successful selectron store ever built and operated;
- The first commercial magnetic core store;
- The most skillfully engineered and operationally-oriented machine of the Princeton family of machines;
- The most protected machine ever built--no other machine can claim so many fuses, meters and protective devices.

In the earliest days of 1954, most programming was done in machine language and in absolute octal at that. In 1955 Jules Schwartz wrote the first assembly routine for JOHNNIAC, and Cliff Shaw produced a revised assembler in 1956. Then came QUAD, an interpretive programming system, and SMAC, a small compiler. Each was noted for being foolproof. The non-professional programmer could use these systems comfortably; his errors would be reported to him in great detail by the machine. There were other significant contributions to the programming art as well; among them were items with such names as EASY FOX, CLEM, JBL-4, J-100, MORTRAN done by Mort Bernstein, and Load-and Go.

In the late '50s, the nature of JOHNNIAC's task changed. The rental equipment from IBM carried most of the computing load from the RAND staff. JOHNNIAC became a free good; its time was available for research use. The cost of operation was sufficiently low that one need not be concerned about using large amounts of machine time. Much of its time was consumed by research on the general questions of artificial intelligence and the initials NSS came to be closely associated with JOHNNIAC. These are the initials of Allen Newell, Cliff Shaw, and Herb Simon who used the machine extensively for research. During this period came such achievements as:

- List structures, list processing techniques and their embodiment in such languages as IPL-2, -3, -4;
- Chess playing routines such as CP-1 and -2;
- Theorem proving routines such as LT--the Logic Theorist;

. The general problem solver--GPS;

. The assembly line balancer of Fred Tonge.

Most recently JOHNNIAC has been the research tool which made possible both of RAND's current highspots in computer research. The initial experiments on graphical input-output terminals was done on JOHNNIAC and from that has come the successful development of the RAND Tablet. Finally, JOHNNIAC has made JOSS possible. JOSS is the JOHNNIAC Open Shop System which provides each of its time-shared users with a typewriter connection from his office to the machine. Those who know JOSS and perceive the friendliness of its help and reaction feel strongly that systems such as it will be one of the prominent, if not exclusive, ways of computing for the future.

Certainly, it is fitting that a machine with the stature of the JOHNNIAC should have completed its career as a research vehicle, dedicated to improving and extending the technology and art which it helped inaugurate.

We have now a small ceremony to turn off the machine. It is appropriate that Cliff Shaw, creator of JOSS, and Bill Gunning, chief engineer of JOHNNIAC's construction, must have the honor. Cliff has programmed JOSS so that it will execute a 60-second countdown and then stop the machine; Bill gets the privilege of disconnecting the power on the final shutdown.

Appendix

PRESS RELEASE (WRITTEN BY SHIRLEY MARKS)

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FOR RELEASE:

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JOHNNIAC 1953-1966

Friday, February 11, 1966, as it must to all men--and machines--the end came to Johnniac, member of a distinguished family of computers known as Princeton-type machines. This noble line of electronic brains was sired by the human brain of mathematician John von Neumann, for whom Johnniac was affectionately named.

The end came to Johnniac in the same room at The RAND Corporation in which, more than twelve years earlier, its neons first flickered into life. Johnniac had entered a world which saw the computer only as a mechanical extension of man's hand on the keyboard of a desk calculator. With the brashness of youth, with the knowledge of its uniqueness, with the spirit of a pioneer, Johnniac has been credited with leading the way to the modern concept of the computer as an information processor--an electronic extension of man's mind, helping him to design, to plan, to judge, to decide, to learn.

As the end came, from nearby rooms was heard the busy chatter of Johnniac's sophisticated descendents. Absorbed in the wonder of their mass-produced cores and graphic displays, of their systems and languages, they seemed unaware of the drama drawing to a close, of a memory fading, a pulse unsteady. And finally, power failure: Johnniac had been unplugged.

Friday, February 18, 1966, final ceremonies were held for Johnniac. Many friends of the early days gathered, but not to grieve. There were no flowers; only coffee, cake, and memories.

Enshrinement will be in the Los Angeles County Museum.