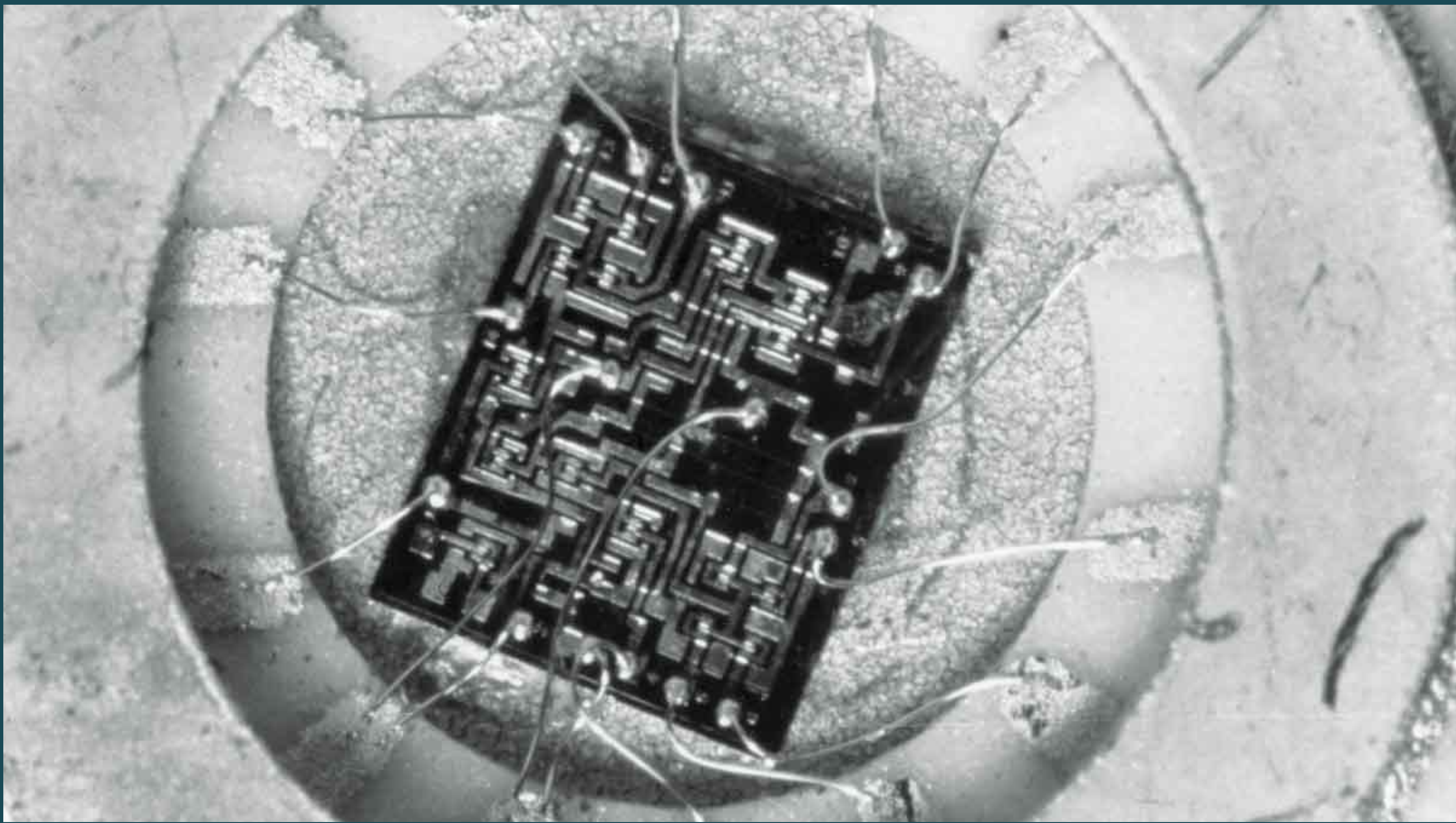
SEPTEMBER 2000

CORE 1.3

A PUBLICATION OF THE COMPUTER MUSEUM HISTORY CENTER
WWW.COMPUTERHISTORY.ORG



The Museum plans to build a permanent facility in front of historic Hangar One at Moffett Field

MAKING IT HAPPEN

Our dream of moving the Museum forward is stronger than ever. It has been a very busy quarter. We held our annual Board retreat in June, and in September we elected two new Trustees: Donna Dubinsky of Handspring and John Mashey of Silicon Graphics. We finished our fiscal year with over $100,000 in the black; and enjoyed welcoming a significant number of new Core Supporters. Meanwhile, we grew our artifact collection; watched our volunteer IBM 1620 restoration team move closer to finishing the project; refined our “new building” concept; and worked closely with NASA as part of their proposed research park. In addition, we had a wonderful volunteer appreciation party at Len Shustek’s home; an elegant donor appreciation party at the home of Dave House and Karla Malechek; participated in the Computer Bowl 2000 preview with the Museum of Science in Boston; and welcomed a constant stream of visitors each week.

I want to thank everyone again–Board, staff, volunteers, supporters–for their enthusiastic efforts in helping to define and evolve our strategies to build a lasting legacy of the information age.

The more we talk to groups and to individuals, the more we affirm the very serious need that our mission fulfills! Over the next six to nine months, you will see a number of visible efforts to integrate our strategy, development, building, collection, exhibit, and volunteer activities.

I hope you are also hearing more about us in the public sector as well. NASA held its first round of public information meetings in July for local communities, and presented options for the proposed NASA Research Park. This is a very exciting project, and we are positioned as a prime partner with building space just in front of historic Hangar One. We will be reporting to you in the future as we progress in building our permanent home. Of course, keep your eye on our website as well—our presence in cyberspace is going to grow rapidly well before the Museum opens its new building. Our unique combination of content, collection, people, and enthusiasm differentiates us from many organizations on the web.

Development activities, now staffed under the direction of Eleanor Weber Dickman, are moving aggressively to define, organize and streamline the fund-raising process. You should already sense a new responsiveness from the staff. All of us welcome your input, suggestions, and comments.

Whether you’ve visited the Museum recently or not at all, we hope to see you visit very soon. Some of the new interesting artifacts on display include an original UNIVAC I mercury delay line and some vintage IBM unit record equipment (1930s).

Finally, we are planning a festive and grand occasion for our annual Fellow Awards banquet on November 9. Make your plans now—it’s a great opportunity to sponsor a table and invite some new people to become part of the Museum community. In the meantime, Karen Mathews, with all your help, is putting together a terrific lecture series program that starts this month—see her column for the specifics.

Again, thanks so much for your help! Please send us your ideas and suggestions, and bring others along to help us build a living legacy of the information age.

JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

September 2000
CORE 1.3
A publication of The Computer Museum History Center

MISSION
TO PRESERVE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMATION AGE

VISION
TO EXPLORE THE COMPUTING REVOLUTION AND ITS IMPACT ON THE HUMAN EXPERIENCE

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Cover: An early integrated circuit (IC)

IN THIS ISSUE

(opposite)
The Northrop brochure introducing Maddida

Another NORTHROP DEVELOPMENT

MADDIDA:

