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In the Beginning... A Legacy of Computing at Marshall University

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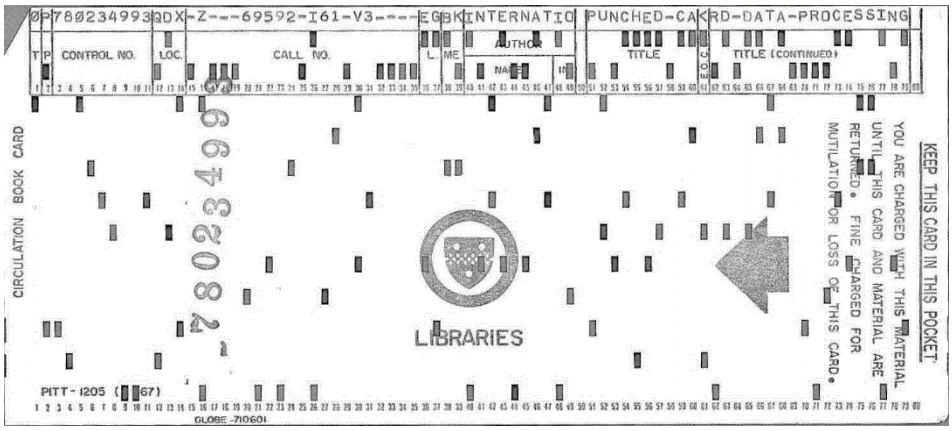
A brief history of the early computing technology at Marshall University, Huntington, W.Va., in the forty years: 1959-1999.



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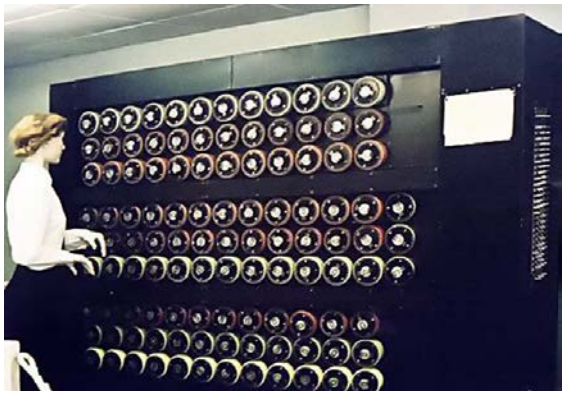
The British Bombe
1942



NOTES TO THE READER:

- If you consider yourself somewhat technically challenged, or simply are not interested in the "bits and bytes, speeds and feeds," then just skip the second part of each section titled "Hardware and Software."

- Images that appear in this work that are captioned as "stock images" were from various websites. The images that are captioned as Marshall images are all from the Marshall University Special Collections Department in Morrow Library.

"There is a point at which the study of the technological past turns into paleontology, and in the history of computation that point is uncomfortably close, and moving closer."

Nicholas Metropolis, Los Alamos Scientific Lab., 1979

In the Beginning…
A Legacy of Computing at Marshall University

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INTRODUCTION

As with many other landmark, groundbreaking inventions, there is no common agreement on when (or who) invented the first computer. So let's jump ahead slightly to WWII. In 1941-42, the British built an electromechanical machine with the means of decrypting Nazi ENIGMA-based military communications during World War II. The British "Bombe" was conceived by computer pioneers Alan Turing and Harold Keen of the British Tabulating Machine Co. Several Bombes were built. Their purpose was to ascertain the daily rotor start positions of Enigma cipher machines, which in turn allowed the Allies to decrypt German messages.[1] But was it a computer? With that begins the debate on what defines a computer as a computer.

The year of 1951 was a busy, important year. Britain put what they claimed to be the world's first computer on the market. That was a machine known as the "Ferranti Mark I," based on the Manchester University computer and delivered in February 1951. A few months later, J. P. Eckert and John Mauchly built the UNIVAC, proving that computers had a business application. Both of these milestone events came only a few years after Thomas J. Watson, Sr., the president of IBM, stated that he didn't see the application for computers in small businesses and personal use. Who knew?

The history of computing and computer technology at Marshall University goes back to 1959, when it was still Marshall College. Marshall experienced, like many similar institutions, the early acquisition and implementation of data processing equipment in a decentralized, departmentalized mode. A single department, or multiple departments, determined their own requirements and went after the hardware to meet that requirement. There was no central computer department or personnel, and these departments trained their own people, usually OJT (on the job training). The Registrar's Office and administration had an obvious need for something to process information and to help automate registration. Later the Chemistry Department, Engineering Department, Morrow Library, the Bookstore, College of Business, and School of Medicine, obtained departmental computers for their needs and other applications. These computers were different platforms from different computer companies: IBM, DEC, HP, Data 100, Pertec, and others. There were very limited communication capabilities or desire to have these different platforms communicate with each other, and if they communicated at all, it was with an outside, remote system. In the 1970's, communication to other on-line devices and to the outside world became more practical, including communication with the large IBM mainframe at West Virginia University. The Marshall Computer Center grew to an interconnected multi-processor configuration. In the 1980's and 1990's came the explosion of the PC technology and a more campus-wide recognition of common needs. The scope of this book ends there. To develop a history of the implementation of PC networking at Marshall is beyond the scope of this work.

Also some departments, such as the Human Performance Lab., in the Henderson Center, and the Marshall School of Medicine, had various machines that were hooked to small computers. These were small, dedicated, single-purpose, computers that were part of the machine or cabled to it. We have not attempted to document those machines.

Jack L. Dickinson
Arnold R. Miller, Ed.D.

ACKNOWLEDGMENTS

We wish to thank the following Marshall University Emeritus members for their help in supplying information and sharing their recollections about the various systems:

Cora Teel, Archivist Emeritus (Libraries: Special collections Dept.)

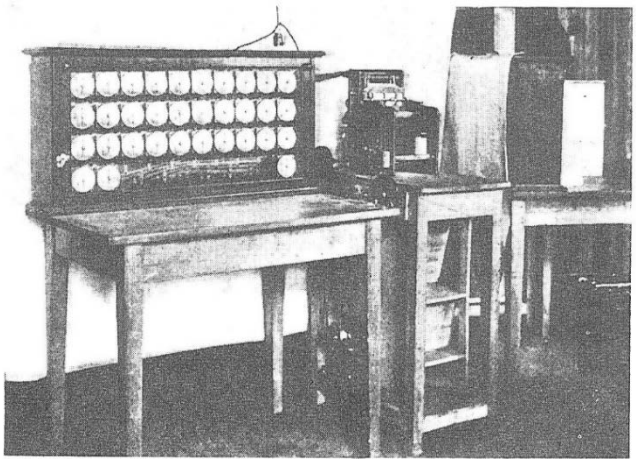
Merry Brown, Emeritus faculty (Libraries, Computer Operator.)

Dr. Earl Z. Damewood, Emeritus faculty, Management/Business.

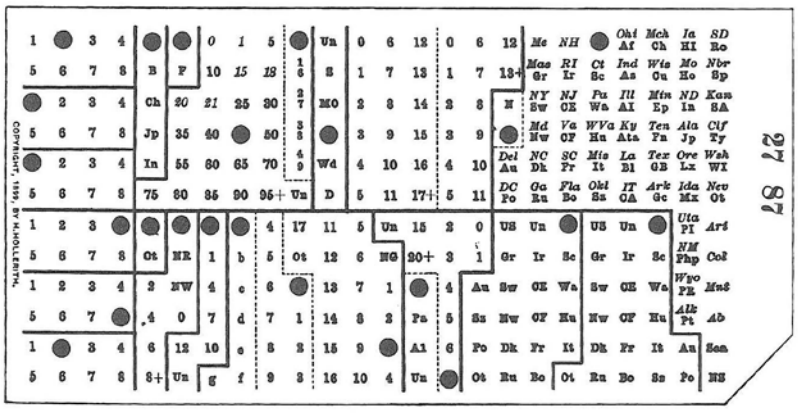
Prof. Thomas Olson, Emeritus faculty, Engineering Dept.

Dr. Robert Alexander, Emeritus Dean of College of Business, and Director of Placement.

Joe Vance, Emeritus Bookstore operations manager, now employed by Follett.



Above: Herman Hollerith's automatic tabulating machine, ca. 1902.
Below: One of Hollerith's original punched cards for the 1900 census.



WHAT MAKES A COMPUTER?

Why even bring this question up? After all, you are probably reading this on a computer, tablet, wrist watch, or other electronic device that passes (or is advertised) as a computer. The reason is, that some earlier machines that were called computers do not fit with the definition of today. Basically these machines, invented in the 1600's to 1900's were mechanical calculating machines. The word itself has been scoffed at as being ambiguous.

Gottfried Wilhelm von Leibniz, who lived from 1646 to 1716, was a mathematician who developed differential and integral calculus, but also invented and constructed a machine in 1694 which is credited as being the earliest calculating machine. This machine carried out all four fundamental arithmetic operations by mechanical means. His machine was never produced commercially. The machine, however, is now known to have given some wrong answers, due to carrying when the multiplier was three digits.

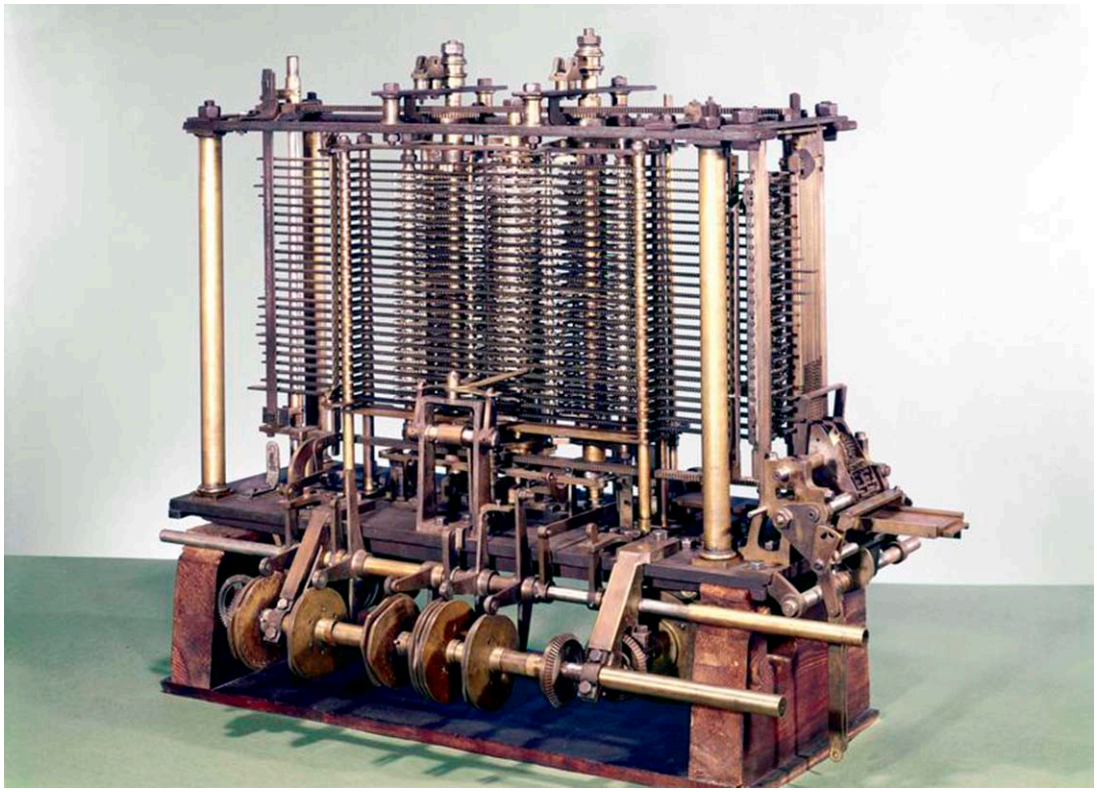
Charles Babbage (1791-1871) is recognized by some as the inventor of the computer, and his machine was named the "Analytical Engine," ca. 1834. If nothing else, he deserves credit for declaring that the numbers in base 10 were the only numbers that were feasible to use on machines. His machine and other early machines, were stated to do "calculation by artificial means," and therefore might be a tool of the devil. Well-known scientist Georges Ifrah holds that Babbage's attempts were not completely successful. [2]

So if these weren't true computers, when and what was the first computer? The answer lies in accepting the modern definition, which defines a computer as "a machine programmable by a program detached from the hardware."[3] Some sources have put forth that it was the ENIAC (Electronic Numerical Integrator and Computer,) which was completed in 1945 by John Eckert and John W. Mauchly. But some have said that this machine was still structurally related to Babbage's Analytical Engine, and it was not self-controlling.

So with that disappointment, our next candidate is the SSEC, (Selective Sequence Electronic Calculator,) invented by a team led by Eckert and Robert Seeber, an IBM engineer. It was unveiled by Thomas J. Watson, President of IBM, in January of 1948, and was basically used to resolve astronomical problems with lunar variations. It was built with vacuum tubes and electromagnetic relays. This attempt comes closer to meeting our definition, for two reasons: it had a stored program, and was capable of conditional branching. But this one has been criticized as being "logically inconsistent" because its stored program was limited.

Following quickly on the heels of the ENIAC and SSEC were several machines invented around 1950-1951: The IAS Computer, the *Whirlwind I*, (invented by MIT,) the UNIVAC I, designed and built by Eckert and Mauchly, and the EDSAC. So maybe it was one of these well-publicized machines.

The lesson to be learned here is that there is no agreement as to who invented the first true computer, because anyone who built a mechanical calculating machine could claim they were the inventor. Also the definition of a computer has morphed in the last thirty years to include the word "program" or "software." The point we are trying to make is that the first machine Marshall installed (The IBM 407 Accounting Machine) was not a true computer, as some reporters referred to it. More later in the "Departmental Systems" section.



Babbage's Analytical Engine now in the British Science Museum.

