THE COMPUTER MUSEUM REPORT

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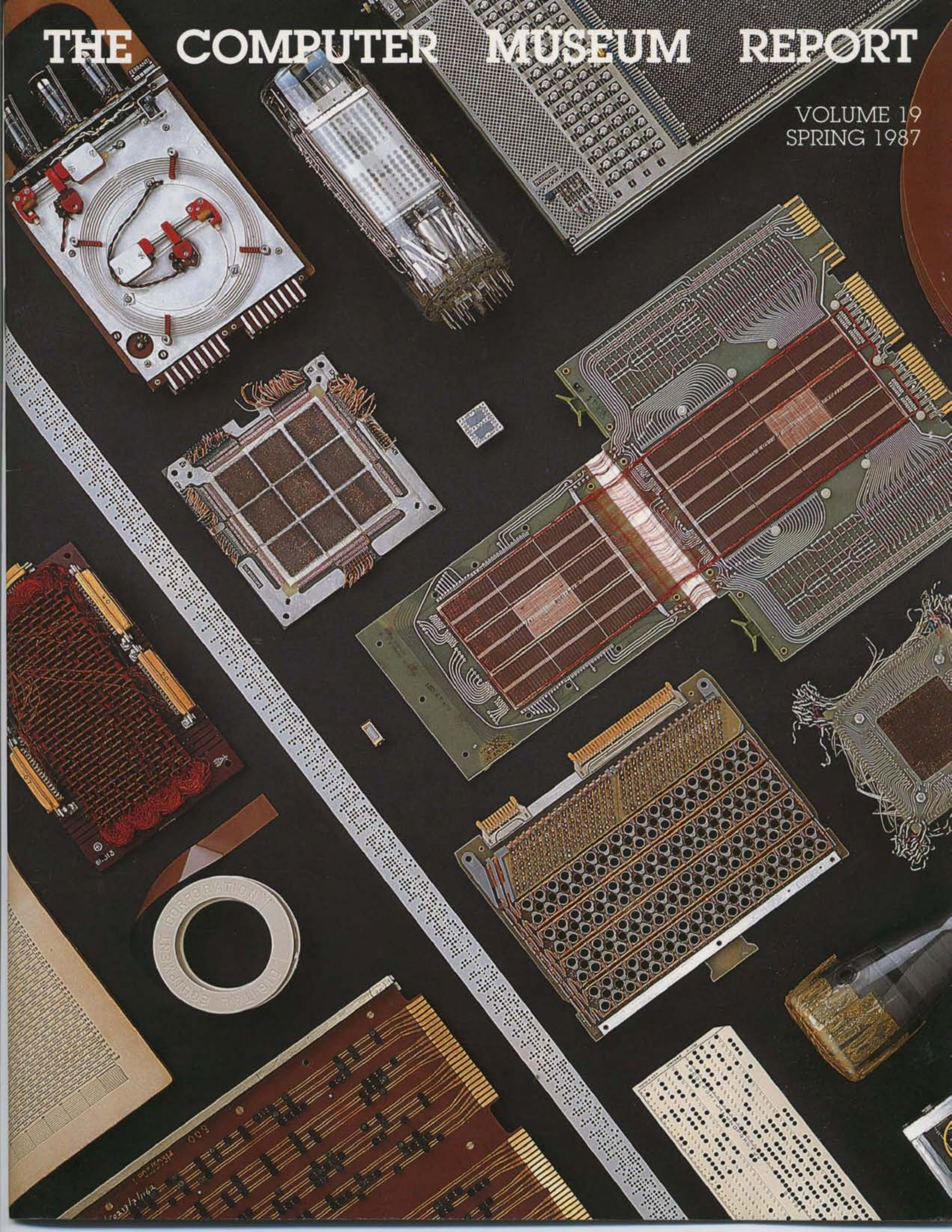

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The Computer Museum Names New Executive Director

The Board of Directors announced the appointment of a new Executive Director, Joseph F. Cashen, 52, one of the seven original founders of Prime Computer, Inc. Chairman J. William Poduska, Sr., formally introduced Cashen at a Board meeting on February 18, 1987. "When we were at Prime together," Poduska commented, "Joe was always a leader. And now as he accepts the responsibility to direct The Computer Museum, an important resource for the whole industry, he again provides a model of service and integrity. We are extraordinarily fortunate to have Joe at the helm."

Formerly an independent consultant to a number of Massachusetts high tech companies, the new director said, "I joined The Computer Museum because I believe in it. The Museum's size and stage of development allows individuals to make contributions that have major impact. I look forward to building on the established base and helping the Museum to grow into a world class institution with a staff of truly dedicated and talented people." Cashen served as Chief Executive Officer of Acorn Computer, Inc., of Woburn, Mass. in 1983. He spent eleven years with Prime, serving as Vice President of Engineering. Previously he was employed in various management positions in the Computer Control Division of Honeywell, Inc.

His appointment highlights an expansion of the Museum's effort to increase the role it plays in educating a wider audience about the technology, applications and impact of computers in today's society. It also marks the beginning of phase two of the Museum's capital campaign . The Museum has raised over three million dollars to date. These funds allowed the Museum to become established downtown. This position must now be firmly secured through the purchase of a half-interest in the building. Campaign Chairman Paul Severino has brought together a talented and diverse team of volunteers, from all corners of the industry, to help raise the three million dollars needed to successfully complete phase two.

Founding President Gwen Bell stated, "I've watched the Museum grow from a lobby to a building; from one person to many; and from static to dynamic exhibits. Many members and supporters have joined along the way. As we enter a new phase of growth, we need further support. There are terrific challenges ahead, in fund raising, membership development, attendance and new exhibits. Please join me in welcoming Joe aboard, and as a loyal supporter, I hope you'll do all you can to help Joe and the Museum meet the important goals ahead."

Executive Director, Joseph F. Cashen

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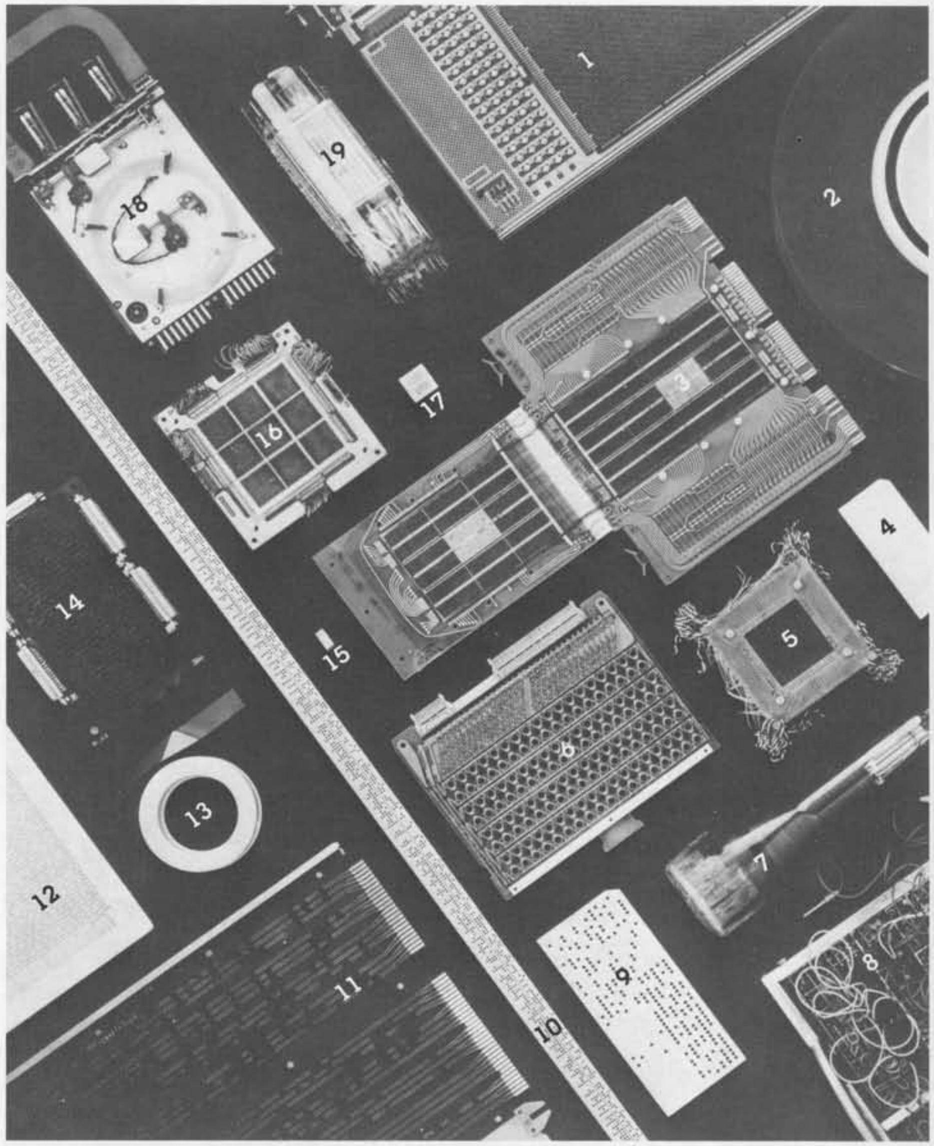
Memories Poster Directory

1. Read only memory from Honeywell (1970)
2. IBM 1316 Disk Pack (1963)
3. Planar core memory board from DEC (1972)
4. Small Powers-Samas punched card (c. 1950)
5. Block of magnetic core memory from CDC 6600 (1963)
6. Rod cell memory board from Nixdorf 82023 (1969)
7. Williams tube from the Maniac (c. 1950)
8. IBM Plugboard (c. 1930s)
9. Univac 90-column punched card (1951)
10. Fan-fold paper tape (c 1961)
11. Pegboard program tray from Fernati Argus 200 (c. 1965)
12. "Complete Mathematical Chart" by C.W. Goodchild (c. 1900)
13. Dec-Tape magnetic tape (1964)
14. Read only Rope Memory from Apollo Guidance Computer (1963)
15. 256K Random Access Memory by Hitachi (1985)
16. Core plane from Honeywell 58 (1970)
17. 64K Random access memory 8 chip double layer package by IBM (1978)
18. Short Magneto-Restrictive delay line from Ferranti Pegasus (1956)
19. Selection from the Johnniac (c.1950)



Memories Chart

The earliest memories appear in the upper left hand quandrant. They have linear access and are readable or writeable by a machine. The latest and most ideal memories are in the lower right hand quadrant: they have random access and are both machine writeable and readable.