BRIDGE BETWEEN WORLDS

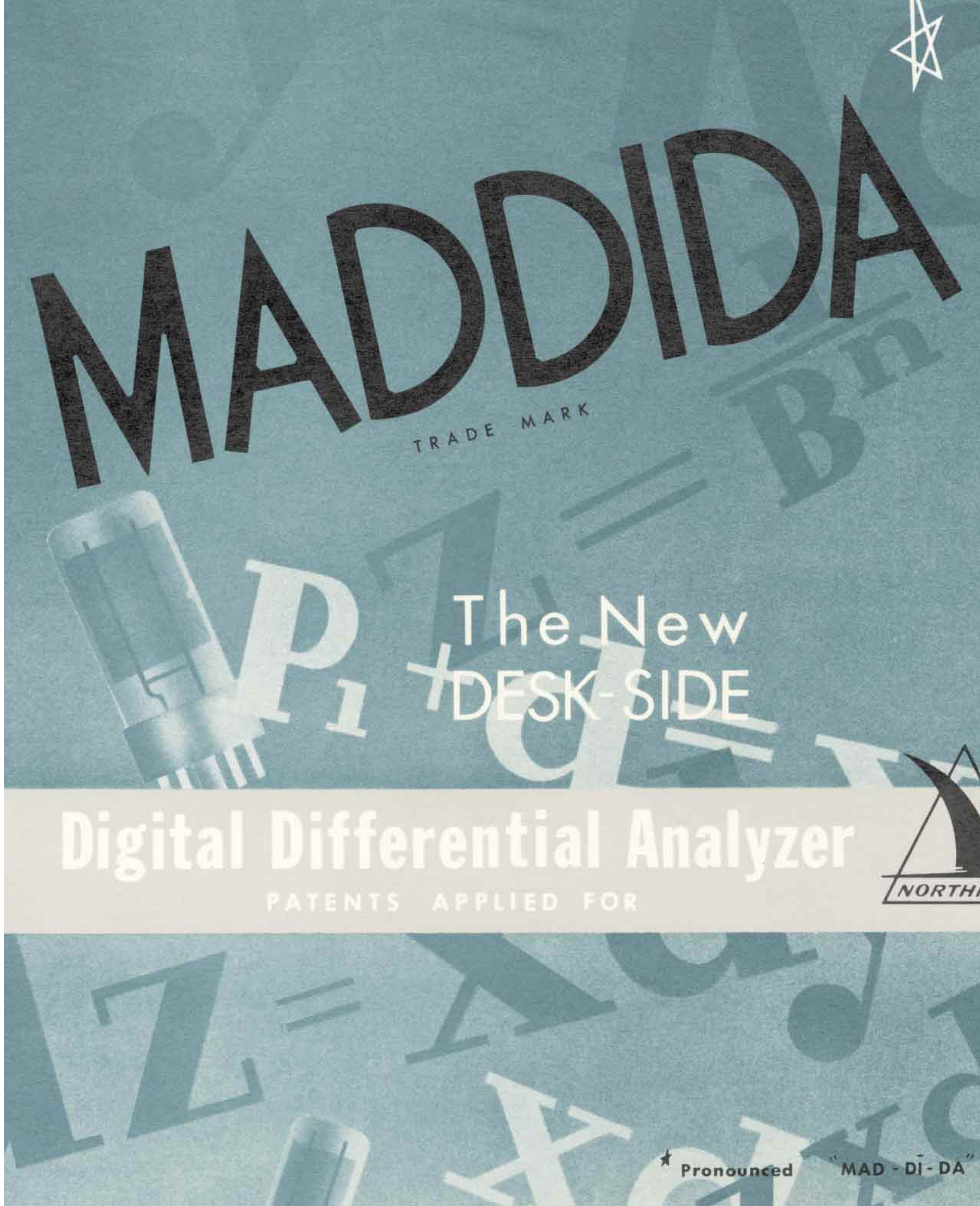
DAG SPICER

Aside from the Yankees beating the Dodgers in the World Series four games to one, 1949 was not a peaceful year for most of America and the world in general. The Berlin Airlift and its attendant tensions simmered on, Communist forces had invaded the Chinese mainland, and the first Soviet atomic bomb test had taken place that August. Pulled in the wake of this political tide were enormous military expenditures in armaments and weapon systems, as well as in basic aeronautical, jet aircraft, and rocket research.

Some of the most advanced of such research was taking place at Northrop Aircraft near Los Angeles. In a delightful turn of phrase, Paul Ceruzzi of the Smithsonian Institution calls Northrop the "midwife of the computer industry," alluding to the importance of that company's computational demands in driving computer development, both at Northrop, and at IBM and UNIVAC, the two major producers of computational devices at the time. Late that year, a small group of Northrop engineers completed a unique computing machine that showcased Northrop's skill in addressing its most important problem—demanding numerical calculation. This machine was a pit stop on the road from mechanical to electronic methods of calculation that combined old concepts with new technology.

Called MADDIDA (**MA**gnetic **D**rum **D**ifferential **A**nalyzer), and pronounced "MAD-DI-DA," this device of about 900 diodes and 50 vacuum tubes started out as a project supporting Northrop's SNARK missile program—essentially an intercontinental cruise missile. Northrop had hired ENIAC co-designer John Mauchly two years earlier to provide an on-board guidance computer for SNARK. The result was BINAC, a room-sized behemoth that never worked reliably. BINAC's failure prompted the MADDIDA project, with Hewlett-Packard building an initial prototype for Northrop under contract.

Although it was still too large to fit inside a missile, being about the size of a refrigerator turned on its side, MADDIDA was robust, reliable, and relatively inexpensive to produce. Due to this size limitation, it did not meet the project objectives of a guidance system for SNARK. However, given that in-house engineering teams had great difficulty in obtaining access to larger mainframe-type machines, MADDIDA was immediately put to use for engineering work. Northrop staff, like that of every other aircraft company, typically used what can only be described as "stockyards" of human "computers" who sat at desks and used mechanical calculators like the popular Friden or Marchant models of the day. The scene was right out of Dickens: rows of crewcut young men as far as the eye could see in shirtsleeves and skinny ties filling in calculation sheets month after month, year after year. Most of these calculations, as Stanford professor and aviation pioneer Walter Vincenti notes, were for "data reduction," that is, the aggregation of flight test and structural analysis data. This data came in great quantity and at great speed—a single aircraft of the



Pronounced "MAD - DI - DA"

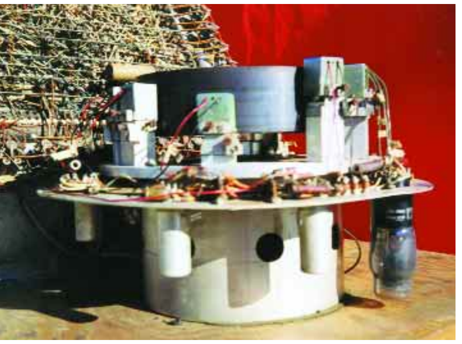
1 The storage drum from the MADDIDA prototype

2 Side view of head and drum assembly

3 Front view of Northop's MADDIDA prototype, showing diode matrix

4 Rear view of the MADDIDA prototype

PHOTOS BY DAG SPICER



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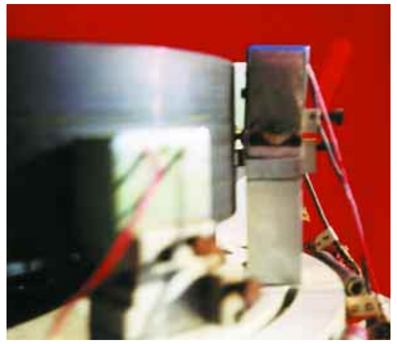

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advanced type that Northrop was developing could require millions of discrete calculations. Although not a general-purpose machine, MADDIDA was ideally suited to a broad range of Northrop's in-house engineering work.

One of the most important milestones in the development program occurred when MADDIDA was flown across the U.S. from it's Hawthorne, California home to the Institute of Advanced Study (IAS) at Princeton, New Jersey. There, project engineers demonstrated MADDIDA to John von Neumann. Don Eckdahl, an original MADDIDA designer, visited The Computer Museum History Center in March of 1998 and remarked that what had impressed von Neumann most was that MADDIDA arrived in Princeton, was plugged in, and almost immediately began performing useful work. von Neumann, with his characteristic aplomb, saw even more applications than the original designers and wrote a paper on the machine's possible new uses.

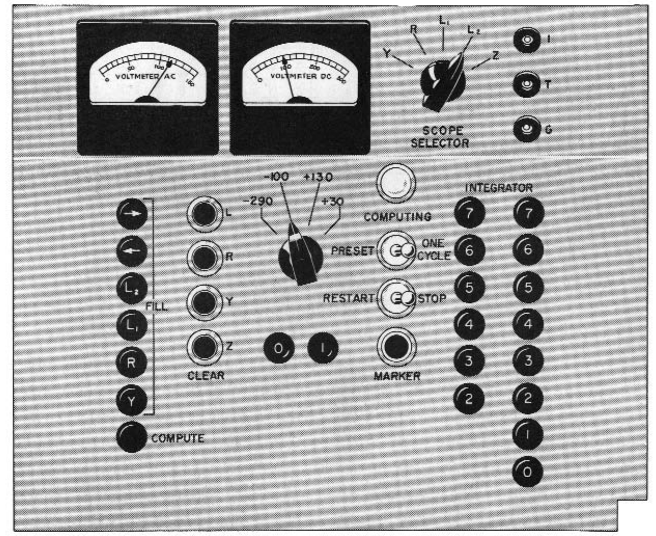
The MADDIDA prototype became a commercial product and was marketed to industry, research labs, and universities. Recapitulating what computer users knew of the larger "giant brains" produced by IBM, UNIVAC, and research institutions, the company brochure proudly stated that MADDIDA would "...operate for months at a time without error or breakdown. This type of performance has been hitherto unheard of for large scale automatic computers."