Part I: Departmental Systems:

Admissions/Registrar Departments

IBM 403/407 Accounting Machine

The unit record concept of data processing originated well before WWII. IBM (International Business Machines) explained it the clearest in its 1961 publication: *Punched Card Data Processing Principles*:

> The unit record principle is that all data concerning a single transaction is recorded in one punched card and the punched data remains the same for each use of the card. Information is punched in the card and becomes a permanent record. Therefore, all similar transactions can be easily grouped. The basic element in IBM punched card accounting is the IBM card. It is 7 3/8 inches by 3 ¼ inches with 80 vertical areas called columns. Each column is then divided into twelve punching positions called rows. The data is in the form of punched holes.[4]

In the 1880s Herman Hollerith invented the recording of data on this medium that could then be read by a machine. This system was first used to partially automate the 1890 Federal Census. IBM came out with equipment to process the punched card data on machines such as a collator, accounting machine, keypunches, and sorters, and they were in wide use by WWII. The IBM 403 and IBM 407 Accounting Machines were electromechanical tabulating machines introduced by IBM in the late 1940s. They had a card reader and printer, and a summary punch could be attached. Processing was controlled by a wired control panel.

Marshall Physical Plant workers unloading the IBM accounting machine (covers removed.) MU image.

The year 1959 marked the appearance of Unit Record equipment in the Office of the Registrar. These were the machines that the movies and newsreel viewers of the 50's and 60's usually saw in action - thousands of IBM 80 column cards being punched, sorted, and collated. Printed reports were primitive listings of the contents of a deck of cards that had been created from summarizing and subtotaling several other decks of cards. It was an enormous advance in record keeping but, to anyone who has been through

arena registration in those days -- walking around picking up cards and submitting your packet at the end of the maze -- can attest, it certainly had its problems. Since the unit record in this application represented one seat in one class section of a course, if you reached for a card for a seat in a particular session to fit in your schedule, and there were no cards left, it meant all the seats had already been taken. So you started over on your whole semester's schedule.

A Marshall "arena registration" utilizing IBM punched cards, 1968.
MU image.

Part of the debate ever since these machines became popular, was "is it a computer?" Most material that defines a computer, uses the words "programmable electronic device" that can perform calculations and display the results. IBM never referred to these machines as computers. Others, such as reporters, did refer to Marshall's machine as a computer. The only calculations these machines were capable of was to accumulate totals. The IBM 403 and probably the 407 had an option of a CAM device, which allowed the board-wirer to wire his panel, or plugboard, to do a multiply or divide instruction.[5] One of the accepted modern definitions of a computer is "A universal [analytical] calculator with stored programmes."[6] This accounting machine was only "programmed" through a hard-wired board that was part of the hardware. Modern computer professionals seem to agree it was not a computer. There was no software on this machine.

Hardware and Software:

The configuration at Marshall is believed to have been an IBM 407, with a IBM 519 reproducing punch attached. (Official name was the IBM 519 Document-Originating Machine.) It was an output punch for the accounting machine, used to produce summary cards.[7] Marshall's 519 also had the mark-sense reading option built in, for reading cards that had been marked with a electrographic pencil, such as answers for a test. Both of these machines were programmed by wiring a different large panel board (plugboard) for each machine.

The IBM 407 Accounting Machine was introduced in 1949. The internal architecture of the 403 and 407 was identical, except the 407 was somewhat faster. The 402 & 403 had the old typebar print mechanism, where the 407 had a printwheel mechanism. They all had a built in 80-column punched card reader. The IBM 403 or 407 was the central component of many unit record installations in the Huntington area.[8]

Marshall's IBM 403/407 was retired in 1974, the same year as the 1620. The 407 was not removed from marketing until two years later.

Stock image of a typical IBM unit record installation: IBM 403 Accounting Machine on left, IBM 519 Reproducing Punch on right.

IBM 1620 Computer system

The road to acquiring Marshall's first true computer was a rocky one. In 1962 or early 1963, Engineering Professor Tom Olson was visited by John Sachs, a marketing representative of the local IBM office, who showed him materials and descriptions of the IBM 1620. In working up a configuration, Olson remembers that the total price was about $60,000 and was too much money for the Engineering Dept. to come up with. Olson developed a program in Fortran for the Biological Sciences Dept. to show them how it could run a statistical analysis dealing with nuclear fallout on plant life, calculating mean and standard deviations, etc. He visited that department and then the department heads of the Math, Physics, Chemistry, Business, and Geology Departments. Olson wanted them to "pool" their money. While they all liked the computer idea, they all turned him down because they couldn't come up with the money required. As a last resort, Olson turned to University Registrar Luther Bledsoe, and showed him how it would greatly enhance and speed up the calculations of grade point averages of students. Bledsoe was sold on the idea and said he could come up with the money.[9]

The computer was ordered and delivered in late 1963. The machine sat for its first year in a lounge dedicated to faculty and staff in Old Main until an area in the basement adjacent to the registrar's unit record operation was physically renovated. Perhaps the

Marshall's IBM 1620 Computer when installed in the basement of Old Main. It was Marshall's first true computer. The IBM "Think" sign came with each IBM computer. MU image.

attitude was akin to Dr. Charles Moffat's description of the acquisition in the section of his book, *Marshall University, An Institution Comes of Age*, describing the expansion of the physical plant after the college attained University status in 1961: "All institutions of higher education felt obliged to acquire one of those mechanical wonders of the decade - the computer. That technical phenomenon first made its appearance in the basement of Old Main in 1963."[10]

With the installation of the IBM 1620 by December of 1964, the Marshall Computer Center was created and its first director named. George Mendenhall, a faculty member in the Engineering Science Department, served as the first director from 1963 through 1969. He had joined the Marshall faculty in 1959, and served at Marshall until 1973.

A 1965 *Parthenon* article explained how class registration would operate on the computer:

> The student's schedule as it appears on his trial schedule will be transferred onto a schedule request card by punches designating the course and section number. All information concerning all classes will be stored in the master plan inside the IBM 1620 computer. If a requested class is closed, the computer will run through all sections of the class to pick out another section. The computer has 500 different combinations to work with before resorting to the substitution of an alternate course. The Registrar's office has written to 27 schools which are using this registration system, such as Washington and Lee, and the Univ. of New Hampshire, to obtain their computer programs. The best from these programs will be combined into the system used this summer. This system eliminates competition for class cards. Schedule request cards belonging to senior students will be fed through the computer first. [11]

The programming was generated and completed by the Marshall programming staff in the Computer Center. In the fall of 1965, the *Parthenon* announced that more than two thousand students had been registered by the computer without having to go through the old registration process.

In addition to the Admissions and Registrar's applications, Prof. Olson saw his dream come true of the engineering classes having access to a real computer. Olson and his Engineering classes were big users of the computer. He would bring the whole class with their Fortran programs and "take over the computer center," which was installed in the basement of Old Main. Their programs were used to design and produce reports on fluid mechanics and to produce machine designs. He remarked that for the first two years the computer was at Marshall, Prof. Olson and the Registrar's office were the only two users of the computer.

Several Marshall people took interest in learning programming. In 1964 or 1965, Sam Bauserman, son of Dr. Thomas Bauserman, chair of the Math Dept., was attending the Marshall Lab School in either the seventh or eighth grade. He studied a Fortran PI (Programmed Instruction or self-study,) course that Dr. Bauserman had, and was writing and keypunching Fortran programs for the 1620. Sam was also an accomplished violinist and a member of the Huntington Orchestra.[12]

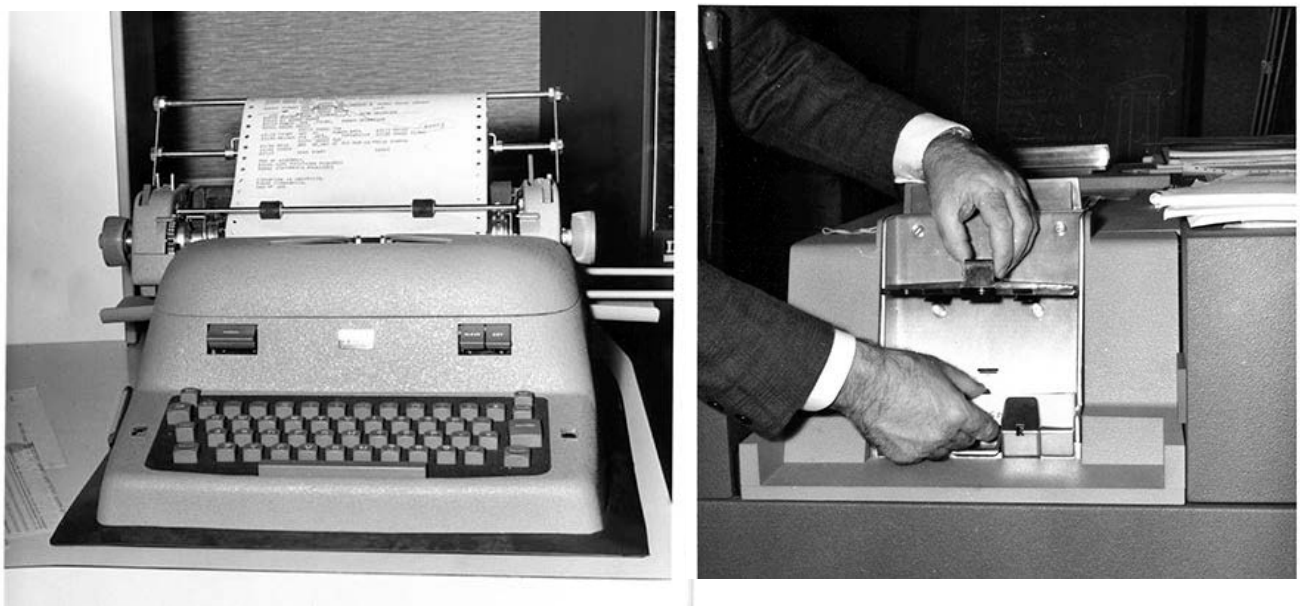
In early 1968, the *Parthenon* reported that the computer had rejected the spring semester schedules of 212 students. This was due to classes being closed or canceled and some conflicts being allowed. A second day of advanced registration was suggested to allow for these problems to be addressed.[13]

In the fall of 1968, there were sessions conducted by George Mendenhall, the director of the computer center, for the faculty and staff, to teach basic use of the computer. Mendenhall also developed and taught a course entitled "Computational Methods."

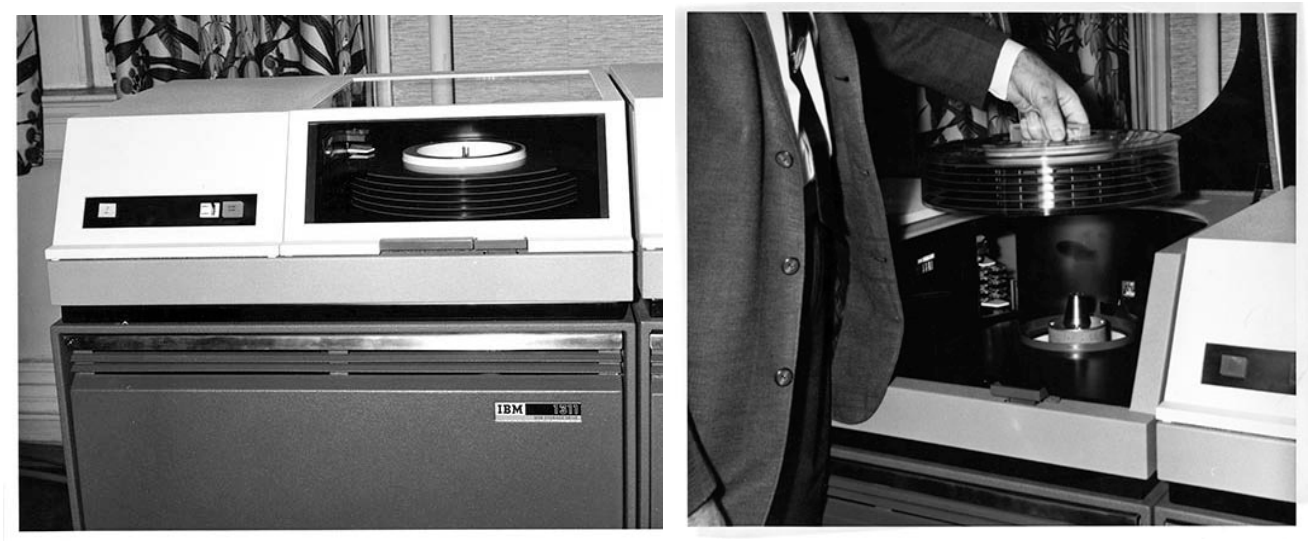
It wasn't all serious work that was programmed on the 1620. A *Parthenon* article of April, 1968, announced that the computer could sing Christmas carols. The first to be programmed was "Away in a Manger." A small transistor radio was placed on the top of the computer and tuned to any channel. The tunes were hummed sounds produced by electrical waves which were picked up by the radio. The computer also was an expert at blackjack.[14] A 1620 was used in a TV episode and a movie of *The Man from U.N.C.L.E.* to portray a THRUSH supercomputer.

Hardware and Software:

The IBM 1620 was a general-purpose, stored-program data processing system for small businesses, research and engineering departments of large companies, and schools requiring solutions to complex problems in the areas of engineering, research, and management science. It was announced October 21, 1959 and withdrawn from marketing on November 19, 1970. Two thousand of these computers were built in the 1960's. It was composed of solid-state components. Due to its unique characteristics, convenient small size and relatively affordable price many of these machines were bought or rented by colleges and universities. As a result, thousands of students had their first hands-on computer experience with the IBM 1620. When the computer was announced, it was touted as an inexpensive "scientific computer." It utilized a unique, six-bit, binary-coded decimal, four-bit numerical value (1-2-4-8) for internal operations. [15] Since it didn't have a hardware instruction for "Add," it was given the nickname "CADET," meaning "Can't Add, Doesn't Even Try." (Addition, subtraction and multiplication were accomplished by an automatic table lookup in core storage.) [16] There was a choice of two "Monitor Systems" available, not referred to as operating systems, which required the use of a IBM 1311 disk drive. It offered two programming languages: Fortran and SPS (Symbolic Programming System.) The IBM 1311 disk drives attached to the system utilized removable disk packs that each contained 2 million (meg) of characters. Input/output devices on Marshall's configuration consisted of an electric typewriter for a console, two IBM 1311 disk drives, an 80-column card reader/punch, and a printer. Marshall's IBM 1620 was retired in 1974.