	Readable OR Writeable: Linear Access	Readable OR Writeable: Random Access
Pre-Computer	Badge Cards Plot Printed Page Punched Cards Punched Paper Tape	CRT Knobs Patchboard Switches
Computer	Badge Cards Plot Printed Page Punched Cards Punched Paper Tape	CRT Keys Knobs Patchboard Switches

Memories
Stories Behind the Devices

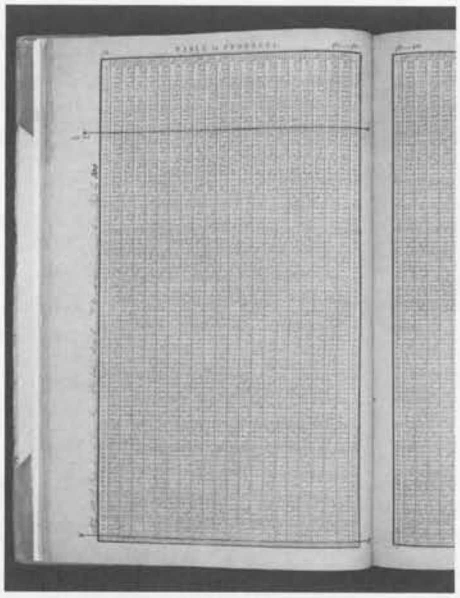
Gwen Bell

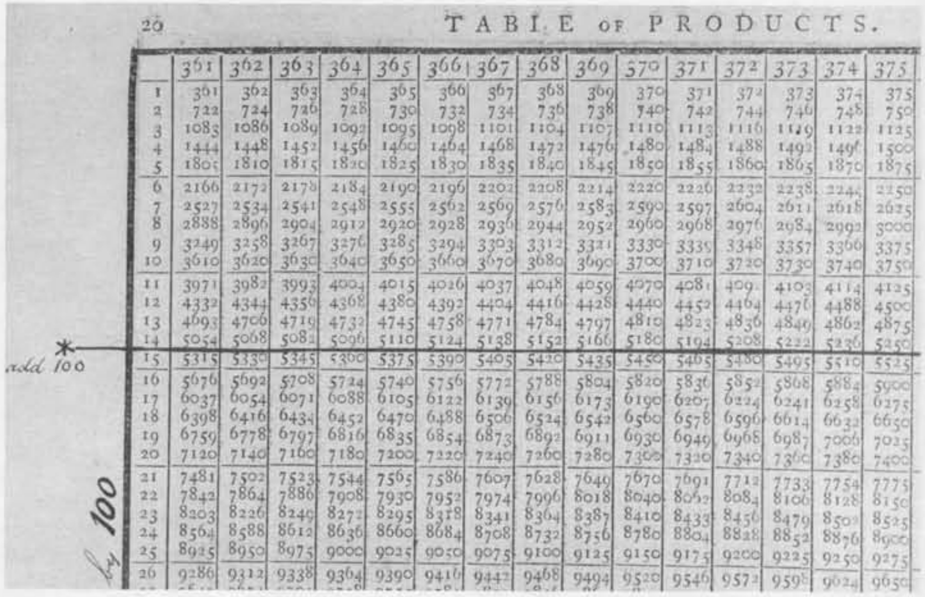
The computer memories on the cover are evocative of the collection of memory devices held by the Museum and of many people's experiences in computing. A large number of these devices were used to store the program, and thus they represent the software as well as the hardware dimension of computing.

The collection of items was made by Dr. Oliver Strimpel and me and was then refined by David Sharpe, the photographer. Our goal was to provide a beautiful and evocative image. In this article I will use the image to tell more stories of the Museum's holdings. In describing the stored program computer, John Von Neumann used the term memory instead of storage because he likened the computer to the human nervous system. Despite a variety of efforts to call computer memory, storage, memory is the word that has stayed with us. Storage is often used for secondary files, such as magnetic tape or discs, and tertiary (archival) memories, such as tape storage that requires human intervention before it is accessed by the computer.

The collection and the poster also include devices for remembering that predate the computer. The PMS classification system described in Bell and Newell's, *Computer Structures*, was used to develop the collection. Their appendix described and further classified memories into three main classes: either machine read or written, machine readable only, and readable and writeable memories. Three other features are considered important: access, portability, and permanency. Of these, the most important is the form of access, i.e., whether it is linear, cyclical, or random. The table shows that the illustrations on the poster are indeed representative of the various sections of the memory taxonomy.

Machine Readable	**Readable AND Writeable**		
Random Access	**Cyclical Access**	**Linear Access**	**Random Access**
	Delay Line Magnetic Tape Mechanical Disk		
Capcitor Array Compact Disk Diode Aray Inductor/Transformer Integrated Circuit Rope Coupled Array	Delay Lines Magnetic Bubble Magnetic Card Magnetic Disk Magnetic Drum	Magnetic Tape	Core Electrostatic Tube Integrated Circuits Logic Technology Photographic Store Plasma Display





20 TABLE OF PRODUCTS.

	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375
1	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375
2	722	724	726	728	730	732	734	736	738	740	742	744	746	748	750
3	1083	1086	1089	1092	1095	1098	1101	1104	1107	1110	1113	1116	1119	1122	1125
4	1444	1448	1452	1456	1460	1464	1468	1472	1476	1480	1484	1488	1492	1496	1500
5	1805	1810	1815	1820	1825	1830	1835	1840	1845	1850	1855	1860	1865	1870	1875
6	2166	2172	2178	2184	2190	2196	2202	2208	2214	2220	2226	2232	2238	2244	2250
7	2527	2534	2541	2548	2555	2562	2569	2576	2583	2590	2597	2604	2611	2618	2625
8	2888	2896	2904	2912	2920	2928	2936	2944	2952	2960	2968	2976	2984	2992	3000
9	3249	3258	3267	3276	3285	3294	3303	3312	3321	3330	3339	3348	3357	3366	3375
10	3610	3620	3630	3640	3650	3660	3670	3680	3690	3700	3710	3720	3730	3740	3750
11	3971	3982	3993	4004	4015	4026	4037	4048	4059	4070	4081	4092	4103	4114	4125
12	4332	4344	4356	4368	4380	4392	4404	4416	4428	4440	4452	4464	4476	4488	4500
13	4693	4706	4719	4732	4745	4758	4771	4784	4797	4810	4823	4836	4849	4862	4875
14	5054	5068	5082	5096	5110	5124	5138	5152	5166	5180	5194	5208	5222	5236	5250
15	5315	5330	5345	5300	5375	5390	5405	5420	5435	5450	5465	5480	5495	5510	5525
16	5676	5692	5708	5724	5740	5756	5772	5788	5804	5820	5836	5852	5868	5884	5900
17	6037	6054	6071	6088	6105	6122	6139	6156	6173	6190	6207	6224	6241	6258	6275
18	6398	6416	6434	6452	6470	6488	6506	6524	6542	6560	6578	6596	6614	6632	6650
19	6759	6778	6797	6816	6835	6854	6873	6892	6911	6930	6949	6968	6987	7006	7025
20	7120	7140	7160	7180	7200	7220	7240	7260	7280	7300	7320	7340	7360	7380	7400
21	7481	7502	7523	7544	7565	7586	7607	7628	7649	7670	7691	7712	7733	7754	7775
22	7842	7864	7886	7908	7930	7952	7974	7996	8018	8040	8062	8084	8106	8128	8150
23	8203	8226	8249	8272	8295	8318	8341	8364	8387	8410	8433	8456	8479	8502	8525
24	8564	8588	8612	8636	8660	8684	8708	8732	8756	8780	8804	8828	8852	8876	8900
25	8925	8950	8975	9000	9025	9050	9075	9100	9125	9150	9175	9200	9225	9250	9275
26	9286	9312	9338	9364	9390	9416	9442	9468	9494	9520	9546	9572	9598	9624	9650

One of the early books, Charles Hutton's, *Table of the Products and Numbers*, 1781, contains the products of the numbers 1 through 1000 by the numbers 1 through 100, and squares and cubes of numbers. This illustration shows all the figures on a line off by 1000. Page from Hutton's - with correction.