Interestingly, MADDIDA's architecture was basically that of a mechanical analyzer implemented with electronics. That is, the machine replicated the analog functional blocks of a mechanical device with vacuum tubes and diodes; mechanical analogies used throughout promotional and training literature made the transition straightforward for people trained on the previous generation of mechanical analyzers. As the brochure notes further on, "There are no plugboards, nor are there any physical interconnections to make in setting up a problem on MADDIDA. The desired connections between integrators are easily expressed as a binary code, and this code is typed into the computer along with initial conditions."

As Ceruzzi noted, Northrop engineers contributed in many fundamental ways to the booming post-WWII aircraft and defense industry in southern California. MADDIDA, for example, was not the only machine invented there to solve computing problems. That same year, for example, William Woodbury and Greg Toben, a pair of young Northrop engineers, had "lashed up" two IBM accounting machines into a programmable (via plugboard) machine, one they whimsically called "the poor man's ENIAC." It is a poignant fact, certainly for Northrop engineers, that the accounting department held most of the computing power in the company—in fact, Toben and Woodbury borrowed one of their machines from Accounting.

IBM did not initially warm to the *fait accompli* of their machines being opened, modified, and operated, but Toben and Woodbury's prototype metamorphosed into IBM's Card Programmed Calculator (CPC), becoming one of the company's most successful

MADDIDA 44A (the commercial version of MADDIDA) Control Panel drawing from the Northrop MADDIDA brochure



machines at the time. With nearly 700 CPCs in the field, IBM management quickly saw a pent-up demand for computing cycles among aircraft manufacturers and others, and thus began a reluctant transition by the company into electronic computers.

As with MADDIDA, the technological advances of so many computing projects are often equaled or surpassed by the formation of computer experts trained by the project themselves, experts who then go on to propagate into and define the industry. When Northrop decided not to pursue the commercial computer business, about a dozen of the MADDIDA project team left to form their own company, CRC. Woodbury and Toben soon joined IBM where they became major contributors to the Model 650 computer design, another highly-successful IBM product. In fact, a 1984 study by the Babbage Institute determined that some 14 companies can be traced back to people in the original MADDIDA group.

Like the changes of 1949 that were redefining many of the basic relationships between peoples and nations, MADDIDA represents a transitional period between two key technologies. While remaining faithful to its roots in the analog analyzers with which its inventors were comfortable, MADDIDA took a bold, bright step forward into the then-new and computationally-driven world of jet aircraft, missiles and rockets. It was such advanced computation, provided economically and reliably by machines like MADDIDA, that enabled both the computing and aerospace industries to move forward. ■

The original MADDIDA prototype forms part of the permanent collection of The Computer Museum History Center.

MADDIDA prototype (1949), X1050.91, Gift of the LA County Museum

Dag Spicer is Curator & Manager of Historical Collections at The Computer Museum History Center

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National Museum of American History website, Computer Oral History Collection: http://www.si.edu/lemelson/dig/computeroralhistory5.html.

Specifications

Machine Type: Electronic Digital Differential Analyzer

Architecture: Integrator functional blocks (22); 44 on commercial version

Word size: 22 bit (6 decimal places)

Memory: Magnetic drum (8" diameter, 2 ½" height), Approx 1.5 Kbits x 4 channels

Logic: vacuum tube (53), germanium diode (904)

I/O: 12 input and 12 output channels; printer, Teletype, unit record equipment

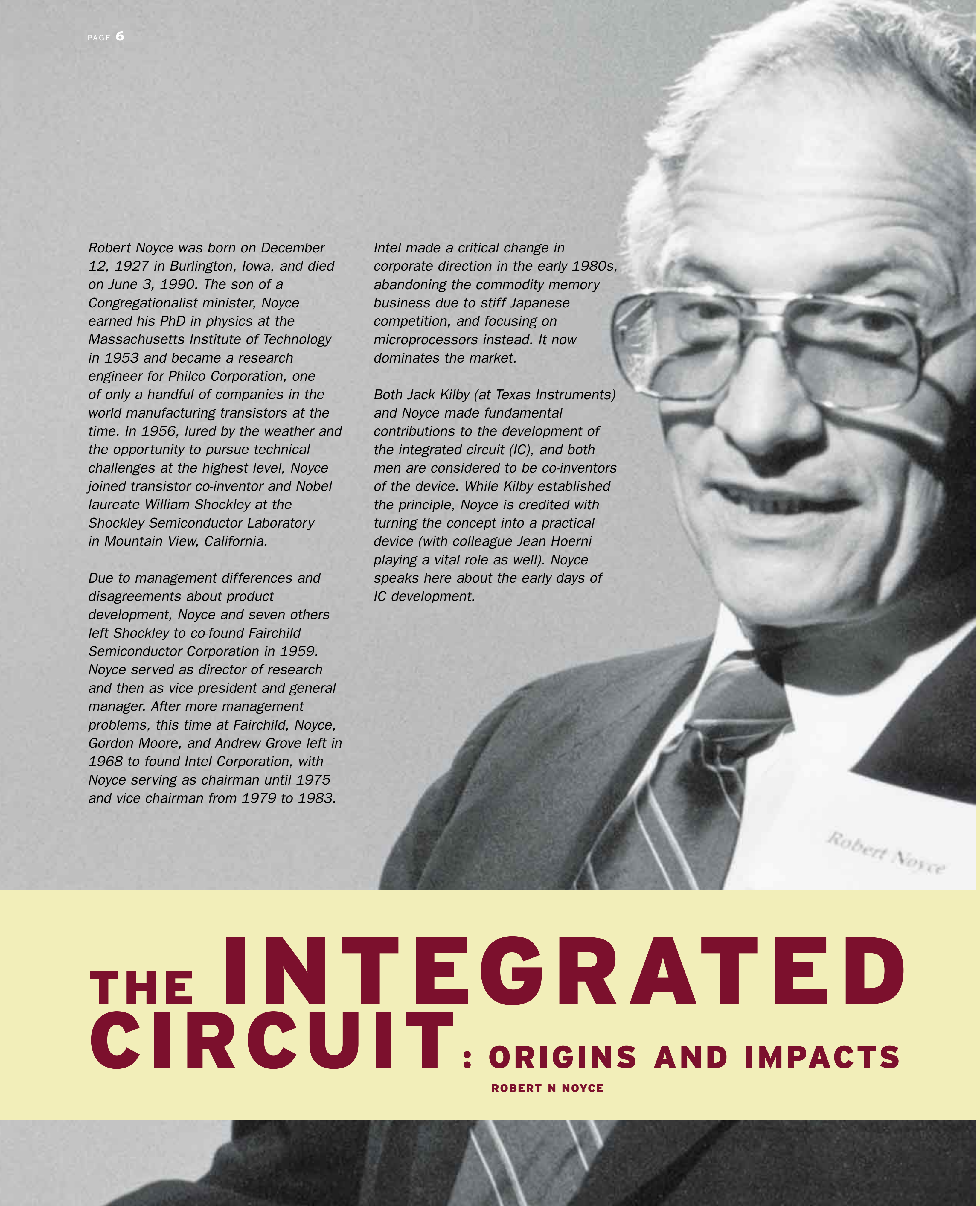
Power consumption: Approx. 750W

Weight: Approx. 400 lbs

Size: 40" x 30" x 50" (HWD)

Applications: Solution of ordinary differential equations (linear and non-linear, any order or degree), aviation industry, engineering, industrial control, education

Cost: $500,000 (USD in 1949)



Robert Noyce was born on December 12, 1927 in Burlington, Iowa, and died on June 3, 1990. The son of a Congregationalist minister, Noyce earned his PhD in physics at the Massachusetts Institute of Technology in 1953 and became a research engineer for Philco Corporation, one of only a handful of companies in the world manufacturing transistors at the time. In 1956, lured by the weather and the opportunity to pursue technical challenges at the highest level, Noyce joined transistor co-inventor and Nobel laureate William Shockley at the Shockley Semiconductor Laboratory in Mountain View, California.