Input/output devices connected to Marshall's IBM 1620 Computer.
Upper left: the typewriter console
Upper right: The 80-column card reader.
Lower left: The IBM 1311 Disk drive.
Lower right: Removing a disk pack from the 1311.
All MU images.



Chemistry Department

DEC PDP 8/I Minicomputer

In the late 1960's another multi-department effort was in operation to obtain funding for a computer system. In addition to the Chemistry Department, the others were Physics and Science. It appears that the Chemistry Department alone received the grant necessary to fund the purchase.

It was the first departmental computing resource on campus, outside of the Registrar's office. A DEC PDP 8/I computer system from Digital Equipment Corp., was purchased and supplied early instrument and computing support in the department but also became the first general purpose interactive computing resource on campus.[17]

The computer was installed in late 1969 or early 1970 in the Science Building. Chemistry Professor George Phillips (Phillips was a Chemistry professor at Marshall from 1967 to 1973) was in charge of the computer. A few years prior to the computer arriving, the department had received a donation from Ashland Oil and Refining of a mass spectrometer and supporting equipment. The department had also purchased a Nuclear Magnetic Resonance (NMR) Spectrometer with funds from the National Science Foundation. The new DEC computer was believed to have been interfaced to these two machines, and others.

In late 1970, the first terminals were installed to interface to the DEC. They were called "terminal calculators," and were installed in three buildings on campus: on the third floor of the Science Building, in the statistics lab in Jenkins Hall, and on the fifth floor of Smith Hall. They were principally for students to solve chemistry problems. The remainder of these terminals were added in 1971. Later a terminal was added in the old Engineering Building.

Marshall Chemistry Dept. Professor George Phillips with the DEC PDP/8, 1970. MU image.

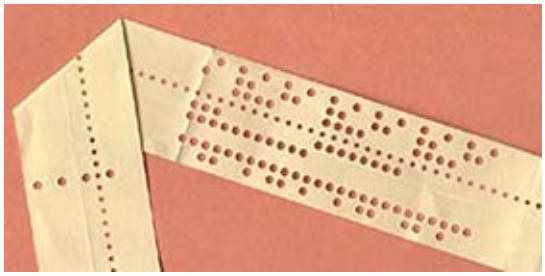
Just as with the 1620, not all was serious work on the Chemistry Department's new machine. A *Parthenon* article of 1970 revealed that the PDP 8 was programmed to play dice and several card games. It also stated that the computer was bought

jointly by the Chemistry Department and the Computer Center at a cost of $60,000, and that its primary job was to figure intricate laboratory calculations fed directly into it by "umbilical cords" from various heavy equipment in the Science Hall. "One such machine is the X-ray Defractometer, all the actions and results of which are stored in the computer for reference purposes."[18] The funniest part of the article is that it referred to the computer as the "IBM PDP-8/I," which was of course, in error.

Hardware and Software:

Manufactured by Digital Equipment Corporation (DEC), the PDP/8 was the first commercially successful minicomputer, with over 50,000 units being sold. (The term "mini" did not denote smallness, but "minimal.") The "PDP" stood for Programmed Data Processor. The first, known as the "Straight-8", was introduced in March 1965, priced at $18,500. Whereas later machines (especially IBM) grouped their binary digits (bits) into sets of four in a system called "hexadecimal", the PDP-8 used "octal" notation, grouping its bits into sets of three. In 1966, The Straight-8 was followed by the PDP-8/S. The later models, such as Marshall's I model, contained a faster, fully parallel architecture, but used much less costly transistor-transistor (TTL) MSI logic. The I-model was introduced in 1968 and was the first PDP/8 with integrated circuits. Most surviving PDP-8s are from this era. It had a teletype-typewriter device for the system console. The PDP-8 is well-regarded because so many types of I/O devices were available for it. Its rack-mounted design made it convenient to install an interface card, and connect the system to analog or digital instruments and machines. By late 1977, the PDP-8 family was the best-selling computer in the world. The last commercial models were introduced in 1979. In the middle era, various paper tape "operating systems" were developed for it.[19] Several utility programs became available on punched paper tape.

Our photo image here of Marshall's PDP 8/I appears to have a paper tape reader, and several programs on paper tape are visible. Paper tape versions of a number of programming languages were available, including DEC's FOCAL interpreter. This language was used by Marshall on its machine when the terminals were put out in the various campus locations. Today (2018) there are still PDP/8's installed and operating, and parts are being sold on the internet. A complete processor appeared on ebay (January 2018) for under $2,000.

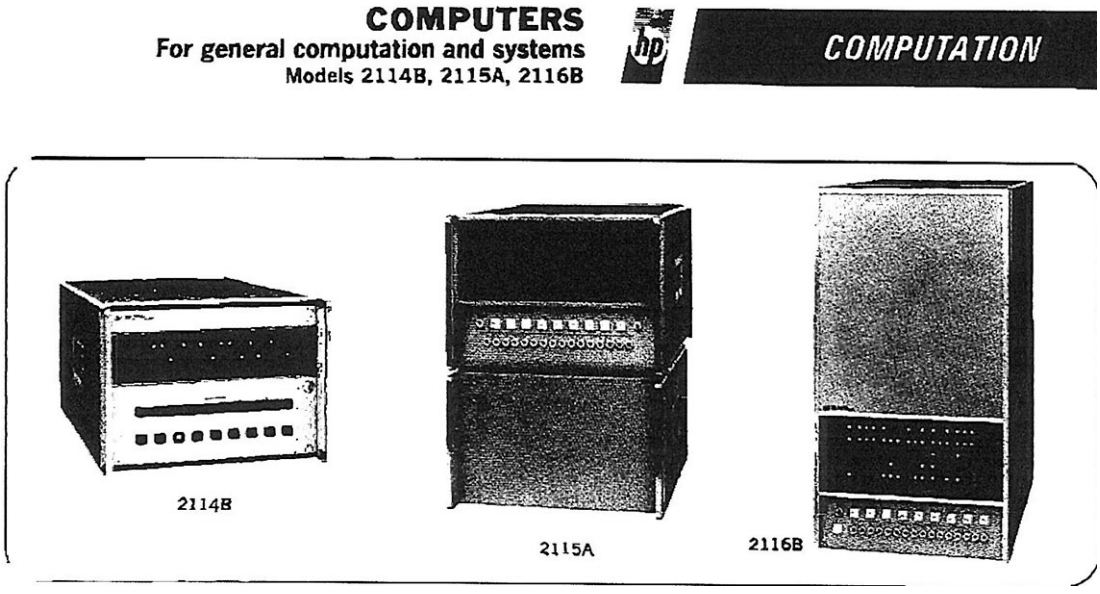


Example of a program in punched paper tape.

Engineering Department

HP 2114B minicomputer

This machine was described by Prof. Tom Olson, then head of the department, as "a small HP analog computer." He remembered it was installed in 1971. It was purchased completely with department funds, and was not connected to instruments or other equipment in the department. It's only input was a typewriter that also acted as the system console. One application was a program Olson and a student wrote in Fortran. The program plotted an infinite number of survey legs, then corrected errors of angles and legs, replotted the corrected survey, and calculated its area in acres. These replots were produced on the plotter attached to the computer.[20] The Engineering Department was in an old building at the corner of Third Avenue and 20th Street that had been a grocery store and meat market. They had slaughtered animals in the back of the old building, and Olson said you could still see the large drain holes in the floor when they moved in. Hence the nickname "the slaughterhouse." In February of 1972, when Marshall was wrestling with the decision to discontinue the 4-year Engineering degree program, an article appeared in the *Parthenon* which exposed the leaky roof in the old building, and that the "analog computer on the second floor had to be covered with plastic whenever it rained, so the drips from the hole in the ceiling would not ruin it."[21] The 4-year engineering degree program was discontinued in 1975. In 1974 Marshall was authorized to offer two-year programs in Engineering. Today the Marshall Engineering program is again thriving and a scholarship in Olson's name has been instituted as the Professor Thomas Olson Scholarship Endowment for Engineering.



Page from 1970 Hewlett Packard catalog.

Hardware and Software:

Marshall's configuration consisted of an HP 2114B computer with a Calcomp plotter attached.[22] The 2114 started at $8,500, not including the plotter, and with only 4k of memory. It had an electric typewriter for input and the system console. That model was introduced in 1969. It was a compact member of the Hewlett-Packard computer family, yet it contained the same multilevel priority interrupt system and used the same powerful instruction set as the larger HP 2115 computers. It allowed for seven device interfaces. It had 16 program registers that could be used in programming. The software package included FORTRAN (Extended,) ALGOL compilers, an assembler, a symbolic editor, and conversational Basic.[23] It was used in the department for 3 or 4 years.

The final disposition of this computer is unknown.

Believed to be the Engineering Department's HP computer covered in plastic because of a leaky roof in the old building. MU image.

Morrow Library

HP 3000 midrange Computer

This computer from Hewlett-Packard was obtained and used primarily to communicate with VTLS. VTLS originated as "Virginia Tech Library Systems," an automated circulation and cataloging system created in 1975 for Virginia Tech's Newman Library, in Blacksburg, Va,. The HP computer was installed in the basement of Morrow Library in 1982. A *Parthenon* article stated the cost as $120,000. It required a raised floor, due to the cabling. Mrs. Merry Brown, Emeritus faculty member, was the system operator for a few years, and trained herself on the VTLS software. It had dumb terminals in the building cabled to the computer.[24] On one occasion in the late 80's, Marshall was selected to be a Beta test site for a new version of the VTLS software. Input to the HP3000 came from index cards that were generated from the library's cataloging dept. The catalogers would enter data into their terminals, which were remote to the OCLC (Ohio College Library Center). These cards would then be sent down to the HP3000 operator, who entered them into the VTLS system, which maintained Marshall's on-line catalog.[25] Marshall had installed two remote terminals to OCLC that went online on Jan. 30, 1979.

A 1984 *Parthenon* article mentioned some of the new functions and tools for the librarians that were being implemented. Merry Brown, the computer operator and one of the librarians, stated that one of the big advantages of the computer system was the tracking of books and helping to control circulation. "Prior to the new system, a student could have an overdue book checked out and come to check out another and the staff would not know it."[26] At that time, there were two computer terminals on the main reference floor for students to use for research, and other terminals were planned for the library. In that same article, Dr. Kenneth Slack, the library director, stated that bar codes on books were to be implemented and a light pen attached to a computer terminal would

Stock image of a HP 3000 with a magnetic tape drive.

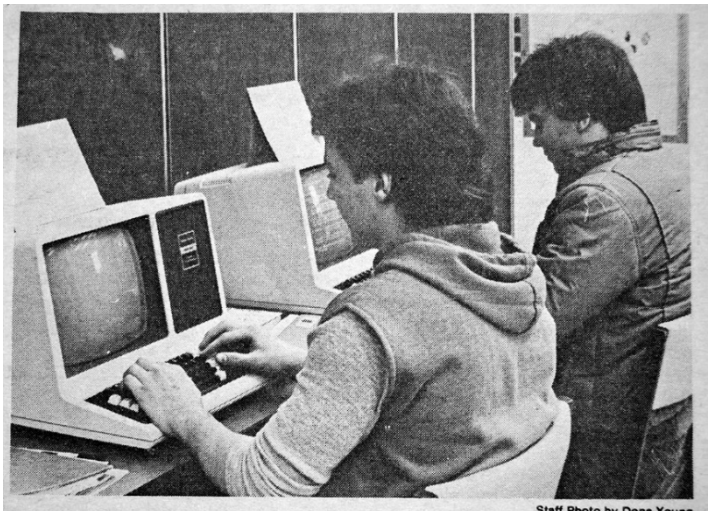
scan the bar code. He admitted in the same interview that the old system of using card catalogs to find books might be around for another two or three years.

Hardware and Software:

The original 3000 was announced by HP in 1971, more than a year ahead of planned deliveries. It was originally named the System 3000. The 3000 was HP's first multi-user business mini-computer. The 3000 models 100, priced at $129,500, and 200, priced at $185,000, were released in July of 1974. The original 3000 computer systems were obsoleted in March of 1980.[27] All models of the 3000 ran HP's MPE 3000 Operating System (Multi-Programming Executive.)

This computer competed very successfully with IBM's midrange systems in the commercial environment, and also with the DEC PDPs. The inclusion of a database management system called IMAGE in their software gave HP a large marketing advantage over both IBM and DEC. In the late 1980's, after Marshall's installation, HP introduced its RISC chip hardware for this series of computers. The 3000 is purported to have been the first computer inside the White House. The Carter administration used the Hewlett-Packard minicomputer "to get business done inside the West Wing." [28] The discontinuance of the last model of the 3000 was announced in November of 2001, but was extended twice.

The model installed at Marshall was probably the "Classic" which utilized a 16 bit processor, or the "XL" which used a 32-bit processor. It required a raised floor, due to the cabling, and used a proprietary operating system. Marshall's configuration included three large disk drives, which Merry Brown described as "looking like three washing machines, side by side."[29] These disk drives were available in 20, 50, and 120 megabyte models. The system had a 1600 bpi magnetic tape drive which was utilized for backup. The computer communicated to VTLS via Marshall's network. The 3000 was moved to the new Computer Center when it was opened in the new Drinko Library.



Staff Photo by Dona Young

Tim Haney, Huntington freshman, and Jim Roam, Huntington freshman, use the new library computer system. The system is already being used instead of the old key punch card system for checking out books, and will eventually replace the card catalog.

MU *Parthenon* article Jan. 26, 1984.