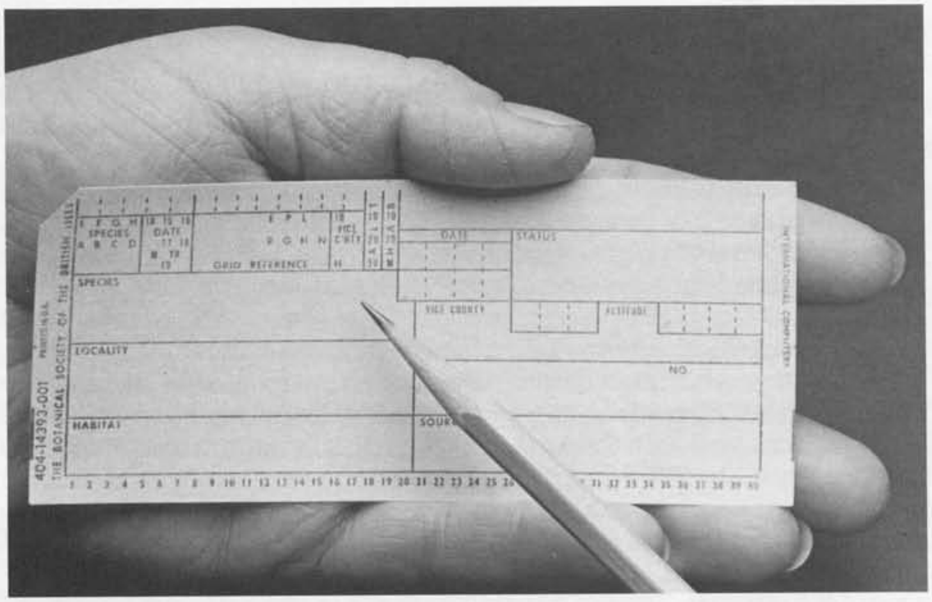
Pre-computer Memories: Read or Write

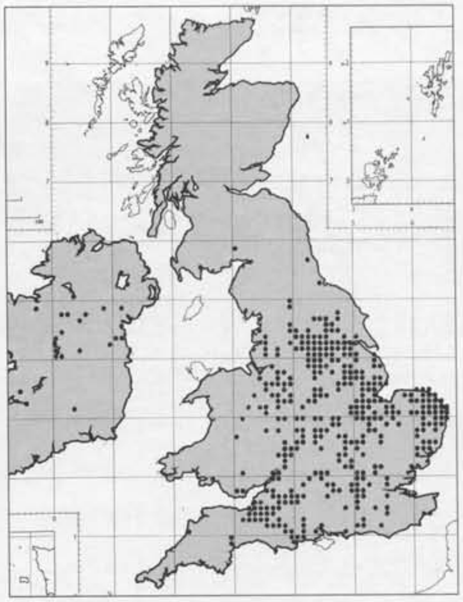
Linear Access

Table Look-up. Napier's Bones, devised at the beginning of the 17th century, were a form of memory for the multiplication tables. Then after John Napier devised logarthms and with the development of calculus, the answers to a series of simple equations were printed and sold widely as books. This phenomena of the book of tables continued through the 1960s. The problem with many of these books was their accuracy. The calculations were done by hand, then the type was set by hand. Sometimes final corrections were made by hand after proofreading..

The Difference Engine was designed by Charles Babbage to accurately produce and print pages of tables of differences. This was later built by Scheutz and produced books of differences. Howard Aiken, whose idea was to produce Babbage's Analytical Engine, desired to produce tables of Bessell Functions of astronomical observations. After the Harvard Mark I had completed these computations, the future use of the computers was questioned

"Complete Mathematical Chart" by Goodchilde, c. 1900 (item 12 in the poster), is two cardboard pages that were available for easy reference. The Museum's collection has a variety of examples of several cardboard pages filled with numbers and very thick books of the thinnest possible paper allowing for as much information as possible. Specialized pocket calculators and computers still maintain frequently used information in lookup tables. General purpose machines perform most calculations rather than relying on lookup tables.





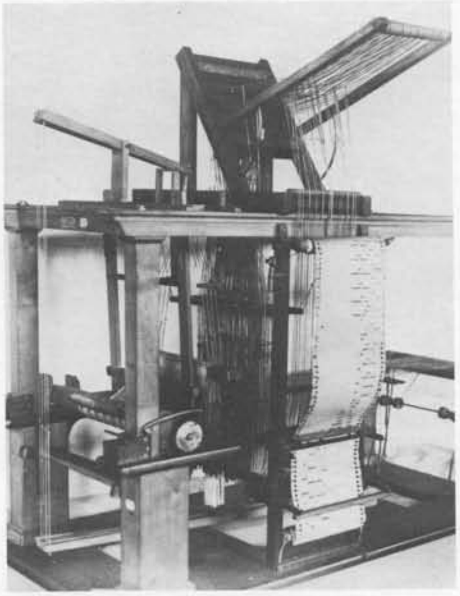
Powers Samas card for recording the distribution of flora and fauna in the British Isles. The map of Abramis was produced directly on a special printer developed for this system.

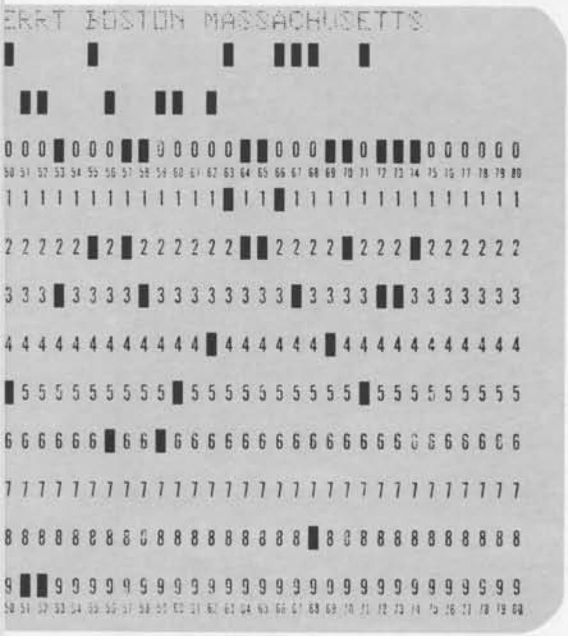
Punched Cards. In the 1790s, Joseph Jacquard designed a machine to weave silk patterns based on the ideas of Bouchon, deVaucauson and Falcon. This machine used an automatic harness controlled by punched cards connected in a roll that held the pattern. Babbage was inspired by the Jacquard loom and planned to use card input in the Analytic Engine.

Hollerith's punched-card system for the 1890 U.S. Census was the first to use cards for data processing. The size of the Hollerith card was based on the size of the dollar bill at the time, and the round punches were those used by trolley conductors. Hollerith's Computing, Tabulating and Recording Company hired Thomas J. Watson, Sr., as its President, and in 1924 the name was changed to International Business Machines. While the eighty column "IBM" card with rectagular holes became the standard, other sizes and shapes of holes were used for special purposes and niche markets.

The Computer Museum's collection includes a very special punched card system developed by Powers-Samas for the Institute for Terrestial Ecology in the UK. (Item 4). Field data on the location and species of flora and fauna were written directly on the card to be punched. In the late forties, Professor Maurice Wilkes, who was building the first stored-program computer, consulted on the design and development of a special printer that would take the data from the cards and produce dot maps of distributions in the British Isles.

The 19th century silk looms, where cards were used to create intricate patterns inspired Babbage to use cards to hold other kinds of information.



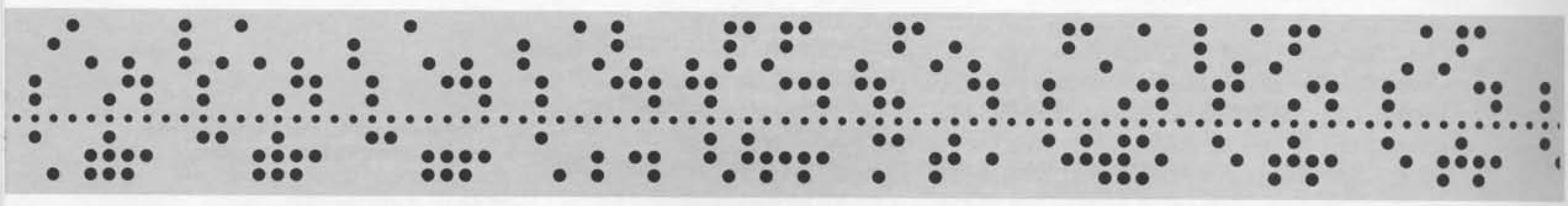


IBM 80 column card with rectangular holes

Computer Memories: Read or Write
Linear Access

Punched Cards. Most of the first computers adapted card systems for the input and output of data. The UNIVAC, the first commercial computer, had a 90 column card with round holes(Item 9). Setting one's own standard is often done to get or keep one part of the market. At the outset, when all the competitors are scrambling, the "winner," or de facto standard, is not always obvious. Then, those without standard products often make special compensations to win new customers. The 80 column IBM card became the standard, and UNIVAC came out with the Solid State 80/90. "Solid State" referred to the fact that it had 700 transistors and 3,000 ferractors or magnetic amplifiers and only 20 vacuum tubes. " 80/90" meant that it could deal with either the IBM 80 or UNIVAC 90 column cards.

One of the many problems with card storage was their very bulk and lack of density of information. For example, 60,000 cards were required to store the master program for the AN/FS Q7, SAGE system computer built in the late 1950s. They took up 24 cubic feet of space and had to be kept in order. (Later, a reader was developed that could accept cards in any direction or order.) To extend the life of card computing IBM developed System 3 with a smaller card that more than doubled the density of information. This provided no competition, however, for the floppy disk or integrated circuit.