Due to management differences and disagreements about product development, Noyce and seven others left Shockley to co-found Fairchild Semiconductor Corporation in 1959. Noyce served as director of research and then as vice president and general manager. After more management problems, this time at Fairchild, Noyce, Gordon Moore, and Andrew Grove left in 1968 to found Intel Corporation, with Noyce serving as chairman until 1975 and vice chairman from 1979 to 1983.

Intel made a critical change in corporate direction in the early 1980s, abandoning the commodity memory business due to stiff Japanese competition, and focusing on microprocessors instead. It now dominates the market.

Both Jack Kilby (at Texas Instruments) and Noyce made fundamental contributions to the development of the integrated circuit (IC), and both men are considered to be co-inventors of the device. While Kilby established the principle, Noyce is credited with turning the concept into a practical device (with colleague Jean Hoerni playing a vital role as well). Noyce speaks here about the early days of IC development.

THE INTEGRATED CIRCUIT: ORIGINS AND IMPACTS

ROBERT N NOYCE

REPRINTED FROM THE COMPUTER MUSEUM REPORTS, VOLUME 11, WINTER, 1984-1985

As I was driving in tonight, I was listening to a Chrysler ad pointing out that the company was 60 years old. I think of Chrysler and the auto industry as old. Then, I thought, the semiconductor business must be reaching middle age, since it is now over 30.

In 1954, the semiconductor business amounted to 25 million dollars: the growth sequence then was 35, 80, 140, 210, 360, and then 550 million [dollars] by 1960. Half the business was in transistors; silicon accounted for a relatively small share.

In the 1950s, everyone was trying to figure out new and better ways of making transistors. At one of the solid state circuits conferences, an explorer's kit, designed to keep you from getting lost in the woods, was displayed. It consisted of a box with a small cube of germanium and three pieces of wire. If you got lost, you were to start making a point contact transistor. Whereupon ten people would lean over your shoulder and say, "That's not the way to do it." Then, you would turn around and ask, "Where am I?"

At the time, germanium alloy transistors were made by putting indium on top of semiconductor germanium and melting it just enough to dissolve some of the germanium and then recrystalizing it on both sides to make a PNP transistor.

One baffling research question was why germanium, when it was heated and then cooled in the laboratory, changed from N- to P-type. Simultaneously transistors were being manufactured with N-type germanium on the factory because the indium acted as a "getter" to pick up all the impurities instead of converting the germanium.

In the mid-fifties, the thinnest possible transistor was a fraction of a mil [one mil = 0.001 inch] and a mil was a megacycle so these weren't very useful for anything except for hearing aids.

Between '54 and '55, we started worrying about diffusion as a way of getting impurities into the semiconductors, giving good control of the depth dimension. The problem was to get control of the other dimensions. Some of the first work was done at Philco because the semiconductor group worked right across the hall from the laboratory that was working on etching shadow mask tubes for color television. They were experienced with photo engraving, which turned out to work a lot better.

The invention of the planar transistor by Jean Hoerni further set the stage for the birth of the integrated circuit. Planar transistors solved the problem of impurities on the surface of the transistors and at their junctions that had been lousing up the specified characteristics. Hoerni's idea was to leave the silicon dioxide, a very good insulator, on top of the transistor when it was being diffused, thus forming a protective cover.

The government gave further impetus by their interest in getting things into smaller packages. The Air Force project Tinker Toy and the concept of molecular engineering didn't really work very well, but it did let everyone know that there was an interest in getting things small. A square inch chip with ten thousand transistors was very labor intensive: each transistor had to be attached by a couple of wires and soldered down. There had to be a smarter way.

I remembered that when I was in college, I could slave over something, finally get the right answer, hand in my paper and it would come back with big red markings on it. My physics professor would say I did it the hard way Then he'd jot down a couple of sentences which clearly made it much easier for me by using some other method. I guess that is what stuck with me because one of the characteristics of an inventor is that he is lazy and doesn't like to do it the hard way. Putting those 20,000 wires on 10,000 chips of silicon seemed like the hard way to me.

Although the printed circuit board was starting to be used, the thought of printing a circuit on top of the transistors had not occurred. It was the genesis of the idea of the integrated circuit. All the elements were converging: photo engraving enabled reproduction and the planar transistor allowed conductors directly on top of it. Three ideas popped up at that time. One was junction isolation, which I patented, even though it turned out that Kurt Lehovic had thought of it years before at Sprague. At Fairchild, J. Last thought of the idea to etch the transistors apart, glue them down to something and if you still knew where they were you hopefully put them together. This idea had been previously patented at Bell Labs. The one I did get a patent on used intrinsic isolation, that is to use the silicon as an insulator. It didn't work well at first because by bombarding it with neutrons or doping it, leakage occurred and the life was too short. Junction isolation is now being broadly used.

After the original concept was developed, things moved very slowly. One reason was the low yield on transistors: with 50% yield and ten transistors together, the final yield of one over two to the tenth is a small number. We didn't even consider putting a thousand transistors together. Another problem was that the early integrated circuits were very slow. And, of course, the market was opposed to this innovation.

Progress followed the classic Moore's curve. Every year you could get something twice as complex as the year before. That extrapolates to a million elements in 1980. We didn't quite make that unless you allow for the introduction of new things like magnetic bubbles. The technology also changed from bi-polar to MOS.

Costs are determined by complexity and the number of leads per square inch of silicon with problems setting to 20,000. Starting with a ⅝th inch wafer in 1963, costs were reduced by increasing the

1 Graph of semiconductor penetration through 1976

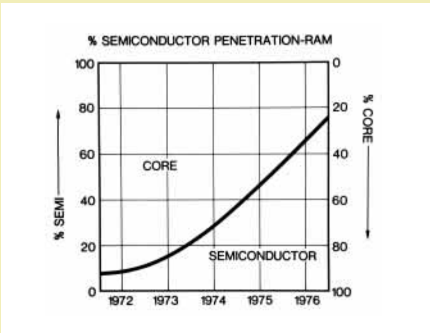
2 Comparative costs of various memories through 1978

3 Photomicrograph of the Intel 4004, the first commercial microprocessor

4 Original Intel ad announcing the 4004-family of microprocessors

5 Worldwide semiconductor shipments went from $.005 billion in 1954 to $149.4 billion (USD) in 1999

"This year, the industry will produce at least 100 quadrillion transistors. This is more than Professor E.O. Wilson of Harvard estimates for the number of ants on earth." Gordon Moore, 1999



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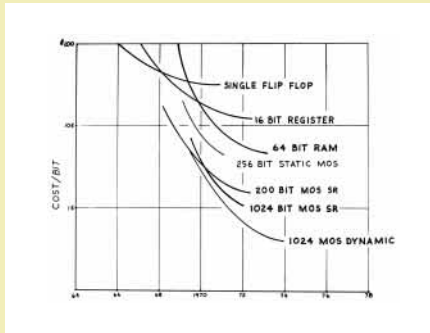

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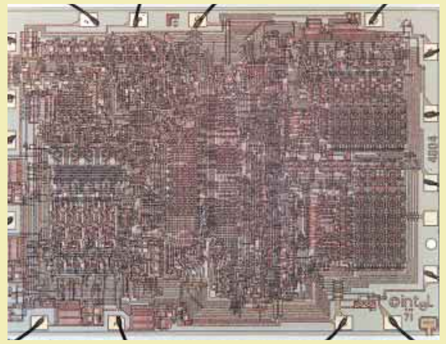

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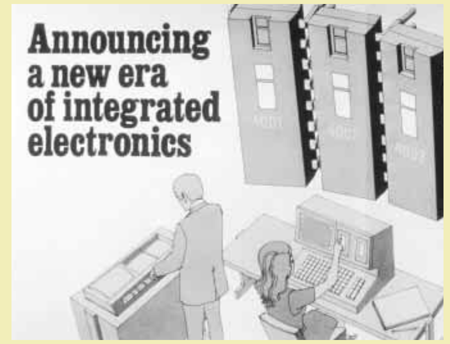

