* “New Electronic Brain, BINAC” Science News Letter 56 (August 27 1949)
* “BINAC Demonstrated, New Electronic Brain” Journal of the Franklin Institute 248 no 4 (Oct 1949)
* Roger Mills, Northrop Aircraft – Jean Jennings Bartik Computing Museum.
* John Mauchly Letter to editor of Datamation : Stored programs in ENIAC BINAC and EDVAC 1979, typewritten document 2011005 Jean Jennings Bartik Papers.
* *Popular Science May 1949*
* Lukoff from Dits to Bits 77-86
* N Stern from ENIAC to UNIVAC : a case study
* Joseph Chapline Operating and Maintenance Manual

"The BINAC (Auerbach, 1952) was a bit serial binary computer with a 512 word acoustic mercury delay line memory divided into 16 channels each holding 32 words of 31 bits with an additional 11 bit space between words to allow for circuit delays in switching. The clock rate was 4.25mh which yielded a word time of about 10 microseconds. The actual instruction execution rate was dominated by the access time for instructions and data and would have averaged about 3000-4000 instructions per second, unless minimum latency programming was employed. Each BINAC word held two instructions. Each instruction had a five bit operation code and a three octal digit address. All operands were 31 bit words. Arithmetic was two's complement and there were single bit arithmetic right and left shift instructions as well as addition, subtraction, multiplication and division. There were no logical instructions and no subroutine calls. Jump on negative was the only conditional instruction.

BINAC operations were checked by complete duplication of components, including the memory. It had no I/O instructions, except for some flip-flop set and reset commands. New programs or data had to be entered manually in octal using an eight key keypad. Eight keys were all that were needed since there were no alphabetic characters or other symbols. Memory could be dumped manually onto a console teletype or to the wire recorder. The wire recorder could be used to load the memory, but because of the duplication, both of the twin machines had to be loaded separately.

BINAC was built by Eckert Mauchly Computer Corporation for the Northrop Aircraft Corporation and was intended to be used in a classified airborne application. (Stern, 1979) It was not originally intended to be a general purpose computer; that was the role of the UNIVAC I which in 1949 was still in the design phase. BINAC was never used for its intended purpose but during its short period of use it was an important training ground and a testing place for new ideas.

In order to run a problem it first had to be keyed into the BINAC memory from the keypad. After that it could be debugged, corrected in memory, saved on wire, and finally run. Most programs proceeded by modifying their own instructions so that a restart would not work unless a complete reset was built into the code so the wire recording was very important as a debugging aid. When the program was run the results could be obtained after a programmed stop by dumping the memory manually to the teletype."  [**Annals of the History of Computing**,  Vol. 10  #1  1988]

**Personal Reflections - Roger Mills:**

The input/output for the BINAC was octal.  The instructions were absolute machine language and since it was a serial access memory, the trick was to have the data for the instruction follow the instruction far enough behind that it can be acted on by the instruction. An engineer at Northrop converted an IBM 010 keypunch (a small 11 key unit, digits 0 - 9 and a space) to put in three binary bits on tape for each octal digit punched.  After processing the input, the output came out in octal digits.  All of the data gad to be converted from decimal to octal and back since there wasn't room in memory for a conversion subroutine.  The most successful run we made was on a deicing problem for an airplane.  Two operators on electric calculators worked for 6 months computing steps in resolving the differential equations.  The BINAC did these steps and completed the calculations in 15 minutes. The reduction steps could be verified by the output from the two operators, thus adding to the confidence in the results.  The idea behind BINAC was to have all operations checked by running two sections of the computer independently and comparing each step on a high speed bus.  Northrop engineers went back to Philadelphia for the acceptance tests.  After the BINAC was shipped to Hawthorne, it sat out under a tarp for 6 months before it was assembled in its air-conditioned room. The poor engineers were constantly working to get BINAC to run.  One side would be running while they worked on the other side.  The two sides never worked together as long as I was there. Doing all arithmetic in octal sure cause havoc with your check book

In 2014 it was my privilege and pleasure to handle the only known copy of the first manual ever written for a functioning electronic computer: the *Operating and Maintenance Manual for the BINAC Binary Automatic Computer Built for Northrop Aircraft Corporation.*This 37-page document, reproduced from typescript by Eckert-Mauchly Computer Corp. in Philadelphia in 1949, was the model for countless numbers of operating manuals for computers that were written in the following decades. As only one BINAC was ever built it is likely that only a handful of copies of the manual were ever produced.

Eckert and Mauchly’s BINAC was the first stored-program computer ever fully operational, since the Moore School’s EDVAC, which was designed to be the first stored-program computer, did not become operational until 1952. The BINAC was also the first stored-program computer that was ever sold.