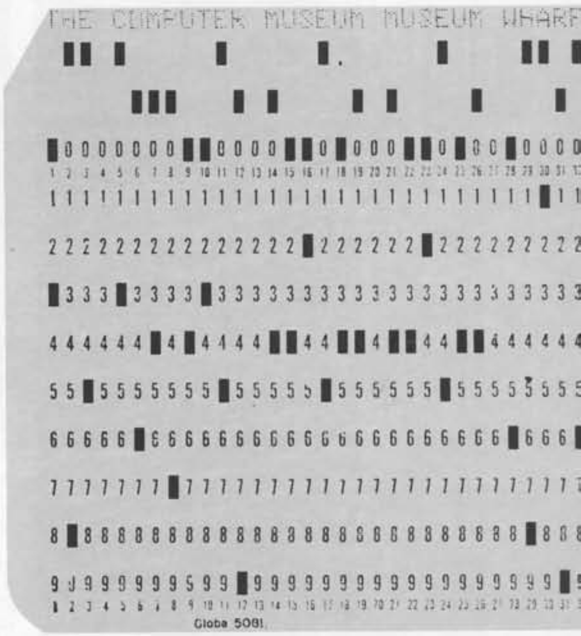


Flexowriters were used to punch the papertape for the input of data for many of the first computers. These machines and their antecedents were cheaper, stored upper and lower case, and had a better human interface than the punched-card machines. They led directly into the development of computers with keyboard input.

Punched Paper Tape. While the ENIAC used cards for input/output, the EDSAC, the first stored program computer built by Professor Maurice Wilkes at Cambridge University, used punched paper tape (Item 10). This form of input and storage of programs and data, adapted from telegraphy, was quite common on the early university computers. Flexowriters were used to punch tape that could be spliced together with previously punched subroutines. Flexowriters were replaced by Teletype, later Model 33s. Paper tape continued as a form of input up through the beginning of the micro-computer era. For example, Bill Gates delivered the first BASIC interpreter for the 1975 Altair on punched paper tape.

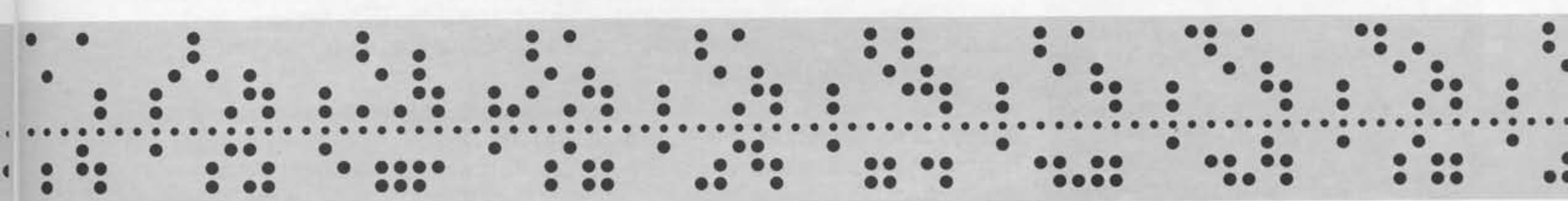
Computer Memories: Read or Write
Random Access

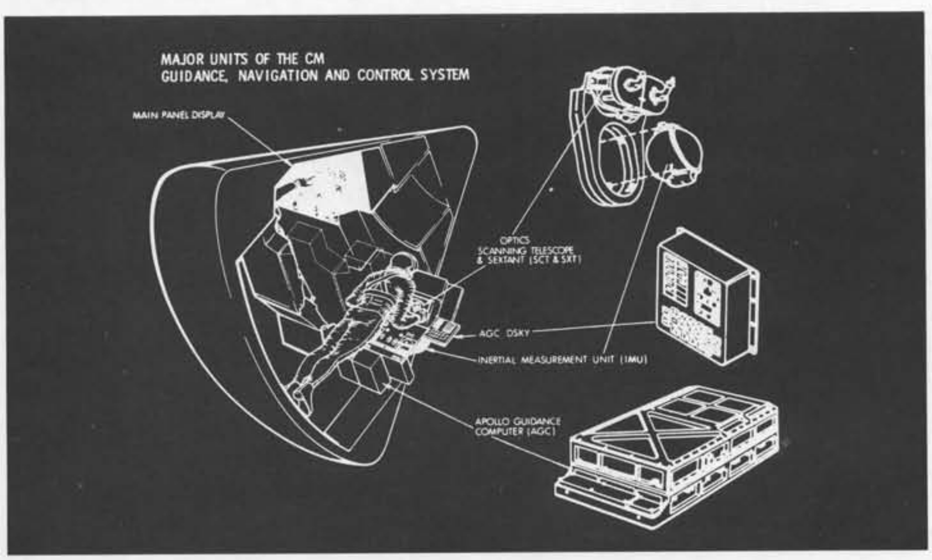
Patchboards. The pegboard program tray from the Ferranti Argus 200 (item 11) contained the master program for the machine. Master programs, the precursor of operating systems, were not placed in a read-only memory because the programmers wanted to be able to change them. This meant taking out the tray and replacing the magnetic pegs to make a different set of connections. The early users had even greater difficulty keeping up with the new versions of fundamental operating systems since programmers could come in and change things overnight.



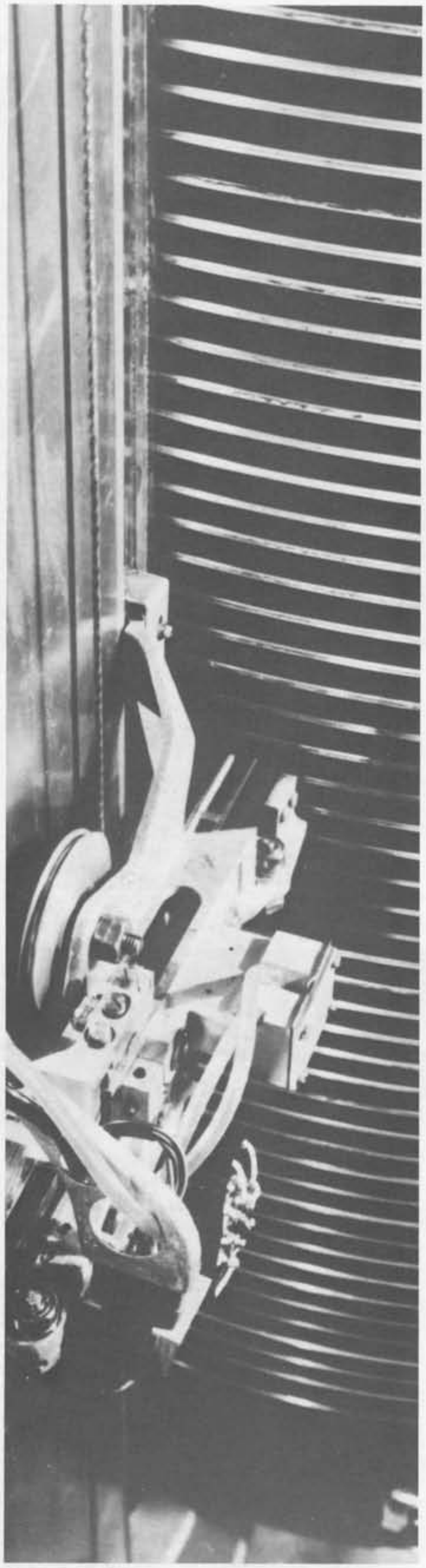
Computer Memories: Machine Readable
Random Access

Rope Memory. The design of the early space computers in the late fifties and early sixties preceded the availability of reliable integrated circuits. In 1962, the designers of the Apollo Guidance Computer took a bold step in choosing integrated circuits (invented in 1959) for the logic component of the machine, but they went with more conservative choices for the memory. The computer had 1024 16-bit words of core memory and 24,576 16-bit words of read only fixed memory made of wired-in ropes and cores. R. L. Alonso and J. H. Laning , two of the AGC designers, described these as "compact and reliable devices." The truly important decision was that the astronauts would be able to use a computer that had a 2K erasable memory that they could control.





Major units of the CM Guidance, Navigation and Control System from the MIT Draper Lab.



When disks were introduced as a secondary storage device in the late fifties, they had the characteristic of looking like the platter set on a contemporary jukebox. The IBM RAMAC for example had a total of 50 disks.

For a short while, a small Massachusetts company tried to make a market that specialized in weaving rope memories for computers. This technology was used for the character set for Digital Equipment Corporation's 338 display unit available in the mid-sixties.