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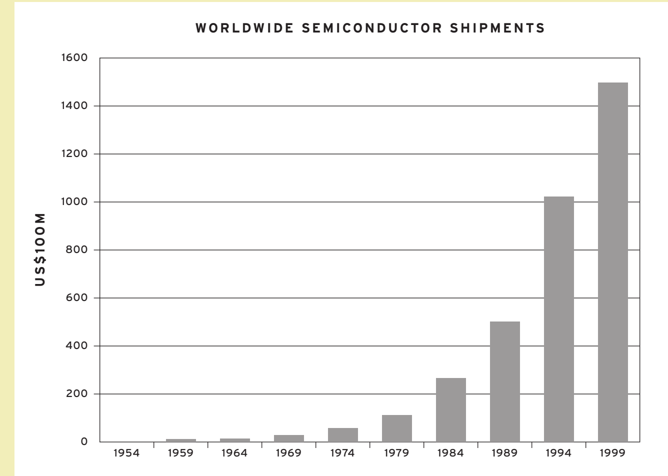

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size to 1½ inch in '65 and two inches in 1970. The die size and area were also increased to reduce the density of defects that would kill the surface. It became possible to use an ever-increasing area to put a circuit on and have it work. Circuit dimensions themselves have been reduced below the size of neurons, 10 microns, and these are being used for speech synthesizers and other products. Today we have two micron circuits and are talking about .7 microns, so we indeed are getting down to biological dimensions and it is conceivable to talk about things the brain can do.

Other new ideas were important. One was MOS and the second was epitaxy. Prior to the use of epitaxy, only the surface could be more impure than the underlying material. This was another bag of tricks.

The first set of integrated circuits had straight Boolean functions. With progress the designers wanted complexity with lots of leads out of a circuit and the semiconductor manufacturers just didn't like that at all. In addition, the more complex products had a lower demand, and as manufacturers we were thinking of making millions of items. Simultaneously, the computer companies in the early seventies were talking about tens of thousands per year. One kind of chip, however, was like heroin to the computer designers and that was memory. Give them a little bit and they want more. Thus, memory chips became a major standard product.

WHAT HAS THE CHIP WROUGHT?

The chip has been one of the main elements allowing the ubiquity of computers. Computers, as tools and devices to help train people to think logically and work precisely, have caused a major revolution in education, business, government, and all aspects of society. The telecommunications manufacturers would have us believe that every telephone in the world will be a computer terminal.

Some people fear this idea, just as I feared the telephone. One day, when I was quite young, my folks were out and left me alone. The telephone rang. I panicked, picked it up, and said, "Hello, nobody's home," then hung it up. Today I can't imagine living without a telephone.

Let me point out a couple of other changes that I've observed. The first computer in an automobile only controlled the non-skid brake and exhaust and it cost twice as much as the car and filled the whole trunk. In fact, the rear seat had to be used as well in order to install the computer. Today computers in cars do ten times more work and cost about $30. They are less expensive than a mechanical carburetor and will pay for themselves in the first year in gas savings.

Jobs in the future are not going to require the skills of the past. One hundred-and-fifty years ago, 50% of the American labor force was employed on the farm. Fifty years ago the greatest proportion was in manufacturing. Today that is about 20%. These latest statistics are inaccurate because the categories have not changed with the economy. Intel is included in the manufacturing sector, even though only 30% of our people actually touch any products that are shipped. Most of our employees sell, keep books, or even do such useful work as design the next generation of products. Today, more than 50% of the labor force is working with information.

The computer is the major tool that can help information workers. It's a productivity enhancer for people who work with ideas as well as for people who work with things. It will allow more human use of human beings. Dull repetitive tasks are the first to go. For example, retyping a letter for one mistake, or reformatting a marketing forecast.

The tradition of liberal arts education was designed to allow people to understand and communicate in society. Grammar, rhetoric and logic came first, and then the quantitative studies of arithmetic, music with its geometrical relationships, geometry and astronomy followed. The same task is essential today. The student has new tools to help understand the continuing accelerating advances in technology. Most students will be working with a computer in some way.

It's not necessary for society to break down into C. P Snow's two cultures in which those who do not work with technology are left behind those who have the modern tools to become productive. Despite the advances in technology, math, science and engineering are not attracting enough people in the US. The power of our computers that can help people as tools is growing beyond common imagination.

The Computer Museum has the CDC 6600, the first production supercomputer from 1963. It cost more than $3 million and only had 500,000 transistors. That will be available on a single chip within a couple of years and everyone can have a supercomputer. All the educational institutions have a challenge to make this work for the science and liberal arts.

POSTSCRIPT BY DAG SPICER

In the 15 years since Robert Noyce gave this lecture at The Computer Museum, much has changed in the world of semiconductors. Noyce speaks of 2 micron circuits; production devices are now made at 0.18 microns (and experimentally even smaller). In 1985, Intel's 386 CPU had 275,000 transistors; the latest Pentium III contains nearly 30,000,000. The value of semiconductor shipments worldwide went from $5 million in 1954 to $149.4 billion (USD) in 1999.[1]

One of the most remarkable constants of this period, which Noyce pointed out, has been the continuing applicability of Moore's Law in terms of transistor counts as well as the resiliency of optical lithography over alternative technologies. Another constant is that IC-making technologies use many similar processes—albeit vastly refined—to those that Noyce started himself some 40 years ago by buying projector lenses from a San Francisco camera store and building his first contact printer. While the technical advances have continued relentlessly, mere quantitative measures do not tell the whole story. Computers changed qualitatively, not just quantitatively, in about the mid-1970s, moving from "number crunchers" to platforms for visualization, entertainment, and communication. And, as Noyce noted, perhaps a bit skeptically, telephones have indeed become computer terminals.

As Noyce's friend and colleague Gordon Moore recently noted in a lecture here at the Museum last October, the industry annually produces more transistors than there are ants on earth. In spite of this astounding rate of diffusion, ensuring the continued miniaturization and proliferation of transistor technology until at least the next decade, the fundamentals of IC design and manufacture are much the same as those Noyce and his colleagues pioneered some four decades ago.

[1] Semiconductor Industry Association

Dag Spicer is Curator & Manager of Historical Collections at The Computer Museum History Center

FROM THE COLLECTION

THE GENIUS ALMOST AUTOMATIC COMPUTER

DAG SPICER

Developed by the legendary Edmund Berkeley (founder of the ACM and author of *Giant Brains or Machines That Can Think*), GENIAC was a very Spartan arrangement of masonite wheels with metal contacts and flashlight bulbs out of which some 30 "small electric brain machines" could be built. Basically, GENIAC provided N-pole by N-throw rotary switches that could be wired in series to perform logical operations.

Berkeley had designed and marketed a previous machine, known as "Simon," that had appeared as a series of 13 articles in *Radio Electronics* from 1950-51. GENIAC stood for "Genius Almost Automatic Computer" and sold for "under $20" in 1955, when first introduced. In addition to the musical and computational uses advertised above in *Astounding Science Fiction* in 1957, a *Popular Science* advertisement listed some of the projects: computer circuits for binary and decimal adding, subtracting, dividing, and multiplying; the solution of problems in symbolic logic, reasoning, and comparing; "psychological testing;" experimental game-playing circuits for tic-tac-toe and nim; as well as "actuarial analysis."

GENIAC is important as both a cultural and technological artifact, one whose pedagogical purpose embedded cultural and political assumptions relating to the cold war that most of GENIAC's young users probably never thought or cared about: GENIAC was fun!