College of Business

IBM Series 1 minicomputer

The College of Business was created as a separate unit of Marshall University in 1969. Since 1996, it has been known as the Lewis College of Business. In the early 1980's, the College of Business received a budget of $300,000 to consolidate the four locations that were scattered across campus, into one, to purchase new furniture, and computers. The new College of Business was housed in Corbly Hall. Sometime shortly prior to 1986, the IBM Series 1 computer system was purchased, and utilized for programming classes in the College of Business. It was installed in a "small room" in Corbly Hall. In 1989-1990 there were programming labs and classes in C++, Pascal, and Cobol utilizing this computer. Marshall's configuration ran under AIX (IBM's version of UNIX.) Dr. Robert Alexander, then the Dean of the College of Business, called it "our little analog computer." Alexander, David Burrows and Chuck Conners formed the Computer Science Department, within the College of Business, and Robert M. Babb was the head of that department. He was with the University from 1981 to 1989. [30]

Stock image of operator inserting an 8 inch "floppy" disk in the IBM Series 1, mounted in the small rack frame. IBM Archives.

Hardware and Software:

The IBM Series/1 was a 16-bit minicomputer, introduced in 1976. Much of its success was due to its ability to interface with analog devices, controllers, and test equipment. The Series/1 was one of the few systems that was offered on a purchase-only basis at prices ranging from $10,000 to $100,000 depending upon configuration. The basic unit was a 19-inch, rack-mountable unit with 16K increments of memory. Although the Series/1 operated using EBCDIC character encoding in native mode, and supported locally attached EBCDIC terminals, ASCII based remote terminals and devices could be attached via an RS-232 interface. The Series/1 was developed and manufactured at IBM's facility in Boca Raton, Fla. High level languages such as FORTRAN, PL/I, Pascal and COBOL were available.[31]

A choice of two operating systems were available: A robust multi-user operating environment (RPS) was available along with several additional high level languages for the RPS OS. The EDX operating system was originally ported from the IBM System/7. Series/1 was also the first computer that IBM supported for Unix. The IBM-supported version was known as AIX.[32]

The Series/1 was also widely used in manufacturing facilities, to monitor and control processes. The Kmart Corporation also had a small Series 1 installed in each of its stores as a communications controller.

In 1986 it was reported that over the system's 10-year life, there had been 42,000 systems installed worldwide. In that same year, three new models were announced that were more cost-effective on the low end. [33]

All models were withdrawn from marketing in the late-1980s.

In May 2016 the United States Government Accountability Office (GAO) released a document that covered the need to upgrade or replace legacy computer systems within Federal Agencies. According to this document, there was still a Series/1 that "Coordinates the operational functions of the United States' nuclear forces, such as intercontinental ballistic missiles, nuclear bombers, and tanker support aircraft. This system still uses 8-inch floppy disks. However, the agency plans to update some of the technology by the end of the 2017 fiscal year."[34]

Marshall's configuration probably consisted of a 4956 Model 3 or Model 4. The base machine could be purchased for around $10,000. 8-inch diskettes were used for program maintenance. Marshall operated the system using the AIX (UNIX) operating system.

Marshall University Bookstore

IBM S/36-PC midrange computer

In the mid-1980's the MU Bookstore installed an IBM S/36 PC, which had been announced in 1985. About the same time, the bookstore installed a few IBM PC/XT's. One of these served as the console for the IBM S/36 PC. The desktop machine ran the S/36 operating system and allowed the customer to attach either IBM PC's or "dumb terminals." The bookstore's configuration consisted of one PC/XT as the console, and three "dumb IBM terminals," which were most likely IBM 5250's, and an Epson printer. Part of its justification was to get to an online POS (point of sale) system, and for textbook management and inventory. The computer was purchased through an IBM VAR (Value Added Remarketer.) The VAR program allowed the broker to sell the hardware, with significant application software as part of the package. The VAR was Missouri Book Services, Columbia, Mo. They supplied software for textbook management and inventory. The programs were written in RPG II. Joe Vance, then manager of the bookstore, stated that they could not get to the POS implementation, because the small machine was too slow, due to the twinax cabling, and a limited number of terminals.[35]

Stock image of an IBM S/36 PC (bottom cabinet), with a IBM PC as the console.

Hardware and Software:

The IBM model S/36-PC or "Baby/36" was actually a IBM 5364. It was the smallest member of the IBM S/36 product line. IBM developed this systems unit to be mounted in an IBM PC/AT cabinet. The machine had a 1.2 MB 5.25-inch diskette drive, which was incompatible with PCs and with other S/36s. It had an integrated, non-removable (hard) disk storage drive of up to 80 MB. It had an integrated workstation controller for up to 4 local workstations including the system console, attached via twinax cabling. The machine ran the IBM System/36 System Support Program (SSP), which was a reduced version of the SSP operating system for the larger S/36's. It was user-friendly, with availability of the HELP menus and text, and prompted procedures. During its life, IBM delivered over 100,000 System/36's -- which had been built in Rochester, Minn. [36] By 1994, the System/36 had been effectively replaced by the IBM AS/400 and IBM was offering customers a trade in of their System/36's toward the purchase of an AS/400. The 5364 was discontinued from marketing in 2000. The biggest complaint about the small system was the restriction of the workstation controller that could only allow 4 devices attached.[37] After being installed for only two years, Marshall's Bookstore machine was put into Marshall's Surplus Equipment Sale.

Stock image of IBM S/36 PC (5364) processing unit.

School of Medicine

IBM S/38 midrange computer

The West Virginia Legislature appropriated funding for the Joan C. Edwards School of Medicine at Marshall University in 1975. It was granted provisional accreditation in 1977. Beginning in 1998 and the decade that followed, Marshall saw the completion of five new clinical, educational and research buildings with an investment of more than $120 million. By the mid-1980's, the school had 155 pc's, most of which were networked. In 1987 Marshall's "Center for Regional Progress" conducted a survey of computer hardware and software installed in each department and school. It broke down the list of pc's and noted that the School of Medicine also had an IBM S/38 midrange computer installed.[38] This system was purchased through the State of West Virginia contract with IBM. It was installed in the old Doctors Memorial Hospital on 6th Avenue, (previously the C&O Railroad Hospital,) where the clinic and offices were located. The main applications were programmed in-house and were patient billing and accounting. It seems likely there was also a patient scheduling application implemented on that machine. The 1987 study stated that "The Office of Academic Computing of the School of Medicine has a staff of full-time personnel which are well versed in several programming languages."[39] A year later, an unfortunate incident occurred, when the S/38 crashed a disk drive, and everything had to be restored from magnetic tape. The lesson of why backup is important came when it was discovered that the doctors' research programs (written in Fortran,) had not been backed up either by the doctors or the Data Processing Dept. (The doctors assumed Data Processing was doing a complete back-up, while Data Processing assumed the doctors were doing their own back-up.) The doctors had to rekey all their programs from old source printouts.[40]

Hardware and Software:

The IBM System/38 was a general purpose, multiuser midrange system. On October 24, 1978, IBM introduced the System/38, but deliveries of the new system did not begin until 1980. It consisted of 5381 & 5382 processors. The S/38 was an advanced concept, integrated into an object-oriented OS, running on a single-level-storage machine. The System/38 and its descendants are the only commercial midrange computers ever to use a machine interface architecture to isolate the application software and most of the operating system from hardware dependencies. The machine utilized both horizontal and vertical microcode, to execute more machine functions outside the operating system, close to a hardware level. The proprietary operating system, Control Program Facility (CPF), supported demand paging as a method of virtual memory management. It had an integrated, relational database system that was integrated in the operating system.[41] For access to large files and other objects, the machine performed "scatter loading" of the object across all available DASD. The machine and operating system were a programmer's dream, due to its "Programmer's Menu," which allowed a programmer to perform all the steps from keying in the program source, to testing in a separate test environment. Many of its advanced concepts were incorporated into the follow-on IBM AS/400. The School of Medicine system had a 5381 processor, with

multiple IBM 3370 Direct Access Storage Devices, each with a capacity of 571.3 MB., and at least one IBM 3410/3411 Magnetic Tape Unit installed, that was used for backup.

[Marshall University *Newsletter*, Nov. 13, 1986:
The Marshall University Center for Regional Progress was established in 1984, through a West Virginia state grant from the governor. Its program was designed to foster economic development by supporting programs and projects which contributed to economic well-being of a center's service areas.]

Stock image of an IBM System 38 processor. (5381)

Miscellaneous or Questionable

The 1987 survey prepared by the Marshall "Center for Regional Progress," showed that the Biology Department had installed an IBM 9000 Laboratory Instruments Computer. It was connected "to several analytical units, including a HPLC and a GLC. This computer runs, controls, stores and analyzes data." HPLC was a High-performance liquid chromatography machine, and GLC was a Gas-liquid chromatography machine. It was a computer dedicated to interface with lab equipment for the College of Science, and not a general purpose or general use machine. It is also referred to in IBM publications as an "Instrument Controller," and therefore may not qualify under our computer definition. It is more closely akin to a pc because it was based on the Motorola 68000 processor.[42] It ran a limited operating system named XENIX, derived from UNIX. On December 17, 1985, new production of the 9000 was discontinued by IBM.[43]

Part II: Marshall Computer Center:

Equipment: DATA 100 RJE Station, DEC PDP 11/40 Computer, DEC PDP 11/34 Computer, DEC VAX 11/780 & 785, Pertec XL/40 key to disk, DEC VAX 8700, DEC Microvax & Alpha computers.

In the early 1970's, Carl Thomas, the second director of the MU Computer Center, was pushing for a new and larger computer. As early as 1968, Marshall had been attempting to get the National Science Foundation to finance an IBM 360 computer system for Marshall. They never succeeded. Thomas even trained the computing staff on the RCA Spectra 70 System, which was competitive to the IBM 360. His recommendation was turned down, and he was replaced with John Jamieson in the summer of 1973. At that time, Marshall's management was in favor of obtaining another IBM System. The second floor of Prichard Hall was renovated and a new computer room was constructed and outfitted for an IBM 360 class of mainframe system. In the spring of 1974, the older IBM equipment was moved to the new facility. The Computer Center staff totaled 19 employees at that time. Both the IBM 403/407 and the IBM 1620 Computer were retired, and a DATA 100 RJE station was installed to communicate with the IBM 360 at Union Carbide's Data Center in Charleston. In late 1974 or early 1975 the new computer was on a truck in Huntington awaiting delivery and word was received that there was a new organization being formed to supply computing to the state institutions and that the delivery of the computer was to be refused - the window had closed. What the system model or configuration was has not been found. In 1975, WVNET (West Virginia Network for Educational Telecomputing) came into being and Marshall was relegated to being a spoke rather than a hub of computing activity. [44]

DATA 100 RJE station

A DATA 100 RJE station was installed in the new Prichard Hall computer facility, with a connection to the Union Carbide Data Center in Charleston. This connection was replaced by the DATA 100 link to West Virginia University's IBM 360/75, which was brought up in 1975.

One of the main users of the RJE system was Earl Z. Damewood, the head of research at INCO (International Nickel Co., now Special Metals.) In working on his doctoral dissertation, in the mid-1970's, he submitted jobs to develop a computer language to model discrete and continuous processes. He developed a computer language to model the dissolution of drug particles, by solving differential equations. The simulation language compiler was programmed in Fortran and ran on the 360/75 at WVU. The compiler produced executable Fortran code which was then compiled and run. For each run Earl submitted, it required two boxes of IBM 80-column cards which contained the data. Typical output was approximately twenty printed pages per run.

Before the data could be submitted, Earl punched the JCL (Job Control Language) cards which submitted and ran the jobs. So a complete job stream consisted of the JCL on the front to load and execute the proper programs, followed by the two boxes of data cards, and ending with a few more JCL cards. Dr. Damewood did finish his doctoral project in 1981, and came to Marshall as a professor in the Engineering Department. He later taught statistics and operations management in the College of Business.[45] Dr. Earl Damewood, Emeritus professor, has been a great help in understanding the RJE environment from a user perspective. The disadvantage of the RJE system was that you submitted your job, then waited…and waited, for output.

Hardware and Software:

The Data 100 Company was established in 1968 by former Control Data Employees. The equipment at Marshall was probably the Data 100 Model 71 (1972) programmable device, emulating the IBM 3780 RJE terminal, or the Model 74 (1975) which was a reduced cost IBM 3780 emulator. It basically consisted of an 80-column card reader from Dataproducts, a line printer, and a CRT video display for an operator console. The Data 100 had 64K bytes of memory and supported communication protocols of ASYNC, Bisync and SDLC. [46] The DATA 100 was removed from service in late 1977. The company was purchased by Northern Telecom (which later became Nortel Networks) in 1978.

Left: operator keying commands on Marshall's DATA 100 console.
Above: Steve Adkins, operator (left) and Computer Center Operations Supervisor Marvin Fulton examine output from the DATA 100. Ca. 1975. MU images.

DEC PDP 11/40 Computer

The WVNET (West Virginia Network for Educational Telecomputing) plan was implemented and a DEC PDP 11/40 system was installed in late 1975 and early 1976. This machine provided RJE services to WVNET as well as a 4 concurrent user time share system. The main applications on the PDP 11 were administrative, including registration. The connection to WVU's 360 was limited (8 terminals) to IBM's CMS (Conversational Monitor System) interactive software on the mainframe.[47]

Hardware and Software:

This machine was introduced after the successful PDP11/45 as a cheaper mid-range machine.[48] It replaced the PDP-8 in many applications, although both product lines existed in parallel for more than 10 years. The PDP-11 (Programmed Data Processor) was one of the (if not the) most successful computers of all times. It was manufactured from 1970 into the early 1990s. Over 600,000 units of this system were sold, due to the popularity of OEM devices. The first model of the PDP-11, (priced $20,000 USD), was shipped in the spring of 1970. PDP-11 was the first system to run an AT&T UNIX operating system which was written in C. It had a word length of 16 bits, speed 800 nanoseconds, the cycle time was 1.5 microseconds and the access time, 0.75 microseconds.[49] It began its career as a minicomputer, and ended up as a "supermicro/supermini." A major advance in the PDP-11 design was DEC's Unibus, which supported all peripherals through memory mapping.[50] This allowed new devices to be added easily. The PDP-11, which was sold in 1970 for $10,800, was the only 16-bit computer ever made by the company. The C programming language was written to take advantage of PDP-11 features and to rewrite Unix in a high level language.[51] The Model 40 was the computer shown in the movie *The Manhattan Project* (1986).