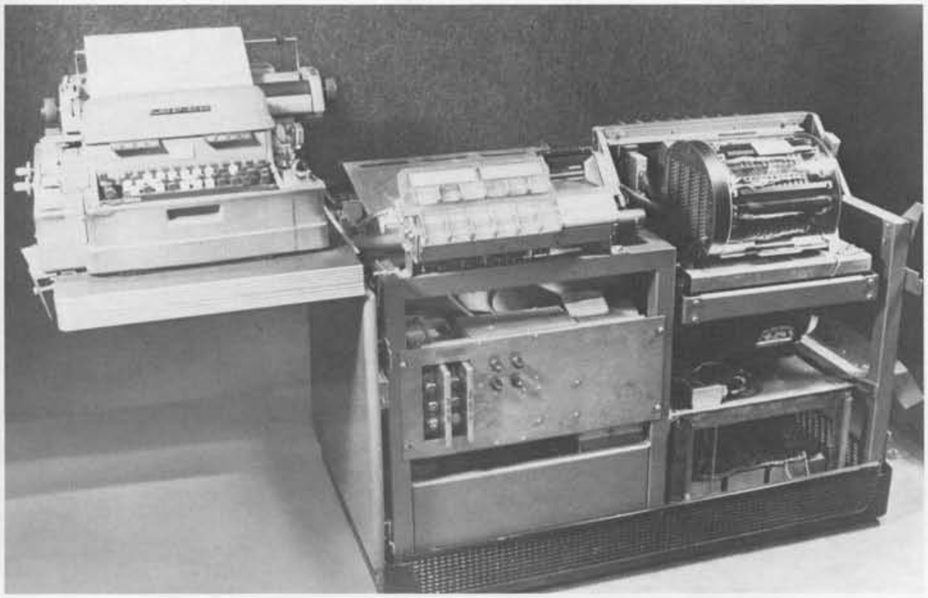
Computer Memories: Readable and Writeable

Cyclical Access

Cyclical memories are still used today primarily as secondary storage in the form of disks and tapes. Prior to the invention of core memory, early computer designers had two choices of primary cyclic memories. Delay lines were reliable but slow and required special talents in logic and programming. The less reliable CRTs were adapted for use as memories by Frederick Williams of Manchester University and called "Williams Tubes."

Delay Lines. Maurice Wilkes, in building the EDSAC, and Alan Turing, in the specifications of the Pilot ACE, chose delay lines. As a result, delay lines were used in English computers throughout the fifties.

The short magneto-restrictive delay line is from Ferranti Pegasus (Item 8). In describing the design philosophy of the Pegasus, its designers W.S. Elliott, C.E. Owen, C.H. Devonald, and B. G. Maudsley, discuss the machine's "rhythm." This rhythm is based on the access to the primary memory of 55 single 42-digit word magneto-restrictive delay lines. A basic 3-beat rhythm was established. Beat 1 of one-word time extracts two orders from the memory; beat 2 of two-word times obeys the first order; beat 3 of two-word times obeys the second order. (Clearly a waltz with a first quickstep.) Programmers of delay-line machines learned to optimize the rhythm and were heard to regret the simplicity of programming for all the later machines based on random-access primary memories.



The LGP-30 was one of the many small scale drum computers sold in the fifties. Built in 1956, in 1962 it rented for $1300 a month. The drum on the far right held 4K bits of information.

Drums and Disks. Magnetic drums were the earliest form of secondary magnetic storage. Prototype magnetic drum computers included the Harvard Mark III and the ERA 1101. The magnetic drum provided a large amount of slow memory at relatively low cost. Typical drum-storage systems are 8-20 inches in diameter and revolve at 1,500-4,000 rpm. There were literally dozens of magnetic drum computers of varying capacity that were the small to medium-sized computers of the first generation.

In the late fifties, the IBM 305 RAMAC (random access method of accounting and control) was among the first -- if not the first -- data processing system to employ a magnetic disk file permitting direct random accessing of records. The system, with 50 disks, stored 20 million characters.

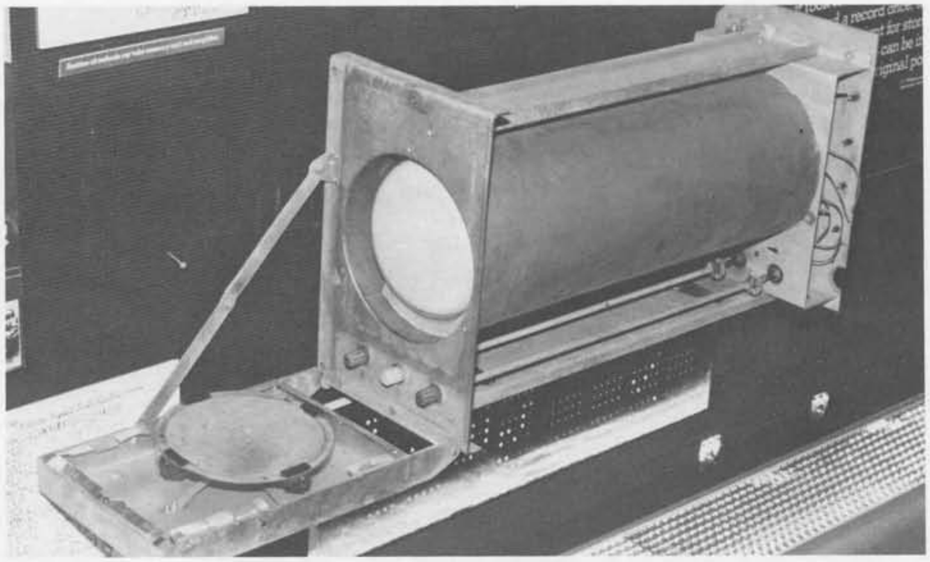
An original hand buit Linc is on the left in use in a laboratory. Several years later DEC sold the Linc as a product.

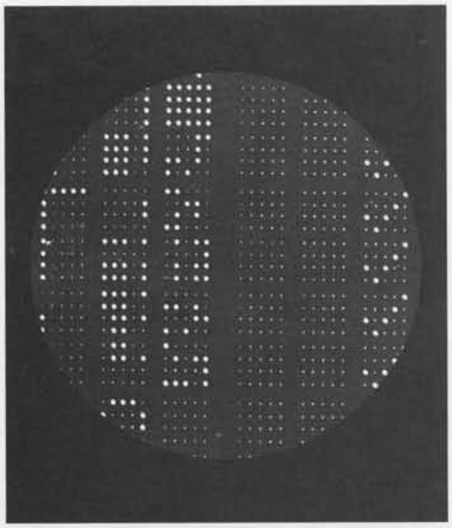
Computer Memories: Machine Readable
Linear Access

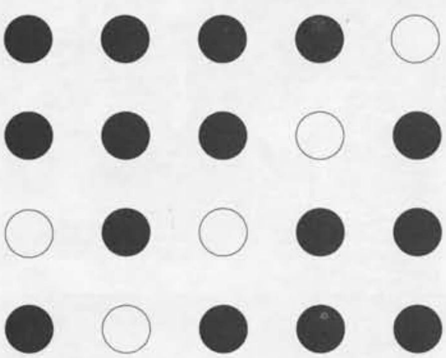
Magnetic tape. Magnetic tape has had the advantage of being a relatively stable product, with specifications for its physical or magnetic properties changing very little. Archival tapes from two decades ago are generally still readable. In contrast, disk technology has rapidly changed.

The "DEC-tape" (Item 13) is a non-standard tape that can be thought of as an important component of mini-computers and a precursor to the floppy disk. The small tape units were designed by Wesley Clark for the LINC computer. Two dozen LINCs (Laboratory Instrument Computers) were built by their users at MIT in 1962. The LINC-tape was small, removable and portable. User's could carry their own around, the same way that users today treat their system and data disks. DEC reverse-engineered the tape and used it on its own LINC-8 system and then on the PDP-12.

The Williams tube was used as a graphic device. Each instruction was read in twice on the same line. If it agreed then a check mark appeared on the second half of the line. Below is a detail of the screen.







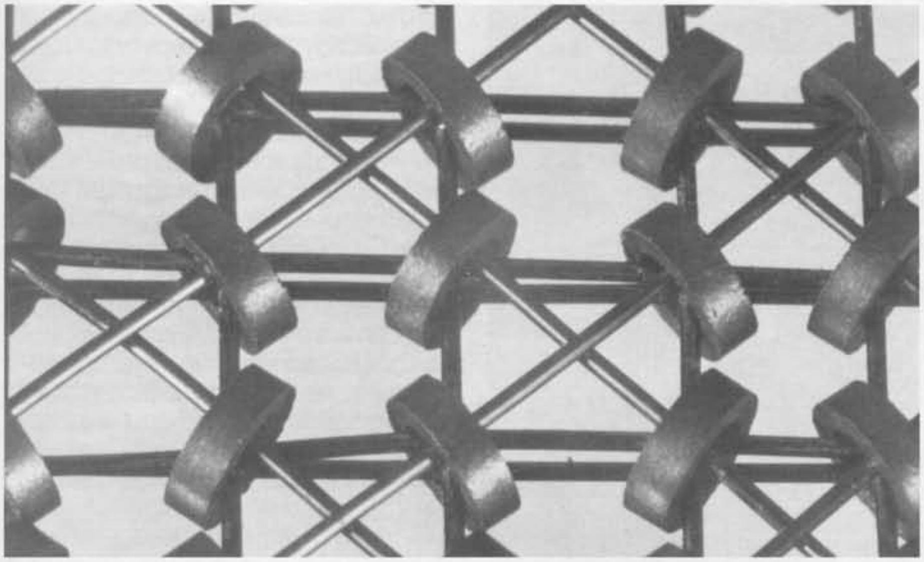
Computer Memories: Machine Readable
Random Access

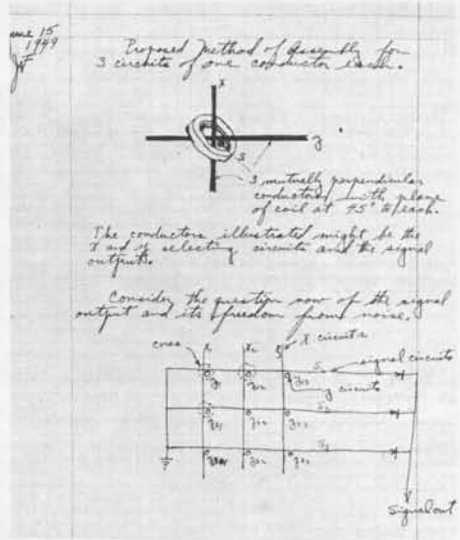
Williams Tubes (Item 7). Professor F. C. Williams of Manchester University developed the first random access computer memory. Julian Bigelow, who was building a computer at Princeton's Institute for Advanced Studies with von Neumann, recalls Williams and his lab: "My visit to Manchester was a delightful experience; F.C. Williams was a true example of the British 'string and sealing wax' inventive genius, who had built a primitive electronic computer out of surplus World War II radar parts strictly on his own inspiration — in the middle of which were two cathode-ray tubes storing digits — the "Williams' memory." I can remember him explaining it to me, when there was a flash and a puff of smoke and everything went dead, but Williams was unperturbed, turned off the power, and with a handy soldering iron, replaced a few dangling wires and resistors so that everything was working again in a few minutes. ...The whole technique depends upon clever exploitation of the fortuitous secondary electron emission properties of cathode-ray-tube phosphor screens — phosphors that are chosen and incorporated purely to give good visual response without regard for secondary electron emission. In this sense it was a lucky accident that the scheme worked at all." (Julian Bigelow, "Computer Development at the Institute for Advanced Study," in *A History of Computing in the Twentieth Century*, N. Metropolis et.al., 1980.)