Several GENIACs form part of The Computer Museum History Center's permanent collection. ■

Dag Spicer is Curator & Manager of Historical Collections at The Computer Museum History Center

GENIAC (Genius Almost Automatic Computer) (1955), X877.88, Gift of William R Simpson

GENIAC (Genius Almost Automatic Computer) (1955), X836.87, Gift of Elliot Linger

GENIAC (Genius Almost Automatic Computer) (1955), X734.86, Gift of Thadeus M Hershey

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GEORGE STIBITZ COMPLEX NUMBER CALCULATOR DESIGN DRAWINGS (1940), X2010.2001, GIFT OF GEORGE ROBERT STIBITZ

CHRIS GARCIA

While working for Bell Telephone Labs, George Robert Stibitz (1904-1995) created the Complex Number Calculator, an electromagnetic relay system used to solve complex calculations. In 1940, Stibitz demonstrated the machine—by then renamed the Bell Labs Model 1—at a meeting in Hanover, New Hampshire, with an operator accessing the machine in New York City via telephone lines. Stibitz allowed the astounded attendees to pose questions while a Teleprinter printed the answers. This may have been the earliest example of a remote job and foreshadowed the later link between communications and computing. Stibitz was born in York, Pennsylvania, and graduated from Denison University in 1926 with a PhD in applied mathematics. He received a second PhD in physics from Cornell in 1930 and joined Bell Telephone Laboratories as a mathematical consultant. In 1964, Stibitz joined the Department of Physiology at Dartmouth Medical School as a research associate. He became a professor in 1966 and professor emeritus in 1970.

In 1986, Stibitz donated to the Museum his collection of design diagrams of the Complex Number Calculator as well as photographs of the original machine in operation. He also presented a lecture for The Computer Museum on the Model 1 and advances at Bell Telephone Labs. ■

An operator at the remote console for the Bell Labs Model 1, 1940

COMPUTER SPACE (1970), X1025.90, GIFT OF ALAN RIFKIN

CHRIS GARCIA

While Pong (1972) is often called the "First Arcade Video Game," the title rightfully belongs to Computer Space, developed a year earlier in 1971 by Nolan Bushnell for Nutting Associates of Mountain View, California. The game closely resembled Steven "Slug" Russell's SpaceWar!, developed at MIT in the early 1960s for play on the DEC PDP-1. Computer Space featured two ships gliding through star-filled space trying to shoot down opponents with missiles. The black and white monitor and console speakers seem quite primitive by today's game standards, but in the 1970s, these were far more sophisticated than anything else that was being played in pinball-dominated arcades.

Perhaps the best reason Pong gets all the attention is the fact that not many people played Computer Space with its complex controls. Pong, possibly the easiest of the early video games, sold more than 100,000 units, while Computer Space sold less than 3,000 units. Realizing that the game itself may have been too complex for most users of the day, Nutting Associates then tried unsuccessfully to market the game in a "Beautiful Space-Age Cabinet" with attendant scantily-dressed model.

After the failure of Computer Space, Bushnell formed Atari (originally called Syzygy), and released the wildly popular Pong game in 1972. Atari went on to become the dominant video game company through the early 1980s. After selling Atari to Warner Brothers, Bushnell later founded Pizza Time Theatres and Sendai Electronic Games. ■

Chris Garcia is Historical Collections Coordinator at The Computer Museum History Center

Computer Space, the first commercial coin-operated video game

MUSEUM VIDEOTAPES MAY NOW BE ORDERED ONLINE

One of the ways The Computer Museum History Center preserves the personalities, stories, and visions of the information age is through its extensive archive of videotapes—now 2,000 titles and growing. These recordings are valuable, not only for historical inquiry, but for contemporary understanding as well. The Museum is proud to offer a wide selection of its video holdings for classroom and personal use. Please visit **WWW.COMPUTERHISTORY.ORG/STORE** for a complete list of titles and prices.

The collection contains a variety of material, including:

MUSEUM "COMPUTER HISTORY" LECTURES by leading computing innovators. Often these videos are the only permanent record of important talks and favorite ideas of people who have influenced the technology revolution.

MUSEUM "HISTORY IN THE MAKING" LECTURES, meant to capture the present vision, technology, and process of people who may one day be important parts of computing history.

RECORDINGS IN THE GRAY-BELL ARCHIVE, including presentations by computing legends and innovators derived from more than a decade of work by University Video Communications (UVC).

The Museum distributes thousands of videos per year and many titles are also available for viewing on the web. Visit our website for more information. Stay tuned, since we update the site and add to the archive regularly.

WWW.COMPUTERHISTORY.ORG/STORE

RECENT DONATIONS

TO THE COMPUTER MUSEUM HISTORY CENTER COLLECTION

MICROCOMPUTERS

Wang 53-2 Personal Computer (1984), X1817.2000, Gift of Harry Brooks

Tandy TRS-80 Model 4 (1982), X1930.2000, Gift of Bob Morgan

Tandy TRS-80 Model 4 (1982), X1931.2000, Gift of Bob Morgan

Apple Powerbook Duo with DuoDock (1990), X1926.2000, Gift of Leslie Lindsay

IBM 5271 Computing System (1983), X1923.2000, Gift of Bill Spangler

Mindset Video Production System (1983), X1921.2000, Gift of Molly Hogan

Mindset Personal Computing System (1983), X1922.2000, Gift of Molly Hogan

Digital Equipment Corporation Hi-Note Laptop (1994), X1938.2000, Gift of Bonnie Sontag

COMPONENTS

NexGen Nx586-60 VLB Motherboard (1995), X1945.2001, Gift of Norbert Juffa

NexGen Nx586 PF110 PCI Motherboard (1995), X1946.2001, Gift of Norbert Juffa

Integrated Information Technologies XC87DLX2/50 Math Coprocessor (1994), X1947.2001, Gift of Norbert Juffa

OTHER / SPECIAL PURPOSE

Lexitron VT 202 Word Processor (1979), X1920.2000, Gift of Holvick Construction

US Robotics Palm Pilot Professional (1995), X1935.2000A-C, Gift of Tuck Takagawa

Matsucom OnHand Wearable PC (1997), X1936.2000, Gift of Tuck Takagawa

Silicon Valleyopoly Board Game (1989), X1937.2000, Gift of Tuck Takagawa

Advanced Concepts Ltd. Crayola Crayon Box Calculator (1994), X1944.2000, Gift of Joseph Camp

Tubular Audion Vacuum Tube (ca 1912), X1943.2000, Gift of Eric Barbour

Kendall Square Research KSR 1 Promotional Model (1992), X1948.2001, Gift of Norbert Juffa

Pre-Production Apple Duo External Floppy Drive (1990), X1928.2000,Gift of Leslie Lindsay

Apple Newton with Fax Modem (1990), X1927.2000, Gift of Leslie Lindsay

IBM UPAC Coupler (1983), X1924.2000, Gift of Bill Spangler

Burroughs 1C Dish Platter (1971), X1977.2001, Gift of William Klehm

FOCUS ON PEOPLE

ELEANOR DICKMAN

DAVE ANDERSON, DAVE HOUSE, AND GRANT SAVIERS: THE RACER'S EDGE

When Trustees Dave Anderson, Dave House and Grant Saviers walk into an Executive Committee meeting at The Computer Museum History Center, the room fairly crackles with their intensity and drive. Their mission is to help preserve the history of computing. Their focus is how this history will be important for future generations. And it is clear that these three engineering executives[1] want to get things done!

Their love for things mechanical, their intellectual energy, and their competitive spirits have made them successful contributors and corporate executives in today's high-tech world. These same traits make them enthusiastic amateur race car drivers.

Anderson is the veteran speedster of the group, having raced for the past eight years. Saviers joined the circuit a year-and-a-half ago, and House will celebrate his first anniversary on the track in November. House has been in love with cars since his childhood "in the automotive state of Michigan." He characterizes himself as "an adrenaline junkie," observing that racing is a "chance to drive fast legally." Speed also motivates Anderson: "It's a natural fit between my heavy foot and my [sense of] competitiveness, an opportunity to provide an outlet for both." For Saviers, the thrill is to "push myself… the adrenaline rush of racing is unbelievable!"

All, however, have approached the fast track with the same methodical preparation required by an engineering or management challenge. Certified by the Skip Barber Racing School, they compete in events sponsored by the Sports Car Club of America (SCCA). Anderson is proudest of his performance in the SCCA Spec Racer Class, in which he won the Pacific Coast championship. House hasn't won any records as of yet, but believes that "racing is more of the challenge than the winning; there is always somebody to compete with." He says that the object of racing is to "keep the car right on the very edge of control but never getting out of control or making a mistake." Saviers agrees, and cites one particularly exhilarating episode, when he managed to regain control of his car as it was spinning at 115 mph, "with only minor damage to the car and nothing to me."