Marshall's configuration included a DEC PDP 11/40 processor, (roughly equivalent to an IBM PC XT,) disk capacity of 5Mbyte, a card reader, Magnetic Tape Drive, 2 600 lpm printers, card punches, 4 terminals and a modem connection to the Nasco AS/5 and IBM 360/75 at WVNET. The operating system, RT-11, on the PDP 11 allowed two tasks to run simultaneously, the first was HASP (Houston Automatic Spool Program), which provided the RJE capability, and the second was a 4 user interactive BASIC language system accessed via the 4 terminals. Eventually the operating system was changed to RSTS-E, a true multi user program, and ran a 2780/3780 emulator (IBM's RJE station.)[52]

Stock image of a DEC PDP/11, Mod 40, in a full rack.

Pertec XL/40 Key to Disk

To improve the Computer Center's batch processing systems, the card keypunch machines at Marshall were replaced. In the summer of 1978, a Pertec XL/40 Key-to-Disk system was procured to replace the production keypunch units and a connection line to WVNET was installed. This resulted in a net savings over the previous expenditures for cards and machines but the real bonus was in the optional capabilities of this new machine - it was programmable and expandable. The COBOL-like language compiler was used to develop programs and the staff used it to develop the new registration system as a proof of concept. This system had a user-friendliness that was rare in text-only human-computer interaction. Marshall's realtime/online administrative systems and registration began on the Pertec, were migrated to the PDP 11/34 (the 11/40 was basically the "academic" machine in those days)… and then finally to the VAX architecture.[53]

Hardware and Software:

Is it a computer? Pertec Computer Corporation (PCC), was formerly Peripheral Equipment Corporation (PEC). It introduced the Pertec XL-40 in 1977, as a more successful follow-on of Pertec's PCC-2100. The XL-40 machine used custom 16-bit processors built from the TI3000 or AMD2900 slices, up to 512 KB operating memory and dedicated master-capable DMA controllers for tape units, floppy and rigid disk units, printers, card reader and terminals. The larger configuration featured two hard disk units (up to 70 MB formatted capacity, manufactured by Kennedy or NEC). It could be configured with a "rigid hard drive" or with floppy disks. Marshall's system recorded on the hard disk drive. The proprietary operating system, called XLOS, supported indexed file operations for on-line transaction processing. The system was programmed in two different ways. The data entry was either described in several tables that specified the format of the input record with optional automatic data validation procedures, or the indexed file operations were programmed in a special subset of COBOL, referred to as "COBOL-Light." This version allowed both IDX and SEQ file support. [54] Since this machine ran a program that was capable of conditional branching, which was independent of the hardware, this machine qualifies under our modern definition of computer.

Stock image of Pertec XL/40, with the hard disk unit.

DEC PDP 11/34 Computer

In the years when Marshall was a slave to WVNET through the RJE system, WVNET had refused to provide online interactive access to applications. In 1979 WVNET was confronted with an ultimatum: "Either provide online computing facilities or get out of the way." WVNET's answer was to wait until they were able to accommodate the requirements – "maybe in a couple of years." The MU Computer Center was convinced to proceed with another option, and permission to purchase a DEC PDP 11/34 system to accommodate the growing administrative systems was granted. The system was installed in the Computer Center in 1980. That summer, the conversion of the Registration and Admissions systems to the new PDP 11/34 system was achieved, and a long list of future projects was placed on the drawing board. One data entry position from the Computer Center was transferred to the Registrar to compensate for the increased data entry load in the office and a year later an additional transfer was made to the Admissions office. The software application was developed in Basic. Marshall was provided the equipment to allow 12 interactive sessions to the WVNET but was advised against using it for administrative applications.[55]

Hardware and Software:

The DEC PDP-11 was the most popular in the PDP (Programmed Data Processors) line of minicomputers, a successor to the previously popular PDP-8. [56] The mod. 34 evolved into three versions (/34,/34a,/34c). It was a 2 hex board processor, with an optional third quad card to run a seven segment display and keypad console. [57] There was also a hardware floating point option available. "If one thinks of the PDP-8 as the "model T" computer (cheap, and designed for mass production), then the PDP-11 is the big old 1950's car!" [58] The PDP-11/34 was a Unibus-based 16 bit minicomputer manufactured by Digital Equipment Corporation. It was introduced in 1977. It had memory management and supported a maximum of 256 KBytes of memory.[59] This system featured RK05 removable disks. These single-platter disk packs resembled the disks on the IBM System 3, which was a strong competitor. This system also ran the UNIX operating system. For a decade the PDP-11 was the smallest DEC system that could run Unix. While Marshall had copies of UNIX for the PDP-11's and VAXes, it was judged as entirely too experimental in those days to run in Marshall's Computer Center environment. Marshall's 11/34 ran RSTS-e from the start without the RJE emulation. The Computer Center didn't start using Unix/Linux until the move to Intel servers after the move to Drinko. The machine was dedicated to the MU administrative systems including registration. [60]

Stock image of DEC PDP 11/34 with magnetic tape drive.

The VAX era

DEC VAX 11/780, DEC VAX 11/785

The VAX 11/780 was placed in production in the early spring 1981. This computer was one of the first off of the assembly line of a new generation of computers from DEC and marked a significant turning point in both Marshall history as well as the development of the computer industry. The DEC VAX was the mainstay of many university computer centers for almost two decades. The year 1981 also marked another industry turning point with the introduction of the IBM Personal Computer, known as the PC.

An OMR (Optical Mark Reader) was lease-purchased from the NCS Corporation. This provided a replacement for the antiquated mark sense card reader that had been in service at Marshall since the 60's. It was indeed a solemn moment in 1983 as the computer center personnel bid farewell to the last vestiges of unit record equipment when they retired the marksense reader and the few remaining keypunches.

All of the administrative applications were moved to the 11/780 and were in production in the fall of 1983. An upgrade of the 11/780 to an 11/785 was procured in 1984 and in the fall of that year the office automation package "All-In-One" was installed. (DEC's office suite.) This package included an integrated set of word processing, calendar management, electronic mail, spreadsheet, and file management to all administrative users with terminal access (about 60 users at the time). This upgrade made the machine faster, and allowed for more memory.

In 1987, a native DECNET link was established between the Marshall VAXCluster and its counterpart at the WVNET central site and in the same time period joined the BITNET, a collaborative network, through a similar connection to the WVNET central site. This infrastructure investment set the stage for the next decade of growth on the campus.[61]

Hardware and Software:

The VAX 11/780, code-named *Star* was introduced on October 25, 1977 at the Digital Equipment Corporation's Annual Meeting of Shareholders. It was the first member of the VAX computer family, the first commercially available 32-bit computer and the first one MIPS (one million instructions per second) machine. This became an industry standard of processor speed measure. The computer and its operating system (VMS) were designed both from scratch. The result was a really reliable, powerful and user-friendly system. The affordable price level allowed many institutions and universities to acquire it. The VAX 11 series was sold until 1988. [62] The letters *VAX* suggest the main feature of VAX computers - Virtual Address eXtension. (This allowed dynamic paging.) The VAX family all utilized the same VMS Operating System. The original VAX 11/780 and VAX 11/750 had multi-chip CPU's that filled an entire circuit board. Called a "complex instruction set computer," VAX systems were backward compatible and so preserved the investment owners of previous DEC computers had in software. The success of the VAX family of computers transformed DEC into the

second-largest computer company in the world. [63] The VAX 11/785, code-named "*Superstar*", was introduced in April 1984. It was essentially a faster VAX 11/780. The memory subsystem was also upgraded to support higher capacity memory boards. Existing user PDP-11 programs which did not need the extended features of VAX-11 could run unchanged in the PDP-11 compatibility mode provided in the operating system. The system ran VMS, VAX, and Ultrix. (Ultrix-32 was DEC's version of Unix.) VAXELN was a real-time operating system. Tools for developing VAXELN applications ran under VMS. It was possible to make VMS secure, and unlike most versions of Unix, VMS came secure "out of the box."[64]

The U.S. F-15 and F-18 fighters, the Hawk missile systems, parts of the U.S. Navy submarine fleet, and Navy fighter test systems on aircraft carriers use DEC's VAX minicomputers from the 1980s. The VAX line provided a bridge to fill the gap between IBM mainframes, and personal computers. It competed with the IBM midrange systems, the S/36 and S/38, but when IBM rolled out the AS/400, it was nicknamed the "VAX killer."[65] The combination of bad results and industry acceptance of IP ultimately defeated DEC and it was sold to Compaq in 1998.

The DEC VAX played a part in the Cold War in the 1980's. The East German Ministry for Electronics (German Democratic Republic), saw that the economy might collapse without the support of computing. One of the ways to replace workers and to prop up the economy was to introduce computer-assisted design or computer-assisted manufacturing applications (CAD/CAM) into companies. Robotron, the largest East German electronics manufacturer, had already produced a 16-bit computer processor, but they were not powerful enough. Therefore the Ministry asked Robotron to copy the VAX 780, a more powerful 32 bit machine. But that system was "strictly embargoed." With the help of the Stasi, (the official state security service of the GDR,) VAXes were being illegally imported, however, under a secret project code named "0023." Two 780's were acquired by Robotron, and the clone was put into production by 1987. It was called the "K 1840." (Complete specification: Robotron RVS K1840)[66]

Stock images of a DEC VAX 11/780-85

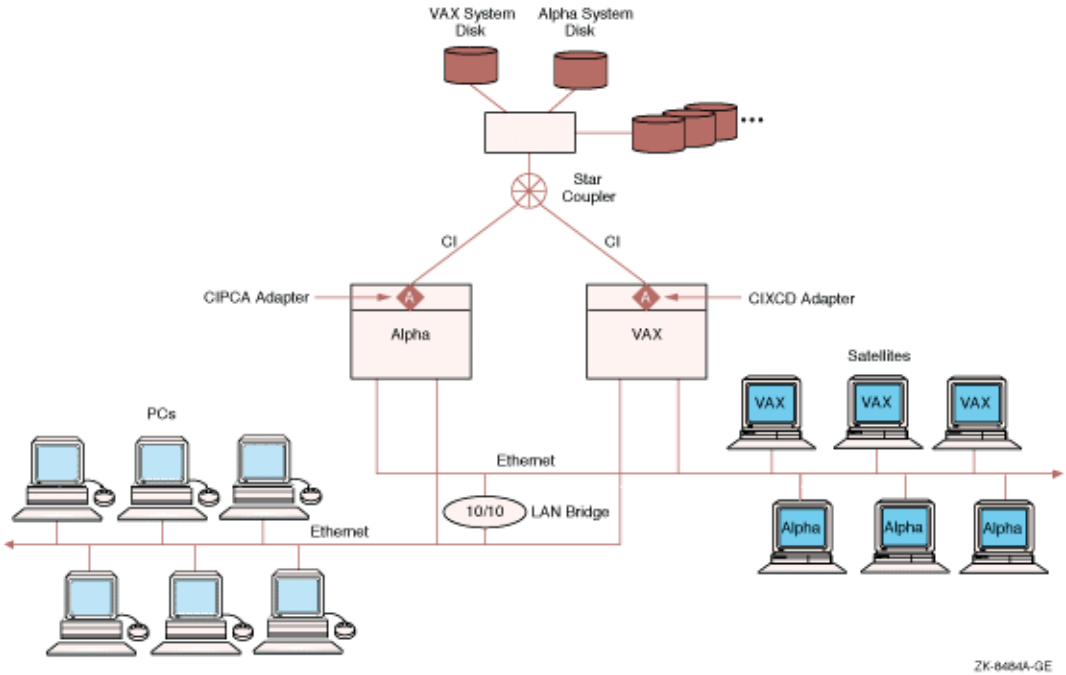
DEC VAX 8700

By 1985 the cable capacity across Marshall's campus for terminals was taken up with single terminal connections (about 100), and Marshall was forced to install T1 multiplexor technology to accommodate the demand for connections.

In 1988 a new computer, a DEC VAX 8700, was installed with a substantial storage upgrade (8GB,) and was utilized to establish a VAXCluster of machines. Along with the new machine came the Oracle Database Management System and the BANNER Student Information System from SCT (Systems and Computer Technology) Corporation. It handles functions in higher education such as enrollment, scheduling, purchasing, and alumni development, and personnel and finance functions. The now famous BANNER software system was installed on the Marshall VAXCluster and was one of the first installations in the world. It is still in use at Marshall today. The VAXCluster was a closely-coupled multiprocessing environment.[67]

Hardware and Software:

The VAX 8700, code-named "*Nautilus*", was introduced in early August 1986. It was similar to the VAX 8800, but with only one CPU and bus. In benchmark tests by DEC, the 8700 performed six times faster than the VAX 11/780.[68] It utilized the VAX instruction set, and the new VAXBI I/O channel. It ran the same VMS Operating System as the other computers on the VAXCluster. It was classed as a minicomputer. The 8700-series was the "low-end" version of the 8000 series, with slower throughput than the 8800.



A stock diagram of a typical VAXCluster configuration, including DEC Alphas and PC's.

DEC VAX 6400 and DEC Alpha AXP

The year 1990 marked the opening of the decade with the installation of the second phase of the capital upgrade begun in 1987. A third machine (DEC VAX 6430) was added to the cluster and an additional 10GB storage. This addition proved adequate until more power was required and in 1992 a fourth processor was added creating a VAX 6440. The voracious appetite for computing power was alleviated for one year and in 1993 a VAX 6510 was leased to add to the cluster but by 1994 that machine required upgrading to a VAX 6620 in an attempt to meet the demand.[69]

Hardware and Software:

This 6000-series of machines was named DEC Alpha, originally known as Alpha AXP. Alpha was a 64-bit RISC architecture that DEC developed as the successor to its VAX platform. Alpha was actually the microprocessor from Digital Equipment Corporation which was based on the 64-bit reduced instruction set. DEC spent much of the late 1990s touting Alpha as a step beyond anything else on the market at the time. It was mostly right: x86-64 didn't arrive until the year 2000.[70] These machines still ran VMS as the operating system so it was an easy port of software to the new machine and little retraining for the Marshall staff to maintain them. With the introduction of the VAX 6000 series, which offered slightly higher performance for half the cost, the older VAX 8000 was discontinued. The VAX 6430 was nicknamed *Calypso/XRP* and featured a triple processor, while the 6440 utilized a quad processor. The Feb. 25, 1991 issue of *Computer World* magazine stated that these two machines were "used primarily for engineering analysis and computer-aided design." Other publications called the 6440 "the file server."