Despite all of this seeming "black magic" around the Williams tube, it was successfully used by IBM on their 701 series of computers.

Short Chronology of Major Events in the Development of Core Memory Abstracted from Emerson W. Pugh, *Memories that Shaped an Industry*, MIT Press, 1984.

1946	1947	1948	1949	1950
1/46 Jay Forrester proposes a computer at MIT			6/49 Forrester begins documentation in his notebook of a memory using magnetic materials 9/49 An Wang describes a shift register using magnetic toroids of Deltamax	8/50 M.K. Haynes thesis describes his coincident-current magnetic core memory proposal. 9/50 Jan Rajchman of RCA files a patent application for a coincident-current magnetic memory. 10/50 Forrester initiates ferrite material work at MIT





The original diagram shows only the coordinate wires for the core. The diagonal wires on the manufactured core plane provide the read element for each core.

Core Memory. Both the IAS machine and MIT's Whirlwind made do with a version of the Williams tube as their original memory devices. But in both cases, the concept of using some sort of magnetic random access device was under consideration.

The IAS group was working with Jan Rajchman of RCA to develop a fast parallel memory to operate the arithmetic unit. After two years of development no wholly operative memory had been produced. Julian Bigelow remembers, "von Neumann and I made an attempt to list all the variables which would have to be kept under control to produce a 50% yield of successful Selectron tubes covering a range of digital capacities from the original goal of 4096 digits per tube, down through 2048, 1024, 512 etc. In any event, although the Selectron tube held out intellectural respect and admiration, we had increasing doubts that it would provide something we could use in the near future." Several years after the IAS Computer was running, a 256 digit Selectron tube was delivered to the Rand Group for the Johnniac (Item 19).

About seven years passed between the beginning of the invention of core memories for computers and their delivery to customers within a commercial product. Over the next twenty years, until the late seventies, core memories were the predominant form of primary memory. After 1971, when IBM shipped their first system with all-semiconductor main memory, engineers tried to pack greater and greater density to compete with these new products. The 1972 planar core memory board from DEC (item 3) achieved two bits of information from each core by reading the memory at two different voltages. Core is still used in a few systems to gain the reliability that comes from a stable memory regardless of power failure.

1951	1952	1953	1954	1955	1956
5/51 Forrester files for a patent on his magnetic core memory 12/51 Successful operation of a 16x16 array of metallic cores at MIT	1/52 2x2x2 ferrite core memory built in Hayne's group at IBM 5/52 4x4x4 ferrite core memory operates at IBM	5/53 First ferrite core main memory operates on MIT Memory Test Computer with a 32x32x17 array			1/56 IBM ships 702, 704, and 705 computers with ferrite core memories.

Entrepreneurism:

The Past, Present and Future of Computing in the USA

William Norris,
Chairman Emeritus
Control Data Corporation

The genesis of Electronics Research Associates (ERA), one of the first computer companies, was the U.S. Navy's World War II Communications Supplementary Activity in Washington (CSAW). Often referred to as "Seesaw" because of its initials, its primary mission was to intercept and decode enemy messages. The mission was of such critical importance that no expense was spared to assemble the best talent and develop the technology needed to assure maximum success.

Toward the end of the War, Dr. Howard Engstrom and I, both members of CSAW, put a plan together to preserve the unity and continuity of the efforts and the team. We suggested that a significant number of the team would form a private company that would make their services available to the Navy under contract. The new company would, at the same time, develop other business based primarily on electronic digital circuit technology. Late in 1944, the Navy accepted our proposal and all we needed was financing.

Venture capital hadn't yet been invented and information about the nature of our expertise was highly classified. About all that we could say was that we had a group of talented professionals with unique expertise in the design of electronic digital circuits that had potential for new products in a number of important fields.

Seventeen companies and a number of individuals in the Washington/New York area were contacted. We visited J. Prespert Eckert and suggested that we undertake a joint activity. Eckert said that the plans for his company had pretty well jelled and that he didn't want to consider that possibility. Later, fate destined us to get together when Eckert-Mauchly became a division of Remington Rand in 1950, as did ERA in 1952.

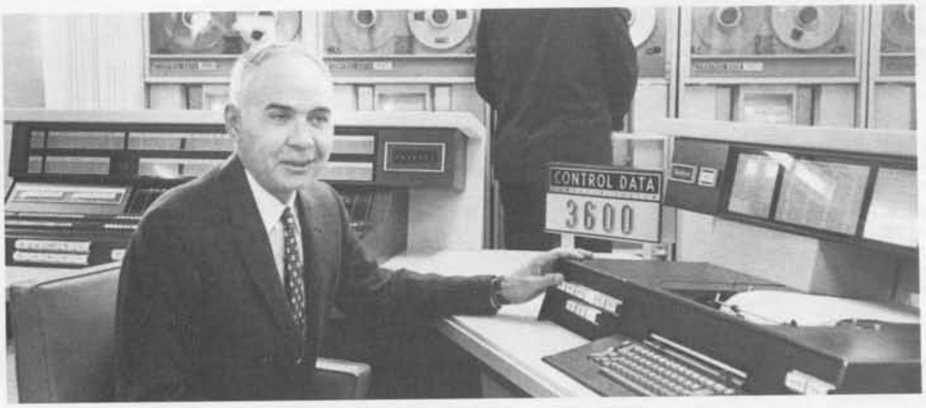
Admiral Lewis Strauss, Assistant to Navy Secretary Forrestal, was one of the partners of the Wall Street firm of Kuhn, Loeb who were identified as a source of financing. Since security was not a constraint in talking to Admiral Strauss, he was greatly intrigued by the concept and said that he would finance the company personally even if his partners in Kuhn, Loeb were not interested. Before signing, Admiral Strauss asked that a member of his staff, Commander Paget, review the proposal. Admiral Strauss pointed out that Commander Paget was planning to establish a consulting company that he was personally financing. Paget concluded that while our plan was interesting, it wasn't economically viable. Both Strauss and Kuhn, Loeb backed out.

The final chapter of this incident was written 25 years later when Control Data acquired the Commerical Credit Company, and the firm of Cresap, McCormick and Paget was one of the consultants proposing to help. When their proposal was presented, the introduction contained a message from Mr. Paget expressing the hope that with the passage of time I had forgiven him for his erroneous conclusion. Indeed, 30 years and the success of Control Data, especially the latter, had mellowed my resentment.

Yet in 1945, Admiral Strauss's rejection was a devastating blow because we were led to believe that we had located our sorely needed financing after a long and arduous hunt. Even worse, by then the war had ended and time was running out.

Then, late in 1945, we learned that Northwestern Aeronautical, a company located in St. Paul, Minnesota, that was a war-time contractor for troop-carrying gliders, was looking for a new direction. After several meetings with the President, John Parker, a deal was struck, and ERA had a home in St. Paul.

Incorporated in January 1946, ERA's equity ownership was divided equally between the founder group and the financial group headed by Mr. Parker. 100,000 shares of stock were sold



William C. Norris seated at the console of a 3600 Computer in 1964.

to each group to provide $20,000 total equity. In addition, Parker's group guaranteed a line of bank credit of $200,000.

Superb human capital and effective government contracting methods helped us to meet the requirements of CSAW. The R&D work for this agency was performed under cost plus fixed fee contracts. This was advantageous and effective because it allowed wide flexibility in setting initial specificiations and altering them to gain maximum performance. Such contracts came both from the Bureau of Ships and the Office of Naval Research. This type of contract was a new and enlightened approach by the Navy. In combination with entrepreneurial enterprise, not only were the needs of the Navy met, but many important advances were made in computer technology. In the process of performing a large number of R&D contracts, ERA built up a vast reservoir of technology, evidenced by the large number of spin-off companies that were spawned.

ERA built the first commercially available digital computers, the 1101 and 1103, and also developed and manufactured magnetic storage devices. By 1952, ERA's growth was outstripping its limited capital base, and the only alternative for maintaining growth was to merge with a large company. I stayed on as general manager of the ERA Division of Remington Rand. When Remington Rand merged with Sperry to form Sperry Rand, I became general manager of the Univac Division, where all computer activities were consolidated.

Although Sperry Rand had acquired the industry's two leading entrepreneurial computer companies with a major part of the leading edge technology in the industry, namely Eckert-Mauchly and ERA, they were unable to capitalize on the technology lead. I resigned to form Control Data.