Many of the qualities that make Anderson, House and Saviers good racers also make them outstanding Trustees. House says, "Clearly the parts of our personalities that make us want to race are also the things that make us want to make things happen." Competitive and inventive, Anderson likes using his leadership skills "to help create and build an effective organization." Saviers, who describes himself as "a builder of things," wants to build the Museum "in different dimensions."

All three have been long-time supporters of The Computer Museum History Center. A DEC employee for 25 years, Saviers has been affiliated with the Museum since he worked for Gordon Bell, who, with his wife Gwen, founded the original Computer Museum. House was introduced to the Museum by fellow Trustee Gardner Hendrie (House's mentor years ago at Honeywell), and later became involved with the Computer Bowl. Participating in the Computer Bowl as a contestant five years ago also connected Anderson to the Museum.

The Trustees agree that the Museum's most important mission is preservation. Notes House: "I'm interested in celebrating the history and the stories of the computer industry, an industry that has changed our world. It is still new, and many of its pioneers are still with us." Saviers describes computing as "a very creative learn-while-doing technology," and wants to ensure that the milestones in computer history are preserved and explained. "It's marvelous," he says, "to celebrate what the best and brightest have done in the past." Anderson fears that "our technology industry has been particularly poor at [preserving its history] and The Computer Museum History Center is absolutely needed to "maintain our valuable artifacts and stories."

With Anderson, House, and Saviers on the "track," the race to build a strong organization and a new facility is one The Computer Museum History Center is sure to win!

Grant Saviers, Dave Anderson, and Dave House share a passion for fast cars and cutting-edge leadership

PHOTO BY ELEANOR DICKMAN

[1] Dave Anderson: CEO, Sendmail; Chairman of GeoFin Corp; former Chief Technical Officer, Amdahl. Dave House: 22-year veteran of Intel; former CEO, Bay Networks; former President, Nortel. Grant Saviers: former Chairman & CEO, Adaptec; former Vice President, Storage Systems, DEC.

Eleanor Dickman is Vice President of Development & Public Relations at The Computer Museum History Center

REPORT ON MUSEUM ACTIVITIES

KAREN MATHEWS

An unbeatable partnership between you—our supporters—and a committed group of talented, hard-working Trustees, staff, and volunteers has put us squarely on track to continue increasing the scope and breadth of the Museum's operations throughout this fiscal year. Thanks to your generosity and commitment, the Museum has exceeded its projections for fiscal year 2000 by over $100,000. It is exciting to be part of this successful effort to build a community resource that will serve as a world center for computing history.

As always, I welcome the chance to answer your questions or discuss any of the information that follows. All contact information can be found on page 17.

Karen Mathews is Executive Vice President at The Computer Museum History Center

Chris Garcia teaches a group of children about core memory in the Visible Storage Exhibit Area

MUSEUM VISITORS

Our Visible Storage Exhibit Area includes many unique and rare objects from the collection such as the Honeywell Kitchen Computer, the Apollo Guidance Computer, two Apple I boards, and pieces of the ENIAC, ILLIAC IV, and SAGE. We are always thrilled to host tours for both individuals and groups. Our many visitors this quarter included Mary Wasik and 25 students from Blach Intermediate School in Los Altos, California. Here are some of the students' written responses:

> "Excellent tour! Extremely old computers with mere K's of memory!"
>
> "My impression... was that the computers were really cool and that technology has changed a lot in a few years."
>
> "I... learned that there are computers in the world worse than ours."

What past or present technology innovations were you marveling at when you were 13?

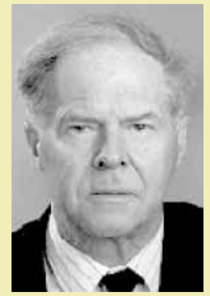
1999 Fellow Award presentations (from top): Horst Zuse (left) accepted posthumously on behalf of his father, **Konrad Zuse** (presented by Hermann Rampacher), **John McCarthy (left)** (presented by Ed Feigenbaum), and **Alan Kay (left)** (presented by Doug Engelbart)

JAN LUNDBERG PHOTOGRAPHY

2000 FELLOW AWARDS BANQUET

Each year the Museum presents Fellow Awards to people who have made significant contributions to computing. To date, we have recognized 14 Fellows, all of whom are featured on our website at www.computerhistory.org/exhibits/hall_of_fellows. We will announce three more honorees at our annual dinner and Fellow Awards Banquet on **THURSDAY, NOVEMBER 9, 2000,** at the Hotel Sofitel in Redwood Shores, California. Please save the date for a magical evening with the pioneers, and movers and shakers of the IT world. The Museum is looking for additional corporate partners to join Citigate Cunningham and Greater Bay Bancorp-Mid Peninsula Bank in sponsoring this memorable event. If you can help or have any ideas, please let me hear from you! We look forward to sharing the experience with you. To reserve your place or arrange for a table, please contact Wendy-Ann Francis.

In a lecture on September 28, Richard Grimsdale will discuss 1950s-era computing in the UK



LECTURE PROGRAM

On Thursday, September 28, the Museum will present Richard Grimsdale lecturing on "The Manchester University Transistor Computer." As a research student at the University of Manchester in 1950, Grimsdale wrote test and diagnostic programs for the Ferranti Mark 1—no small feat, due to the almost total lack of circuit diagrams. From programming the EDSAC in 1950 to his recent work in VLSI accelerator chips for 3-D image generation, Grimsdale has many fascinating stories to relate.

Grimsdale is one of many speakers in our terrific lecture program for 2000. Stay tuned for upcoming announcements. In addition to our popular History Lecture Series, we will be adding "History in the Making" presentations featuring people who are "potentially making history today." To receive lecture announcements, please contact info@computerhistory.org.

Lecture sponsorship opportunities are available. Sponsors ensure their own place in history with permanent recognition in the Museum's video archive as supporters of this important effort to preserve the stories of the information age. You and your company can make a highly-visible, long-lasting contribution to this effort through your participation. Please contact me if you can help or would like to know more.

Trustees and donors relax at the donor appreciation party in July: (left to right) Christine Hughes, Andy Cunningham, Gordon Bell, Donna Dubinsky, and Peggy Burke

PHOTO BY ELEANOR DICKMAN

DONOR NOTES

On July 27, 2000, donors, Trustees and staff celebrated the successful end of our fiscal year with a recognition party for Core Supporters (those who make annual donations of $1,000 or more). The event was graciously hosted by Dave House and Karla Malechek at their lovely hilltop home in Saratoga, California. For those of you who were unable to attend, please know that you were missed and that we plan to hold other such events in the future.

As you know, The Computer Museum History Center welcomes donations to help preserve computing history through collecting, educating, and public communications efforts. The Museum recognizes all of you as very special people and organizations. You loyal, consistent supporters with an abiding interest in preserving the history of computing truly set an example for others to emulate.

In June, volunteers received thanks and awards for the help they gave over the previous year at the Volunteer Appreciation Event 2000. Staff members also shared plans for the upcoming year at the Museum.

PHOTO BY WENDY-ANN FRANCIS

VOLUNTEER APPRECIATION EVENT

Over 50 people gathered at Museum Chairman Len Shustek's home on a sunny afternoon in June to honor the many and varied contributions of Museum volunteers. In addition to enjoying a relaxing picnic on the lawn and lots of socializing, volunteers received personalized certificates and Superman T-shirts! Special thanks to Len Shustek, Lee Courtney, Karyn Wolfe, Wendy-Ann Francis, Betsy Toole, John Francis, and John Toole for helping out! There are many rewarding opportunities to get involved at the Museum as a volunteer. Please contact our Volunteer Coordinator, Lee Courtney.

CURATOR LECTURES IN FINLAND

Last March, Curator Dag Spicer travelled to the Kiasma Museum of Contemporary Art in Helsinki, Finland, where he spoke to an international audience of 300 on the "Archaeology of Computer Culture." Dag was invited to lecture as part of a major exhibition and symposium called "Alien Intelligence" (http://www. kiasma.fi/outoaly/en/cont_outo.htm) that focused on the past, present, and future of computer-mediated interactions. The exhibition featured a "media-archeological" gallery, with historical artifacts from 19th century automata to 20th century autonomous robots and digital pets, including what is likely the world's first artificial life form, Grey Walter's turtle, *Machina speculatrix* (http://www.plazaearth.com/usr/gasperi/walter.htm).