Stock image of one of the DEC Alpha file server models.

DEC MicroVAX 3000 Series

By 1990 a significant growth was taking place in Marshall's academic area. In 1990 a VAX 3100-90 was purchased for the academic users to replace the MicroVAX 3900. The 3100 was one of the new MicroVAX series. The MicroVAX 3100 was a multiuser system which was a general purpose desktop VAX computer, which resembled the PC. To this was added in 1995, two of the first of DECs new generation architecture machines. These were two twin processor AXP 2100/275 which were installed in the Computer Center as Oracle database machines.[71]

Hardware and Software:

The MicroVAX was a family of low-end minicomputers developed and manufactured by Digital Equipment Corporation (DEC). The first model, the MicroVAX I, was introduced in 1984. The MicroVAX family used processors that implemented the VAX instruction set architecture. The MicroVAX 3100 Series was introduced in 1987. These systems were all packaged in a desktop enclosure. PC clients based on MS-DOS, OS/2, and Macintosh could be connected to the MicroVAX 3100 system, enabling the entire company or business to share information.[72] The MicroVAX 3800 and MicroVAX 3900, code-named "*Mayfair III*", were introduced in April 1989. They were high-end models in the MicroVAX family, and were intended to compete with the IBM AS/400.

Several MicroVAX and VAXstation models have the 3100 number, and sometimes it's difficult to tell them apart. They are microprocessor-based systems with SCSI storage elements. A MicroVAX 3100 is a multiuser machine, a VAXstation 3100 is a graphical workstation, while the VAXserver is a MicroVAX 3100 with a single-interactive-user OS license (e.g. fileservers). Other models were the Infoserver 100 and 150, which are MicroVAX 3100's designed for servicing CDROM's, tapes and disks to network clients (this is useful for remote booting or OS install over the network). [73] The 3100 Model 90 was code-named *Cheetah*, and was introduced in October, 1993, and used SCSI for its interface protocol.

Stock image of a DEC MicroVAX 3100

The Move to Drinko and Y2K

In the 1970's and 1980's the PC became popular. With the MAC, and the TRS-80 (referred to by some as the "Trash 80,") and then the IBM PC, the concept took hold. The first computer "PC Lab" at Marshall was in the College of Business around 1990 and it was a problem managing and supporting those facilities (they were not networked at that point so no internet access, and all of the support was total hands-on using floppies etc., to reload and update, etc.) The 1992 proposal was to use the network not only to allow internet access from the labs, but to provide more uniform access/support to the end point PC and create a distributed support network of expertise, i.e., in those colleges that wanted to invest in their own support services the Information Technology Dept. would provide leadership and support.

By 1995, there were four sites on Marshall's Huntington campus, containing a total of about 200 fully networked PC clones and MACs available for student use and they could be reserved by faculty for classes.[74]

Toward the end of 1998 and for all of 1999, the big issue in data processing or I/T was the Y2K (year 2000), or the "millennium bug." A world-wide panic ensued over this anticipated disaster. The doomsayers predicted that on Jan. 1, 2000, smoke would roll from system consoles and all computers would self-destruct. The other extreme was those who said it was all a hoax or a joke and nothing would happen. As usual, reality was somewhere in between. The problem resulted from the several decades of thousands of legacy programs and files having adopted the de facto default of storing dates in six digit fields, ie. mm/dd/yy. (This was to save file space.) In the beginning with low-capacity disk drives, saving space in files was a major concern. But with a year being represented by only two digits, in 2000 the year would appear as "00" and most date-comparing programs would default this to be 1900 and date calculations would not work. Banks and other financial institutions were required by the federal examining agencies to test the time locks on their vaults, and to institute a backup plan for all operations. Applications had to be tested and proven to operate with the new dates before the end of 1999. The fix for the problem involved converting files and databases to four-digit years and converting all the software that referenced dates. Enterprises had a huge amount of legacy data files and thousands of programs that accessed them. With many older applications, the programmers who wrote them were long gone, and documentation was lacking. In many instances, the source code was missing. The major hardware vendors who also supported major operating systems were the first to fix problems of changing the system date to 2000. This fix they supplied in operating system updates. Application programs were a larger problem. Major application providers went to work immediately and developed software upgrades. Most were supplied without any major costs to the customer. But some saw it as an opportunity to announce a major program version, and they charged something to obtain the upgrade. Practically all third party contract programmers had all the work they could handle, changing software systems that were not supplied by national software companies. Many installations changed software or discarded much of the old "non-compliant" code and sought other solutions. Marshall was in this category.

In 1998 the new John Deaver Drinko Library was completed on Marshall's Huntington campus. It became the main library building and contains; library services

and computer and advanced technological education facilities, multimedia training rooms, distance education, study rooms, an auditorium, and houses the I/T (Information Technology) Department. When the big move to the new Computer Center in Drinko Library occurred in late 1998-1999, none of the VAX architecture was moved, only the AXP processors and Intel servers. (See Appendix) The disposition of the VAX machines was that the ones with residual value were traded in to offset the cost of the Alpha systems and the others with less value were transferred to WVNET to provide some computing to other institutions and some went for spare parts.[75] Also Digital Equipment Corp. announced the phase-out of VAX systems in 1999. Several pieces of software were discontinued or replaced, due to the Y2K problem. New software options were examined to replace some of the legacy software. The move to Drinko brought about the real migration to Intel based servers with Windows Server and Linux. The study of the hardware, software, and applications on the new PC server-based, network platform, is a project for someone else to document.

"An historical view of the various measures of the Computer Center at Marshall University."

	1960	1965	1970	1975	1980	1985	1990	1995
Staff (FTE)	2	3	8	18.8	20	17.5	19	21
Personnel					$241,000	$376,000	$484,000	$700,000
Equipment					$39,000	$167,000	$300,000	$250,000
Admin. Capacity*	0	0	0	4	12	52	150	400
Academic Capacity*	0	0	0	0	12	64	100	300
MUNet Connections	0	0	0	0	0	75	300	1500

*the numbers represent an approximate number of concurrent users supported
(Compiled in 1996 from Computer Center Dept. files by Arnold Miller)

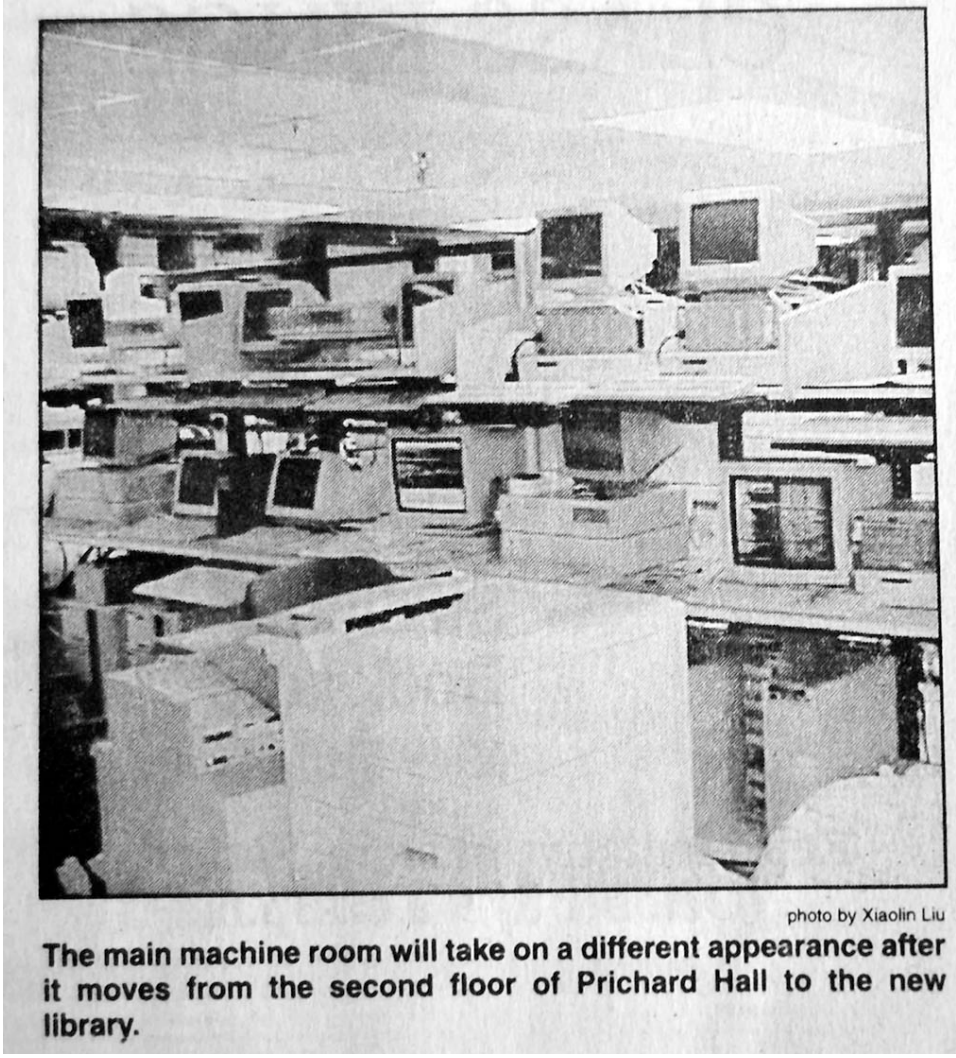


photo by Xiaolin Liu

The main machine room will take on a different appearance after it moves from the second floor of Prichard Hall to the new library.

An Image from the *Parthenon* of Oct. 1, 1998, showing part of the main Computer Center room in Prichard Hall, just before the move to Drinko.

GLOSSARY OF TERMS

ASYNCH: Asynchronous refers to transmission of data through networks, and the transmission is not governed by specific timing requirements on the transmission end. Asynchronous transmission is used on a byte level as well as on the level of entire messages. This was one of the earliest protocols and the slowest.

BASIC: (Beginners All-purpose Symbolic Instruction Code) A programming language developed in the mid-1960s at Dartmouth College. Originally developed as an interactive language for mainframes, it became widely used on small computers.

Bisynch: (**BI**nary **SYNC**hronous) A major category of synchronous communications protocols used in mainframe networks. Bisync communications require that both sending and receiving devices are synchronized before transmission of data is started.

BITNET: "Because its Time Network," a collaborative network of Higher Education institutions interconnected to allow file transfer and electronic mail.

BPI: Abbreviation for bits-per-inch. Usually used to describe magnetic tape drive encoding specifications.

Bus: A common electrical conductor shared by multiple related devices. Sometimes referred to as a channel.

COBOL: Common Business Oriented Language, like Fortran, was one of the standard hi-level programming language available across platforms and vendors. COBOL was the programming standard for most of the U.S. Government installations in the 1960's and 70's.

Compiler: A vendor supplied software program that edited and converted high-level language statements into machine-level executable code.

CPU: The central processing unit, or brain of any computer. It controls the interpretation and execution of instructions.

DASD: Direct Access Storage Devices, usually disk or "hard" drives.

DECNET: Digital Equipment Corp's proprietary network architecture, which supported Ethernet-style LANs and baseband and broadband over private and public lines. It evolved into one of the first peer-to-peer network architectures.

Dumb terminals: Cathode ray tube (CRT) devices which had no memory or calculation capability. To display or input anything, it had to be controlled by the computer it was attached to.

EBCDIC: (Extended Binary Coded Decimal Interchange Code.) An 8-bit character set and encoding representing 256 alphanumeric and special characters. Developed by IBM in 1962 to enable different IBM computer systems to communicate based on a standard coding scheme.

Floppy disk: A reusable magnetic storage medium and drive introduced by IBM in 1971. It was officially a "diskette," but nicknamed "floppy," because the first varieties were housed in bendable jackets. Starting in the late 1970s, the floppy was the first personal computer storage medium. It was used in a 1.44 meg size on various minicomputers and PC's.

Fortran: Short for "Formula Translation," it was one of the first program compilers of the 1960's. The language resembles algebra in some statements. It was the standard high level programming language on the IBM 1620 computer at Marshall. It and COBOL were the standard languages on IBM computers, HP and others of that period.

HASP: (Houston Automatic Spooling Program) An earlier mainframe spooling program that provided task, job and data management functions. It queued or stacked up waiting reports to be printed.

Integrated circuit: Synonymous with microcircuit and semiconductor chip. In computer hardware, a miniaturized electronic circuit comprising many individual circuit elements, such as transistors, diodes, resistors, capacitors, and inductors, etched on a tiny wafer of semiconducting material such as silicon.

IP: Internet protocol, a packet-switching protocol that has address and control information so that packets can be routed.

JCL: The Job Control Language that set up and executed jobs under IBM OS on the IBM 360 family of computers. Each card (or record) started with "//". The control language could also specify where disk files were located and any overrides of standard defaults.

OCLC: (Ohio College Library Center,) is a nonprofit cooperative organization that provides WorldCat, a world-wide catalog application. Based in Columbus, Ohio. Marshall Libraries have utilized this service since 1979.

OMR: Optical Mark Reader. The process of gathering data with an optical scanner by measuring the reflectivity of light at predetermined positions on a surface.

RISC: Short for "Reduced Instruction Set Computer." Developed by IBM and others, it cut down the set of hardware instructions required. The object was to build a computer that had a small set of simple and general instructions, rather than a large set of complex and specialized instructions.

RJE: Remote Job Entry was the protocol and methodology established by IBM to enter jobs remotely to the computer, to monitor (and to a certain extent, control) the jobs'

progress, and receive the results of the computation process, i.e., receive printed reports and/or punched cards for further analysis.

RS232: (**R**ecommended **S**tandard-**232**) A TIA/EIA standard for serial transmission. Although employed for numerous other purposes, the RS-232 serial port was widely used on earlier personal computers to attach devices.