Contol Data's first day on the New York Stock Exchange, March 6, 1963.

The shipment of the First 1604 computer to the U.S. Navy.

Control Data Corporation

In July 1957, CDC was incorporated based on an initial financing by the sale of 615,000 shares of stock to the public for $1.00 per share. Control Data was the first publicly financed new computer company. Part of the ERA team came with me and we focused on a line of engineering and scientific computers that included supercomputers at the top.

My definition of a supercomputer is "today's most powerful, general purpose, computer." That definition implies that there can be only one supercomputer at any one time. Since any computer's power varies for different applications, this means that there may be two or three machines that deserve to be called supercomputers at any one time. Thus, in their day, the ENIAC, EDVAC, ERA 1103, CDC 6600, CDC 7600, CRAY 1, and CDC Cyber 205 could all be legitimately called supercomputers. In the early seventies, CDC also initiated the Plato computer-based education system in cooperation with the University of Illinois and the National Science Foundation, because computer-based education is the most significant application area. High quality relevant courseware consisting of more than 15,000 hours on material in a broad range of 150 subject areas is currently available.

Education and Competitiveness

Computer based education not only delivers and manages instruction, it also provides the capability for reducing or eliminating the time consuming administrative tasks associated with teaching, thereby making more efficient use of instructional resources. This allows teachers to spend more time with students and gives students more time for improving their skills. Unfortunately, utilization of computer-based education has not kept pace with the growing availability of high quality courseware and decreasing costs of hardware and software. The adverse consequences of this lag are especially serious in the K-12 educational spectrum where the basic underpinnings of a skilled work force are formed.

The decline in the ability of our work force to handle comprehensive notions of science and technology translates into an important factor in declining U.S. competitiveness in world markets. Ample evidence is available to show that the Japanese school system far exceeds ours in its ability to prepare educated workers for business and industry. For example, youngsters in Japan spend more time developing their ability to handle science, math and foreign language than in the USA.

Knowledge is becoming an increasingly important factor in the work force. Unless education and training is significantly improved, our technically illiterate work force will place us at an even greater competitive disadvantage. Considering all the constraints, the only practical solution is a massive increase in the use of computer-based education.

Environment for Entrepreneurship

Despite the critically important role entrepreneurism has played in the computer industry and indeed in our entire national economy, the environment for small enterprise innovation is deteriorating along with our competitive position in world markets. Most markets suffer from unprecedented domination by multinational corporations, many of them foreign-based, to the disadvantage of medium and small companies with limited resources, especially for manufacturing.

The passage of the Mansfield amendment to the military procurement authorization act of 1970 required that research be related to weapon systems. This act significantly reduced access to technology by small companies and gave large military systems contractors more control over research.

Small companies receive less than three precent of total government R&D funds. Given the record of small enterprise as a major source of innovation, this resource is far from being utilized. The small business innovation research program passed by Congress about 1982 has only helped modestly.

Fortunately, venture capital, a major stimulus to small enterprise innovation, continues to be in plentiful supply. Unfortunately, the innovations are made in the pre-venture capital stage, where government R&D can greatly help. Seed capital is required to advance technology from the research and idea stage to the point where venture capital commitments can be made.

Broadly speaking, our foreign competitors, especially Japan, have greatly accelerated research and development, dramatically increased the number of trained scientific and technical personnel, reduced needless and wasteful duplication of technology development, fostered growth and lowered the cost of capital in carefully targeted industries. The Japanese government has promoted cooperation among industry members at the base technology level as a key ingredient for success.

The declining US competitiveness is largely related to inefficient and, at times, inept management of technology. Public/private cooperation is needed to substantially increase the efficiency of research, development and manufacturing. Three new institutions provide models: The Microelectronics and Computer Technology Corporation; A Job Creation Network; and The Midwest Technology Development Institute.

The Microelectronics and Computer Technology Corporation (MCC)

The MCC was established in 1982 in Austin, Texas. It has grown from eleven to twenty-one participating companies from the US computer and semiconductor industries. Base technologies are developed by MCC's scientific and engineering talent and provided to the members. Member corporations can each add their own value and continue to compete with products relating to their own freely selected markets. MCC also licenses technologies on reasonable terms to others, including small companies.

A ten-to-one leverage is gained by the member companies in MCC. If every industry had a similar cooperative arrangement, it would provide a much-needed boost to innovation and competitiveness.

The Microelectronics and Computer Technology Corporation (MCC) Corporate Membership List.

Advanced Micro Devices, Inc.
Sunnyvale, CA
Bell Communications Research, Inc.
Livingston, NJ
Digital Equipment Corp.
Maynard, MA
Harris Corp.
Melbourne, FL
Honeywell Inc.
Minneapolis, MN
NCR Corp.
Dayton, OH
Westinghouse Electric Corp.
Pittsburgh, PA
Allied-Signal Inc.*
Morristown, NJ
Boeing Co.
Seattle, WA
Control Data Corp.
Minneapolis, MI
Eastman Kodak Co.
Rochester, NY
General Electric Co.
Fairfield, Conn
Lockheed Corp (Lockheed Space and Missile Co.)*
Sunnyvale, CA
Martin Marietta Corp.
Bethesda, MD
3M Co.
St. Paul, MN
Motorola Inc.
Schaumburg, Ill
National Semiconductor Corp.
Santa Clare, CA
Rockwell International Corp.
Pittsburgh, PA
Unisys Corp.*
Detriot, MI
Hewlet-Pacckard Co.
Palo Alto, CA

*Companies that have announced they are leaving MCC at the end of 1987.

Job Creation Network

The Job Creation Network operates at the community level to improve initiatives for expanding innovation. It consists of three elements.

1) A cooperation office is a non-profit organization that helps a new company shape a business plan, obtain financing, or locate a base technology. The staff is bolstered by a volunteer advisory panel of experts.

2) A seed capital fund is accumulated from a consortium of state and local government and private investors with tax credits made available.

3) A business and technology center provides consulting services, shared laboratory, manufacturing, office or other services to facilitate the startup.

Aggressive programs have been established in Illinois, South Carolina, Minnesota and Canada.

The Midwest Technology Development Institute (MTDI)

The MTDI was established in 1985 with nine member states. MTDI has the threefold objective of:

1) expanding technological cooperation among midwest universities and industry to increase the efficiency of research and the commercialization of the results;

2) extending technological cooperation to include universities in foreign countries;

3) providing a mechanism to increase the availability of technology to industry, especially small businesses and to achieve an equitable transfer of technology between the US and foreign countries.

Unbalanced Technology Flow

A partial list of reasons for the inequitable technology flow that goes from the US to Japan includes:

* A significant part of Japan's basic research is carried out in government laboratories that are closed to foreigners.

* US companies cannot participate in Japanese government-funded R&D projects that have explicit commercial objectives, nor, for the most part, do US companies have access to Japanese patents.

* Small US companies are a major source of technology for Japan that is obtained by licensing or acquisition. US enterprise does not have a similar opportunity.

* Japan has virtually unlimited access to US research.

* The best Japanese graduate students come to the US and are supported both intellectually and financially and do not repay this capital investment.

* The US has not diligently pursued the acquisition of Japanese technology.

One of the first corrective actions was taken in 1986 with the amendment of the Stevenson-Wydler Innovation Act that gave the directors of the US federal laboratories discretionary authority to deny access to research to any foreign country that does not grant similar privileges to American organizations.

Implementing equitable technology flow agreements with other countries will require that the US keep track of technology transfer. MTDI is playing a major role in establishing a measurement system that will include mechanisms for inventorying and tracking technology. They will also institute a large scale program aimed at helping transfer Japanese technologies to small US companies.

Technology Momentum

The flourishing of entrepreneurial enterprise during the decade between 1945 and 1955 provided the momentum that accelerated through the early 70s to put the US into world leadership in the computer industry. A great deal of credit must be given to the Navy, especially the Office of Naval Reserach Program in Computing for the stimulation and support of the development of computer technology until it was ready for commercialization. This early support coupled with entrepreneurism was a major factor in helping to build the momentum that propelled the United States into world dominance of the computer industry. Indeed, leadership in computer technology was also a catalyst to innovation in other fields and until recently, the US has been dominant in technological innovation in the world.

The position has been deteriorating in the last decade. Unless corrective action is undertaken with massive technological cooperation and with an environment for entrepreneurial enterprise, the erosion will continue. If the corrections are made then entrepreneurial enterpise will again realize its potential and play a leading role in expanding innovation on the scale necessary for assuring the well-being of the country.

Computer Memories Poster

Mark Hunt

You may have seen the image on the cover of this issue of the *Report* in advertisements in leading computer publications over the past few months. The story of how this public service campaign developed is worth telling because it illustrates how enormously the Museum benefits from collaborative efforts.

In the spring of 1985 Gabe d'Anunzio, vice-president of marketing programs for MICOM-Interlan, suggested to the Museum staff a public service announcement campaign advertising a poster picturing "antique" computer memories.

Gabe put the Museum in touch with Grafik Communications, of Arlington, Virginia. They volunteered to design the poster and the advertisement, and to arrange for free photography and production of the posters in exchange for limited in-kind services for their client, VM Software. VM Software photographed the Museum's exhibits and items from the collection for their annual report.

The key elements still missing were commitments from the publishers to run the ads at no cost and a color separation for each publication.