The BINAC was extremely advanced from a design standpoint: It was a binary computer with two serial CPUs, each with its own 512-word acoustic delay line memory. The CPUs were designed to continuously compare results to check for errors caused by hardware failures. It used approximately 1500 vacuum tubes, making it virtually a mini-computer compared to its predecessor, the large-room-sized ENIAC, which used approximately 18,000 vacuum tubes. The two 512-word acoustic mercury delay line memories were divided into 16 channels each holding 32 words of 31bits, with an additional 11-bit space between words to allow for circuit delays in switching. The clock rate was 4.25 MHz (1 MHz according to one source) which yielded a word time of about 10 microseconds. The addition time was 800 microseconds and the multiplication time was 1200 microseconds. New programs or data had to be entered manually inoctalusing an eight-key keypad. BINAC was significant for being able to perform high-speed arithmetic on binary numbers, although it had no provisions for storing characters ordecimaldigits.

In 1946, after developing and building the ENIAC (the first general-purpose electronic computer) for the U. S. Army during World War II, J. Presper Eckert and John Mauchly founded their own company for the purpose of designing and manufacturing electronic stored-program computers on a commercial basis. In October 1947, needing money to keep their business afloat while working on their UNIVAC machine for the U.S. Census Bureau, Eckert and Mauchly entered into a contract with Northrop Aircraft to build the Binary Automatic Computer (BINAC). Northrop, based in Hawthorne, California, was then engaged in a project to build a long-range guided missile for the U.S. Air Force, and had the idea of using electronic computers for airborne navigation; the BINAC, while not designed to work in flight, would perhaps be an initial step toward that eventual goal. Airborne computers did not become feasible until the 1960s, when miniaturized solid-state transistorized components became available.

The BINAC was completed in August, 1949, $178,000 over budget; Eckert and Mauchly absorbed the loss themselves. Built with two serial processors, the BINAC functioned more like two computers than one, with the goal of providing a safety back-up for airplanes. Each part of the device was built as a pair of systems that would check each step. All instructions were carried out once by each unit, and then the result would be compared between the units. If they matched, the next instruction would be carried out; but if there was a discrepancy between the two parts of the machine, it stopped. The processors were only five feet tall, four feet long and a foot wide, tiny for those days. The machine could only do 3,500 additions per second compared to 5,000 on the ENIAC, but it could do 1,000 multiplications per second, compared to only 333 on the ENIAC.

Many histories of computing state that the BINAC never operated successfully; however, Northrop’s “Description of Northrop Computing Center,” an internal company document dated September 16, 1950, which I also handled in 2014, listed the BINAC as one of its three main pieces of computing equipment, and even though the machine was currently “being revised and improved for more reliable operation,” it was still functioning at least somewhat satisfactorily a year after its delivery.

"This machine has solved in seven minutes a problem on the effect of a certain wind pressure on a rubber diaphragm that would have occupied a mathematician for a year. It has solved Poisson’s Equation and obtained a network of 26 solutions in only two hours. For each of these solutions, the BINAC performed 500,000 additions, 200,000 multiplications, and 300,000 transfers of control, all in the space of five minutes. . . . This machine, which is a general purpose computer calculating in the binary system but receiving and emitting its instructions in the octal system, will be demonstrated today on a short test problem (“Description of Northrop Computing Center,” p. 2).

The task of writing the BINAC’s operating manual was assigned to Joseph D. Chapline, an EMCC employee who had helped Eckert and Mauchly on the ENIAC project at the Moore School. Realizing that the BINAC’s users at Northrop would not be electronic computer specialists, Chapline decided to model his BINAC guide on the owner’s manuals issued by automobile companies, rather than on the technical reports written for the Moore School’s ENIAC and EDVAC, which were intended for highly trained engineers and scientists already familiar with the respective machines. Chapline’s *Operating and Maintenance Manual* provided the BINAC user with a full overview of the machine’s construction, operations and maintenance in a step-by-step, readable manner, with clear diagrams illustrating the BINAC’s various components. Chapline’s instructional, user-oriented approach set the pattern for the millions of computer manuals that would follow it.

Chapline, who also wrote the documentation for the ENIAC, was a pioneer in the field of modern technical writing, which “translate[s] complex technical concepts and instructions into a series of comprehensible steps that enable users to perform a specific task in a specific way” (Wikipedia). Chapline taught over 200 classes in technical writing at the Moore School before leaving the computer profession in 1953 to become the organist and choirmaster at the Unitarian Church of Germantown in Philadelphia. Brockman, *From Millwrights to Shipwrights to the Twenty-First Century*, ch. 7.