SCSI: (**S**mall **C**omputer **S**ystem **I**nterface) Pronounced *scuzzy*. A high speed parallel interface defined by the X3T9.2 committee of the American National Standards Institute (ANSI) for connecting minicomputers to peripherals, to other computers, and to local area networks (LANs). It became one of the standards in IBM and DEC systems.

SDLC: (Synchronous Data Link Control,) A bit-oriented, synchronous data communications protocol. SDLC supports high-speed transmission (56 kbps or better) over dedicated circuits in point-to-point or point-to-multipoint network configurations and operates in either half-duplex (HDX) or full duplex (FDX) mode.

T1: A broadband, digital, data-transmission system for multiplexing signals over a telephone line, as for voice communication, at 1.54 million bps. This allows for the concentration of up to 23 data channels on 2 pairs of wire. Corresponds to *DS-1* (Digital Signal level One) in the North American digital signal hierarchy.

Twinax: Twinaxial cabling, or "Twinax", is a type of cable similar to coaxial cable, but with two inner conductors instead of one. It was the cable specified for the IBM 5250 terminals and printers, used with IBM's System/34, System/36, System/38,and AS/400.

Unibus: A bus architecture from Digital Equipment Corp. that was introduced in 1970 with its PDP-11 series. The bus was a circuit or set of circuits to allow attachment of devices, including disk drives and I/O devices.

UNIX: A powerful multi-tasking, multi-user computer operating system (OS). UNIX was developed at AT&T Bell Telephone Laboratories during the years 1969 to 1973 for minicomputer application. As UNIX is written in the highly portable C programming language, it is used on a wide variety of computers.

VAXCluster: A group of Dec VAX computers coupled together in a multiprocessing environment. A VAXCluster has separate processors and memories connected by a message-oriented interconnect, running separate copies of a distributed VAX/VMS operating system.

VLSI: **V**ery **L**arge **S**cale **I**ntegration) Between 100,000 and one million transistors on a single chip.

APPENDIX:

Marshall University Computing Services
400 Hal Greer Blvd.
Huntington, WV 25755-5320

Memorandum

To: The Marshall University Community

From: Arnold R. Miller
Executive Director, Computing Services

Date: November 2, 1998

Subj.: Reminder of Phase out of Computing Systems

Phase out of Computing Systems

This is a reminder to everyone that we are taking some of the older computers out of service as of December 31, 1998. These computers are known to you as **MUVMS4** and **MUVMS5** or generically as "**the VAX Cluster**". You probably will be affected if you "login" to either of these systems to perform some task. As a result of the retirement of these computers, several software systems that run on these machines will also be retired. On the reverse side of this memo you will find a list of the software systems or programs that will be retired as well as those critical systems that will be continued on a machine, MUVMS7. **All of these systems are legacy software that have been or are in the process of being functionally replaced by other systems.**

Even though we will be extending the life of several of these critical systems by moving them to MUVMS7 it needs to be noted that all of these programs have year 2000 problems and cannot continue past December 31, 1999. I will be updating you later with other details concerning the Year 2000 effort at Marshall.

As always if you have questions please contact the Help Desk at 3200.

Systems and programs to be discontinued as of December 31, 1998 due to the retirement of MUVMS4 and MUVMS5:

A1	The All-In-One office automation system. Some of you may still be using this system for letter generation.
PTS	The Payroll Tape System
PTS_LOOKUP	Query program to determine if a person is an employee
PBS	The Payroll Budget System
PAY	The Payroll System
DOF	The DOF Budget System
INS	The Institutional Research System
PER	The Personnel System
Cam001	The Telecommunications billing system
I9_LOOKUP	The I9 Lookup System
IAD010,20,and 2A	Foundation 1099 System
INV	Inventory System
PO	Purchasing System
JNET/BITNET	Communications software that allows for remote job entry to WVNET Mainframes and BITNET mail
PINE	Email program (PINE will still be available on the HOBBIT cluster)
SNAPRE	Allows SNA based printers to print to certain campus printers (used by CUFS, FIMS, and FinAid PHEA printers)
SmartMailer	A system to generate mailing labels and lists. Wordprocessors and database programs on your PC generally replace this function.
Some Email addresses	email addresses of the form *my_user_name*@muvms4.wvnet.edu, @muvms5.wvnet.edu, @marshall.wvnet.edu, @ mu.wvnet.edu, and Bitnet mail (this is usually an historical address, formatted as listed, used generally before 1992 that may still exist on listserves, and other personal directories etc.)

Currently scheduled to be migrated to MUVMS7:

PTS, PBS, PAY, JNET, SNAPRE, INV

THE AUTHORS:

Jack L. Dickinson
Biographical Sketch

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Jack is a West Virginia native and a 1966 graduate of Marshall University. He is a retired IBM Systems Engineer. In that position in the late 60's, he wired control panels for the IBM 403/407 Accounting machines, similar to the one that was at Marshall. He also supported the system software on the IBM 1620 Computer, including the one at Marshall. He also supported the S/38 at the School of Medicine. He is currently employed by Marshall as the Curator of the Rosanna Blake Library of Confederate History, part of Marshall's Special Collections Department. This collection has been ranked among the top five Southern and Confederate history collections in the United States outside the National Archives. Jack is the author of over a dozen books and numerous magazine articles on the Civil War, including two unit histories in the Virginia Regimental Histories Series. He and his wife have also co-authored a five volume set of books on the railroad history of southern West Virginia, and a volume on the history of lumbering and timbering in southern West Virginia. Jack is also a member of the Company of Military Historians, a group of writers on military subjects, and has had articles published in their Journal. Jack is the 1999 recipient of the Jefferson Davis Historical Writing Award from the United Daughters of the Confederacy and the History Writer's award from the West Virginia Dept. of Archives and History. He is also the 2009 recipient of the West Virginia National Society of Daughters of the American Revolution (DAR) award for outstanding contributions to West Virginia state and local history and a recipient of the DAR's National History Medal. He recently completed his term on the West Virginia Archives and History Commission and is a Kentucky Colonel.

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Biographical: Arnold R. Miller is currently retired as the Asst. Vice President for Information Technology at Marshall University. He is a graduate of that institution having received a Bachelors Degree in Chemistry with minors in Mathematics, Physics, and Biology a Master of Science degree in Biological Sciences and the Ed. D. in Higher Education Administration. He has attended various professional development seminars on Management Effectiveness, Strategic Planning, Computing Systems and Network Design, Designing the Classroom of the Future, Effective Telecommunications Design and Management, and Remote Sensing Techniques. He has served on the faculties of both Marshall University and Ohio University teaching courses ranging from Introductory Computer Science, Systems Analysis, Programming, and Compiler Design, to Laboratory Instrumentation and Scientific Computing. At various times, Dr. Miller has held the positions of Television Technician and Studio Assistant at Marshall University Instructional TV and WPBY-TV, Producer-Director of Instructional TV at Marshall University. Clinical Chemist, Assistant Section Chief of Automated Chemistry, and Bioelectronics and Quality Control Specialist at Cabell Huntington Hospital, Huntington WV, and Programmer/Analyst, Assistant Director, Director, and Executive Director of University Computing Services and the Assistant Vice President for Information Technology at Marshall University. Dr. Miller enjoys Traveling, skiing, running and holds a 1st Degree Black Belt in Tae Kwon Do.

Publications:

Miller, A. R. (2003). An Analysis of the Relationships Between the Perceived Organizational Climate and Professional Burnout in Libraries and Computing Centers in West Virginia Public Higher Education Institutions. Dissertation Abstracts International, 64(11), p. 3973.

Brumfield, J. O., V. B. Robinson, A. Miller and R. Boyd, "Experiments in the Spatially Distributed Processing of Land Resources Data," invited paper presented at the International Conference on Integration of Remote Sensed Data in Geographic Information Systems for Processing of Global Resource Information, May 29-31, 1985, Washington D.C.

Brumfield, J.O., A. Miller, V.B. Robinson and A. Yost, "EARTHNET: A Spatially Distributed Processing Experiment for Earth Resources Data, "

paper presented at and published in the proceedings of the International Conference on Advanced Technology for Monitoring and Processing, Global Environmental Information, convened by CERMA and the Remote Sensing Society. September 9-13, 1985, London, UK.

Presentations: Whitt, Joseph, Miller, Arnold R. "The MARC (Mobile Alternative for Residents on Campus) Program", ACUTA (American College and University Telecommunications Association) Fall Symposium, October 27, 2004, Hyatt Regency, St. Louis, Mo.

Fox, Jan I., Miller, Arnold R. , Whitt, Joseph. "Moving Dorm Phones to Cellular, Losing Revenue or Gaining Students?" EDUCAUSE 2004 Annual Conference, October 21, 2004, Colorado Convention Center, Denver, Co.

Miller, Arnold R. "A One Room School – The Future of Education?" ACUTA (American College and University Telecommunications Association) 30th Annual Conference & Exposition, July 29- Aug. 3, 2001, Disney Contemporary Resort, Lake Buena Vista, Fl.

Miller, Arnold R. "The One Room School – 2000" WVNET 2000, November 13-15, 2000 Lakeview Scanticon Resort Morgantown, WV.

Miller, Arnold R. "Technology at Marshall University: The 3 Rs" WVNET 1993, November 1993, Sheraton Lakeview Resort Morgantown WV.

Grants: Enhancing Inter- and Intra-campus Cyber-Infrastructure at West Virginia's Research Institutions, Project Manager, NSF EPSCoR RII C2 grant. $500,000, July 2010 - June 2012

WV Rural Health Connectivity Infrastructure Initiative, Project Manager, FCC Rural Health Pilot grants, $400,000, July 2009 – June 2013.

CrossRoads 2000, Principal Investigator, U.S. Department of Commerce, National Telecommunications Infrastructure Administration (NTIA), Telecommunications and Information Infrastructure Assistance Program (TIIAP), $520,000, October 2000.

One Room School-2000, Principal Investigator, U.S. Department of Commerce, National Telecommunications Infrastructure Administration (NTIA), Telecommunications and Information Infrastructure Assistance Program (TIIAP), $550,000, October 1998.

ENDNOTES

1 .http://www.bbc.co.uk/history/topics/enigma
http://www.rutherfordjournal.org/article030108.html
http://home.bt.com/tech-gadgets/cracking-the-enigma-code-how-turings-bombe-turned-the-tide-of-wwii-11363990654704

2. Georges Ifrah, *The Universal History of Computing.* New York: John Wiley & Sons, Inc., 2001, 188-191. Ifrah builds this whole argument against the early machines because they were electromechanical and weren't driven by a software program that could perform conditional branching.

3. Marie-Laure Ryan, Lori Emerson, Benjamin J. Robertson(ed). T*he John Hopkins Guide to Digital Media.* Baltimore: Johns Hopkins Univ., 2014, 290.

4. IBM Corp., IBM Personal Study Program: *Punched Card Data Processing Principles*, White Plains, N.Y.: International Business Machines Corp., 1961, sections 1 and 7.

5. Jack Dickinson, IBM technical education and hands on training, wired many control panels in the 1960's for customers with an IBM 402, 403, 407, and 519.

6. Ifrah, 242.

7. IBM Corp., sections 6 and 7.

8. Jack Dickinson, IBM technical education and hands on training, 1960's and 70's.

9. Interviews with Emeritus Prof. Thomas Olson, Jan. & Feb., 2018.

10. Charles Moffat, *Marshall University: An Institution Comes of Age 1837-1980.* Huntington, WV: Marshall University Alumni Association ; [s.l. : American Yearbook Co.], 1981, 201.

11. Marshall University, *Parthenon*, May 14, 1965.

12. Jack Dickinson taught the class that Sam Bauserman was in and discussed his programming with him.

13. Marshall University, *Parthenon*, Feb. 1, 1968.

14. Marshall University, *Parthenon*, April 19, 1968.

15. IBM Archives: http://www-03.ibm.com/ibm/history/exhibits/mainframe/mainframe_PP1620.html
Also: http://www.computerhistory.org/projects/ibm_1620/ibm1620/

16. http://www.columbia.edu/cu/computinghistory/1620.html, and IBM Corp: *IBM 1620 Data Processing System Reference Manual*, A26-4500-2, (pub. 1959, major revision 1961), found at:
https://usermanual.wiki/Document/A26450021620refJul61.1013315994

17. Arnold Miller, *A History of Computing at Marshall University*. Unpublished manuscript. WVU Graduate School, 1995, 5.

18. Marshall University, *Parthenon*, Aug. 13, 1970.

19. Wikipedia contributors. PDP-8. Wikipedia, The Free Encyclopedia. April 28, 2018, 01:32 UTC. Available at: https://en.wikipedia.org/w/index.php?title=PDP-8&oldid=838597424. Accessed April 28, 2018. (Cited here because as of this writing, most of the DEC technical manuals for this machine are not available online.) Also: The Computer History Museum: http://www.computerhistory.org/revolution/minicomputers/11/331/1907. Also: Gibson Research Corp: https://www.grc.com/pdp-8/docs/PDP-8_Small_Computer_Handbook_1972.pdf.

20. Olson interviews.

21. Marshall University, *Parthenon*, Feb. 4, 1972.

22. Olson interviews.

23. Hewlett-Packard Corp: *1970 Electronics* (1970 products catalog), 67.

24. Interview with Emeritus faculty Merry Brown, Jan. 17, 2018, and Emeritus Archivist Cora Teel, Jan. 22, 2018.

25. Ibid.

26. Marshall University, *Parthenon*, Aug. 2, 1984.

27. HP Computer Museum: http://www.hpmuseum.net/display_item.php?hw=100, and Hewlett-Packard Corp: http://hparchive.com/Catalogs/HP-Catalog-1984.pdf.

28. https://fedtechmagazine.com/article/2017/05/hp-3000-made-history-first-computer-white-house.