Our first calls were to David Bunnell, publisher of *MacWorld* and *PC World*, and Harry Brown, publisher of *Byte*. They agreed to run the ads if we provided color separations. Paul Thiel, vice-president of marketing communications at Scitex America Corp., maker of state-of-the-art computer-controlled color separating equipment, then agreed to supply color separations and we were in business.

Almost every publisher we spoke with was eager to participate. Each offered a full-page, full-color advertisement. The total advertising space committed is valued at almost $225,000, with a combined circulation of 3.4 million high-tech readers of 25 publications. The total value of the program is almost a quarter million dollars. All from the hard work of many dedicated friends and staff of the Museum.

Responses to the advertisement are streaming in daily. Readers send a tax-deductable contribution of $25 or more to receive the elegant full-color poster. To order your own poster, check the appropriate box on the membership coupon on page 17, and return it to the Museum with your own $25 tax-deductible contribution.

Participating Publications

AI Expert
Boston ComputerNews
Byte
Circuits Manufacturing
Computer
Computer Design
Computer Graphics World
ComputerWorld
Data (Denmark)
Datamation
DEC Professional
Digital Design
Digital News
Digital Review
Electronics Test
Hardcopy
High Technology
Information Center
InformationWEEK
InfoWorld

People that Made it Happen

Gabe d'Anunzio
MICOM-Interlan
Gwen Bell
The Computer Museum
Alex Berry
Grafik Communications Ltd.
Mark Hunt
The Computer Museum
Judy Kirpich
Grafik Communications Ltd.
Megan McCarthy
Scitex America Corp.
Renate Brown Neely
VM Software
Gail Rosen
Scitex America Corp.
David Sharpe
David Sharpe Studio
Oliver Strimpel
The Computer Museum
Rich Theis
Scitex America Corp.
Paul Thiel
Scitex America Corp.
David Vanable
Scitex America Corp.

Companies that Donated Services

David Sharpe Studio
Grafik Communications Ltd.
Scitex America Corp.
Type Studio
Virginia Lithograph

Calendar *Spring 1987*

May 3
Sunday
4 pm

Dick Shoup, Aurora Systems.
"A Perspective on DigitalVideographics or, How Computer Graphics Can Brighten Up The Evening News".
Learn about the process and equipment that won Shoup an Emmy for his pioneering work in computer graphics.

May 17
Sunday
4 pm

Jean Louis Gassée, Vice President of Product Development, Apple Computer, Inc.
"The Future of Personal Computers".
Gassée will share his predictions about what lies ahead in the fast-paced and ever changing world of personal computing.

May 30
Saturday
2 pm

Bruce Schwoegler, WBZ-TV Meteorologist.
"Computers and the Weather".
Learn how computers are used to gather weather to television viewers.

Coming Events

June 18
Thursday

Opening of SMART MACHINES, a major new gallery on robots and artificial intelligence.
Visitors will see and interact with the history and current state-of-the-art of intelligent machinery. The gallery will feature over 20 hands-on demonstrations, a unique collection of historic robots, and entertaining film. The working exhibits will include programs with expert knowledge of areas of medicine, geography and art. Others will try to answer questions posed in plain English. There will be working industrial, teaching and toy robots. Members will receive invitations to an exhibit opening and preview.

June 19
Friday
7:30 pm

Herman Budnick, Herman Budnick & Associates.
"Development and Implementation of Videodisk/Videotex Information Systems".
Learn about the state-of-the-art distributed videotex approach used to create a system of public tourism information kiosks for Boston's Logan International Airport .

May 9
Saturday
7pm

The Computer Museum's 5th Birthday Party!
A fun-filled evening of live and silent auctions with entertainment by clowns, magicians and jugglers!

☐ **YES!** I want to become a Member of The Computer Museum.

☐ **YES!** Please refresh my memories by sending my *Memories Poster*. A tax-deductible contribution of $25. or more is enclosed.

☐ **$20 Student** ☐ **$ 45 Family** ☐ **$250 Sponsor**
☐ **$30 Individual** ☐ **$100 Donor** ☐ **$500 Patron**

Members receive free admission for one full year, invitations to exhibit previews, advance notice of exhibitiions and lectures, invitations to members-only events, a subscription to our exciting quarterly magazine, The Computer Museum Report, and a 10% discount in the Museum Store. Members who send a contribution of $25. or more are entitled to receive the elegant full color Memories Poster. Check the box above if you want to receive the poster.

Enclosed is my check ,made payable to **The Computer Museum** for $____________

or charge to: ☐ VISA ☐ MasterCard ☐ American Express

Card # ______________________________ Expiration Date __________

Signature ______________________________

Name ______________________________

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City ____________________ State __________ Zip __________

Contributions are tax-deductible to the extent provided by the law.
The Computer Museum, 300 Congress Street, Boston, MA 02210

The Computer Museum

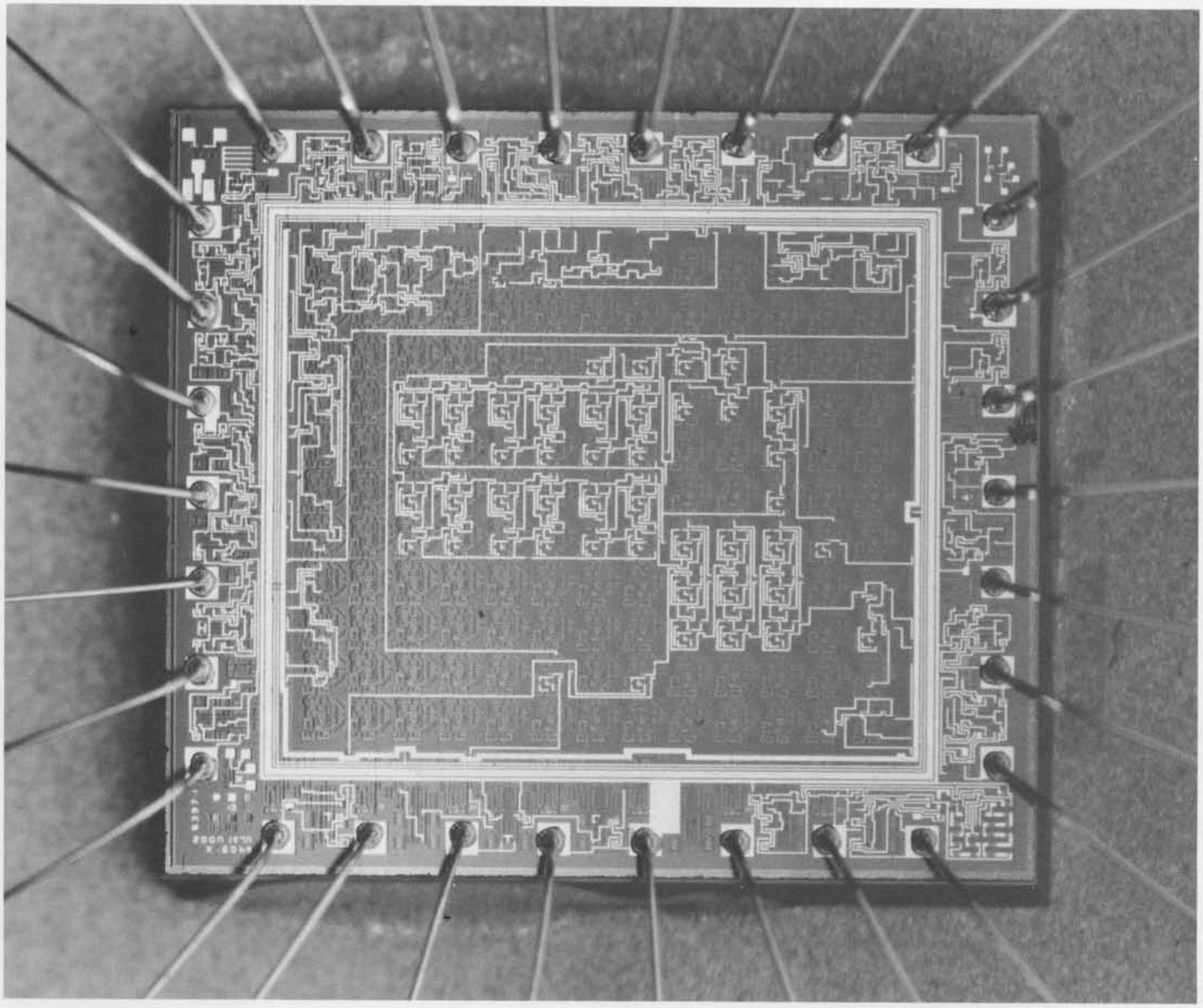
The Computer Museum is a non-profit 501(c)3 foundation that chronicles the evolution of · information processing through exhibitions, archives, publications, research and programs.

Museum Hours: *Summer:* Open daily 10 – 6, Friday 10 - 9. *Winter :* Open Tuesday – Sunday 10 - 6, Friday 10 - 9. Open Mondays during Boston school vacation weeks,10 - 6. Closed Thanksgiving, Christmas, and New Years Day. Hours are subject to change.

Membership All members receive a membership card, free subscription to the Computer Museum Report, a 10% discount on merchandise from the Computer Museum Store, free admission and invitations to Museum previews. For more information contact Membership Coordinator at the Computer Museum, 300 Congress Street, Boston, MA 02210. Telephone (617) 426-2800.

The End Bit 0000000000000001

This 1984 experimental memory chip by IBM holds 288K bits on a single integrated circuit. It is part of the History of Computing slide sets, available along with the Personal Computer slide set from The Computer Museum Store.



The Computer Museum
300 Congress Street
Boston, Massachusetts 02210

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