THANKS TO OUR ANNUAL FUND DONERS

We acknowledge with deep appreciation those individuals and organizations that have given generously to the Annual Fund of The Computer Museum History Center.

CORE BENEFACTORS 16K+ ($16,384+)

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This list is current as of September 20, 2000. Please notify us of any changes to your listing (wolfe@computerhistory.org). Thank you.

YOUR ANNUAL DONATION to The Computer Museum History Center will help preserve the artifacts and stories of the Information Age for future generations. Please help us fulfill this important mission.

CORE BENEFACTOR

___ other $ ____________

___ 16K ($16,384)

MAJOR CORE SUPPORTER

___ 8K ($8,192)

CORE SUPPORTER

___ 4K ($4,096)

___ 2K ($2,048)

___ 1K ($1,024)

GENERAL SUPPORTER

___ $500

___ $250

___ $100

___ $35 (student)

___ other $ ____________

Please return this form (or facsimile) with your remittance to:

The Computer Museum History Center
P.O. Box 367 Moffett Field, CA 94035
+1 650 604 2575 (tel)
+1 650 604 2594 (fax)
www.computerhistory.org

YES, I want to help save computing history. Please process my donation at the level indicated. I look forward to learning more about the programs and activities of The Computer Museum History Center, especially its plans for growth in the coming years.

___ Enclosed is my check payable to: The Computer Museum History Center

___ I prefer to donate stock and will notify you when the transfer is made

___ Charge my Visa ____ Mastercard ____

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WELCOME to our network of supporters. We look forward to getting to know you!

TRIBUTE DONATIONS

What do you give the entrepreneur who has everything? To commemorate a birthday, anniversary, job promotion or successful IPO venture, or to honor the memory of a colleague or loved one—consider making a donation to the Museum on their behalf. We'll be happy to send an acknowledgement to the recipient or family. Your thoughtfulness will be appreciated by those you have remembered, and by the Museum as well.

STOCK DONATIONS

We gratefully accept direct transfers of securities to our account. Appreciated securities forwarded to our broker should be designated as follows:

FBO: The Computer Museum History Center; DWR Account # 112-014033-072; DTC #015; and sent to Matthew Ives at Morgan Stanley Dean Witter, 245 Lytton Avenue, Suite 200, Palo Alto, CA 94301-1963.

In order to be properly credited for your gift, you must notify us directly when you make the transfer. If you have any questions regarding a transfer of securities, please contact Eleanor Dickman.

DONOR SPOTLIGHT

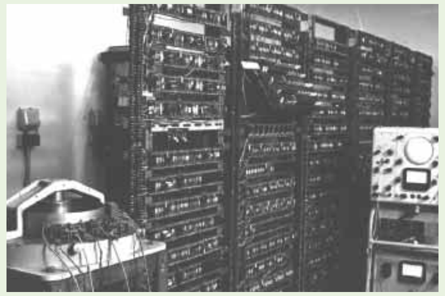
DEL THORNDIKE & STEVE TEICHER

DEC alums Steve Teicher and spouse Del Thorndike have supported the Museum since its inception. Steve was a senior group engineering manager at DEC, and Del was the head of technical education for the semiconductor group. Steve has always endorsed the idea of preserving the inventions and biographies of pioneers of the information age, and praises Gordon and Gwen Bell, founders of the original Digital Computer Museum, "for their good sense of keeping bits of history."

Now pursuing an MBA at Rollins College (FL), Steven indicates that The Computer Museum History Center has "a unique opportunity to preserve artifacts, photographs, and videotaped lectures of industry titans" that might otherwise have been lost. "If you were an archeologist a few hundred years from now, these are the types of things you would want to have preserved." Del sees The Computer Museum History Center as contributing "a new form of art," by highlighting the beauty of machines that "somebody worked hard to put together" in aesthetic as well as functional ways. "We tend to be interested only in the new," she says, "but it's the old that we learn from."

UPCOMING EVENTS

SEPTEMBER 28, 6 PM



THE MANCHESTER UNIVERSITY TRANSISTOR COMPUTER
Richard Grimsdale
University of Sussex, UK
Computer History Lecture
Moffett Field, California

OCTOBER 11, 6 PM
A CARTOONIST'S LOOK AT COMPUTER HISTORY
Richard Tennant, 5th Wave Cartoonist
Special Presentation
Moffett Field, California

OCTOBER 14, 9 AM - 5 PM
VOLUNTEER WORK PARTY
Bldg 126, Moffett Field, California

OCTOBER 21, 4 PM (TENTATIVE)
TONY SALE
Computer History Lecture
Location TBD

NOVEMBER 8, 6 PM
THE STRETCH-HARVEST COMPILER
Fran Allen, IBM Fellow
Computer History Lecture
Location TBD

NOVEMBER 9, 6 PM
FELLOW AWARDS BANQUET 2000 INDUCTEES: FRAN ALLEN, VINTON CERF, AND TOM KILBURN
Hotel Sofitel at San Francisco Bay
Redwood Shores, California

NOVEMBER 18, 9 AM - 5 PM
VOLUNTEER WORK PARTY
Bldg 126, Moffett Field, California

DECEMBER 9, 9 AM - 5 PM
VOLUNTEER WORK PARTY
Bldg 126, Moffett Field, California

ATTENDING EVENTS AND TOURING THE COLLECTION

The Museum is housed at NASA Ames Research Center, Moffett Field, California. The collection is open to the general public by appointment on Wednesdays at 1:00 pm. To attend an event or to tour the collection, please call Wendy-Ann Francis at least 24 hours in advance. Donors may also request private tours.

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+1 650 604 2594 (fax)

or
THE COMPUTER MUSEUM HISTORY CENTER
PO Box 367, Moffett Field, CA 94035

WWW.COMPUTERHISTORY.ORG

VOLUNTEER OPPORTUNITIES

The Museum tries to match its needs with the skills and interests of its volunteers. Monthly volunteer work parties are listed in the calendar to the left. For more information, please contact Betsy Toole or visit our volunteer web page at www.computerhistory.org/volunteers.

MYSTERY ITEMS

FROM THE COLLECTION OF THE COMPUTER MUSEUM HISTORY CENTER

Explained from CORE 1.2

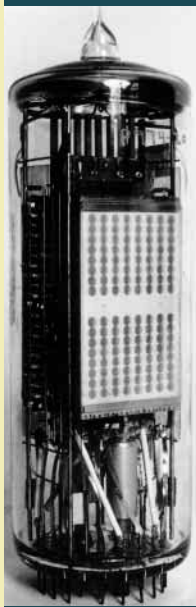
The MIT RDA Differential Analyzer Component was part of an enormous mechanical "computer" built at MIT in late 1941 under the direction of U.S. wartime research head Vannevar Bush. The RDA, or "Rockefeller Differential Analyzer" (funding came in part from the Rockefeller Foundation), weighed 200,000 lbs (100 tons), had 2,000 vacuum tubes, 200 miles of wiring, and 150 motors. Legendary mathematician and electrical engineer Richard Hamming donated this particular component to the Museum in May of 1987. At the time of his donation, Hamming wrote, "I had used it for important work in guided missiles in 1946-47 and later, when I heard it was being torn down, I asked, politely, for a piece. They sent the differential gears that were the form of addition on the machine. I have dropped it numerous times so that the gears are not as backlash free as they were originally on the machine, which was perhaps the most accurate analog computer of its size yet built."

MIT RDA DIFFERENTIAL ANALYZER COMPONENT (1941), X838.87, GIFT OF RICHARD HAMMING

The RDA operated 24 hours per day and solved many critical problems in atomic physics, acoustics, ballistics, and other fields during WWII. By 1949, a digital version of the differential analyzer called MADDIDA (see page 2) was constructed by the Northrop Corporation. The RDA ran its last calculation in 1950, when it was finally dismantled, bringing to a close the era of large mechanical differential analyzers. ■

WHAT IS THIS?

THIS ITEM WILL BE EXPLAINED IN THE NEXT ISSUE OF CORE.



Please send your best guess to mystery@computerhistory.org before 10/15/00 along with your name and shipping address. The first three correct entries will receive free posters: 25 YEARS OF MICROPROCESSOR EVOLUTION.

The Computer Museum History Center
PO Box 367, Moffett Field, CA 94035

Address Service Requested