29. Brown interview.

30. Interview with Emeritus Dean of College of Business, Dr. Robert Alexander, Mar. 15, 2018.

31. IBM Archives: http://www-03.ibm.com/ibm/history/exhibits/vintage/vintage_4506VV4024.html Also Rhode Island Computer Museum: http://www.ricomputermuseum.org/Home/equipment/ibm-series1

32. IBM Corp: Series 1 Programming System Summary Jan 81.pdf (description of S/1 operating systems), found at: http://bitsavers.trailing-edge.com/pdf/ibm/series1/GC34-0285-2

33. *Computerworld* magazine, June 9, 1986.

34. https://www.extremetech.com/extreme/229239-the-united-states-nuclear-system-still-runs-in-part-on-eight-inch-floppy-disks (Series/1 used for nuclear control)

35. Interview with Emeritus MU Bookstore manager, Joe Vance, Mar. 12, 2018.

36. *IBM S/36 Systems Reference*, SC21-9020-4, *IBM S/36 Facts Folder*, G360-0809-4. Found at: http://www.typewritten.org/Articles/IBM/g360-0809-04.pdf

37. Jack Dickinson, IBM technical education and hands on training, 1980's.

38. Marshall University Center for Regional Progress, "Computer Capabilities and Resources of Marshall University." Paper. 1987, 11.

39. Ibid., 40.

40. Jack Dickinson personal experience. He was the IBM Systems Engineer who had to restore their system.

41. IBM Archives and IBM Knowledge Center, found at: https://www.ibm.com/support/knowledgecenter/

IBM S/38 Functions Reference Manual, *GA21-9331-1*, found at http://bitsavers.trailing-edge.com/pdf/ibm/system38/GA21-9331-_System_38_Functional_Reference_Manual_Feb81.pdf

IBM Product Design and Development, General Systems, *"Introduction to IBM System/38 Architecture," IBM System 38 Technical Developments, G580-0237-1*, found at: http://bitsavers.org/pdf/ibm/system38/IBM_System_38_Technical_Developments_Dec1978.pdf

42. https://www.ithistory.org/db/hardware/ibm/ibm-system-9000

43. https://www.ibm.com/search?q=%22ibm+system+9000%22&v=17&en=utf&lang=en&cc=us)

44. Miller, 6-7, and 34.

45. Interviews with Emeritus faculty Dr. Earl Damewood, Jan. & Feb. 2018.

46. IBM internal education course: “IBM 3780 vs DATA 100,” (Class for IBM systems engineers and marketing reps,) Detroit, Mich., ca. 1977.

47. Miller, 8-9.

48. http://www.psych.usyd.edu.au/pdp-11/11_40.html

49. http://history-computer.com/ModernComputer/Electronic/PDP-11.html

50. *DEC PDP 11/40 Processor Handbook*, found at: https://pdos.csail.mit.edu/6.828/2005/readings/pdp11-40.pdf, 1-2.

51. https://chessprogramming.wikispaces.com/PDP-11.

52. Miller, 9.

53. Ibid., 10-11.

54. https://deskthority.net/keyboards-f2/pertec-computer-corporation-pcc-xl40-detachable-keyboard-t13334.html

55. Miller, 11-12

56. http://www.cpushack.com/CPU/cpu3.html

57. http://www.psych.usyd.edu.au/pdp-11/models.html

58. http://www.technology.niagarac.on.ca/people/mcsele/hobby/vintage-digital-pdp-11-computers/.

59. Rhode Island Computer Museum: http://www.ricomputermuseum.org/Home/equipment/pdp-11-34a

60. Arnold Miller, email to Jack Dickinson, Jan. 31, 2018.

61. Miller, 12-15.

62. http://www.old-computers.com/history/detail.asp?n=20&t=3

63. http://www.computerhistory.org/timeline/1978/

64. Wikipedia contributors. (2018, January 13). VAX. In *Wikipedia, The Free Encyclopedia*. Retrieved 14:36, May 2, 2018, from https://en.wikipedia.org/w/index.php?title=VAX&oldid=820117825

65. IBM Education course: Competition seminar, “IBM vs DEC VAX,” IBM Region 5 Center, Chicago.

66. Kristie Macrakis, *Seduced by Secrets: Inside the Stasi's Spy-Tech World.* Cambridge University Press, 2008, 119-122.

67. Miller, 16.

68. DEC brochure:”VAX 8700-Start with High Performance and Grow,” found at: https://www.1000bit.it/js/web/viewer.html?file=%2Fad%2Fbro%2Fdigital%2Fdec%2Dvax8700overview%2Epdf#zoom=page-fit

69. Miller, 17

70. ttps://www.theregister.co.uk/2016/11/02/ghost_of_dec_alpha_sees_microsoft_dumb_down_windows_file_compression/ and: https://www.techopedia.com/definition/18752/dec-alpha

71. Miller, 17-18.

72. http://www.computinghistory.org.uk/det/10535/Digital-MicroVAX-3100/

73. http://home.iae.nl/users/pb0aia/vax/dsvs3100.html (Best VAX 3100 article)

74. Miller, 18.

75. Arnold Miller, email to Jack Dickinson, Apr. 13, 2018.

BIBLIOGRAPHY

Published Sources:

Hewlett-Packard Corp., *1970 Electronics* (1970 products catalog).

IBM Corp. IBM Personal Study Program: *Punched Card Data Processing Principles*, 7 vols. [sections], White Plains, N.Y.: International Business Machines Corp., 1961.

Ifrah, Georges. *The Universal History of Computing.* New York: John Wiley & Sons, Inc., 2001.

Levy, Henry M. and Richard H. Eckhouse, Jr. *Computer Programming and Architecture: The VAX*. Digital Equipment Corp: 1980.

Macrakis, Kristie. *Seduced by Secrets: Inside the Stasi's Spy-Tech World.* Cambridge University Press, 2008.

Moffat, Charles. *Marshall University: An Institution Comes of Age 1837-1980.* Huntington, WV: Marshall University Alumni Association ; [s.l. : American Yearbook Co.], c1981.

Ryan, Marie-Laure, Lori Emerson, Benjamin J. Robertson(ed). T*he John Hopkins Guide to Digital Media.* Baltimore: Johns Hopkins Univ., 2014.

West Virginia Network for Educational Telecomputing (WVNET). *WVNET VAX User's Guide.* Morgantown, WV: 1991.

Manuscripts and Other Sources:

IBM Education course: Competition seminar, "IBM vs DEC VAX," IBM Region 5 Center, Chicago, ca. 1985.

IBM Education course: Competition seminar, "IBM 3780 vs DATA 100" (Class for IBM systems engineers,) Detroit, Mich., ca. 1977.

Following six interviews all by Jack L. Dickinson:
Interview with Emeritus Dean of College of Business, Dr. Robert Alexander, Mar. 15, 2018.
Interview with Emeritus Archivist, Cora Teel, Jan. 22, 2018.
Interviews with Emeritus faculty Dr. Earl Damewood, Jan. & Feb. 2018.
Interviews with Emeritus Prof. Thomas Olson, Jan. & Feb., 2018.
Interview with Emeritus faculty Merry Brown, Jan. 17, 2018.
Interview with Emeritus MU Bookstore Manager, Joe Vance, Mar. 12, 2018.

Marshall University Center for Regional Progress. “Computer Capabilities and Resources of Marshall University.” Paper, 1987.

Marshall University, *Parthenon* (student newspaper), 1959-1999.

Miller, Arnold R. *A History of Computing at Marshall University*. Unpublished manuscript. WVU Graduate School, 1995.

Internet Sources by Machine type:
(In the order they appear in the book.)

The Computer Dictionary: http://computer.yourdictionary.com/

IBM 403/407:

IBM Corp. Archives: http://www-03.ibm.com/ibm/history/exhibits/vintage/vintage_4506VV4007.html

IBM Corp*: IBM 402, 403 and 407; IBM 421, 444, 407 and 447 for World Trade Corporation Computing Accounting Machines*, IBM, undated, 11pp, A24-3475-0.

IBM Corp: http://www.bitsavers.org/pdf/ibm/punchedCard/AccountingMachine/22-5765-7_407_Operation_1953.pdf (407 Operations Manual)

IBM 1620:

IBM Corp. Archives: http://www-03.ibm.com/ibm/history/exhibits/mainframe/mainframe_PP1620.html

IBM Corp: *IBM 1620 Data Processing System Reference Manual*, A26-4500-2, (pub. 1959, major revision 1961) Found at: https://archive.org/stream/bitsavers_ibm1620A26_10244733/A26-4500-2_1620ref_Jul61_djvu.txt

Columbia University: http://www.columbia.edu/cu/computinghistory/1620.html

http://www.textfiles.com/bitsavers/pdf/ibm/1620/Basic_Programming_Concepts_and_the_IBM_1620_Computer_1962.pdf

DEC PDP 8:

https://www.pdp8.net/query_docs/query.shtml

http://www.computerhistory.org/revolution/minicomputers/11/331

Rhode Island Computer Museum:
http://www.ricomputermuseum.org/Home/equipment/pdp-8s

http://www.faqs.org/faqs/dec-faq/pdp8-models/section-1.html#b

https://web.archive.org/web/20060304190934/http://americanhistory.si.edu/collections/comphist/objects/pdp8.htm

Gibson Research Corp: https://www.grc.com/pdp-8/docs/PDP-8_Small_Computer_Handbook_1972.pdf

HP 3000 and 2114B:

Hewlett-Packard Corp. Archives: www.hparchive.com

Hewlett-Packard Corp: *1970 Electronics* (1970 products catalog)

Hewlett-Packard Corp: http://hparchive.com/Catalogs/HP-Catalog-1984.pdf

HP Computer Museum: http://www.hpmuseum.net/exhibit.php?class=3&cat=32

https://fedtechmagazine.com/article/2017/05/hp-3000-made-history-first-computer-white-house

http://bitsavers.trailing-edge.com/pdf/hp/3000/configurationGuide/5953-0580D_HP3000_Price_Configuration_Guide_Oct79.pdf

IBM Series/1:

IBM Corp. Archives:
http://www-03.ibm.com/ibm/history/exhibits/vintage/vintage_4506VV4024.html

Rhode Island Computer Museum:
http://www.ricomputermuseum.org/Home/equipment/ibm-series1

https://www.extremetech.com/extreme/229239-the-united-states-nuclear-system-still-runs-in-part-on-eight-inch-floppy-disks (S/1 used for nuclear control)

IBM Corp: Series 1 Programming System Summary Jan 81.pdf (description of S/1 operating systems), found at: http://bitsavers.trailing-edge.com/pdf/ibm/series1/GC34-0285-2

IBM S/36-PC:

IBM Co. Archives: https://www-03.ibm.com/ibm/history/exhibits/rochester/rochester_4018.html

IBM S/36 Systems Reference, SC21-9020-4

IBM S/36 Facts Folder G360-0809-4, (Aug. 1985 edition) Found at: http://www.typewritten.org/Articles/IBM/g360-0809-04.pdf

IBM System 38:

IBM Archives and IBM Knowledge Center, found at: https://www.ibm.com/support/knowledgecenter/

IBM S/38 Functions Reference Manual, *GA21-9331-1*, found at http://bitsavers.trailing-edge.com/pdf/ibm/system38/GA21-9331-_System_38_Functional_Reference_Manual_Feb81.pdf

IBM Product Design and Development, General Systems, *"Introduction to IBM System/38 Architecture," IBM System 38 Technical Developments, G580-0237-1*, found at: http://bitsavers.org/pdf/ibm/system38/IBM_System_38_Technical_Developments_Dec1978.pdf

DATA 100:

https://en.wikipedia.org/wiki/Data_100

https://aadl.org/taxonomy/term/30822 (1978 newspaper article)

http://www.cbi.umn.edu/resources/mncomphist-d.html

DEC PDP 11/34 and 11/40:

https://trmm.net/PDP-11

http://bitsavers.trailing-edge.com/pdf/dec/pdp11/handbooks/PDP11_Handbook1979.pdf

http://www.cpushack.com/CPU/cpu3.html

http://www.psych.usyd.edu.au/pdp-11/11_40.html

http://www.psych.usyd.edu.au/pdp-11/models.html

Pertec XL/40:

https://deskthority.net/keyboards-f2/pertec-computer-corporation-pcc-xl40-detachable-keyboard-t13334.html

https://www.bing.com/images/search?q=%22pertec+xl%2F40%22&qs=n&form=QBILPG&sp=-1&pq=%22pertec+xl%2F40%22&sc=0-14&sk=&cvid=73C39B8C9212400582DBB5F0BE027086 (Pertec images)

computer.wikia.com/wiki/Pertec_Computer

http://www.liquisearch.com/pertec_computer/pertec_business_systems/pertec_xl-40

DEC (general history):

https://digital.com/about/dec/ (Best general history of DEC Corp.)

http://archive.boston.com/business/technology/gallery/dectimeline?pg=9

https://chessprogramming.wikispaces.com/PDP-11
https://pdos.csail.mit.edu/6.828/2005/readings/pdp11-40.pdf

http://history-computer.com/ModernComputer/Electronic/PDP-11.html

DEC VAX & DEC VAX 780/785:

https://pdfs.semanticscholar.org/5871/e752c6aabe8ccb04e05a3a8b8604f494ce4e.pdf

http://www.old-computers.com/history/detail.asp?n=20&t=3

https://williambader.com/museum/vax/vaxhistory.html (Best technical history of VAX)

https://fedtechmagazine.com/article/2017/07/decs-vax-superminicomputer-became-mainstay-federal-research

http://www.computerhistory.org/revolution/mainframe-computers/7/182/736

Digital Equipment Corp: *DEC Product Sales Guide-VAX*, found at
http://www.bitsavers.org/pdf/dec/vax/EG-21731-18_VAX_Product_Sales_Guide_Apr82.pdf

DEC VAX 8700:

DEC brochure: "VAX 8700-Start with High Performance and Grow," found at: https://www.1000bit.it/js/web/viewer.html?file=%2Fad%2Fbro%2Fdigital%2Fdec%2Dvax8700overview%2Epdf#zoom=page-fit

MicroVAX (3000 & 3900):

http://www.computinghistory.org.uk/det/10535/Digital-MicroVAX-3100/

http://home.iae.nl/users/pb0aia/vax/dsvs3100.html (Best VAX 3100 article)

Q: What is an elephant?
A: A mouse with an IBM operating system.